HOW TO SELL RENEWABLE ELECTRICITY - INTERACTIONS OF THE INTRADAY AND DAY-AHEAD MARKET UNDER UNCERTAINTY

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Overview

The increasing share of renewable energies in the electricity system has changed the structure of electricity markets. Uncertainty about renewable production increases the importance of sequential short-term trading. We consider a two-stage market where conventional and renewable producers compete in order to satisfy the demand of consumers. The trading in the first stage takes place under uncertainty about production levels of renewable producers, which can be associated with trading in the day-ahead market. In the second stage, which we consider as the intraday market, uncertainty about the production levels is resolved. Our model is able to capture different levels of flexibility for conventional producers as well as different levels of competition for renewable producers. We find that it is optimal for renewable producers to sell less than the expected production in the day-ahead market. In situations with high renewable production it is even profitable for renewable producers to withhold quantities in the intraday market. However, for an increasing number of renewable producers, the optimal quantity tends towards the expected production level. More competition as well as a more flexible power plant fleet lead to an increase in overall welfare, which can even be further increased by delaying the gate-closure of the day-ahead market or by improving the quality of renewable production forecasts.

Methods

For answering the research question, we use an analytical model. Here, we consider a profit maximizing function for the renewable producers as well as for the conventional producers which compete in fulfilling electricity demand of consumers in two stages (day-ahead and real time market). The profit maximizing functions are solved analytically (under certain constraints) to derive the optimal bidding strategies in the first and second stage.

In the model, conventional producers are represented as competitive fringe. They are able to produce electricity with an increasing cost function. These quantities are sold into the market at a uniform price of the marginal production costs. The conventional producers also act as market makers, which means they always satisfy the residual demand in both stages.

Renewable producers produce electricity at zero marginal costs. Their final production level is uncertain in the first stage and resolves over time (from stage 1 to 2). We investigate the cases of different levels of competition for the renewable players i.e. monopoly or oligopoly situations among renewable producers. We vary the flexibility of the conventional power plant fleet in the second stage which increases the cost function (motivation is an inflexible power plant fleet which is not able adjust production freely in the intraday market). Besides the optimal bidding strategies, we evaluate the welfare effects, i.e. renewable producer surplus, conventional producer surplus, consumer surplus and total welfare change.

Results

Renewable producers are able to increase their profits by selling only part of their expected production in the first stage and thus raising the price in the first stage. The optimal quantity in the first stage tends towards the overall expected quantity with an increasing number of renewable producers. Conventional producers are considered as a competitive fringe that satisfies the residual demand in both markets. If conventional power producers are less flexible in their operation, renewable producers have a larger incentive to increase the traded quantity in the first stage. In general, prices in the first stage (day-ahead) are higher compared to the second stage (intraday), but with an increasing number of renewable producers or with arbitrageurs entering the market this difference decreases. In situations with very high production levels, that are at least able to serve half of the demand, renewable producers

have an incentive to withhold production in the second stage. This effect is decreased by an increasing number of players but increases in a setting with low flexibility of conventional producers.

A reduced forecast uncertainty leads to an increase in overall welfare. This leads us to two conclusions. First, overall welfare can be increased by delaying the trade in the day-ahead market closer to the time of physical delivery. For example by shifting the auction from noon to the evening. Second, an increase in forecast quality has a positive effect on overall welfare.

Conclusions

We derive the optimal quantities for renewable producers that are strategically selling their production in a two-stage game with uncertainty about production in stage 1 and knowledge about the realization of their production in stage 2. It is profit maximizing for renewable producers to bid less than their expected total quantity in the first stage, which we consider as the day-ahead market.

Based on the results it becomes obvious that in a future electricity system with high shares of renewables, regulators need to pay attention to the possible abuse of market power by large renewable producers. In situations with low liquidity and the absence of arbitrageurs this could lead to significant distributional effects and even welfare losses.

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