CEG COMPETITION ECONOMISTS GROUP

CEG White Paper on Principles for the design of and bidding in Renewable Energy Auctions

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1 Introduction

1. Regulators and governments around the world use auctions to allocate scarce resources. Probably one of the most famous examples are spectrum auctions where radio frequencies are allocated to mobile telecommunications companies to provide services to consumers. Spectrum auctions have been scrutinized and optimized over years, providing rich insights into bidding strategy and the design of auctions. Thus, spectrum auctions offer several valuable lessons for the design and implementation of auctions in other markets, such as for renewable energy auctions.

2. The generation of renewable energy has become increasingly important for transitioning to green policies in Europe and all parts of the world. Renewable energy can be defined as the energy that are derived from natural resources which replenish faster than the rate at which they are consumed.[1] Common types of renewable energy sources are solar, wind, geothermal, hydropower, ocean and biopower energy.[2]

3. Regulators have been increasingly turning to reverse auction (i.e. procurement) designs to allocate projects or contracts for the generation of renewable electricity. In this context, auctions are used to support renewable energy generation or to purely allocate the rights to generate renewable energy and are used in the areas of (on-shore and off-shore) wind, solar and biomass among others. Typically, authorities also incorporate other elements such as a rigorous pre-qualification stage and penalties in the case of non-supply.

4. There is not one auction format that is optimal in all circumstances and all markets. A design that serves one objective may be detrimental to another. Also, some factors (for example, uncertainties regarding future market prices, or cost or value synergies across different projects) may be more important in some markets than in others. Auction theorists have therefore designed different auction formats to deal with this variety of circumstances. As we will argue in this paper the underlying auction principles are very similar and do apply across markets.

5. For both regulators and bidders, it is paramount that the appropriate auction format is selected. To achieve this, it is essential that the objectives of the regulators are articulated with clarity. Typically, bidders possess more comprehensive information regarding market conditions than regulators. Hence, it is crucial that bidders are afforded the opportunity to convey their perspectives on the suitable auction format.

6. In what follows we explain key considerations for the design of an auction in general, and in the market for renewable energies in particular. We also touch upon policy considerations that may inform not only the auction design but also the consultation phase which might be considered as a bargaining step between regulators and private parties.

7. The structure of this paper is as follows. In Section 2, we discuss various auction formats and rules typically used in renewable energy auctions. In Section 3, we elaborate on key aspects that are relevant to bid strategy formation and consultation phase. In Section 4, we conclude.

[1] See United Nations, 'What Is Renewable Energy?' (United Nations) <https://www.un.org/en/climatechange/what-is-renewable-energy> (Accessed 20 May 2024).

[2] United Nations.

2 Formats of Renewable Energy Auctions

8. Typically, renewable energy auctions start with a pre-qualification stage where interested parties make their applications; submit information on their qualifications and try to prove their competences to deliver the required volume. The parties might additionally be required to make upfront payments. After these submissions are in, the regulator determines which parties are eligible for bidding.

9. In the bidding part of an auction, volumes and associated remunerations are awarded to the winning parties depending on the specific design and the behaviour of the bidders. The bidding part is then followed by a last stage in which the winning bidders build their generators with the determined capacity and generate energy for a determined duration of time. In this stage, if the winning parties fail to deliver their contractual obligations, they may be required to make penalty payments to the regulator.

10. The particular format of the bidding part of a renewable energy auction usually varies in the following four dimensions:

    i. The number of projects the auction concerns: single-project or multi-projects.[3]
    ii. The number of winners the auction admits for the project(s): single-winner or multi-winner auctions.[4]
    iii. Whether the bidders submit their bids in sealed bids (simultaneously), in a dynamic auction or in hybrid format.
    iv. The way of determining the remuneration for the winning bidders.

11. Renewable energy auctions are typically conducted about a particular project (site) or regionally for the support of energy generation or for allocating the right to generate energy at a particular site with a given renewable technology.[5] Although different formats are possible and employed in various settings,[6] in Europe, renewable energy auctions are most commonly used for support

[3] In the theoretical literature, these auctions are typically referred to as single or multi-object auctions. We preferred to use this terminology as it is more transparent.

[4] Similarly, the literature refers to these categories as single or multi-unit auctions.

