Uncovering bidder behaviour in the German PV auction pilot Insights from agent-based modelling

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Executive summary

Auctions are becoming an increasingly popular approach worldwide to determine renewable energy support. There is broad a variety in auction designs and market environments and these differ largely in their respective interaction. This paper analyses bidder behaviour in the German PV (photovoltaic) auction pilot and thereby sheds light on one specific application of auction design in a large and interestingly structured market. It uses a novel approach combining insights from data analysis and decision theory to optimise an agent based simulation model. The findings are especially relevant in the eye of a current legislatory change: the Bundesländerklausel/Freiflächen-Öffnungsverordnung (Land Baden-Württemberg 2017, Bayerische Staatsregierung 2017). This new law allows the German federal states (Bundesländer) to come up with their own restrictions or open their disadvantaged arable land for tendering of ground-mounted solar PV. The change in legislation will likely lead to an opening of these formerly restricted areas for upcoming auctions. We show through our modelling how this may influence future auction outcomes.

First, the auction-theoretic foundations of static multi-unit auctions, the format applied in the German PV auction pilot, are laid to outline limits of transferability between theory and practice. While theory provides a thorough understanding of simplified cases, multi-unit auctions with repeated rounds, multi-project bidders and participation over several auctions make the assessment too complex to be solved quantitatively from a theoretical perspective.

Therefore, in a second step, an agent-based model is introduced, which we use to model the German auction scheme for large-scale solar PV. We depict the given market structure, deploy the actual technology cost development and model cost distribution and participation of the bidders. Modelling results are contrasted with empirical data from the German Federal Ministry of Economic Affairs and Energy on the first auction rounds conducted. We analyse both a uniform pricing scheme, which serves as a benchmark case, and a pay-as-bid scheme, where agents adapt their bidding strategy. Furthermore, we conduct a forward-looking exercise, simulating a separate auction for bidders using ground-mounted PV at arable land. This specific

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assessment aims for gaining further insights into this particular type of bidders' behaviour, and to provide an indication on how auction results might change with the ongoing legislatory development.

Our comparison of modelled with empirical data shows two main results. Firstly, the support costs in the early rounds of the actual PV pilot have been higher and the cost decrease has been stronger than in our simulation. Possible explanations for this are the following: we can show that the decrease in technology costs is not sufficient to explain the support cost reduction and thus the reduction is likely backed by economies of scale of multiple project/multiple round bidders. Furthermore, the continuous cost decrease in the actual PV pilot, independent of the auction volume, can be explained by low expected competition in the first auction round and the subsequential bid adaption to the actual competition level. A further reason could be learning effects in the course of the transition from an administratively set support system towards the auction-based support scheme.

Secondly, from simulating a separate auction for arable land bidders, we see that these bidders are able to reduce required support substantially and that they are the most competitive types of all PV bidders. Moreover, we can also observe that an implicitly discriminatory auction by restricting the arable land areas as is currently implemented in the German Renewable Energy Law (EEG) yields more aggressive bids amongst these bidders and can therefore even lead to further cost reductions. Future opening of this type of land should furthermore also consider bidder's difference in opportunity costs: arable land of lesser quality, is currently likely to be more competitive due to lack of alternative area use, i.e. these bidders have lower opportunity costs. It will be interesting to see future results on this, also when e.g. other land use regulations change.

The analysis shows that after a short adaptation phase, the German PV pilot proved to actually be very efficient in creating competition and reducing bidder's average profit. We see that in the second year already, bid prices from the actual auction and modelled prices are almost equivalent.

Aside of providing interesting insights into the overall agent behaviour in the German large-scale solar PV auctions, we further see that arable land bidders, being the most cost-competitive, bring down bid prices and thus overall support costs compared to a system where such bidders are not allowed. It is further shown that restricting the arable land areas and therefore creating an implicit discriminatory auction for this type can lower prices in this bidder group even stronger.

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