2016

DEUTSCHE WINDGUARD

STATUS OF OFFSHORE WIND ENERGY DEVELOPMENT IN GERMANY

On behalf of:

AGOW Arbeitsgemeinschaft Offshore-Windenergie e.V.

BWE Bundesverband WindEnergie

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STATUS OF OFFSHORE WIND ENERGY DEVELOPMENT

The development of offshore wind energy in Germany during the calendar year 2016 is explained in detail in this fact sheet. Table 1 shows the data for new construction across the entire year and the cumulative status as of 31 December 2016.

TURBINES FEEDING INTO THE GRID

During the course of 2016, 156 offshore wind turbines (OWT) started feeding into the grid. Their installed capacity is 818 MW. Of these OWT, 41 were erected in 2015. For the remaining 115 OWT, both their construction and their initial feed-in into the grid occurred in 2016. In addition, during the year the rated capacity of six existing OWT was increased by 1.1 MW in total. One turbine (nearshore) with a capacity of 5 MW was dismantled in 2016.

Table 1: Offshore Wind Energy Development, as of 2016-12-31

	Status of Offshore Wind Energy Development	Capacity [MW]	Number of OWT
Additions 2016	OWT's (feeding in)	818.0	156
	Capacity Modifications of existing OWT's	1.1	6
	Installed OWT's (no feed-in)	122.7	21
	Foundations w/o OWT		194
	Dismantling of OWT's	5.0	1
Cumulative (2016-12-31)	OWT's (feeding in)	4 108.3	947
	Installed OWT's (no feed-in)	122.7	21
	Foundations w/o OWT		198

Additions decreased by 64% compared to the previous year. This comes as a result of comparatively high offshore developments being recorded due to grid-dependent catch-up effects in 2015. Compared to 2014, however, a development increase of 66% was recorded. The development of grid-connected OWTs (in MW) over time is illustrated in Figure 1. The cumulative capacity of all 947 OWT's, which have executed their initial feed-in into the grid, amounts to 4 108.3 MW as of 31 December 2016. This is equivalent to an increase of 25% compared to the cumulative capacity of the previous year.

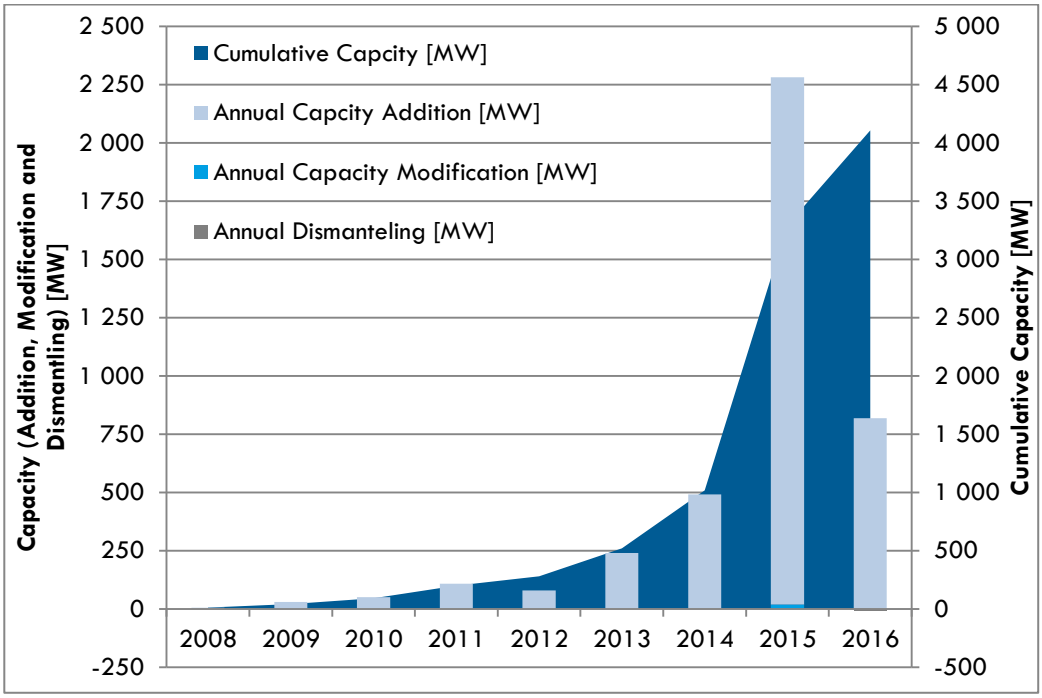

Figure 1: Development of Offshore Wind Energy in Germany (Capacity of OWT Feeding into the Grid) as of 2016-12-31

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

On behalf of: AGOW, BWE, Offshore Windenergie, wab, VDMA

INSTALLED TURBINES AND FOUNDATIONS

Between 1 January 2016 and 31 December 2016, OWT's with a total capacity of 694.7 MW were erected. 21 of these OWT's with a capacity of 122.7 MW did not start feeding into the grid over the course of the year. Turbines that started feeding into the grid during 2016 were evaluated as turbines with grid feed-in, regardless of whether the grid connection was functional by the deadline.
Furthermore, within 2016 a total of 212 foundations were installed. 194 of these foundations had not received OWTs. In addition to the foundations installed in 2015 that had not received OWT's, at the end of 2016 there were 198 foundations ready to be equipped with an OWT.

