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Gale Force Competition? Auctions and Bidding Strategy for Offshore Wind

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Introduction

Many governments worldwide are rolling out auctions as their preferred method for allocating subsidies to renewable energy projects. Well-designed auctions can harness the power of competition to deliver renewables more cost-effectively than when government officials set support levels. Auctions, however, introduce allocation risk—i.e., the risk that a project will not be allocated support. Bidders need to understand auction dynamics and must be able to identify which bidding strategy is most likely to result in a favourable outcome. Ideally, bidders seek a winning bid at an attractive price, or at the very least, at a price that does not leave them regretting their success: the so-called "winner's curse".

This paper considers the use of auctions to set support levels for offshore wind power projects—both the experience to date and the implications for bidders in future auctions. Offshore wind auctions have recently been run in Denmark, the United Kingdom, France, and the Netherlands, and are planned for Germany in 2017. The paper begins by comparing recent clearing prices in offshore wind auctions, discussing some of the reasons that they differ, and outlining plans for future auctions. The paper then explores the issues that bidders must consider when developing their strategy in these auctions and how they can analyse the risks. Finally, the paper concludes with some lessons learned and reflections on the potential evolution of these auctions.

Recent Offshore Wind Auctions in Europe

Until recently, offshore wind has been a relatively expensive form of renewable electricity, but governments and the offshore wind industry have undertaken concerted efforts to make it more cost-competitive. In early June 2016, energy ministers from nine European countries signed a Memorandum of Understanding to reduce offshore wind costs, days after 11 major energy companies issued a letter confirming their belief that offshore wind costs can fall to €80/megawatt hour (MWh) by 2025.[1] The industry has been given strong incentives to cut costs; several countries have made clear that further offshore wind auctions will not go ahead without significant cost reductions.

In the UK, the maximum allowed strike prices are expected to be set at £105/MWh for delivery year 2021, falling to £85/MWh for delivery year 2026 (all in 2012 prices).[2] In the Netherlands, the maximum prices in the 2016 auction were €124/MWh (not inflation-indexed) and will fall to €100/MWh for the 2019/2020 auction (for projects to be delivered by 2025 at the latest). In Germany, the maximum prices will be based on prices achieved in initial "Phase 1" auctions.

Recent evidence suggests these ambitions may already be within reach. The clearing prices from the auctions in Denmark, the UK, and the Netherlands are set out in Table 1 below (see Appendix A for additional details). These clearing prices are the guaranteed, above-market electricity prices per MWh of renewable electricity produced by the wind farms over a set period. All three support schemes pay out a subsidy on top of the electricity price in order to achieve the total price shown below.

Table 1. **Offshore Wind Auction Results – Denmark, the UK, and the Netherlands**

Country	Year of Auction	Site	Price (£(2012) /MWh)	Delivery Year
UK	2015	East Anglia ONE, Neart Na Gaoithe	115-120	2017-2019
Denmark*	2015	Horns Rev 3	81 (DKK 770 in 2015 prices)	2017-2020
Netherlands	2016	Borssele I and II	56 (€73 in 2016 prices)	By 2021

Notes:

Exchange rate assumptions: £1=€1.2, £1=DKK9

Neart Na Gaoithe's contract has been terminated by the Low Carbon Contracts Company after it failed to meet an interim milestone.

* Near shore offshore wind auctions in Denmark in September cleared at around €64/MWh (around £50/MWh in 2012 prices, though it is unclear whether the Danish Government will fund this scheme.

The prices in Denmark and the Netherlands are significantly lower than those in the UK. A simple comparison of winning prices is inappropriate, however, as the policies in each country differ, as do site characteristics. For example, in the case of Denmark and the Netherlands, investors bidding into the auctions do not need to pay for grid connection, transmission, or project and site development costs. These costs are paid by the government or the Transmission System Operator (TSO). In addition, the UK projects are located in deeper waters than the Danish projects and in somewhat deeper waters than the Netherlands Borssele sites. The Danish support scheme has a capped number of hours (equivalent to approximately 12 to 14 years at prevailing load factors), while in the UK and the Netherlands, the support is for 15 years. Projects commissioning in later years are also expected to cost less, as turbine and construction costs decline and bigger turbines are used – the UK sites are due to be commissioned somewhat earlier than the others.

