Is Offshore Already Competitive? Analyzing German Offshore Wind Auctions[1]

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***Abstract* — Two German offshore wind auctions in 2017 and 2018 saw more than 50% of winning capacity with "zero bids". The nature of these surprisingly low bids is, however, not yet clear. In our paper, we discuss four hypotheses for possible causes for the auction results: (i) the bids are expected to be profitable due to market development and technological progress, (ii) bids can be perceived as "options to build" that can be realized if projects are profitable, (iii) bids are adjusted to secure grid access, and (iv) other long term reasons not primarily driven by the profitability of the winning bids. Our results suggest that there is evidence for all hypotheses to influence the decision making of auction bidders. In fact, we suggest to see the four hypothesis as cumulative value components, which reveal the true value of winning the auction at "zero cost" in aggregate.**

***Index Terms* — Renewable energy auction, offshore wind**

I. Introduction

Germany has recently held two offshore wind auctions. The first auction was held on 1 April 2017, the second auction on 1 April 2018.

The results of the first auction stunned the industry: the average price for 1,490 MW of awarded capacity was just 4.6 €/MWh, three out of four winning projects bid 0 €/MWh – meaning that the projects claimed to entirely rely on wholesale electricity prices to make a revenue. The results of the second auction were not an anticlimax but showed more variation. The average successful bid for 1,610 MW of awarded capacity was at 46.6 Euro/MWh, hence ten times the first auction's. The highest awarded bid was 98.3 Euro/MWh, but the auction also had bids with 0 Euro/MWh. Especially the zero bids attracted much media attention because if these projects are constructed, the "break-even" point of offshore wind and conventional power plants would no longer be a future but instead a present state of affairs.

This paper contributes to the understanding of zero bids in the two German wind offshore auctions. We derive four hypotheses and analyze how well they correspond to both auction design and results. The four hypotheses are:

a. Projects are expected to be profitable on the wholesale market;
b. Bids can be perceived as "options to build";
c. Bids are adjusted to secure grid access to specific clusters;
d. Other reasons.

II. Discussion

In the following, we highlight the key aspects of the German Offshore Wind Act (WindSeeG[2]) which sets the rules for the offshore wind auctions (part A). Later, we discuss the four hypothesis mentioned above (parts B - E). In the context of the first hypothesis, we will analyze the time frame for winning bids to come online. A late deadline is an opportunity for investors to e.g. profit from longer learning intervals. Furthermore, grid access is a cost component not included in the bids. We will analyze the value of these benefits to investors. The second hypothesis reflects the fact that winning the auction does not force winners to actually build the project. However, there is a cost associated with non-compliance (a bid bond is lost). We will quantify these costs and compare them to total investment costs. In the context of the third hypothesis, we will discuss the general scarcity of the auction (aggregated capacity of planned projects versus auctioned capacity), as well as a specialty of the German offshore auction where projects compete for limited grid connection capacity in specific clusters. In the context of the fourth hypothesis, will discuss other factors such as signaling to competitors and improving the reputation of offshore wind.

A. General aspects of the auction scheme and results of the auctions

The WindSeeG came into force on 1 January 2017 as a part of a wider reform of the Renewable Energy Act (EEG 2017). The purpose of WindSeeG is to increase the installed capacity of offshore wind energy installations in Germany to 15 GW by

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[2] We will use WindSeeG in the remainder of this paper.

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2030 in a *steady* and *cost-efficient* way [1]. In addition, the WindSeeG coordinates the newly introduced competitive technology-specific auction system for renewable energy technologies with the coordination of planning and construction of offshore grid connection projects. The WindSeeG distinguishes between the following two time periods:

First, a "transitional auction period" is applied for the offshore wind projects with a scheduled start-up date between 1 January 2021 and 31 December 2025. In order to be eligible, a project should have received a special permit before 1 August 2016 under the Offshore Installations Ordinance (*Seeanlagenverordnung*) or, when planned in coastal waters, under the Federal Immission Control Act (*Bundes-Immissionsschutzgesetzes*). The BSH has announced the list of 29 projects that satisfy the mentioned criteria [2]. Projects eligible for the transitional period are located either in the North Sea (subdivided into 8 clusters) or Baltic Sea (3 clusters) within the German Exclusive Economic Zone (EEZ).[3] The transitional period comprises the two auctions discussed in this paper (1 April 2017 and 1 April 2018). In each round 1,550 MW of capacity were auctioned – with volumes not awarded in the first auction added to the second. At least 500 MW of total capacity must be allocated to the Baltic Sea. Both auctions use the "pay-as-bid" mechanism.