TYPES OF FOUNDATIONS

Across 2016, a total of 212 foundation structures (partially without their associated OWT) were installed in German offshore wind projects (OWP). Only monopiles and jackets were erected during that year. Monopiles clearly dominate with a share of 68% or a count of 145, respectively. 67 Jackets cover the remaining 32% of the foundation additions of 2016.
With regard to the total number of 1 166 installed foundations at the end of 2016, 796 monopiles equating to 68% of the total are the primary foundation structure used in Germany. 14% are jacket foundations and 11% are tripods. Tripiles are used as foundation structures for OWT's in 7% of installations. Other foundation types had not been installed in relevant numbers by the end of 2016. Figure 2 shows the distribution of foundation types installed annually since 2012.

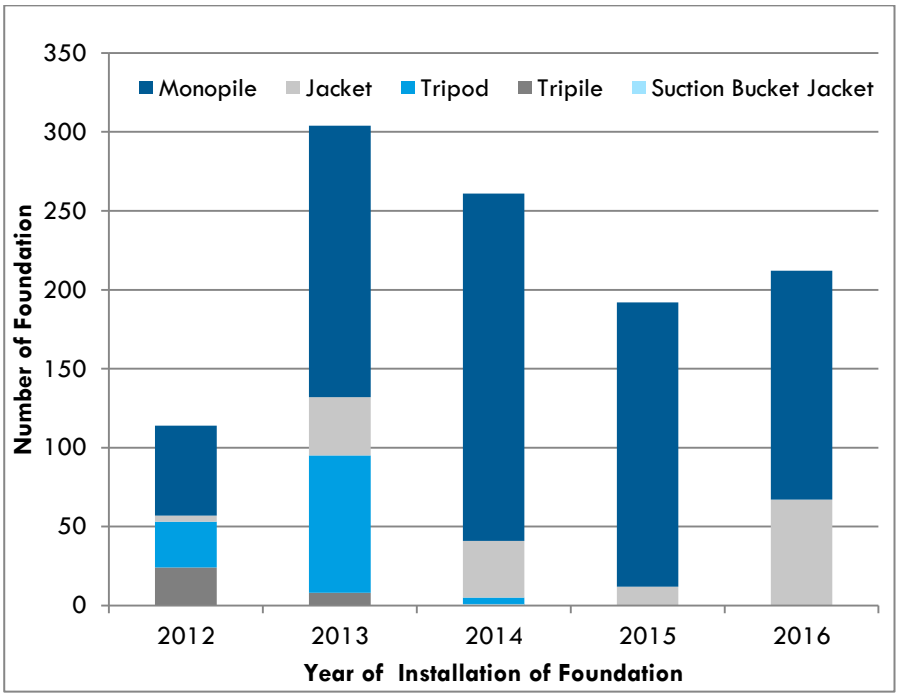

Figure 2: Development of Installed Types of Foundations

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

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DISTRIBUTION ACROSS THE NORTH AND BALTIC SEA

The distribution of installation and commissioning activities among the North and Baltic Seas in the year 2016, as well as the distribution of the cumulative development is shown in Table 2. 156 OWT's in the North Sea with an installed capacity of 818 MW started feeding into the grid during the course of the year. Hence, as of 31 December 2016, there are 845 OWT's with a total capacity of 3 769.5 MW in operation in the North Sea. The number of OWT's in the Baltic Sea remains unchanged compared to the previous year at 102 OWT's with a capacity of 338.8 MW. This is equivalent to a share of about 92% in the North Sea and 8% in the Baltic Sea. Furthermore, at the end of 2016 in the North Sea 21 OWT's with a capacity of 122.7 MW and 131 foundations had been erected and prepared for further activities. At the end of 2016, 67 foundations had been prepared in the Baltic Sea.

Table 2: Distribution Across the North and Baltic Sea as of 2016-12-31

Regional Distribution		North Sea		Baltic Sea	
		Capacity [MW]	Number of OWT	Capacity [MW]	Number of OWT
Additions 2016	OWT's (feeding in)	818.0	156	0.0	0
	Capacity Modifications of existing OWT's	1.1	6	0.0	0
	Installed OWT's (no feed-in)	122.7	21	0.0	0
	Foundations w/o OWT		127		67
	Dismantling of OWT's	5.0	1	0.0	0
Cumulative (2016-12-31)	OWT's (feeding in)	3 769.5	845	338.8	102
	Installed OWT's (no feed-in)	122.7	21	0.0	0
	Foundations w/o OWT		131		67

DISTRIBUTION ACROSS THE GERMAN STATES

The individual offshore wind projects can be associated with federal states based on the connection to the grid they feed into. The development over time of the distribution of the OWT's feeding into a grid across the federal states is shown in Figure 3. Lower Saxony is the first state where an OWT was connected to the grid. From 2009 until the end of 2016, the connected capacity increased steadily to 2 071.9 MW. The development of OWT's with connection in Schleswig-Holstein is relevant since 2014 and encompassed 1 697.6 MW at the end of 2016. The capacity connected in Mecklenburg-Western Pomerania totaled 338.8 MW at the end of the year. Here, the development occurred in 2011 and 2015. At the end of the year 2016, thus nearly 51% of the offshore capacity is connected in Lower Saxony, 41% in Schleswig-Holstein and 8% in Mecklenburg-Western Pomerania.