Future Offshore Wind Auctions

Additional offshore wind auctions are currently planned for the UK, Germany, and the Netherlands (see Appendix A for details on schedules and budgets). As noted above, cost remains a government concern, and Denmark recently announced that it was postponing or cancelling a planned tender, citing the high cost burden on consumers. The UK, Germany, and the Netherlands are planning to each commission about 0.5 to 1 GW of offshore wind capacity per year over the next few years. The level of certainty provided by the governments about the timing of auctions, the precise volumes targeted, and the available budgets all vary by country.

The formats of the auctions also vary. In the UK, the policy is expected to continue to allow projects (and technologies) to compete against each other, with development and connection costs paid by the project sponsors. In the Netherlands, the Government will continue to identify specific sites that will be developed and connected for bidders, who will then compete on the price required to construct and operate the site.[3] In Germany, the plan is for projects that will be commissioned from 2021 through 2025 to compete against each other (as in the UK), but then to switch to the Dutch/Danish model for projects commissioning after 2025. (In Germany, project sponsors will not have to pay connection costs in either phase.)

European Union State Aid guidelines require that renewable energy subsidies be granted through a competitive bidding process on the basis of clear, transparent, and non-discriminatory criteria starting in 2017 (though there are a number of potential exceptions that could allow continued technology-specific auctions).[4]

Developing a Bidding Strategy

Bidders seeking to identify the best bidding strategy in a given auction will need to consider their own objectives and risk appetite, as well as the auction format and rules. More risk-averse bidders, or bidders with wider strategic objectives such as market share, may tend to bid lower, closer to their break-even price (the minimum price they need to provide a return that makes their investment worthwhile). In doing so, however, they may run the risk of the winner's curse. Less risk-averse bidders whose objective is to maximise their return on a particular project will potentially bid higher (especially if there are prospects for the project in future auctions—see below).

Bidding above the minimum break-even price is not simply about boosting profits; given uncertainties about project costs, it can also help to mitigate certain downside scenarios. The break-even strike price may be calculated on the basis of P50 assumptions[5] on turbine and construction costs, wind speeds, and load factors. Bidding slightly higher would improve the chances of delivery and mitigate against the risk of cost overruns and lower returns. Of course, it may also reduce the likelihood of winning. When some winning scenarios are actually bad outcomes, however, this may be desirable.

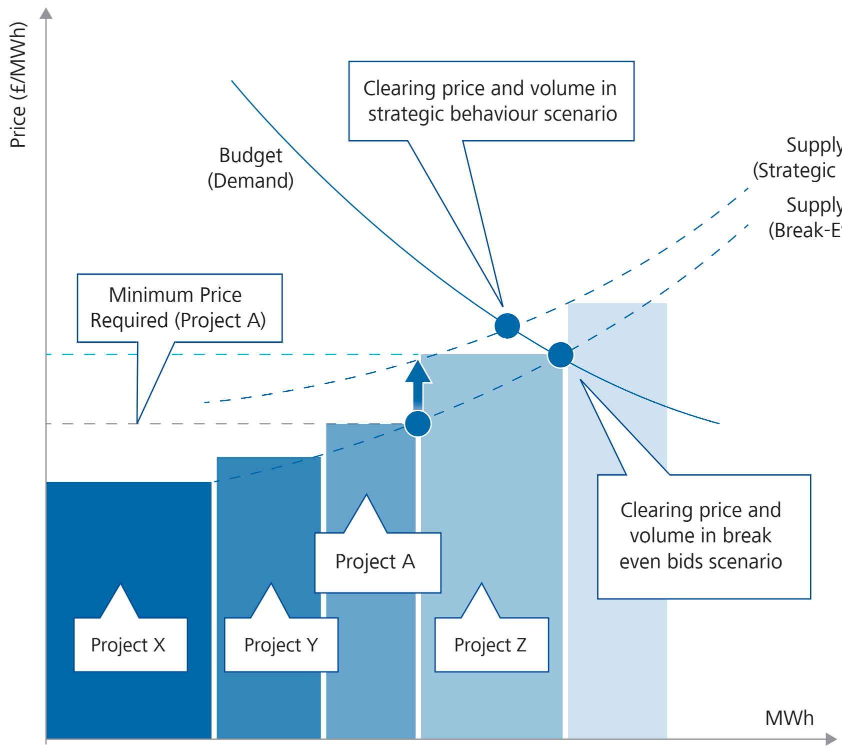
As noted above, many bidders may simply bid at their (P50) break-even price. If a bidder believes that its competitors will bid strategically (above break-even prices), this makes analysing the auction all the more complicated. In any case, the starting point for developing a bidding strategy involves a thorough analysis of competitor's cost structures.

