

Status of Offshore Wind Energy Development in Germany

Year 2023



On behalf of



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Notes

The data was obtained through surveys with industry representatives as well as through additional research. Retroactive adjustments to the data are done based on corrected notifications if required.

The installed capacity of offshore wind energy projects is not always equal to the assigned grid connection capacity.

Future offshore wind energy projects are assigned with their total capacity to the respective expected year of commissioning.

The information provided within the text and figures partially includes rounded values. Thus, when added, there is a possibility of deviations from the overall values.

Photo on Title Page

Monopile installation at Borkum Riffgrund 3

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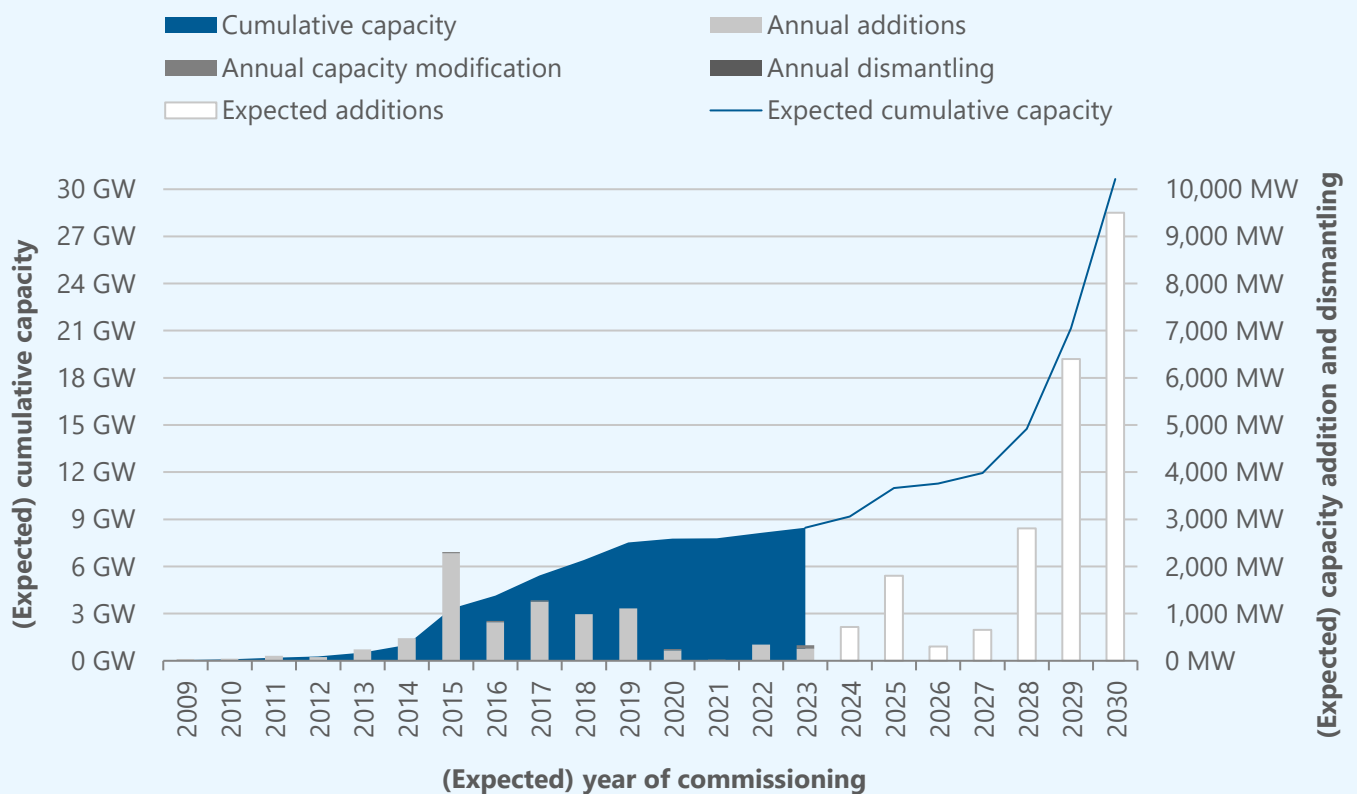
Offshore Wind Energy Development

As of December 31, 2023, 1,566 offshore wind turbines (OWT) with a total capacity of 8.5 GW were in operation in Germany. Of these, 27 turbines with a total capacity of 257 MW fed into the electricity grid for the first time in 2023. In addition, capacity modifications were implemented on 222 existing offshore wind turbines in the course of 2023. Furthermore, 74 new foundations were installed; the associated offshore wind turbines had not been erected by the end of 2023.

With the turbines commissioned in 2023, the implementation of the offshore wind energy projects (OWP) awarded in the transitional system (tender rounds in 2017/2018) is progressing. The implementation began in the previous year with the commissioning of the first of these projects. All projects from the transitional system are expected to be fully commissioned by the end of 2025.