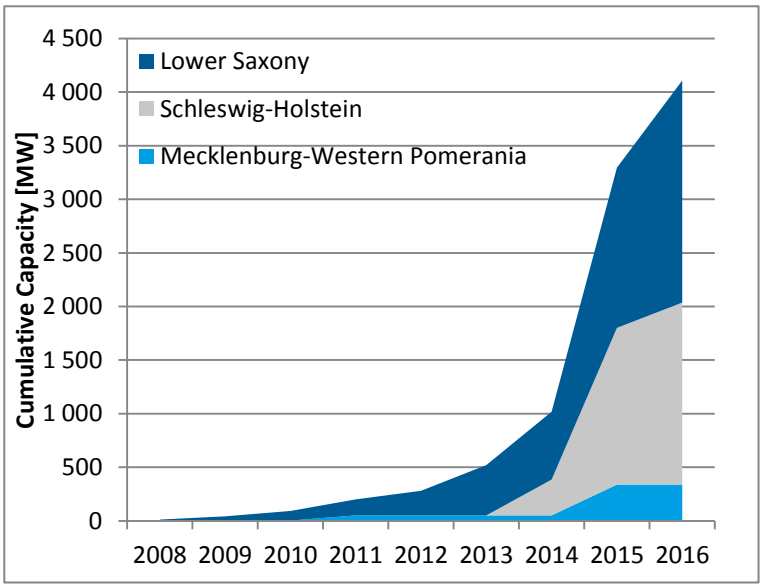

Figure 3: Distribution of Cumulative Capacity of OWT's Across the German States

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

On behalf of: AGOW, BWE, Offshore Windenergie, wab, VDMA

TURBINE CONFIGURATION

The average configuration of an OWT that fed into the grid for the first time in 2016, as well as the cumulative portfolio is shown in Table 3. The capacity, hub height and rotor diameter of OWT's feeding into a grid for the first time increased considerably compared to the previous year. Thus, those OWT's that started feeding into the grid for the first time in 2016 have an average installed cumulative capacity of 5 244 kW, which is equivalent to an increase of 27% compared to the previous year. The average rotor diameter increased by 21% to 145 meters. Correspondingly, the average hub height increased by 18% to 104 meters at the end of 2016. At 314 W/m² on average, the specific power, which describes the relation between the nominal capacity to the area swept by the rotor, was 15% lower than that of the previous year.

On average across all OWT's feeding into the grid in Germany, the installed cumulative capacity at the end of 2016 was 4 318 kW, the rotor diameter was 123 meters, the hub height was 91 meters and the specific power was 362 W/m².

Table 3: Average turbine configuration of OWT (feeding in) as of 2016-12-31

	Additions 2016	Cumulative (2016-12-31)
Average Nameplate Capacity [kW]	5 244 kW	4 318 kW
Average Rotor Diameter [m]	145 m	123 m
Average Hub Height [m]	104 m	91 m
Specific Power [W/m²]	314 W/m²	362 W/m²

WATER DEPTH AND DISTANCE TO SHORE

The average water depth in which OWT's were erected that fed into the grid for the first time in 2016 was 30 meters. This equates to an increase of 12% over the average of the previous year. The average distance from shore of the new turbines feeding into the grid was 68 km. These turbines are thus 13% further away from shore than those that were first connected to the grid in 2015.

The average distance to the shore of all OWT's feeding into the grid in Germany is 62 km. The average water depth these OWT's are installed in is 28 meters.

Figure 4 shows the water depth and distance to the shore of portfolio projects, projects implemented in 2016, projects currently being implemented and projects with approved financing.