Auction formats and rules vary considerably, leading to substantial differences in bidding strategy. In a pay-as-clear (uniform price) auction with many small bidders, the best strategy is for a project to bid its minimum required price. When there are fewer bidders, however, or when bidders would account for a large proportion of the auction support budget, it is more likely that a project's bid will affect the clearing price, which creates incentives to modify the bid strategy.

In the UK's offshore wind auctions, the size of projects compared to the size of the budgets means that if a project wins, there is a relatively high probability that its bid will determine the clearing price. Similarly, the first set of German auctions is explicitly pay-as-bid, so bidders will set their own prices and, therefore, they will have incentives to bid strategically.

Figure 1 below illustrates the incentive to bid above cost for a project (Project A—the blocks represent projects with different sizes). The project is shown in the middle of a cost-based supply curve (consistent with projects bidding conservatively at their minimum break-even prices). The UK auctions are for support to projects commissioning over four separate years, but with a total budget that is shared across projects commissioning in all four years. This means that Project A may actually set the price in one year, even though Project Z clears the auction overall (and in another year) and exhausts the budget. In this case, Project A has an incentive to increase its bid. The result would be to squeeze the budget space remaining for Project Z, which would need to reduce its volumes to still be affordable within the budget (though Project Z could also respond by increasing its bid to the clearing price shown at the intersection of the budget curve with the "strategic behaviour" supply curve).

Figure 1. **The Incentive to Bid Strategically**



This theoretical analysis already gives bidders various questions to consider as they think about how to position their projects in the auction. Box 1 sets out these and a variety of additional questions.

Box 1: **Checklist of Questions to Be Answered in Defining a Bidding Strategy**

1. How likely is it that my bid will affect the clearing price?
2. What are my competitors' costs?
3. How will my competitors bid? Cost-based or strategically?
4. Will successive auctions become more or less competitive, given the pipeline?
5. How will the results of the earlier auctions affect bidding in later auctions?
6. What is my attitude to risk? How important is receiving a support contract relative to receiving the right price?
7. Are there portfolio effects (options to develop and bid multiple projects) that need to be considered?
8. Should project phasing be considered? (For example, is there any difference between bidding 100% of capacity in the same round, or 50% in one round and 50% in another?)
9. Do auction budget constraints matter more in some years than others?
10. How sensitive are the results to key assumptions (e.g., load factors or wholesale price assumptions)?

Taking Future Auctions into Account

The prospect of future auctions may change the calculus of optimal bid strategies. Bidders should consider whether it would be better to target the first auction and earliest delivery year that is feasible, or whether they would prefer to focus on future auctions. There are various potential reasons to wait but also reasons to prefer to bid early. Table 2 lists some pros and cons of both bidding early and waiting.[6]