In a second period, for offshore wind energy installations with a start-up date after 1 January 2026, the so-called "central model" will be applied. It implies that governmental authorities will select and investigate the appropriate coastal sites.[4] The auctions for the development rights of offshore wind parks on such preselected sites will take place every September starting from 2021, with a capacity of 700 to 900 MW per year.

Note that the current German renewable energy auction design essentially determines a (one sided) contract-for-difference payment: The average wholesale price received by a technology in a year is subtracted from the bid to derive the payment received as result of the auction ("market premium"). To give an example, an investor bidding 60 €/MWh receives a payment of 10 €/MWh if the average revenue for the technology was 50 €/MWh on the wholesale market. The average market value received by a technology (i.e. all installed capacity of that technology) is used to give an incentive for single projects to exceed the technology average.[5]

Table I summarizes the results of the first and second German offshore wind auctions.[6]

TABLE I. ACCEPTED BIDS IN THE 1ST AND 2ND GERMAN AUCTION FOR OFFSHORE WIND

Project name	Owner	Capacity awarded (MW)	Bid (€/MWh)
First auction (April 1st, 2017)			
OWP West	Ørsted*	240	0
Borkum Riffgrund West II	Ørsted	240	0
Gode Wind 3	Ørsted	110	60
He Dreiht	EnBW AG	900	0
Second auction (April 1st, 2018)			
Baltic Eagle	Iberdola	476	64
Gode Wind 4	Ørsted	131.75	98.3
Wikinger Süd	Iberdola	10	0
Kaskasi	Innogy	325	-
Arcadis Ost 1	KNK Wind	247.25	-
Borkum Riffgrund West I	Ørsted	420	0

*Ørsted is the current name for DONG Energy

In the first auction, three out of four winning projects (with total capacity of 1,380 MW out of overall awarded 1,490 MW) have bids of 0 Euro/MWh. The biggest project is EnBW's project "He Dreiht", with 900 MW capacity. The remaining 110 MW is the "Gode Wind 3" project owned by Ørsted. Based on these four winning bids, the average volume-weighted auction price is 4.4 Euro/MWh.

The second auction saw six winning projects, three in the North Sea ("Kaskasi", "Borkum Riffgrund West I", "Gode Wind 4") and three in Baltic Sea ("Baltic Eagle", "Wikinger Süd", "Arcadis Ost 1"). Zero bids were submitted by Ørsted ("Borkum Riffgrund West I") and Iberdrola ("Wikinger Süd"). The bids of Innogy and KNK are not (yet) published.[7] The average volume-weighted auction price is 46.6 Euro/MWh.

Combining the first and second auction, more than 50% of winning capacity was bid at zero. This is surprising as wind offshore was perceived to be significantly more expensive than wind onshore – and even recent ground mounted PV projects [5]. Below we attempt to explain the surprising results by means of the four hypothesis introduced in section I.

B. *Projects are expected to be profitable on the wholesale market*

In the context of the first hypothesis, we will discuss all factors in favor of financing offshore wind projects based on wholesale prices alone, i.e. without additional payments from the auction.

[3] Clusters are defined in the Spatial Federal Offshore Plan (*Bundesfachplan Offshore*), which is available at: http://www.bsh.de/de/Meeresnutzung/BFO/index.jsp

[4] The selection and investigation of appropriate sites will be done by the Federal Maritime and Hydrographic Agency (*Bundesamt für Seeschifffahrt und Hydrographie (BSH)*). This process is supposed to be coordinated with the Federal Network Agency's (*Bundesnetzagentur (BNetzA)*) planning of offshore transmission network development.