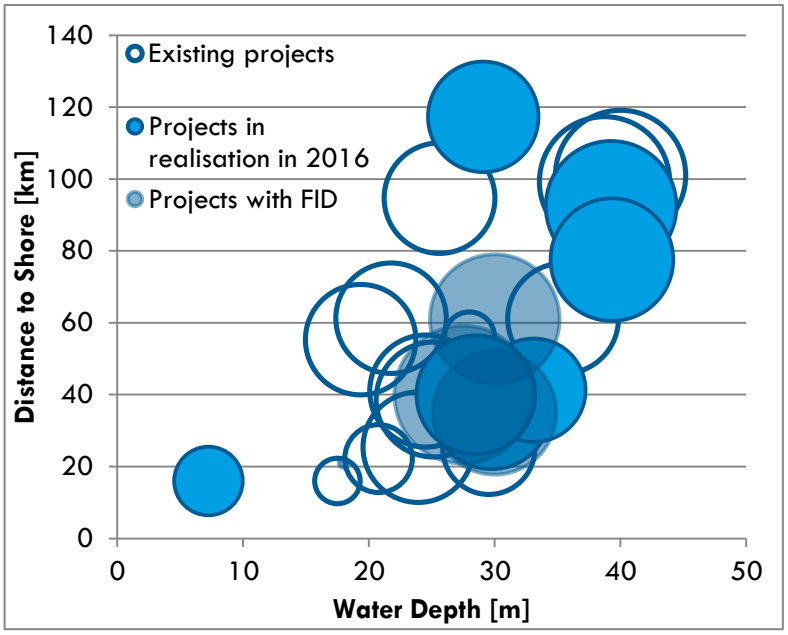

Figure 4: Water Depth and Distance to Shore

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

OFFSHORE-WIND PROJECTS – ACTIVITIES IN 2016

All OWT's within the Gode Wind 1 and Gode Wind 2 projects started feeding into the grid for the first time in 2016. Hence, as of 31 December 2016, there is a total of 15 OWP's and two single near-shore turbines in operation. Another project achieved its initial feed-in of an individual OWT with the OWP Sandbank, but it is currently not fully connected to the grid. In addition to futher commissionings, at the close of 2016 there are still turbine erections pending in OWP Sandbank. The installation of turbines in the Nordergründe OWP was completed in 2016. As of the end of 2016, the project awaits the completion of the offshore substation. The foundation installation of the Nordsee One and Veja Mate projects were completed by 31 December 2016. The final foundation installations are still ongoing in the OWP Wikinger.

The installation of foundations for the OWP Arkona Becken Südost and Merkur Offshore has not yet commenced, but the investment decision has been made and construction preparations on the sea floor are under way. Start of construction of these projects is expected to occur in 2017. A final investment decision for OWP Borkum Riffgrund 2 and for a single turbine (Gicon SOF), respectively, exists. A graphical overview of the status and the geographical location of the various OWP in Germany are provided in Figure 5.

At the close of 2016, four additional projects not included in the figure have grid connection confirmation. These projects are OWP Albatros, Trianel Windpark Borkum (Phase II), Deutsche Bucht and EnBW Hohe See.

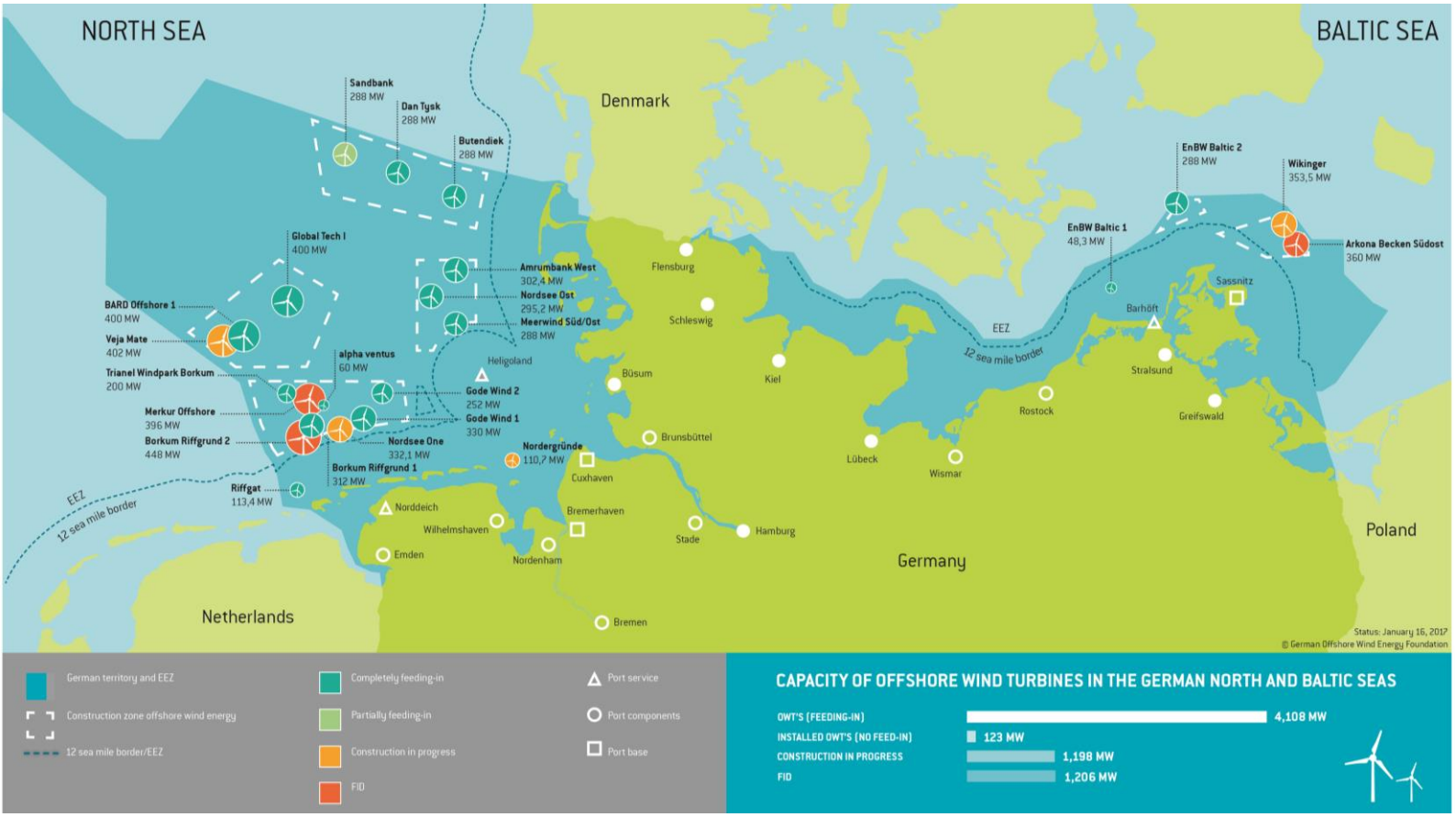

Figure 5: Completely / Partially Feeding-In OWP, OWP under Construction and OWP with Final Investment Decision made as of 2016-12-31