Table 2. **Arguments for Competing Early or Late**

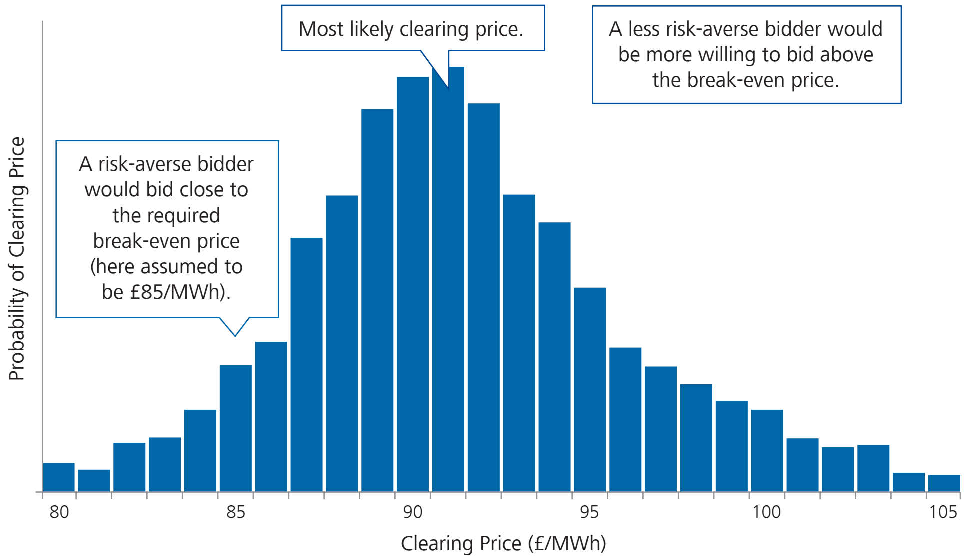
Possible Reasons to Delay	Possible Reasons to Bid Early
Competition in later auctions may be less fierce because: 1) projects that are successful in earlier auctions are removed from the supply curve and 2) new projects may be slow to come through the pipeline (due to the high cost of development and the significant risk that the projects will not be awarded any support).	If there is already a large pool of projects and a limited number of auctions or budget, the field may become even more crowded and competitive as the chances to secure support are used up.
Cost reductions, technological improvement.	The current historically low cost of debt could increase (commodity prices or exchange rates could also move unfavourably).
Financial markets may offer better terms as they become increasingly familiar with offshore wind and the support regime.	Costs of maintaining project team and delaying project revenues.
	Regulatory risk that a government could change auction rules, reduce the budget, reduce maximum prices, or introduce new technologies into the competition.

Using Simulation Modelling to Inform Bidding Strategy

Modelling the auctions can provide additional insights into optimal bidding strategies. As mentioned above, it is crucial to gather as much data about competitors' costs and likely strategies as possible. Nonetheless, there will always be some uncertainty about competitors' costs and about their likely bidding strategies.

These uncertainties can be modelled using Monte Carlo simulation techniques, which allow project sponsors to map out the bidding space and to consider different available strategies. Figure 2 below shows an illustrative simulation of the expected UK 2016/17 auction, in a particular scenario. In this case, the analysis suggests that the most likely clearing price in the auction would be £91/MWh.[7]

Figure 2. **Monte Carlo Simulation of Clearing Prices, Assuming Cost-Based Bidding, with Cost Uncertainty**

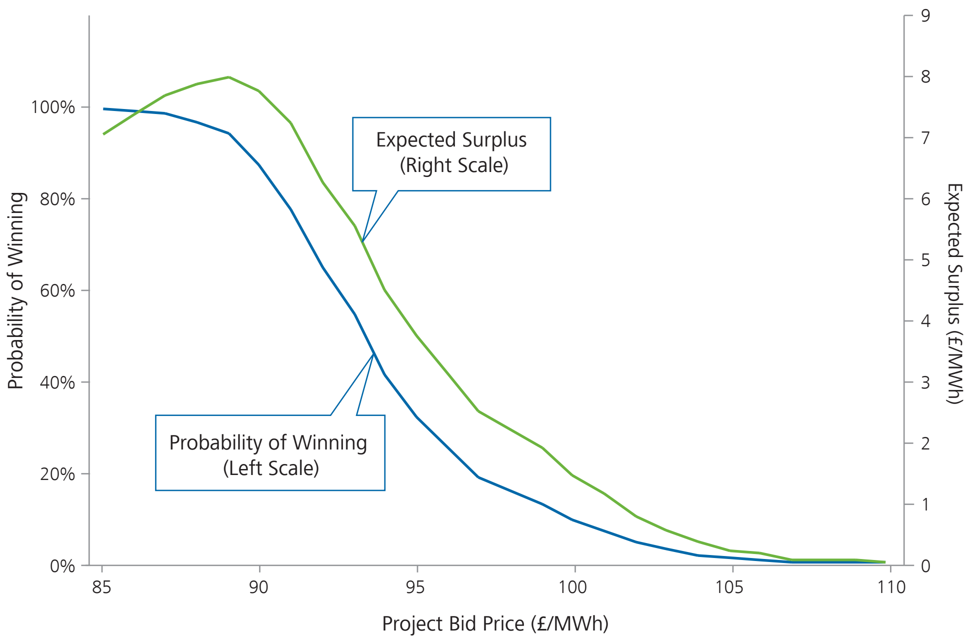


Source: NERA analysis.