[5] See [3] and [4] for a discussion in the context of wind onshore.

[6] Note that BNetzA only publishes: Names of winning bids' companies, highest, lowest and average bid as well as total awarded capacity. Gaps in the table were filled based on press releases and other available information.

[7] Innogy revealed that the bid was "one of the most competitive" [10] – however, this may just mean it was competitive enough to be among the winning bids in the auction.

i. Time for further learning

According to press releases of Ørsted, the company plans to commission all their five winning projects in 2024/25, after a Final Investment Decision (FID) in 2021 [6], [7]. EnBW plans the FID on the "He Dreiht" project in 2023 [8]. Therefore, the owners of these projects exploit the late realization deadline, which is established by the years of offshore grid connection: year 2023 for North Sea cluster 3 ("Gode Wind 3" and "Gode Wind 4"), 2024 for North Sea cluster 1 (OWP West as well as Borkum Riffgrund West I and 2), 2025 for North Sea cluster 7 ("He Dreiht"). The situation for e.g. "Kaskasi" and "Baltic Eagle" is different: both Innogy and Iberdrola plan FID in 2020 and commissioning in 2022 [10], [11].

A late deadline is an opportunity for investors to reap the benefits of longer learning intervals and the resulting expected cost decrease. Both Ørsted and EnBW expect that much bigger turbines of size 10+ MW will be available on the market by 2024 [6], [8]. This would allow for significant cost reductions due to economies of scale. Based on this learning argument, both Iberdrola's and Innogy's bids should be higher than the others. This can be confirmed for Iberdrola [11]. Unfortunately, the height of Innogy's bid is currently unknown.

ii. Costs of grid connection are not included[8]

In addition to being entitled to the market premium, winning projects "receive", or effectively, are assigned to the offshore grid connection capacity. The planning and coordination of offshore grid development is performed by the Federal Network Agency. As such, costs of grid connection are paid by electricity consumers as a part of network charges.

Hence, from the perspective of investors, revenues on the wholesale market do not have to cover these costs to make the investment feasible. This is another factor making zero bids possible. The cost reduction for investors can be quantified by looking at the share of grid connections costs per kW installed. [12] estimates the costs for offshore grid connection in Europe in the range 400 – 1,200 $€_{2017}$/kW.[9] De Decker et al's report estimates average grid connection costs for Germany of 1,160 $€_{2017}$/kW for individual connections and 770 $€_{2017}$/kW for hub connections, which is at the upper end of the levels provided by [13]. We performed also our own estimation of grid connection costs for projects that were accepted at the first and second German offshore wind auctions. We focus the analysis on North Sea projects (Table II) and find them slightly higher but at similar levels.

TABLE II. OWN ESTIMATION OF GRID CONNECTION COSTS FOR ACCEPTED PROJECTS IN THE NORTH SEA*

Project name	Associated offshore grid project	Estimated costs of grid connection, €/kW
OWP West and Borkum Riffgrund West I&II	DolWin5 (NOR-1-1)	1,289
Gode Wind 3&4	DolWin6 (NOR-3-3)	1,200
He Dreiht	BorWin5 (NOR-7-1)	1,556
Kaskasi	HelWin2 (NOR-4-2)	1,056

*Cost estimators are from [14]. Data about projects specification is based on [15].

iii. Operational period extension

All successful projects profit from the possibility of extending the operational lifetime period allowed for offshore wind energy installations from 25 to 30 years [1]. This means that project owners can expect lower LCOEs by spreading costs over longer operational periods.

iv. Expectations on wholesale electricity prices

Ørsted reports that all cost reduction drivers lead to expected LCOEs being below the expected future wholesale electricity price. Even so, according to their 2017 press release, '*…DONG Energy [Ørsted] will monitor the key factors which will determine long-term power prices in Germany*' prior to making their final investment decision (FID) in 2021. '*These factors include the impact of EU actions to reinvigorate the European carbon trading scheme; the phase-out of conventional and nuclear capacity; the future role of coal in Europe; and the build-out of onshore transmission grids.*'

C. "Option bidding"

The factors mentioned above analyze the expected profitability of projects at the time of FID. In addition, the current auction design allows for the interpretation of zero bids as purchasing an "option" to keep the project in an investor's balance sheet and, when market uncertainties resolve, decide on further action.

