Auctions for Renewable Energy
An Agent-based Modelling Approach for Wind and Solar PV Auctions in the EU

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Abstract

The following analysis looks into auctions for renewable energy in Europe, specifically wind power and solar PV. The analysis starts with an extensive literature review on auctions for renewable energy and lessons learned, drawing strongly on developments in Latin America and especially in the Brazilian energy market.

With an agent-based modelling approach, different auction designs like uniform pricing and pay as bid pricing are then compared and first conclusions on their outcomes are drawn for future policy design in Europe. The analysis is based on auction theory. For the uniform pricing and pay as bid auctions, individually rational and independent agents are assumed.

Determining the support level for renewable energy through auctions has been made mandatory through the directive 2009/28/EC on the promotion of the use of energy from renewable sources by the European Commission for all European member states starting 2017. As auction rounds in Europe are to be held multi-annually, a focus of this analysis is also on learning of agents over time. Specific learning algorithms and strategies of long-term portfolio optimization have been tested to best approximate the decision making of different bidders in the wind power and solar PV sector.

While the model is applicable to markets and auction design scenarios in different countries, case studies are usually able to provide more intuitive and applied insight into the workings of auctions for renewable energy. For this reason, a case study in the German electricity spot market has been executed. Auctions in this case study have been modelled to closely represent the auction design foreseen in the German "Erneuerbare Energien Gesetz" and replicate their criteria, tendered amounts and ceiling prices. The agents are supposed to approximate the structure in the German market for wind power and solar PV respectively.

The model results show, exemplary for onshore wind, that pay as bid pricing generates a 0.43% lower average price compared to uniform pricing and a 12% lower mark-up on the cost on average. This effect can be attributed to the maximization of the agents' profits, taking into account the competition in the several auction rounds. Thus, we have shown that pay as bid pricing (under the aforementioned assumptions) generates indeed a more cost efficient outcome than the uniform pricing rule in the German onshore wind power auctions.

Over time, one can further observe a decline in the strike price, which is due to learning effects, decreasing costs, as well as increased bid shading by agents trying to maximize their possibility of winning. Conclusions and policy implications are drawn from the case study for other countries. In future research, more cases will be assessed and the model will be extended to analyse a broader variety of market structures.