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

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POLTICAL DEVELOPMENT TARGET AND ASSIGNED GRID CONNECTION CAPACITY

The objective of the German government is the implementation of 6.5 GW of offshore wind energy capacity by 2020. The by the end of 2017 maximum legally assigned grid connection capacity is 7.7 GW for projects that can be implemented by 2020. Shown in Figure 6 are those shares of this capacity that by the end of 2016 had reached a high level of certainty.

Aside from the 4.1 GW already feeding into the grid and the additionally erected 0.1 GW, under construction are OWT's with a capacity of about 1.1 GW. Additionally, the final investment decision has been made for another roughly 1.2 GW. In total, about 85% of the capacity assigned for grid connection capacity is in actual implementation. Grid connection capacities totaling about 1.1 GW were assigned to other projects that can now be financed and implemented. Moreover, by 31 October 2016 an application for the assignment of grid connection capacity for pilot wind turbine generators of up to 50 MW could be submitted.

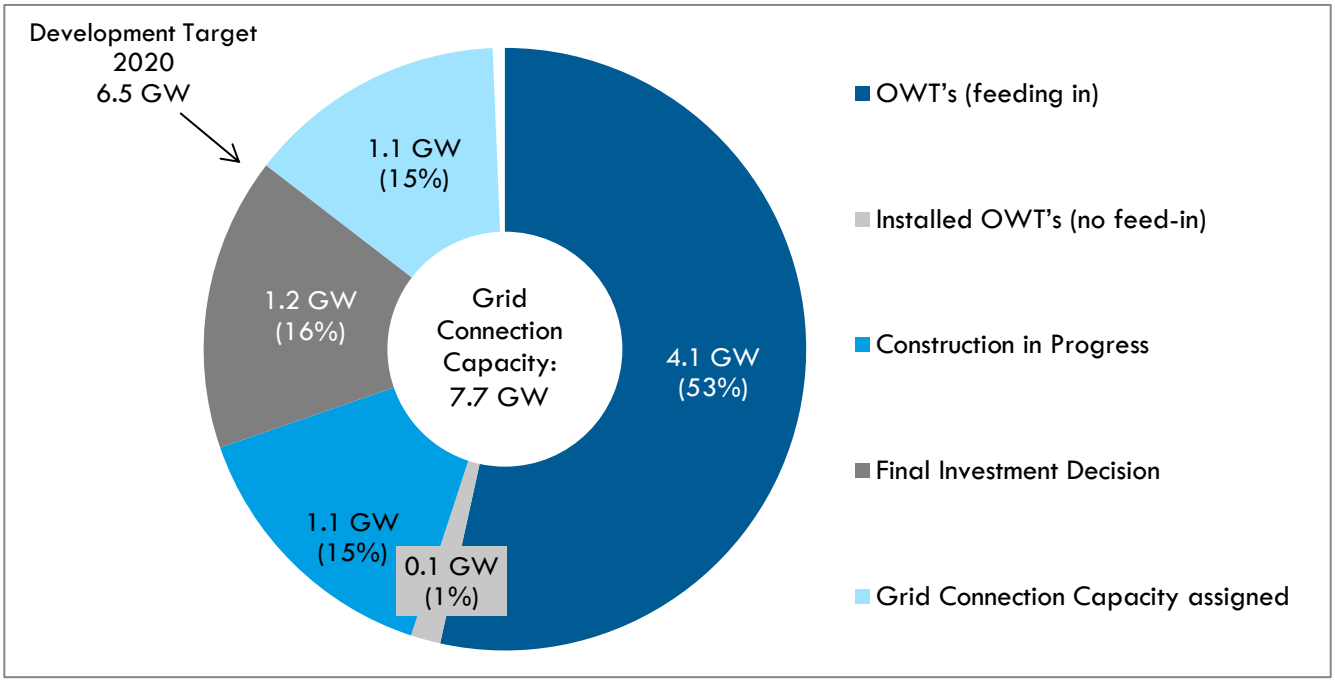

Figure 6: Offshore Capacity with High Degree of Certainty and its Share of the Assigned Grid Connection Capacity as of 2016-12-31

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

TENDER DATES, TENDER CAPACITIES AND INTENDED DEVELOPMENT OF ADDITIONS

Projects that did not secure a grid connection confirmation have to participate in tender proceedings to obtain a confirmation. Table 4 lists the planned tender release dates and tender capacities until the year 2025. In the tendering rounds 2017 and 2018 overall no less than 500 MW must be awarded in the Baltic Sea. From 2021 on, 700 to 900 MW are to be put to tender for commissioning in the years of 2026-2030 to reach the German government's development target of 15 GW in the year 2030. The projects that won the individual tenders are to be commissioned consecutively starting in 2021. Analogous to the grid expansion, projects in the Baltic Sea are to be commissioned first. Figure 7 shows the development of additions as intended from 2021 until 2030. The actual development additions progress is also influenced by the individual awarded projects and the commissioning dates of the relative individual grid connection systems.