[5] Renewable energy auctions might be open to multi-technologies or be technology-neutral. See del Río, Pablo and Christoph P. Kiefer, 'Academic Research on Renewable Electricity Auctions: Taking Stock and Looking Forward', Energy Policy, 173 (2023), 113305 <https://doi.org/10.1016/j.enpol.2022.113305>.

[6] As we will see, zero-subsidy (tie-breaking) auctions might also be conducted especially in the off-shore settings. Moreover, in the UK, the authorities have recently employed a design which combines a fixed-lease-fee with an agreement of sharing revenues. According to the format, an auction determines "option fee" that the winning bidder pays to the authority for the lease, but the winning parties are also required to pay a-percentage of their revenues to the authority as part of the -agreement. See 'Offshore Wind Leasing Round 4 | The Crown Estate' <https://www.thecrownestate.co.uk/our-business/marine/Round4> [Accessed 11 April 2024]. In the US, auctions are conducted for only the lease of a site (e.g. seabed). 'What Are The Auction Procedures, And How Will BOEM Determine Winners? | Bureau of Ocean Energy Management' <https://www.boem.gov/renewable-energy/state-activities/what-are-auction-procedures-and-how-will-boem-determine-winners> [Accessed 11 April 2024].

and they are used to determine the additional premium[7] that generating parties receive for supplying (parts of) the advertised volume into the market, which is commonly defined by built capacity.[8]

12. Furthermore, research indicates that most renewable energy auctions are multi-winner (multi-item) and they are conducted in sealed-bid format with 95% in Europe and 91% in the world.[9] Furthermore, most of the auctions employ pay-as-bid rule (discriminatory or first-price pricing) amounting to 84% in Europe and 91% in the world, where bidders have to pay their own bid.[10]

13. More complex multi-project auctions have not (yet) gained general prominence for renewable energy support or allocation of production rights. However, there have been instances of such auctions in Europe in the context of on-shore and off-shore wind and there are serious proposals for employing them, as such auctions might allow bidders to pass-on cost synergies that they may enjoy across multiple projects.[11]

14. In what follows we discuss the most common types of auction formats for renewable energy auctions following the above dimensions in turn.

2.1 Single-Project (Site), Single Winner Sealed Bid Auctions

15. The simplest single-project auctions allow for one winner who is then expected to supply the whole of the advertised volume. In such an auction, the bidders submit bids on the additional (on top of the market price) premium that they demand to get for each kWh energy unit they generate.[12]

[7] The premium typically takes the form of a fixed premium or sliding premium which could be one or two-sided. According to a one-sided sliding premium construction, the premium fluctuates according to the market conditions. Whenever the market reference price, typically an average of the market price in a given period, lies below the remuneration benchmark determined at the time of the auction, the premium paid to the generating party is equal to the difference between the two. In contrast, whenever the reference price exceeds the benchmark, no premium is paid to the generating party. If a two-sided sliding premium is implemented, then the generating party is also required to pay the difference between the reference price and the benchmark price whenever the former exceeds the latter. The remuneration can also take the form of a fixed tariff. See AURES II, 'FIP, Fixed or Sliding' <http://aures2project.eu/glossary-terms/fip-fixed-or-sliding/> (Accessed 3 April 2024); del Río, P. and C. P. Kiefer, 'Analysing Patterns and Trends in Auctions for Renewable Electricity', Energy for Sustainable Development, 62 (2021), 195–213 <https://doi.org/10.1016/j.esd.2021.03.002>.

[8] See Fleck, Ann-Katrin and Vasilios Anatolitis, 'Achieving the Objectives of Renewable Energy Policy – Insights from Renewable Energy Auction Design in Europe', Energy Policy, 173 (2023), 113357 <https://doi.org/10.1016/j.enpol.2022.113357>; Matthäus, David, 'Designing Effective Auctions for Renewable Energy Support', Energy Policy, 142 (2020), 111462 <https://doi.org/10.1016/j.enpol.2020.111462>.

[9] Ehrhart, Karl-Martin, Marion Ott, Stefan Seifert and Runxi Wang, 'Combinatorial Auctions for Renewable Energy — Potentials and Challenges', Energy Policy, 186 (2024), 113988 <https://doi.org/10.1016/j.enpol.2024.113988>; Szabó, László, Mária Bartek-Lesi, Bettina Dézsi, Alfa Diallo, András Mezősi, Fabian Wigand, et al., 'AURES_II_D2_3_case_study_synthesis_report', a (2020).

