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Equilibrium pricing of reserve power

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Overview

Reserve power markets play a significant role in securing the stability of the grid and in matching the inelastic demand of electricity consumers in the case of unforeseen disruptions or fluctuations in supply. Increasing shares of fluctuating renewable generation make this task more difficult because the feed-in of renewables is not synchronized with consumption and, due to its volatility, hard to predict. Since most countries are set to reduce CO_2-emissions in order to mitigate global warming, renewable generation is likely to increase. As a result reserve power markets are expected to further gain in importance.

Key to a well-functioning market is the market design. Competitively organized reserve power markets like in Germany are characterized by high prices with considerable fluctuations. In the light of the discussed difficulties, the market design of reserve power markets merits further investigations.

Method

Firstly, a theoretical model is built in order to investigate fundamental analytical relations in a partial equilibrium framework. Secondly, different specifications of the reserve power products are implemented in a detailed unit-commitment model depicting the European electricity market in order to obtain numerical results.

The basic theoretical model is a merit-order model expanded by reserve restrictions so that both the spot market and the reserve power market are taken into account as separate markets. Consequently, power plant operators face opportunity costs when bidding into one of the markets. The model is solved using the Lagrangian and the corresponding Karush-Kuhn-Tucker conditions from which spot and reserve capacity prices can be deduced as shadow prices.

The analytical results are tested numerically using the Joint Market Model (JMM) of the Chair for Energy Economics. The JMM is a detailed unit-commitment model depicting the European electricity market. It uses a rolling planning horizon on an hourly resolution basis. Both the spot (day-ahead and intra-day) and the reserve power market (spinning and non-spinning) are included.

Results

The analytical investigations reveal that reserve is provided in efficient markets preferably through the marginal units. Correspondingly capacity prices will only be positive when submarginal units have to contribute to the reserve demand due to technical restrictions on the marginal units. Otherwise, if reserve power is auctioned on an hourly basis, capacity prices should be zero. Since in reality capacity prices are higher but also the contract durations are longer, numerical analyses are then used to quantify the impact of different specifications of the reserve power products. Implementing different contract durations for supplying spinning reserve capacity for the year 2012 shows that capacity prices are lower the shorter the contract period is. This effect is somewhat mitigated when large generation portfolios are allowed to supply reserve capacity.

Conclusions

Key to a well-functioning market is the market design. Competitively organized reserve power markets like in Germany are characterized by high prices with considerable fluctuations even though theoretical and numerical analyses show that with the optimal specifications of the reserve power products (e.g. shorter contract durations) reserve capacity prices should be much lower.

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