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# Auction-theoretic analyses of the first offshore wind energy auction in Germany

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**Abstract.** The first offshore wind energy auction in Germany led to a striking result. The average award price was 0.44 ct/kWh and even more interesting, 3 out of 4 awarded projects had a strike price of 0.0 ct/kWh. That implies that those projects will only receive the actual wholesale market price for electricity as revenue. Although there has been a strong decline in costs of offshore wind projects, such a result is still surprising. We analyzed this result auction-theoretically and showed how the auction design and the market environment can explain part of the outcome. However, another aspect of the explanation is the high risk that the awarded bidders take regarding the future development of both the project costs and the wholesale market price.

## 1. Introduction

Since 2017 all renewable energy support (RES) in Germany is determined in auctions [1] in accordance to the EU state aid guidelines [2]. The results of the first offshore wind energy auction in April 2017 were astonishing and attracted attention worldwide [3]. Out of the four awarded projects, three bids were 0.0 ct/kWh [4]. The biggest awarded project was the EnBW Project 'He Dreih't' with 900 MW a bid of 0.0 ct/kWh. The remainder of 590 MW was awarded to three projects of DONG Energy (now Ørsted) of which two also bid 0.0 ct/kWh and one 6.0 ct/kWh. All of those projects are located in the North Sea.

Although record low auction results for offshore wind energy were obtained in Denmark and the Netherlands in 2016, such an outcome was totally unexpected. Therefore, we analyze the reasons and implications of this result auction-theoretically. Furthermore we evaluate whether the current auction design fits the altered conditions and which consequences they have regarding the future support of renewable energy. Beside these questions we will analyze further interesting aspects of the first auction round.

## 2. Model

In addition to the already existing economic and political analyses of this topic, we will focus on the auction- and game-theoretic implications of the design, bidding strategies and the outcome of the first offshore wind energy auction in Germany. We will not discuss whether it is possible to economically run an offshore wind park at the given prices but whether it is reasonable to submit a 0.0 ct/kWh bid under the given conditions. We will analyze the auction regarding



economic indicators such as efficiency and auction-specific risks for bidders and auctioneer like the Winner's Curse [5, 6] and non-realization [7].

For the further analyses, we introduce a consistent nomenclature of the used terms. Besides the auctioneer, the bidders  $i = 1, \dots, n$  participate in the auction. Each bidder represents one offshore wind project. Each bidder has specific project costs  $c_i$  which represent the individual generation costs for each unit of electricity produced from this project. The support payment is limited to  $T = 300^1$  months, each month is denoted with  $t = 1, \dots, 300$ . Furthermore, each bidder  $i$  has an expectation regarding the average electricity wholesale market price  $e_i$ . The actual wholesale market price is denoted  $p^t$  for each month  $t$  and the average over the 25 years of support is  $P$ . Moreover the projects are characterized by their nominal size  $s_i$  and their minimum bid quantity  $s_i^{min}$ . Finally, each bidder participates in the auction with a bid  $b_i$  and if a bidder is awarded, his corresponding bid determines the respective support level. The actual support payment is denoted  $v_i^t$  and is depending on the month  $t$  and awarded bidder  $i$ .

### 3. Analyses

The first question that arises is how the sudden drop from 5.0 ct/kWh in recent auctions for offshore wind energy in Denmark and the Netherlands to 0.0 ct/kWh in such a short time can be justified. The explanation is given by the chosen remuneration type of a sliding feed-in premium. The awarded bidders are obligated to sell generated electricity directly to the market. They receive an additional payment of the difference between their bid price (which determines their sliding premium) and the average wholesale market price as long as this difference is positive. Therefore the revenue of an awarded bidder  $i$  in month  $t$  is

$$r_i^t = \max(p^t, b_i) \quad (1)$$

and thus the respective actual support payment is

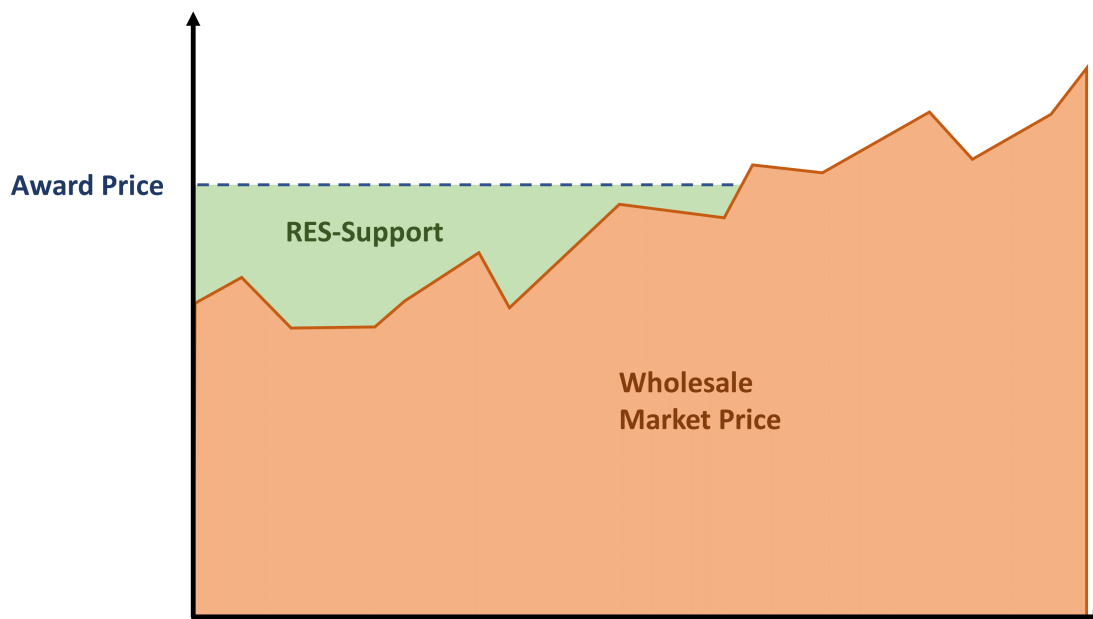
$$a_i^t = \max(0, b_i - p^t). \quad (2)$$

