Multi market bidding strategies for demand side flexibility aggregators in electricity markets

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Due to the electricity systems' increasing need for flexibility, the concept of demand side flexibility aggregation becomes more important. In this paper, we propose a coordinated bidding strategy for a flexibility aggregator with the objective to maximize the profit from a flexibility portfolio by participating in three sequential markets. We demonstrate the approach in a generalized market design that is flexible enough to capture today's market structure and still relevant in the next generation market design, both at wholesale and local level: an options market where flexibility is reserved for later use, a spot market for energy day-ahead or shorter, and a flexibility market where flexibility units are dispatched near real-time. Since the bidding decisions are made sequentially and the price information is gradually revealed, we formulate the problems as multi-stage stochastic programs. To ensure feasible operational schedules, the flexibility units are modelled with technical constraints. We illustrate the application of the models by performing a realistic case study in cooperation with four industrial companies and one aggregator, simulating participation in the Norwegian wholesale markets. In the case study we quantify and discuss the value of flexibility and the value of aggregation.

Real data and rules are used from three current Norwegian electricity markets to simulate over a two-month period: January and February 2016. The study shows that our models ensure that bids and schedules are feasible. Further, we have calculated the value of flexibility and analysed how the different markets generate profits and discussed how this is influenced by price levels, price variations and directions of regulation. To analyse how well the models perform, we have compared with an analysis based on perfect information. We find that the value of the flexibility is 30 % higher with perfect information and that the reason for the loss is two-fold: 1) The stochastic approach chooses strategies that are more flexible to possible different outcomes of the market prices and 2) due to the spiky price situation in January which was very difficult to predict. This also shows the importance of proper price forecasting models and scenario generation methods.

Finally, we have analysed how the aggregator adds value to the portfolio by comparing to a situation where each flexibility vendor participates in the markets separately. We find that the value is 3 % due to increased ability to commit volumes to the markets and to provide feasible scheduling solutions for the flexibility units.