A bidder with a minimum required price of £85/MWh can then choose from a menu of different bidding strategies. If a project sponsor believed the current auction was the only chance to win a contract, the sponsor may wish to bid close to its break-even price, to maximise its chance of success. Alternatively, if bidders considered their prospects to be good in later auctions, they may prefer to bid closer to the expected *clearing price*, rather than their own costs.[8]

The expected value from a given bidding strategy is the probability of winning multiplied by the profit (in the case of winning). Figure 3 shows the expected profit or surplus (the probability of winning multiplied by the expected surplus above minimum required price) for a generic offshore wind farm with a minimum required price of £85/MWh. For illustration, we show an auction where all other participants bid at cost. In this case, the surplus would be maximised at a bid of around £89/MWh.[9]

Figure 3. **Bidding Strategies that Maximise Expected Surplus**



Source: NERA analysis.

Whether this is the strategy that an individual firm would prefer will depend not only on the expected surplus but also on the firm's attitude towards risk. More risk-averse bidders may still prefer to bid lower, increasing their chance of winning, but at a cost of lower returns. Nonetheless, the best strategy may differ, depending on competitors' strategies.

Conclusions

The recent results from renewable electricity auctions have illustrated how effective auctions can be at generating competition and driving down prices. In the UK, the Department of Energy and Climate Change (DECC)[10] estimated that last year's introduction of auctions for renewable subsidies has already saved consumers more than £100m a year.[11] Governments under pressure to reduce consumer bills will be keen to identify ways to extract further cost savings.

Bidders and investors will want to analyse their strategies carefully, given the amounts of money at stake. Some of our analysis suggests that a £2/MWh increase in the subsidy level could increase expected internal rates of return (IRRs) by 0.5%. For large projects that have the potential to influence clearing prices, bid strategy is a complex area that requires project sponsors to answer a number of difficult questions (see Box 1). Careful modelling and analysis of potential auction outcomes can help to design an appropriate strategy. The best strategy will vary depending on bidder characteristics and preferences (including risk appetite and ultimate objectives). Getting this analysis right can significantly improve the likelihood of a project winning a support contract, the level of this support, and the likelihood of successful project delivery.

Investors will also want to understand the likely evolution of future auctions for offshore wind and other technologies. It remains to be seen whether governments will continue to be split between the "UK" (and Phase 1 German) model (projects bidding against each other) and the Dutch/Danish model (bidding for the right to build government-developed projects), or whether the recent very low costs of the Danish and Dutch auctions will shift sentiment towards that format. Government involvement in selecting and developing sites may help to prevent the project pipeline drying up and the auctions becoming uncompetitive; however, private actors might be more successful than governments at identifying and developing the best sites.

One advantage of the UK's auction format is that it is more technology-neutral and thus provides another way to promote robust competition. For countries within the European Single Market, State Aid guidelines are pushing governments to allocate subsidies via technology-neutral competition. Denmark has flagged the need for greater technology-neutrality as one reason for reconsidering its previously planned offshore wind auction. The Dutch already have a form of such competition for many renewable technologies within the SDE+, the Dutch subsidy regime for renewables that covers other technologies. And in Germany, although the bulk of the auctions are expected to be technology-specific, the final version of the Renewable Energy Sources Act (EEG 2017) introduced a small "pot" to trial technology-neutral auctions. If offshore wind costs are indeed starting to approach the costs of onshore wind and solar, then it is likely that pressure for technology-neutral competition will mount.

The question of technology-neutrality is connected to wider questions, such as how best to integrate renewables into the electricity grid, how to incentivise the required flexibility (e.g., storage, flexible generation, and demand-response), and how this should be financed. Technology-neutral auctions seek to ensure that all MWh are remunerated equally by support regimes, but looking further ahead, the next step may be to recognise that in fact, electricity produced at different times of the day or year—or on demand—has fluctuating values.[12] It is likely that as renewables continue to expand, so will the pressure to ensure that auction designs account for these differences, to keep overall system costs down. Prospective bidders should watch this space.