Table 4: Tender Dates and Tender Capacities for Offshore Wind Energy

Tender Date	Tender Capacity		Intended Year of Commissioning
01.04.2017	1 550 MW	thereof min. 500 MW in the Baltic Sea	2021 - 2025
01.04.2018	1 550 MW		
01.09.2021	700 - 900 MW		2026
01.09.2022	700 - 900 MW		2027
01.09.2023	700 - 900 MW		2028
01.09.2024	700 - 900 MW		2029
01.09.2025	700 - 900 MW		2030

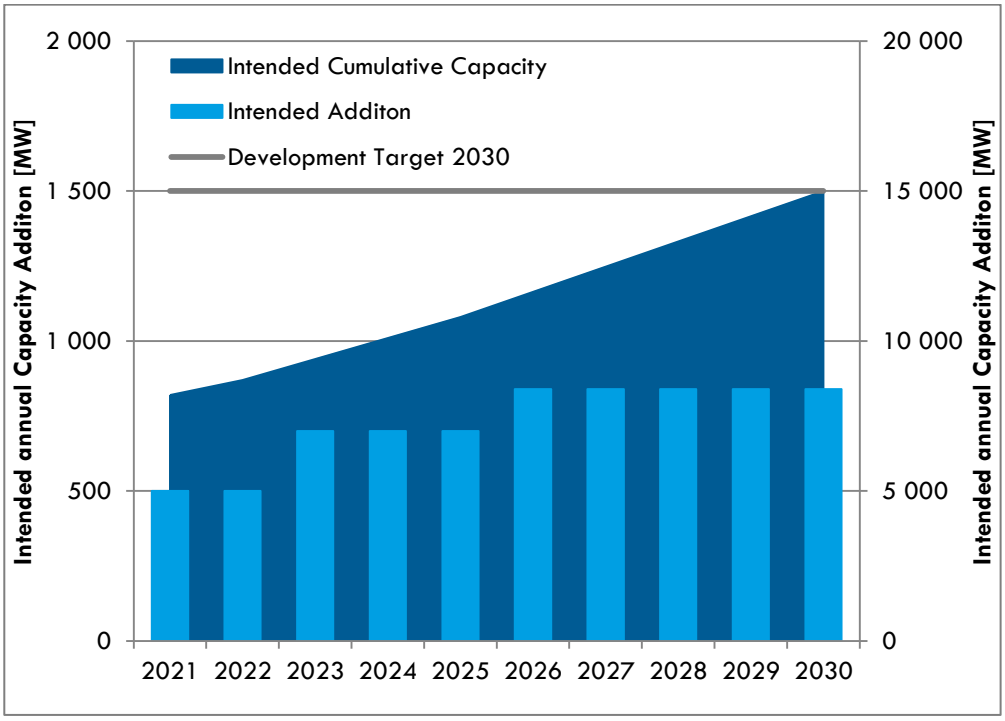

Figure 7: Intended Development and Achievement of Development Targets as of 2021

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

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APPROVED AND DISCUSSED PROJECTS IN ZONE 1 AND 2

From 2017 to 2018 tenders will be released for grid connection capacities for existing offshore wind energy projects that are scheduled to come online between 2021 and 2025. Allowed to participate in these tenders are only projects that have been approved or discussed before 1 August 2016 and that are located in the coastal waters or in the clusters of Zone 1 and 2. The projects that are either approved by or have been discussed with the German Federal Maritime and Hydrographic Agency (German: BSH) are listed in Table 5. Ten projects in the North Sea have been approved in the respective zones and an additional five have been discussed. In the Baltic Sea one project has been approved and seven others have already been discussed.

Table 5: Approved and Discussed Projects in the North and Baltic Sea [Source: BSH]

Project	Project Sponsors	Zone	Cluster	Date Approval	Date Discussion
North Sea					
Borkum Riffgrund West I	DONG Energy Borkum Riffgrund West I GmbH	1	1	25.02.2004	
OWP Delta Nordsee 1	OWP Delta Nordsee GmbH	1	3	11.02.2005	
Nördlicher Grund (64 WEA)	Nördlicher Grund GmbH	2	5	01.12.2005	
Nördlicher Grund_Teil Sandbank	Vattenfall Europe Windkraft GmbH	2	5	01.12.2005	
EnBW He Dreiht	EnBW He Dreiht GmbH	2	7	20.12.2007	
OWP Delta Nordsee 2	OWP Delta Nordsee GmbH	1	3	31.08.2009	
Gode Wind 04	Gode Wind 04 GmbH	1	3	31.07.2013	
Nordsee Two	Nordsee Two GmbH	1	3	26.08.2013	
Nordsee Three	Nordsee Three GmbH	1	3	26.08.2013	
OWP West	Northern Energy OWP West GmbH	1	1	15.04.2014	
Borkum Riffgrund West II	DONG Energy Borkum Riffgrund West II GmbH	1	1		19.03.2013
Global Tech II	Vattenfall Global Tech II Offshore Wind GmbH	2	7		05.06.2014
Gode Wind III	PNE Gode Wind III GmbH	1	3		19.09.2014
KASKASI II	innogy Kaskasi GmbH	1	4		08.10.2014
Atlantis I	PNE WIND Atlantis I GmbH (veräussert an Vattenfall, Januar 2017)	2	6		06.11.2014
Baltic Sea					
ARCADIS OST 1	KNK Wind GmbH	1	4	09.09.2014	
Adlergrund 500	Adlergrund 500 GmbH	1	1		05.11.2012
Adlergrund GAP	BEC Energie Consult GmbH	1	1		05.11.2012
Wikinger Nord	Iberdrola Renovables Offshore Deutschland GmbH	1	1		14.12.2012
Wikinger Süd	Iberdrola Renovables Offshore Deutschland GmbH	1	1		14.12.2012
Baltic Eagle	Baltic Eagle GmbH	1	2		15.05.2013
Ostseeschatz	Financial Insurance GmbH	1	2		15.05.2013
Windanker	Iberdrola Renovables Deutschland GmbH	1	1		27.07.2016