[10] Ehrhart et al.

[11] For such proposals, see Bichler, Martin, Veronika Grimm, Sandra Kretschmer and Paul Sutterer, 'Market Design for Renewable Energy Auctions: An Analysis of Alternative Auction Formats', Energy Economics, 92 (2020), 104904 <https://doi.org/10.1016/j.eneco.2020.104904>; Ehrhart et al. Keep in mind that designs used in multiple-project auctions would be more complicated compared to single-project auctions, as the former type of auctions need to accommodate the fact that bidders submit multiple bids for a subset of projects akin to spectrum auctions. For information on spectrum auctions see Milgrom, Paul, Putting Auction Theory to Work (Cambridge University Press), 2004; Janssen, Maarten(ed.) Auctioning Public Assets: Analysis and Alternatives (Cambridge University Press), 2004.

[12] The bids can be alternatively given as the total of the premium and a fixed market price at the time.

16. Single-winner sealed-bid auctions are commonly employed in off-shore wind settings.[13] In such auctions, the bidders make their bids without observing the bids of other bidders (simultaneously) and the project is awarded to the bidder with the lowest bid. If there is a tie at the lowest bid, a tie-breaking lottery or an additional auction may be employed. The design may vary with respect to the payment that the winning bidder receives (payment or pricing rule).[14]

17. In the most commonly employed variant called a first-price auction, the winning bidder's remuneration is exactly equal to her bid: the lowest submitted premium. Alternatively, the regulators may employ a second-price auction where the winning bidder's premium equals the second lowest bid.[15]

2.2 Single-Project (Site), Multiple Winner Sealed Bid Auctions

18. In multi-winner single-project auctions multiple parties are allowed to supply parts of the advertised capacity and they are also asked to indicate the capacity that they are willing to build on top of the desired remuneration.[16]

19. In a multi-winner sealed-bid auction, the bidders simultaneously bid for prices and capacities. In such an auction, submitted bid-prices are ordered by the regulator and the capacities are awarded one-by-one to the bidders of lowest bid-prices until the total supply reaches the total advertised capacity. Again, different pricing rules can be employed. Two common variants are the discriminatory (pay-as-bid) auction and the uniform-price auction, which are generalizations of the first and second price auctions, respectively.

20. In the discriminatory auction, which also happens to be the most common sealed-bid variant, remunerations of the winning bidders are equal to their bids, whereas in the uniform pricing auction, remunerations are uniform and typically equal to the lowest submitted losing bid. As before, in each variant, a procedure might be employed to break ties.

21. In Europe, multi-winner sealed-bid auctions have been the common format in the contexts of on-shore wind, photo voltaic and biomass.[17]

2.3 Dynamic Formats of Single Project (Sites) Auctions

22. The most commonly used dynamic auction used for renewable energy generation is the descending auction. In a descending auction, the regulator initially announces a sufficiently high value for the remuneration and at each round decreases the remuneration by a pre-determined increment. The bidders react to the round prices by indicating either that they are willing to supply

[13] The countries such as Denmark, the Netherlands (before 2017) and France have implemented several single-winner sealed auctions in the context of off-shore wind. After 2017, the Netherlands transitioned to single-winner sealed no-zero subsidy off-shore wind auctions which incorporate non-price criteria. AURES II, 'Database' <http://aures2project.eu/auction-database/> [Accessed 20 May 2024]. See also Szabó et al.

[14] In some cases, the regulator may employ a hybrid design combining a last-sealed stage with a dynamic auction. We describe these different formats below.

[15] Note that irrespective of the format, the submitted bids are required to comply with the constraints set by the regulator. For instance, the regulator may explicitly limit the allowed bids by a price-ceiling or a price-floor (typically at no (zero) premium) or may choose to define a maximum capacity per bidder to ensure plurality among suppliers. Furthermore, the employed design may only allow a certain form of bids at different rounds of an auction.

[16] In the typical variant, the bidders are allowed to only submit a single-bid capacity combination, although some formats may allow submitting complex bid-capacity schedules.

[17] AURES II.