Of course, in addition to cost savings, another key objective is to ensure that generating capacity is actually built on time. There are trade-offs in designing auctions that are competitive enough to drive down prices but secure enough to ensure delivery. Different governments may well place different weights on these competing objectives. Under-delivery of projects remains a significant issue (the UK Government has consulted on greater incentives to deliver). It may be that by de-risking development, the Danish auction format helps to reduce delivery risk; however, the possibility of problems during construction means that delivery risk will persist under both auction formats.

Appendix A: Detailed Auction Results and Future Plans

Table 3. **Offshore Wind Auction Results – Denmark, the UK, and the Netherlands**

Country /Project	Size	Auction Year	Strike Price			Inflation Indexed	Water Depth	Distance from Shore	Delivery Year	Years of Support	Costs Faced by Project
	MW		Local Currency /MWh	€/MWh	£/MWh (2012 prices)		m	km			
Denmark											
Horns Rev 2	209	2004-5	518	70	67	No	9-17	32	2009	50,000 full load hours (approx. 12 years at 47% load factor)	Construction and operation of site only (not site development or grid)
Rodsand 2	207	2008	629	84	76	No	6-12	9	2010		
Anholt	400	2009-10	1051	141	123	No	15-19	15	2013		
Horns Rev 3	392	2013-15	770	103	81	No	10-20	20	2017-2020		
UK											
Neart Na Gaoithe (NNG)*	448	2015	115	138	115	Yes	45-55	13	2017-2018	15	Development, connection, construction, operation, and transmission
East Anglia ONE	714	2015	120	144	120	Yes	43-53	46	2017-2018	15	
Netherlands											
Borssele I	350	2016	73	73	56	No	14-38	22	by 2021	15	Construction and operation of site only (not site development or grid)
Borssele II	350	2016	73	73	56	No	14-38	22	by 2021	15	

Source: NERA analysis.

Notes:

1. NNG has had its Contract for Difference (CfD) contract terminated by the Low Carbon Contracts Company (LCCC) – the Government-owned company that acts as the counterparty to the CfD contracts – due to a failure to meet its milestone delivery date. The future of this project is therefore uncertain.
2. UK CfD prices are quoted in 2012 prices and are inflation-indexed.

The clearing prices for recent auctions in Denmark, the UK, and the Netherlands are compared in Table 3 above. The prices set through the auctions determine the total amount a wind farm will receive for each MWh of output. In practice, winners are entitled to receive top-up payments above the wholesale price so that the total amount received is equal to the winning auction price. In the UK, the support system is called a CfD FiT (Contract for Difference Feed-in Tariff). In Denmark, the Netherlands, and Germany, the support system works in a similar way, but the terminology is different (e.g., in the Netherlands, the system is called a sliding premium Feed in Tariff).

Denmark

In Denmark, auctions have been used to set support levels for offshore wind since 2005. The Danish auction is a technology-specific sealed bid[13] tender, for specific sites where the site surveys have been conducted, consents granted, and the grid connection is provided by the TSO. Bidders for these projects therefore bid to acquire a project at the construction stage. The support agreement being offered through the auction is similar in structure to the UK CfD; the project receives a top-up on the wholesale price up to a strike price set through the auction. However, the support volumes are capped at 50,000 full load hours—around 12 years assuming a load factor of 47% (or less if the load factor is actually higher). The volume cap effectively takes away most of the volume upside from the project (if it generates more in early years, this reduces the length of support). The price awarded is also not inflation-indexed, as it is in the UK.

United Kingdom

In the UK since 2015, the support levels for new subsidised renewable projects have been set through auctions that pit different technologies against each other. The renewable technologies are grouped into three main "pots" with separate budgets and clearing prices:

- Pot 1, for "Established Technologies", includes onshore wind, solar, and others;
- Pot 2, for "Less Established Technologies", includes offshore wind, Advanced Conversion Technology (ACT), biomass with combined heat and power (CHP), remote islands onshore wind[14], and others; and
- Pot 3 includes biomass conversion only (though no auction has been held for this so far).

The product being auctioned is a 15-year CfD with a price per MWh determined in the auction. The auction format is sealed bid, first price, and pay-as-clear,[15] covering multiple delivery years. For example, in the 2015 auction, projects could bid to commission in any of the four years between 2015/16 and 2018/19. The auction administrator (National Grid) ranks all of the bids based on price only across four delivery years. All successful bidders receive the clearing price for their delivery year.[16] To participate in the auctions, projects have to be well-advanced (have planning permission and a grid connection agreement offer).