The upside profit potential of this "option" is a profitable project at FID, including the right to offshore grid connection, a grid connection subsidy (discussed above) and revenues from selling electricity at wholesale market prices.

The downside loss potential (if FID is negative or postponed) is limited to (unrecoverable) costs paid for the

[8] This includes costs of transmission infrastructure components as AC/DC converter stations and sea/land cable connection to converter stations onshore.

[9] Based on stated 3,300 - 5,000 USD_{2011}/kW total project investment costs, a share of 15 - 30 % for grid connection components (including cabling, substations and buildings), a EUR to USD annual average rate of 1.39 for 2011 and an average increase of the consumer price index in Germany from 2011-2017 of 1.3%. We rounded values up to the two decimal places left to the decimal point, following the original source.

project[10] and a security deposit (i.e. a bid bond in form of a bank guarantee or cash deposit provided by each auction participant in advance). The structure of sanctions for non-compliance with implementation deadlines includes penalties of 30%, 70% and 100% of the bid bond, for violations of specific milestones [1]. The maximum expected loss is the full bid bond value, which is equal to 100 €/kW for the "transitional period". Therefore, in the case of total non-compliance, project owners pay a maximal penalty of 2.5 - 3.8 % of total development costs (assuming total costs of 2,600 - 3,900 $€_{2017}$/kW, again converting and discounting [12], see above). Hence, a number of analysts have argued that project owners benefit from the current design of the auction system, focusing on the option value in their bids [16], [17], [18]. We agree with these studies. There exists a significant payoff asymmetry: potential upsides, given significant uncertainty in key elements such as investment costs and wholesale electricity prices several years from now, seem significantly higher than the potential downside of losing the bid bond. Also, note that this auction design element favors projects with late FIDs: The upside potential increases over time as uncertainty in learning (costs) and wholesale prices (revenues) increases – but the downside potential remains constant. Again, this may explain why EnBW and Ørsted bid zero – but Iberdorla did not.

D. Securing grid access in (i) a generally constrained setting and (ii) capacity restricted "clusters"

Securing grid access has two components, firstly the general scarcity of the auction and secondly competition for limited grid connection capacity in specific sea clusters.

i. Constrained overall setting

During the "transitional period", a total capacity of 3,100 MW was auctioned. The sum of capacities of all projects that are at an advanced stage in the planning procedure or are already approved is 8,654 MW (own calculation based on BSH [2]). Thus, less than 36 % of approved capacity will be realized during the transitional period.

The consequences of not winning in the transitional auctions are as follows: Approved projects winning neither the first nor the second auction will lose planning approval. Approved projects' investors cannot finish these projects, not even without subsidies. The only exception is an "Eintrittsrecht" for owners of existing projects, which means they may replace another winning bidder if their former project is auctioned under the central model in later years.[11] However, the first such auction is held in 2021. Furthermore, this requires several conditions to be met.

Both the limited capacity auctioned (in relation to total approved capacity) as well as the consequences of not winning lead to fierce competition in both auctions of the "transitional period". However, overall competition was slightly less severe in the Baltic Sea because at least 500 MW were reserved for it. This is one of the reasons why bids in the Baltic were higher than in the North Sea.

ii. Constrained clusters (i.e. subsets of competing projects)

One special feature of the German auction adding complexity is that winning bids receive the right to get connected to the grid – and that this connection is limited. Projects are grouped in sea clusters (i.e. regions with physical connection points) and not all projects within a cluster can be connected. Thus, a bid is accepted *if it neither exceeds the auction volume nor triggers a capacity shortage within a cluster* [1]. Otherwise, the next (more expensive) bid is chosen.