(single-winner auction) or the amount of capacity that they are willing to supply at the announced round price (multi-winner auction). Typically, the bidders cannot increase their supply during an auction, that is their capacity bids at a given round are constrained by the minimum of their capacity bids of the earlier rounds.[18]

23. The regulator continues the iterative process until the total supply of the suppliers is equal to the advertised capacity or until the price reaches the pre-determined price floor- typically given by a zero premium. If the auction is successful in equating the supply and the total capacity, the capacities are awarded to the winning parties and their remunerations are equal to the last-round price. If the round price reaches the price-floor before ensuring an equilibrium, a tie-breaking procedure is employed.

24. In the context of single-winner off-shore wind auctions, a tie-breaking ascending (forward) auction might be employed in case the original auction generated multiple "winners" at the lowest premium of zero. Such auctions are used to determine the additional payment that the winning parties will make to the regulator to obtain the rights to generate energy. In such an auction, the regulator announces the amount of the payment and iteratively increases the amount until only one bidder is left in the auction. Recently, Germany started incorporating such dynamic (zero-subsidy) tie-breaking single-winner auctions in the context of off-shore wind.[19] In 2023, 4 simultaneously conducted tie-breaking auctions on off-shore wind generated €12.6 billion for a total capacity of 7000 Mw.[20]

2.4 Multi-Project (Site) Auctions

25. Multi-project auctions refer to auctions in which multiple-projects are auctioned within a single auction and they differ from simultaneous or nearly simultaneous auctions of related multiple single-projects.[21]

26. To the best of our knowledge, multi-project auctions have barely been implemented in the context of renewable energy auctions. In the literature, variations of a sealed-bid auction with package bidding have been suggested.[22]

27. In a sealed-bid auction with package bidding, the bidders submit a bid schedule covering bids for different combinations of projects. Such a schedule would allow the bidder to differentiate prices that she is willing to commit to for a particular project depending on whether she also obtains another project. For instance, if there are two projects: (A, B), a bidder's bid would contain a premium bid for each individual project A and B for the case in which that project is won by the bidder, and a pair of premiums for the case in which both projects are won by the bidder. The

[18] In the single-winner setting, the bidders are typically eliminated from the auction whenever they indicate they are not willing to supply at a given round-price, except for some exceptional situations.

[19] The regulators implemented slightly different auction regimes for pre-investigated ("centrally investigated") sites and not pre-investigated cites. Our discussion here applies to pre-investigated sites. See 'Bundesnetzagentur - Offshore-Windenergie / EEG' <https://www.bundesnetzagentur.de/DE/Beschlusskammern/BK06/BK6_72_Offshore/BK6_offshore.html> [Accessed 21 May 2024].

[20] 'Bundesnetzagentur - Presse - Ergebnisse Der Offshore-Ausschreibungen Aus Dem Dynamischen Gebotsverfahren' <https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2023/20230712_OffshoreErgebnisse.html> [Accessed 16 May 2024].

[21] Similar considerations may nevertheless arise in multiple auctions conducted (almost) simultaneously. See the section on strategic considerations.

[22] Both of these multiple-project auction designs only allow a single party to win a constituent project. This is a natural starting point and all multi-project renewable energy auctions that we are aware of in Europe had this property.

auctioneer then might employ a cost-function to calculate the bid-combination that would minimize the total expected payment[23] and would award the projects to the corresponding bidders.

28. The simple version of sealed-bid auctions with package bidding discussed in the literature has resemblance to the Dutch off-shore wind auction of Borssele I&II conducted in 2016.[24] In this auction, the total advertised capacity was divided into two projects of equal capacity and the bidders were allowed to submit sealed bids for each project separately or combined bids (premiums for each project). According to the auction rules, each project could only be awarded to the bidders who bid the lowest premium for that project. Because of this rule, the auction differed from a typical combinatory auction where the auctioneer minimizes its total costs but not necessarily the cost for each project. The employed format in this auction resembled a design with two separate adjacent auctions with a conditional withdrawal rule that allows bidder to withdraw their bids for an auction if they don't win the other auction.

3 Strategy and Policy Considerations

29. In this section, we discuss key considerations for a successful auction strategy against the background of renewable energy auctions more generally. First, we will explain briefly why lobbying and influencing is crucial in auctions and how such efforts need to be informed by economic theory and the policy objectives of the regulators. Then, we will elaborate on aspects relevant to bidding strategy depending on the specific auction design. These later discussions will enable us to link policy and strategic considerations and indicate why some designs may be better not only for the bidders but also for the regulators.