That is, the awarded bidder receives at least the sliding premium and can increase his revenue if the market price is above this value. This remuneration type was chosen to reduce the bidders' uncertainty regarding the future electricity market price [8]. The principle of the sliding feed-in premium is illustrated in Figure 1.

The orange line represents the wholesale electricity market price and the blue dashed line the award price. The resulting orange area corresponds to the revenue the bidder receives from selling the generated electricity to the market. Additionally the bidder obtains the support payment corresponding to the green area which he receives as the market price is below the award price and is represented in (1) by  $r_i^t$ . In contrast to the Contract for Difference (CfD) auction in the United Kingdom, revenues above the award price do not have to be paid back to the auctioneer [9]. The bidders have an asymmetric opportunity to increase their revenues in case of market prices above the award price without fearing the risk in case of low market prices, as in this case they would still receive the award price as a reliable payment.

As a result, bidding 0.0 ct/kWh means that the respective project can be run economically entirely on basis of the average wholesale market price. This implies that from an auction-theoretic point of view bids in a specific interval are dominated. This means that, independent of the behavior of the other bidders, it is never optimal for the bidder to bid in this interval.

<sup>1</sup> The support period is 25 years.



**Figure 1.** Illustration of the concept of a sliding feed-in premium.

If, for example, a bidder expects the average market price to be at 5.0 ct/kWh, all bids greater than 0.0 ct/kWh and lower than or equal to 5.0 ct/kWh are weakly dominated by a 0.0 ct/kWh bid. The bidder receives the same payment independent of the height of his bid in this interval as the sliding premium is lower than or equal to the market price. That is, for all bids  $b_i$  between 0.0 ct/kWh and 5.0 ct/kWh and an expected wholesale market price of  $e_i = 5.0$  ct/kWh,  $b_i - e_i$  is always negative and thus  $r_i^t = 0.0$  ct/kWh. However, the probability of award is higher the lower the bid is. This would be the right side of Figure 1, where there is no green area.

That renewable energies are already competitive with conventional energy sources could not be foreseen when designing the auction, and therefore bidders and auctioneer face new challenges. The sliding premium was chosen to shift the risk of wrong prediction of the future market price from the bidders to the auctioneer as he faces the whole risk of unfortunate market price development. It was assumed that the award price of the auction would be higher than the actual market price for most months and thus a sliding feed-in premium gives the bidders a higher reliability than a fixed feed-in premium. However, in the light of such low bids it has the opposite effect.

The bidders face a double risk. They must predict their project costs for offshore wind parks that go online not earlier than in five years and additionally the future market price. The future market price is identical for all bidders and a high percentage of the project costs is depending on the costs for the wind turbines that are in principle available to all bidders at similar prices. Thus, auction-theoretic, both variables include a high common value component [5]. This does not imply that all bidders have the same costs to realize the projects but that those costs are interdependent. Although some bidders may get better turbine prices due to large contracts, the prices will still be similar and the electricity generation of the same turbine at the same

location is the same for different companies.

In such a case, there is always the risk of the Winner's Curse which occurs when the bidder who underestimated the costs the most and did not price in this underestimation in his bid is awarded in the auction. That is, if bidders do not adapt their bids accordingly in such a case with a high common value cost component, it is very likely that those bidders that underestimate the value of the common cost component most submit the lowest bids (based on their estimation) and are awarded. Furthermore, there is a high probability that this estimation was lower than the actual costs and thus those bidders may have a very low or even negative profit from realizing the project. The risk obviously increases if there are two common value components.<sup>2</sup> The risk of non-realization of the projects is therefore enlarged as awarded bidders are not willing to face a loss in the case of unfavorable development of the market conditions. Both awarded bidders in the first offshore wind auction in Germany already notified that they will make the final investment decision not before 2021 [10].