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

OVERVIEW OF PROVISION OF ADDITIONAL GRID CONNECTION CAPACITY

Table 6 lists the current status of the grid connections that are planned, under construction or operational in the North and Baltic Sea. At the end of 2016, a grid capacity of roughly 4.7 GW for OWP is available in German coastal waters and in the exclusive economic zone (German: AWZ), an additional 3.6 GW are either under construction or are in construction preparations.

Further grid connection systems with total transmission capacities of about 4.4 GW and anticipated commissionings between 2021 and 2025 are provided for in the Offshore Grid Development Plan 2025 (German: O-NEP 2025) and confirmed by the Federal Grid Agency (German: BNetzA) on 25 November 2016. 3.6 GW will be located in the North Sea and 0.8 GW in the Baltic Sea. By 2030, the available grid connection capacity is expected to be increased to nearly 15.8 GW, which will make the development objective of 15 GW achievable. By 2035, according to the O-NEP 2025, an additional 3.6 GW of grid connection capacity can be added.

Table 6: Installed and Planned Grid Connections in the North and Baltic Sea [Source: O-NEP 2025, Confirmation of O-NEP 2025, Additional Research]

Number	Name	Status	Planned Commissioning Year	Capacity [MW]
North Sea				
Nearshore Emden		Operating	2004	4.5
NOR-2-1	Alpha Ventus	Operating	2009	62
NOR-6-1	BorWin1	Operating	2010	400
NOR-0-1	Riffgat	Operating	2014	113
NOR-2-2	DolWin1	Operating	2015	800
NOR-4-1	HelWin1	Operating	2015	576
NOR-4-2	HelWin2	Operating	2015	690
NOR-5-1	SylWin1	Operating	2015	864
NOR-6-2	BorWin2	Operating	2015	800
NOR-0-2	Nordergründe	Under Construction/Construction Preparation	2016	111
NOR-3-1	DolWin2	Under Construction/Construction Preparation	2016	916
NOR-2-3	DolWin3	Under Construction/Construction Preparation	2017	900
NOR-8-1	BorWin3	Under Construction/Construction Preparation	2019	900
NOR-3-3	DolWin6	Approval Procedure in Progress	2023	900
NOR-1-1	DolWin5	Approval Procedure in Preparation	2024	900
NOR-5-2	SylWin2	Approval Procedure in Progress	2025	900
NOR-7-1	BorWin5	Approval Procedure in Preparation	2025	900
NOR-3-2	DolWin4	Planned	2028	900
NOR-6-3	BorWin4	Planned	2029	900
NOR-7-2	BorWin6	Planned	2030	900
NOR-13-1		Planned	2031	900
NOR-11-1		Planned	2032	900
NOR-12-1		Planned	2034	900
NOR-9-1		Planned	2035	900
Baltic Sea				
Nearshore Rostock		Operating	2006	2.5
OST-3-1	Baltic I	Operating	2011	51
OST-3-2	Baltic II	Operating	2015	288
OST-1-1	Westlich Adlergrund	Under Construction/Construction Preparation	2018	250
OST-1-2	Westlich Adlergrund	Under Construction/Construction Preparation	2019	250
OST-1-3	Westlich Adlergrund	Under Construction/Construction Preparation	2019	250
OST-2-1		Confirmed	2021	250
OST-2-2		Confirmed	2021	250
OST-2-3		Confirmed	2022	250
OST-B-2		Planned	2029	500

The data was obtained through a survey with industry representatives, as well as additional research (e.g. BNetzA, BSH, ONEP).

Data for the previous year was adjusted.

GEOGRAPHICAL LOCALIZATION OF FUTURE PROJECTS AND GRID CONNECTIONS

The geographic localization of future offshore wind energy projects and grid connection systems will occur according to Figure 8 (North Sea) and Figure 9 (Baltic Sea). Depicted are the currently approved and discussed OWP's that do not yet have grid connection confirmation, as well as grid connection systems that are to be implemented by 2030 according to the O-NEP 2025. In general, OWP's will be connected to grid connection systems in their respective clusters. Grid connections across clusters are possible as exceptions.