3.1 Goals of the Regulator and Consultation Phase

30. In the consultation phase of an auction regulators consult with private parties/suppliers in relation to the auction design and rules. Influencing the auction rules in the consultation phase is important for bidders for multiple reasons. The auction rules, among other things, determine whether at a given site, a single or multiple actors will generate energy and what information bidders receive about the actions of other bidders. Furthermore, as we will see, the auction rules also have relevance for (i) how close the bidders are willing to bid to their willingness to be paid, (ii) whether the project(s) end up in the hands of those firms that value them the most (efficiency), and (iii) how much entry is encouraged.

31. The success of bidder's efforts on influencing the conditions of the auction depends on whether these efforts are consistent with the goals of the regulators and economic wisdom. The regulators typically aim to generate sufficient energy by renewable sources. By using auction designs, they want competitive processes to bring prices to lower levels (short-run efficiency), entry and innovation are encouraged such that generating costs can be reduced and in the long-run prices can go down (long-run efficiencies). If the proposed auction design does not allow learning/ adjustments to competitors' behaviours or it has the potential of inducing irrational behaviour - such as very low bid prices, it may lead to inefficient (non-optimal allocations) or ineffective (no project realizations) results and it would be important to let the authorities know of the risks about employing such a design. Furthermore, if an auction design gives certain players an unfair

[23] Such a measure might take the expected value of total generated energy at a site into account.

[24] RVO, 'Borssele Wind Farm Sites I & II', RVO.Nl <https://english.rvo.nl/en/subsidies-financing/offshore-wind-energy/borssele-sites-i-ii> [Accessed 3 April 2024].

advantage over other others, and does not stimulate entry into the market, these concerns also need to be shared with regulators.[25] Such efforts would not only be useful for bidders but also would be desirable from the viewpoint of the regulators.

3.2 Bidding Strategy

32. For a bidder, to obtain a good outcome in an auction it is essential to have a strategy that covers every decision-making step regarding the auction. A successful auction strategy requires (i) the ability to influence the auction rules, (ii) the formation and execution of a robust bidding strategy based on the information and preferences of the bidder, and (iii) the ability to react unexpected actions by competitors during an auction.

33. We will now elaborate on aspects that are relevant to bidding strategy formation while also pointing out how these considerations may inform consultations between the regulator and the bidders. The aspects that we will discuss are as follows:

i. Accurate valuation
ii. Bid shading (Demand reduction)
iii. Preparedness and reactiveness to various scenarios and competitors' behaviours
iv. Learning from others and the winner's curse
v. Cost-synergies and exposure problems
vi. Rivals' costs and entry concerns

Note that these aspects should not be considered in isolation, and one needs a broad approach that takes all these aspects into account.

34. Accurate valuations: One of the first steps in preparing for an auction and forming a bid strategy is putting together valuations for the auctioned objects that is as accurate as possible. Having accurate valuations is essential to be able to compare various outcomes of an auction.

- Single Project (Site) Auctions:
    - In the simplest setting of a single-winner support auction, a bidder's valuation can be given by the break-even per-kWh price at which a bidder is willing to generate energy. This sounds easier as it is as a bidder would likely need to consider uncertainties regarding the expected yield at a site and the future market electricity price at which it can sell. The risk attitude of a bidder is therefore important as this will determine the risk premium to be included.[26]
    - More generally, in multi-winner auctions where bidders are not ex-ante certain of the capacity that would be awarded to them, a bidder optimally uses a price-capacity curve to represent their valuations to accommodate the possibility that the break-even price varies with respect to served capacity.

[25] Regulators also typically care about constraints such as transmission restrictions and prefer designs that do not create imbalances in the electric supply at particular high-yield sites but are keener on designs that result in capacity allocations in line with transmission costs and constraints.

[26] The expected yield would have a significance in simple support auctions as the expected average cost depends on the amount of production. The expected yield would also be highly significant in tie-breaking auctions, simply because the total profit depends on it. The market price fluctuations might also need to be accommodated in the risk premium calculation of the bidder. However, this would depend on whether the premium is fixed or sliding. If a sliding premium is used, the bidders would not need to internalize the risks as premium is adjusted to ensure a sufficient compensation.