Furthermore, there is the economic risk of inefficiency. Efficiency means that those bidders are awarded in the auction that have the lowest electricity generation costs. However, in this auction efficiency is not ensured. For example, two bidders participate in the auction with one project each, where both projects have the same size ( $s_1 = s_2$ ) and network connection point. If Bidder 1 has project costs of  $c_1 = 4.7$  ct/kWh and estimates the average market price at  $e_1 = 4.5$  ct/kWh, he will bid at least  $b_1 \geq 4.7$  ct/kWh to receive a positive profit. On the other hand, if Bidder 2 has costs of  $c_2 = 5.1$  ct/kWh but estimates a market price of  $e_2 = 5.5$  ct/kWh, it is reasonable for Bidder 2 to bid  $b_2 = 0.0$  ct/kWh. In this case, Bidder 2 has higher costs than Bidder 1 ( $c_2 > c_1$ ), but would be awarded in the auction leading to inefficiency.

Another problem of this auction design is a possible accumulation of bids with 0.0 ct/kWh. In this scenario, the projects would be awarded according to their minimum bid quantity  $s_i^{min}$ , which represents the minimum capacity down to which the bid price  $b_i$  is valid, starting with the smallest one. This could also lead to an inefficient outcome. This inefficiency becomes even more striking by considering the additional cluster restrictions in this auction. It is possible that a 0.0 ct/kWh bid is not awarded whereas in the same cluster a smaller project with a higher bid is awarded. In the concrete example of the recent auction it could have happened that the EnBW Project 'He Dreih't would not have been awarded if another project in the same cluster with a smaller minimum bid quantity would have bidden 0.0 ct/kWh as well. If this project were to be smaller than the cluster restrictions, another project in this cluster could have been awarded with a bid higher than 0.0 ct/kWh, e.g. a project with a 5.5 ct/kWh bid. This means in the same cluster the same capacity as the EnBW project would have been awarded, but at higher costs. It is furthermore actually possible that in this auction more projects submitted bids of 0.0 ct/kWh but have not been awarded due to general and cluster volume restrictions.

From bidders' perspective, the criteria so that a 0.0 ct/kWh bid dominates higher bids may not be very realistic as the average electricity wholesale market price is fluctuating from month to month. Even if the average market price is estimated correctly, that is  $P = e_i$ , for some months it may be lower ( $p^t < e_i$ ), and thus the bidding interval which is dominated by a 0.0 ct/kWh bid is smaller. In principle, the actual interval of dominated bids is  $[0, \min_t(p^t)]$  which is much more complicated to predict than  $P$ . In other words, a bid that was higher than 0.0 ct/kWh but lower than the average market price  $b_i \in (0, P]$  would have resulted in a higher profit

<sup>2</sup> Two common cost components increase the overall share of common costs for the bidders and thus the risk of the Winner's Curse.

$$\sum_{t=1}^T \max(b_i, p^t) \geq \sum_{t=1}^T p^t. \quad (3)$$

The same holds for the uncertain future development of the wholesale market price. This development is subject to different influencing factors and might increase less than expected or even decrease, at least for some of the 25 years of contract duration. A bid that was originally dominated by a 0.0 ct/kWh bid due to the expected value of the future market price would insure the bidder against such scenarios.

And finally, it is striking that not all the auctioned capacity (1550 MW) was allocated. Four projects with combined 1490 MW of capacity were awarded in the auction and thus 60 MW were not. As a result, a bidder could have been awarded for this 60 MW with the ceiling price of 12 ct/kWh if he would have had a lower bidding limit of 60 MW or less. The fact that no bidder embraced this opportunity is even more surprising as the participants had the chance to submit two bids ranging over a installed capacity interval. Especially for smaller projects in the Baltic sea, this would have been a great chance.

#### 4. Conclusion

The latest results from the first German offshore wind energy auction show that the prices for renewable energies are developing faster than expected and that there is a future need to advance the auction design. The main goal of such adaptations should be to obtain efficient outcomes and still incentivize further cost reductions. That is, auctioneers should focus on reducing the possibility of inefficient outcomes and at the same time to mitigate the risk of the Winner's Curse. Depending on the auctioned technology, there are different possibilities to achieve this goal through changes in the auction design, for example an adaptation in the remuneration type to the respective market environment.

In the long-term it may even be possible that renewable energy sources do not need further support in the next decade, a result not foreseeable in past years. For a successful transition to such a scenario, it is important to not preclude possible market participants through an unfavorable auction design, e.g. not award bidders with 0.0 ct/kWh bids. Any future auction design has to keep the possibility in mind that bidders might be able to generate electricity at costs at or below the average market price. Nevertheless, the generated supply of renewable energy sources will be variable depending on the current conditions.

However, the bidders must adapt to the new situation also and carefully consider the risks and benefits of future projects and bidding strategies. Companies participating in auctions for offshore wind energy support have to consider the game theoretic nature of auctions when bidding. Their behavior and bidding strategy will influence the other players' future behavior in the market and a favorable short-term result may not be beneficial in the long-term. Therefore, it is vital to understand the auction design and its underlying structures so that the bidders can avoid risks and exploit opportunities.

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