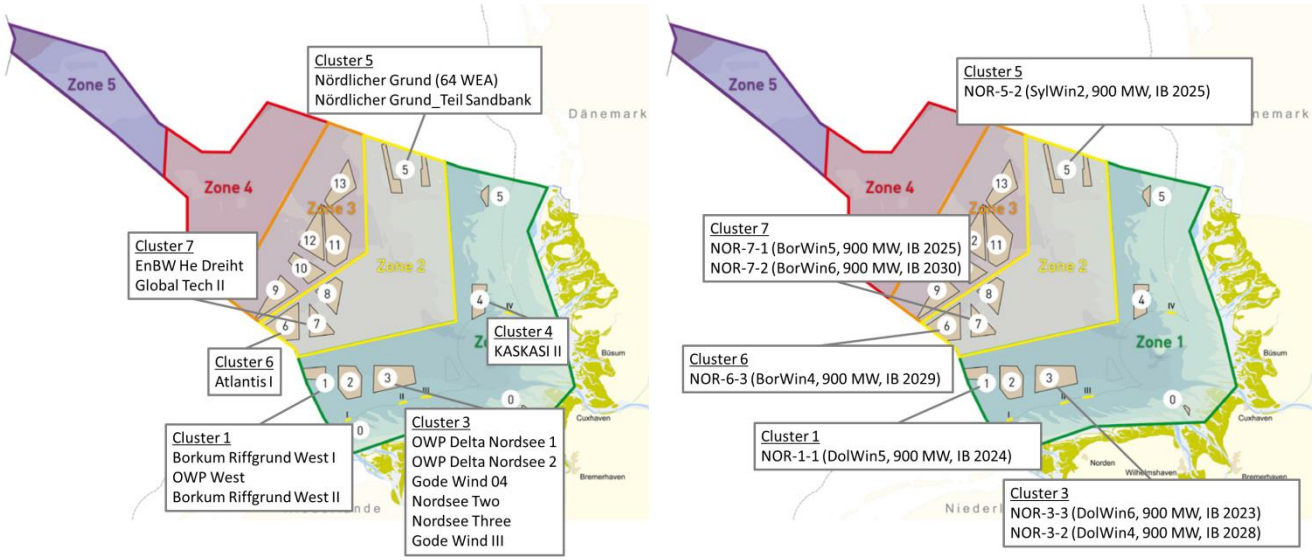

Figure 8: Geographical Localization of Approved and Discussed OWP without Confirmation of Grid Connection and Planned Grid Connections up to 2030 in the North Sea (base graphic: O-NEP 2025)

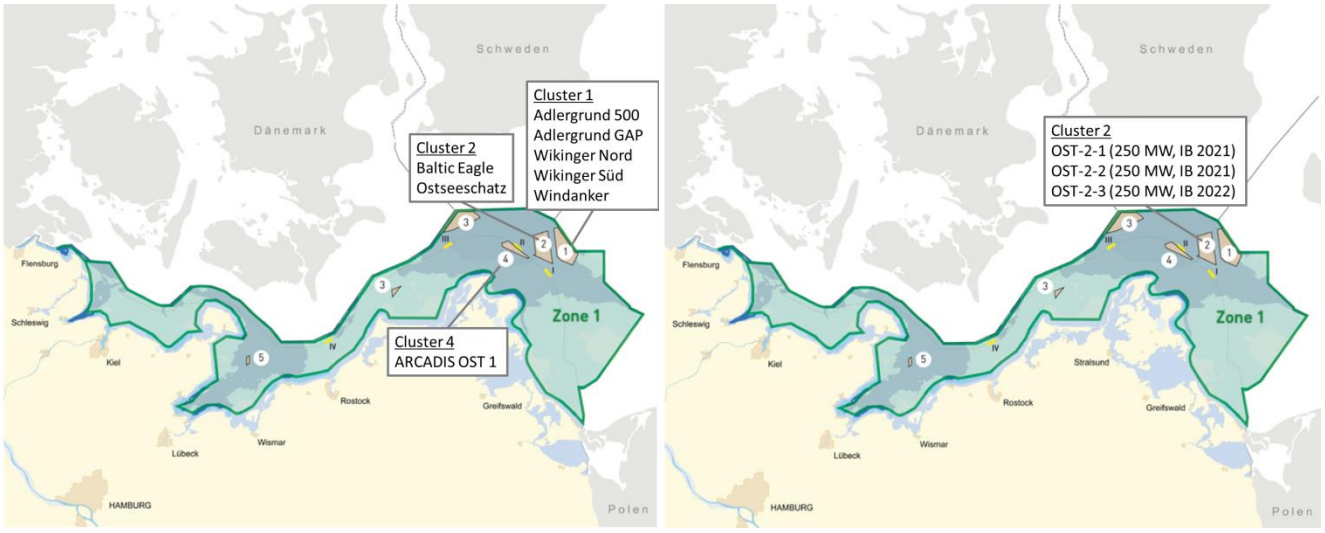

Figure 9: Geographical Localization of Approved and Discussed OWP without Confirmation of Grid Connection and Planned Grid Connections up to 2030 in the Baltic Sea (base graphic: O-NEP 2025))

Data Collection and Adaptation:
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