Two aspects may come into play: first, bidders' feelings of "now or never" may be increased if a cluster is adding constraints beyond the overall auction setting. Second, bidders may submit low bids (i.e. below cost calculations) to block cluster access for other projects and then submit a very profitable bid for remaining capacity in the same cluster in the second auction.[12] In the following, we analyze the winning bids in the North Sea and their relevant clusters based on [19].

Cluster 1 consists of three projects owned by Ørsted. Two projects ("OWP West" and "Borkum Riffgrund West 2") won the first auction with bids of 0 Euro/MWh. The third project "Borkum Riffgrund West I" won the second auction with the zero bid as well (with a capacity of 420 MW instead of originally planned 360 MW). Thus, capacity of all three projects matches the planned capacity of NOR-1-1 grid connection (900 MW). There was no in-cluster competition with projects of other companies.

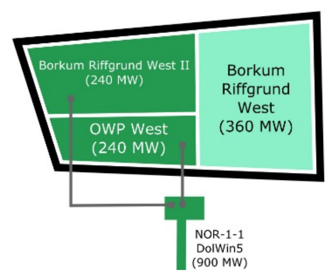

Figure 1: Cluster 1 [19]

In cluster 3 there are 9 projects overall. Three of them are already operating and utilizing the full capacity of the NOR-3-1 connector ("Nordsee One", "Gode Wind 1" and "Gode Wind 2"). The other six projects (owned by E.ON, Innogy and Ørsted) with a total capacity 1,490 MW were competing in the first and second offshore auctions for the NOR 3-3 connector (900 MW).[13] Therefore, the cluster is constrained, as only 55 %

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[10] In the context of analyzing zero cost bids, rational "option bidders" would only include future costs (i.e. after participating in the auction). We assume that costs between winning the auction and FID are negligible even compared to the bid bond. Costs paid before entering the auction are already sunk at the time the bid is determined.

[11] See WindSeeG section 39 for a detailed description.

[12] This complex strategy requires some assumptions (e.g. fixed costs associated with projects).

[13] NOR-3-2 project is planned for year 2030.

of planned capacity could be connected during the "transitional period".

Despite these observations, Ørsted bid less aggressively in the cluster 3 than in the cluster 1 in both auctions (see Table 1). This may result from the earlier connection in cluster 3 (2023 instead of 2024) and economies of scale with the larger projects in cluster 1 outweighing the effect of hypothesis (D).

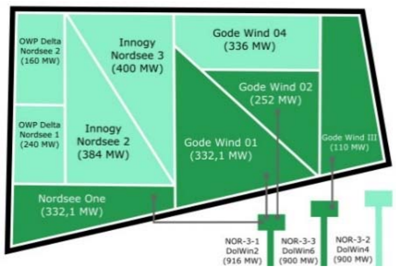

Figure 2: Cluster 3 [19]

Innogy's "Kaskasi" project had no competition in cluster 4, as the only existing project "Amrumbank West" owned by E.ON is already operating. The project was accepted with the capacity of 325 MW that again exceeds initially planned 272 MW (Figure 3).

In cluster 7 the project "He Dreiht" owned by EnBW competed with the project "Global Tech II" owned by Vattenfall for the 900 MW of capacity of NOR-7-1 connector. The cluster is congested, as only one of the two projects can be connected to the grid. Furthermore, the competition is strengthened by projects located in cluster 6 which can also compete for the connection capacity of the NOR-7-1 connector [9]. Thus, the "He Dreiht" project was competing with 486 MW (nominal capacity of "Global Tech II"), as well as with 582 MW of additional capacity from cluster 6 [9].

These observations suggest that EnBW's zero bid for "He Dreiht" project in cluster 7 could be motivated by strategic considerations to ensure its entitlement to connector capacity. [20] confirms this hypothesis, by stating that the "Global Tech II" project cannot participate at the second auction, as NOR-7-1 capacity is booked out.

