STOCHASTIC OPTIMIZATION IN ELECTRICITY MARKET MODELLING: THE EFFECTS OF UNCERTAINTIES IN CO2 CERTIFICATE PRICES AND NETWORK EXPANSION COSTS

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Overview

The deregulation and the increasing use of renewable power generation both have significantly increased uncertainties for market participants and made planning more difficult. Investment decisions have to be made under various unknown parameters. Amongst others, transmission planners as well as electricity producers especially have to cope with uncertain future cost structures. Depending on which generation technology is used, variable power production costs are fundamentally affected by the prices for CO_2 emission rights. However, the further development of carbon and renewable energy legislation is difficult to forecast as the attitude towards environmental protection and general political targets might vary with a change of government. As generation investments depend on the expected outcome which can be obtained with a generation technology at a certain location, variable costs are a central element of the investment decision. Uncertain future certificate costs therefore have to be incorporated into the generation planning process. Transmission planners are more likely to be affected by uncertainties in their future line construction costs. When planning grid development, network operators have to decide not only whether but also when to build potential lines. That date might significantly depend on what line expansion can be expected to cost at a later time. While even today's costs for a specific line are hard to predict, no one could currently guess what the same grid expansion project will cost in 10 to 20 years. In addition there is the debate about earth cables or overhead electrical cables which is one of the main drivers of uncertain line construction costs. The paper at hand addresses the problem of integrating these uncertainties about future costs into the planning processes of the participants of electricity markets by using a stochastic optimization approach. In a case study for the German electricity market, the effects on the investment decisions are being analyzed and policy recommendations can be derived.

The paper is organised as follows: After the introduction, the second section gives a brief overview about the existing literature on uncertainties in electricity markets and approaches to integrate these uncertainties into electricity market models. The third section describes the stochastic electricity market model developed in this paper. Besides discussing data sources, in the fourth section the results of an application of the stochastic optimization model to the German electricity market are presented. The paper concludes with policiy implications and further research ideas.

Methods

To model the decisions and interactions within the German electricity market under uncertainty, based on the model by Grimm et al. (2015) a multi-level optimization model is used. Uncertainties are included with a stochastic optimization approach. The model was implemented in GAMS.

Results

We developed an electricity market model incorporating uncertainties via stochastic optimization. Computational results show that uncertainties regarding the political framework result in significant cost increases for investors and efficiency losses in general.

Conclusions

For investors costs of uncertainty are significantly high and they might be passed on to customers via electricity prices. To counteract the loss of welfare, policymakers should try to eliminate uncertainties as far as possible. Transmission planners should opt for more flexible network expansion plans that can adapt quickly to new

situations at minimum cost. Although this examination presents important results about the effects of uncertain costs in liberalized Energy only markets, further research on this topic remains necessary and should address the more realistic and complex situation with an increased number of decision stages.

References

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