- Multi Projects (Sites) Auctions

    - When generation of energy at multiple sites is allocated in a single auction or in a sequence of auctions, it is necessary to prepare more complicated valuations based on different combinations of projects. It is likely that certain cost-synergies exist among multiple projects and a bidding strategy based on only valuations regarding singular projects may not be optimal. To illustrate this, consider the case of two sequential auctions each concerning generation of energy at adjacent sites. In such a scenario, if a party only prepares individual valuations for each site, a bidding strategy based on this information might make the bidder bid less-aggressively for each project and would potentially leave the bidder empty-handed.[27]

35. **Bid shading (Demand Reduction):** Although having accurate valuations is essential for the bidding strategy, in general, what bidders should bid in an auction would differ from their valuations as it is optimal to shade their bids - use bids that exceed the break-even price depending on the auction design and the context including competitors' behaviours. In particular, the pricing rule has a relevance for the extent to which parties might need to shade their bids. If an auction incorporates first or discriminatory pricing, bidding exactly at the break-even price cannot be optimal for a bidder, as the expected return from such a strategy would be 0, and a bidder would be better-off by choosing a bid that exceeds the break-even price. The extent of bid shading would be reduced if second or uniform pricing is used. With such a pricing rule, the bid of a bidder has less (or no) relevance on what is paid by the same bidder, and it only affects the probability of winning the auction.

36. **Preparedness and reactiveness to various scenarios and competitors' behaviours:** It is important to be prepared for scenarios regarding competitors' potential bidding strategies/behaviours and, given the chance to strategically react to observed behaviours of the competitors. This is the case as except for some specific situations such as the one mentioned above, the optimal bidding strategy in an auction varies with respect to the valuations and strategies of competitors.

    - Sealed-bid auction: In a sealed-bid auction with first or discriminatory pricing, a bidding strategy needs to be informed by the expected valuations and bidding behaviour of competitors. In such an auction, submitting a lower bid increases the chance of winning the auction while reducing the potential returns from winning. Accordingly, a bidder when deciding on her bid, needs to assess where competitor's bids might lie. If the bidder is reasonably sure that the competitors' bids should lie above a certain price, it would not be optimal to choose a bid that is significantly lower than that level, as such a bid would only reduce the potential returns without substantially changing the probability of winning.

    - Dynamic auctions: In such auction formats the strategy would also need to be reactive to the observed behaviours of others. Based on the obtained information at each round, the bids can be adjusted. Chosen bids would be informed by, among other things: the level of demand, the number of competitors or by whether particular objects attract extra attention from others. If one pre-prepares a solidly founded reactive bid strategy that specifies plans for expected

[27] The extent to which the bidders can make use of cost-synergies in their bidding also depends on the amount of expected competition each separate auction is expected to attract and more generally on the rules of the auction such as penalties and withdrawal rules. See the discussion on cost-synergies and exposure problems.

events and contingency plans for unexpected events during an auction, then such a strategy can be successfully executed with fine-tuning during the auction.

37. **Learning from others and the winner's curse:** In renewable energy auction settings, the valuations of bidders are likely to be strongly correlated since the expected yield at a given site is common for all the bidders akin to a situation in oil extraction-rights auctions. This phenomenon opens up the possibility of learning from others about the "common value" of a project and facing a so-called "winner's curse". Below, we will describe these opposing forces and explain how these should be considered when building a bidding strategy.

- Learning from others:
    - Sealed-bid auction: In the context of isolated sealed-bid auctions, there would not be any role for learning as in such auctions bidders don't observe the bids of others. Learning, however, would still be relevant when bidders aim to obtain the generating rights at adjacent sites and the yield and cost of generating at these sites are common for bidders and they correlate across sites. In such a case, the bidders need to consider the winning price and if that information is available the amount of demand in adjacent auctions in forming their bidding strategy.
    - Dynamic auction: In such auction set-ups, bidders may learn from others about the "common" value of the project(s) and update their bids by incorporating this information. This possibility may arise even in the context of single-project dynamic (descending) auctions. For instance, if at a certain round price, there are many more competitors than expected, the bidders may use this information and update their estimations of the yield or costs. As another example, consider a situation in which an established supplier knows that she has a clear cost advantage over other competitor suppliers, but she is just as uninformed as the others about the potential yield at a site. In such a case, the supplier may choose to keep fighting for the generating rights even when the round prices are lower than her initial estimations.[28]
- The winner's curse: In a common value setting, the winner of an auction may also face a winner's curse at the end of an auction – realizing that she has likely paid too much for a project.[29] This may arise because a winning bidder is generally the one who has received the most optimistic private signal, and her bidding is shaped by this relatively optimistic information. To eliminate the possibility of encountering a winner's curse, bidders will want to adjust their bidding strategies and make less aggressive bids than when the valuation of each bidder is independently determined.