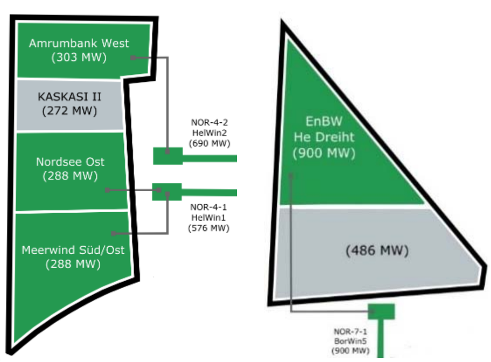

Figure 3: Cluster 4 (left) and Cluster 7 (right) [19]

E. Other reasons

While we find the three hypothesis presented above convincing in explaining zero bids, additional factors may also contribute. However, they are even harder to quantify. For example, low bids improve the reputation of offshore wind projects in general. Offshore wind was often considered the next cost driver of the Energiewende [21]. Following recent auctions, they are perceived as being on the verge of competitiveness.

Furthermore, low bids can be perceived as a signal to competitors for future auctions. If a potential competitor has costs requiring bids significantly above those submitted by successful projects, they may decide to leave the market and thus reduce competition in future auctions – both nationally and internationally.

Last but not least, other considerations may be part of the equation. For example, EnBW is partly owned (46.75 %) by the German state of Baden-Württemberg which has a government coalition lead by the Green Party. This ownership structure may increase the incentive for EnBW's management to pursue ambitious renewable energy targets in electricity generation.

III. Conclusion

This article discusses the results of two auctions for wind offshore in Germany with a total auctioned capacity of 3,100 MW. We started with a brief description of the auction results, in particular that the majority of capacity was bid at zero, i.e. investors will not receive any payments in addition to market revenues.

In the main part of the paper, we discussed four hypotheses as possible explanations of low bids. We conclude that they all contribute to the explanation of the low bids. They can even be seen as additive value components, which in the aggregate explain low bids.

Regarding the first hypothesis, we found evidence that investors may expect projects' revenues on the wholesale market exceeding costs. At least three factors contribute to this: a long time span until projects have to go online, which may firstly bring down investment costs due to technical progress and secondly bring higher wholesale prices due to excess electricity generation capacity leaving the market. Thirdly, a socialization of grid connection costs also reduces costs for investors.

The second hypothesis also contributes significantly to low bids: future payoffs for the investments are both highly uncertain and highly asymmetric. Upside potential is significant (e.g. due to wholesale price rises or investment cost reductions); however, the downside potential is limited to a penalty for non-compliance, which amounts to only approximately 3 % of investment costs. While the incentive resulting from this low non-compliance penalty is a significant value driver bringing bids down, it comes at the cost of a significant risk that winning projects will not be built. If we will see an unsatisfactory compliance rate in German offshore wind, especially from zero bid projects, low penalties will be a primary reason. We stressed this point already in [18], but it is still not sufficiently reflected in the current debate. This may be due to lobbying pressure in the transitional period as WindSeeG already specifies that the penalty will double to 200 €/kW in the year 2026. Even assuming constant development costs from the transitional auction period to the central model starting in 2026, this increases the penalty of non-compliance to 5 to 7.6 %.

The third hypothesis discussed the importance of winning in the auction to secure grid access for investors. We conclude that both auctions were very competitive due to a) qualified project capacity exceeding auctioned capacity by a factor of nearly three and b) the danger of losing project approval without accepted bids. We also find that intra-cluster competition may increase competition even further (in particular in clusters 6 and 7) but find no evidence for the more complicated strategy of blocking access in the first auction and reaping profits in the second.

REFERENCES

[1] Offshore Wind Energy Act (*Windenergie-auf-See-Gesetz - WindSeeG*), 2017. Available at: http://www.gesetze-im-internet.de/windseeg/index.html.

[2] Bundesamt für Seeschifffahrt und Hydrographie (*BSH*), Liste über Offshore-Windparkvorhaben im Sinne des § 26 WindSeeG, 19.12.2016. Available at: http://www.bsh.de/de/Das_BSH/Bekanntmachungen/Bekanntmachungen_Windparks/Liste_WindSeeG.pdf.

[3] O. Grothe and F. Müsgens, "The influence of spatial effects on wind power revenues under direct marketing rules," *Energy Policy*, vol. 58, pp. 237–247, 2013.