Netherlands

The Netherlands held its first auction for offshore wind in 2016 (though the SDE+ is already auction-based and multi-technology). The offshore wind auctions follow the Danish model of tendering for specific sites for which the site surveys and grid connections are provided. The Dutch Government has set out a plan to auction up to 10 sites of 350 MW, which would bring the total offshore wind capacity in the Netherlands to 4.5 GW. As noted above, both site tenders (Borssele I and II) were won by DONG Energy at a support price of just under €73/MWh. This is significantly lower than the prices in the UK and in the 2015 Danish auction, which are on comparable terms. In the UK, the cost of transmission could potentially represent about £10-12/MWh[17] (approximately €12-15/MWh).

Even if one were to make allowances for the additional costs of developing the site, of obtaining planning permission, and for the differences in water depth, the Netherlands support costs appear to be far lower than the recent UK prices. Moreover, the UK support contracts have at least two advantages (which are likely to be reflected in the UK bid prices) in that support is paid on an unlimited volume of output over the 15-year support period, and they are inflation-indexed, whereas the Danish and Dutch contracts lack these features. The low Dutch bids thus appear to reflect DONG's confidence that by 2021 (when the wind farms need to be commissioned), innovation and scale will significantly reduce costs.[18]

Future Auctions—Additional Details

Future planned auctions in the UK, Germany, and the Netherlands are set out in Table 4 below. In Germany, Phase 1 will involve auctions similar to those in the UK, in that different projects at different sites will compete against each other (though not against other technologies). Phase 2 will involve moving to a system along the lines of the Danish/Dutch model of auctions for specific sites. The first auction is expected in 2017 for around 500MW per year to be delivered in 2021, rising up to 700-900 MW per year by 2026 (depending on the specific sites identified).[19] In Denmark, a tender is expected to conclude later this year for 600 MW at the Kriegers Flak site. The prospect for future Danish tenders, however, remains uncertain. The Government announced in May 2016 that it was postponing or cancelling a 350 MW tender for near-shore offshore wind and that the public service obligation which pays for the subsidy would be scrapped and potentially replaced by funding renewable subsidies from general taxation.[20] One of the reasons cited in reports is the EU State Aid rules, which require technology-neutral competitions.

Table 4. **Future Auctions for Offshore Wind in Northern Europe**

Country	Auctions Planned	Auction Years	Budget	Technologies	Auction Format	Price Indexed?	Years of Support	Costs Paid by Project
UK	3	2016, 2017? 2018?	Up to £730m (4GW)	Multiple	Sealed bid, first price, pay as clear	Yes	15	Development, connection, construction, operation, and transmission
Germany - Phase 1	2	2017? 2019?	2-3 GW?	Single	Sealed bid, first price, pay as bid	No	20	Development, connection, construction, and operation
Germany - Phase 2	6-12	Yearly?	About 5GW?	Single	Single site	No	20	Construction and operation
Netherlands	10	2016-2020 (yearly)	3.5GW (700MW/year)	Single	Single site	No	15	Construction and operation

Source: NERA analysis.

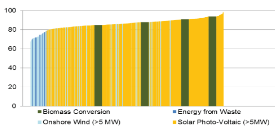
Appendix B: NERA's Renewable Energy Auctions Model

	CfD Valuation Model	CfD Auction Model
Inputs	• Projects sourced from DECC's Renewable Energy Planning Data • Cost data (e.g., detailed cost modelling for offshore wind) • Hurdle rates, asset lives, load factors, forecast wholesale prices, Capacity Market prices	• Supply curve from Valuation model • LCF budget • Auction rules (e.g. reserve prices, pots, maxima and minima) • Bidder strategic parameters
Approach	• A cash flow model for each project is developed based on the expected costs and revenues over the life of the asset, including post CfD • For each project the model solves for the CfD strike price that would give an NPV over the life of the asset of zero.	• Taking contract valuations as a baseline, bids can be tested against different scenarios and strategic assumptions • Bids are then passed through the auction allocation mechanism which determines strike prices, allocations and budget usage
Outputs	• Pipeline of projects with expected commissioning years • Valuations of CfD contracts for each project – i.e., a supply curve	• Allocations awarded and strike prices • Budget usage by project by year • Project portfolio values and surplus