38. Learning from others and the counterforce arising from a winner curse need to be considered carefully, and depending on the specifics of the case upward or downward bid adjustments might be necessary. As an illustration, re-consider the situation of an established supplier with the cost advantage. In that situation, the cost advantage of the supplier may be so large that it outweighs the winner's curse effect that may arise from following the most optimistic rival. Accordingly, in

[28] Note that this is an example of a hybrid model where the valuations have both a common and a private element.

[29] The effects of a winner's curse may be mitigated if withdrawal is possible, or the penalties are not substantial.

such a case it would be optimal for the supplier to follow other bidders until they leave the auction even if the end-price is substantially lower than the initially estimated break-even price.

39. From a policy perspective, the regulators would also want to avoid a winner's curse as stability of the sector requires that firms do not go bankrupt. This can be done by setting up the auction rules such that in a dynamic auction, bidders are informed about the bids or demand of others. This helps bidders to learn about other bidders' valuation.

40. Cost-synergies and Exposure Problems: As mentioned before, in the context of a multiple-project (sites) auction or a series of related auctions, the bidders might benefit from cost-synergies/complementarities between the projects, and they might be willing to accept generating energy at relatively low prices at a single site provided that they also obtain the generation rights at an adjacent site. In such auctions, the bidders might face the risk of obtaining only mere subset of the desired projects and paying relatively too much for them without realizing the cost-synergies. This phenomenon is commonly called the exposure problem. The exposure problem would be particularly pronounced if it is expected that each desired project would attract substantial demand from competitors and attaining each of them at reasonable prices remains uncertain. To avoid the repercussions of exposure problems, the bidders might be advised to use less aggressive bids for individual projects in certain situations.

41. From a policy perspective, the regulators would also have an incentive to eliminate exposure problems as these might result in substantial inefficiencies and higher (support) prices. To mitigate exposure problems, a regulator might set-up the auction rules (i) to allow for package bidding or (ii) to enable bidders to withdraw their bids during a dynamic auction. Such adjustments might enable the bidders to pass-on the cost-synergies into their bids to a greater extent and allow them to obtain multiple objects without facing substantial risks.[30] Accordingly, bidders who are wary of exposure problems that might arise in the context of particular designs, may propose certain adjustments to the regulator in the hopes of influencing the auction rules.

42. Rivals' costs and entry: Another related issue concerns increasing rivals' costs and foreclosure of entry by rivals. If package bidding is not allowed and cost-synergies are significant, the incumbents in a market may use aggressive bidding strategies to increase rivals' costs and limit entry to the market. For instance, in the case where multiple auctions over adjacent sites are conducted, an incumbent firm may bid below its break-even price in one of the earlier auctions in the hopes of attaining the generating rights and limiting future competition from entrants who would need a certain scope to be able offer competitive prices. Like exposure problems, such concerns may be shared with the regulators.

4 Concluding Remarks

43. The importance of auctions has been steadily rising supporting on- and off-shore wind energy markets and many other renewable energy sources. In this paper, we have described typical formats of such auctions and presented key considerations that are relevant for auction design and bid strategy, following common auction principles. As the discussions have illustrated, regulators and private parties need to carefully consider the goals and choices of all other relevant parties. The bidders need to carefully consider the chosen design, other bidders' potential and actual behaviours, and the goals of the regulators, and make use of relevant theoretical insights

[30] Note that lowering penalties or enabling withdrawal of bids may affect project realization rates or stimulate irrational behavior among the bidders. Accordingly, regulators might also need to consider the potential drawbacks of such adjustments.

in forming a successful bidding and consultation phase strategy. Similarly, the regulators need to consider the potential behaviours of the bidders and potential market outcomes before implementing a specific design. In developing the appropriate auction conditions for the particular market situation both regulators and bidders can learn from each other.

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