[4] T. Engelhorn and F. Müsgens, "How to estimate wind-turbine infeed with in-complete stock data: A general framework with an application to turbine-specific market values in Germany," Energy Economics*, to appear*, 2018.

[5] S. Kreuz and F. Müsgens, "The German Energiewende and its Roll-Out of Renewable Energies: An Economic Perspective," *Frontiers in Energy, vol. 11 (2), pp. 126–134*, 2017.

[6] Ørsted, Press release: "DONG Energy awarded three German offshore wind projects", 2017. Available at: https://cns.omxgroup.com/cdsPublic/viewDisclosure.action?disclosureId=768902&messageId=965625.

[7] Ørsted, *Press release*: "Ørsted wins 551.75MW in German offshore wind auction", 2018. Available at: https://orsted.com/en/Company-Announcement-List/2018/03/Orsted-wins-German-offshore-wind-auction.

[8] D. Güsewell, S. Kancy, and M. Münch, *EnBW press conference,* 12.02.2018. Available at: https://www.enbw.com/media/presse/docs/dokumente-zu-pressemitteilungen/2018/20180212_praesentation_pressegespraech_alishan_12022018_v14.pdf.

[9] Bundesnetzagentur (*BNetzA*), "Offshore-Netzentwicklungs-plan 2025: Bestätigung", Az.: 613-8572/1/1. Available at: https://www.netzausbau.de/bedarfsermittlung/2025/nep-ub/de.html.

[10] Innogy, *Press release*: "Innogy successful in German offshore auction", 2018. Available at: https://news.innogy.com/innogy-successful-in-german-offshore-auction/.

[11] REUTERS, "Iberdrola Plans One Billion Euro Investment in Baltic Sea Wind Farms", *The New York Times*, April 27, 2018. Available at: https://nyti.ms/2vUEA0u.

[12] International Renewable Energy Agency (*IRENA*), "Renewable energy technologies: cost analysis series. Volume 1: Power Sector, Issue 5/5. Wind Power.," 2012.

[13] J. de Decker and P. Kreutzkamp, "Offshore Electricity Grid Infrastructure in Europe," *Final Report*. 3E (coordinator), dena, EWEA, ForWind, IEO, NTUA, Senergy, SINTEF, 2011.

[14] Bundesnetzagentur (*BNetzA*), "Netz entwicklungs Plan Strom 2030", 2017. Available at: https://www.netzausbau.de/SharedDocs/Downloads/DE/2030_V17/NEP/O-NEP2030_UENB-Entwurf2a.pdf?__blob=publicationFile.

[15] TENNET, Offshore-Projekte Deutschland. Available at: https://www.tennet.eu/de/unser-netz/offshore-projekte-deutschland-2/.

[16] J. Guillet, "Offshore Wind in a zero bid climate," EMEA Report, 2017.

[17] D. Radov D. Huebler and L. Wieshammer, "Method or Madness: Insights from Germany's Record-Breaking Offshore Wind Auction and Its Implications for Future Auctions," *NERA economic consulting*, 2017.

[18] Bade A., Käso M., Lienert M., Müsgens F., Schmitz C., Wissen R., "Ausgestaltung eines Auktionsmodells für EE-Anlagen in Deutschland," r2b Energy Consulting GmbH, *Gutachten im Auftrag des BDEW*, 2015.

[19] Bundesnetzagentur (*BNetzA*), "Offshore-Netzentwicklungs-plan 2025", Schematische Übersicht Nord- und Ostsee. Available at: https://www.netzausbau.de/bedarfsermittlung/2025/nep-ub/de.html.

[20] 4C Offshore consultancy, offshore wind projects in Germany. Available at: http://www.4coffshore.com/windfarms/.

[21] Institute for energy research (*IER*), "Offshore Wind Energy: A Very,Very Expensive Electricity Source", 2013. Available at: https://www.instituteforenergyresearch.org/wp-content/uploads/2013/06/Offshore-Wind-Energy-DRS-4.pdf.