Project pipeline

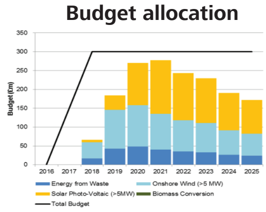
Project	Current Phase	MW
Galloper	Pre-construction	336
Dogger Bank Teesside (A,B)	Consented	2,400
Dogger Bank Creyke Beck (A,B)	Consented	2,400
Triton Knoll	Consented	900
Seagreen (Alpha, Bravo)	Consented	1,050
Inch Cape	Consented	784
Moray Firth - Eastern development	Consented	1,116
Hornsea Two	[illegible]	
[illegible] Anglia Three		

Supply Curve



Strike Prices

Budget allocation



Notes

1 https://windeurope.org/newsroom/press-releases/windeurope-welcomes-energy-ministers-deal-to-cooperate-on-offshore-wind; https://www.theguardian.com/environment/2016/jun/06/renewable-energy-firms-urge-eu-back-offshore-wind.

2 The UK auctions require renewable technologies to compete within pots. Pot 2 includes offshore wind, biomass with combined heat and power (CHP), Advanced Conversion Technologies (ACT), anaerobic digestion, wave, tidal stream, and geothermal. Each technology has a specific maximum price.

3 It is interesting to note that while the main Dutch policy is to support forms of renewable energy apart from offshore wind, the Stimulation of Sustainable Energy Production (SDE+) in the Netherlands does allow projects and technologies to compete against each other, as in the UK.

4 See paragraph 126 in "Guidelines on State aid for environmental protection and energy 2014-2020", (2014/C 200/01), http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014XC0628(01).

5 Project economics can be modelled with distributions over uncertain variables like wind speed, load factor, etc. The P50 assumption represents the midpoint of these distributions.

6 In Germany, there is an added dimension to the question of timing, in that the maximum prices in later auctions are expected to be capped by the outcomes of earlier auctions.

7 The Monte Carlo analysis shows clearing prices over a number of different delivery years.

8 They may even wish to bid higher than the expected clearing price, as there is a chance that the price could be higher than the most likely or the expected price.

9 If the project bids at £85/MWh, it is almost certain to secure support based on the assumed competitor bids, even though in some delivery years the clearing prices without the project's bid are lower.

10 Since August 2016, DECC has been subsumed into the Department of Business Energy and Industrial Strategy (BEIS).

11 https://www.gov.uk/government/news/world-leading-auctions-to-provide-major-green-electricity-boost.

12 For a discussion of some of the relevant differences, see "NERA (2015): System integration costs for alternative low carbon generation technologies – policy implications", a report for the Committee on Climate Change (CCC), https://www.theccc.org.uk/publication/system-integration-costs-for-alternative-low-carbon-generation-technologies-policy-implications.

13 Sealed bid auctions involve bidders placing bids simultaneously and without seeing the bids of any other bidders, as opposed to ascending or descending clock auctions where the price often emerges over several rounds of bidding.

14 ACT is Advanced Conversion Technologies—forms of biogas from waste and pyrolysis, and remote islands onshore wind was formerly known as Scottish islands onshore wind.

15 Pay-as-clear auctions, also called "uniform price" auctions, are those in which all successful bidders receive the clearing price, in this case, the bid of the highest successful bidder. A first price auction means that the winner in the auction pays (or in this case receives) the price of the winning bid, rather than the price of the runner up (a second price auction).

16 Or the maximum price if the clearing price is higher.

17 https://ore.catapult.org.uk/wp-content/uploads/2016/05/Transmission-Costs-for-Offshore-Wind.pdf.

18 http://www.dongenergy.com/en/media/newsroom/news/articles/dong-energy-wins-tender-for-dutch-offshore-wind-farms.

19 Final recommendations on changes to the Renewable Energy Sources Act (EEG) by the Economics Committee of the Bundestag (as adopted by Parliament in plenary session): http://dip21.bundestag.de/dip21/btd/18/090/1809096.pdf.

20 http://www.rechargenews.com/wind/1432610/denmark-may-scrap-350mw-near-shore-tender-as-pso-is-axed.

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