Status of the offshore wind energy development

		Capacity	Number
Additions 2023	OWT (feeding in)	257 MW	27 OWT
	Capacity modifications of existing OWT	72 MW	222 OWT
	Installed OWT (no feed-in)	0 MW	0 OWT
	Foundations w/o OWT		74 Foundations
Cumulative 2023-12-31	OWT (feeding in)	8,465 MW	1,566 OWT
	Installed OWT (no feed-in)	0 MW	0 OWT
	Foundations w/o OWT		74 Foundations

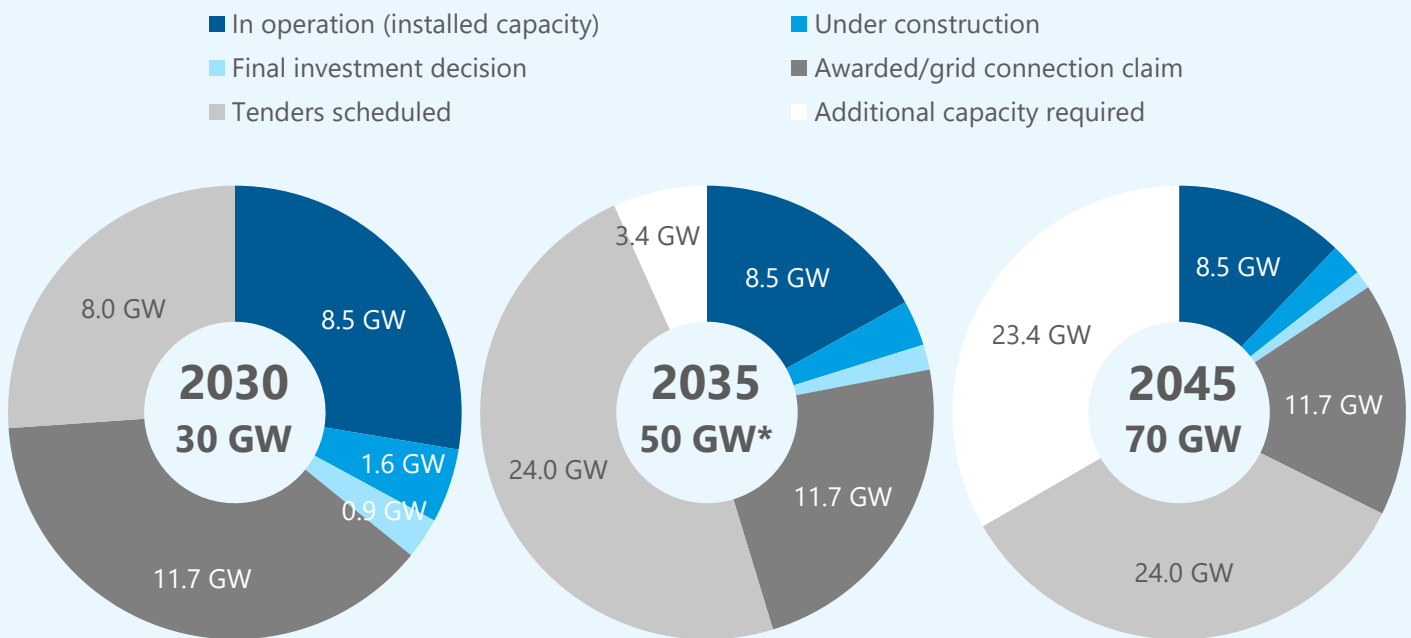


(Expected) development of the offshore wind energy capacity in Germany
(Database: own surveys, MaStR, FEP 2023)

Expansion Targets Offshore Wind Energy

The political expansion targets for offshore wind energy are defined in the German Offshore Wind Energy Act (German: Windenergie-auf-See-Gesetz or WindSeeG). It specifies that the installed capacity of offshore wind turbines connected to the grid is to be increased to at least 30 GW by 2030, to at least 40 GW by 2035 and to at least 70 GW by 2045. According to the current plan of the Federal Maritime and Hydrographic Agency (German: Bundesamt für Seeschifffahrt und Hydrographie or BSH), the legally specified minimum target of 40 GW by 2035 is set to be exceeded, with 50 GW to be installed by 2035. In order to achieve the expansion targets for offshore wind energy, the BSH is constantly designating new areas for future expansion in the Site Development Plan (German: Flächenentwicklungsplan or FEP). The FEP 2023 was published in January 2023. Its update was initiated in

September 2023 with the publication of the preliminary draft. According to the FEP 2023, additional sites with an installed capacity of 8 GW are to be tendered and put into operation by 2030. Together with the projects that were in operation, under construction and in preparation (projects with a final investment decision and with an award/grid connection claim) at the end of 2023, the legal expansion target of 30 GW by 2030 can therefore be achieved. In addition, the plans of the FEP 2023 and the preliminary draft envisage further new sites with a total of 16 GW, which are to be commissioned in the period from 2031 to 2035. In order to achieve an installed capacity of 50 GW in 2035, additional sites need to be designated accordingly. To achieve the long-term expansion target of 70 GW by 2045, further large areas will be required.



* According to the WindSeeG, the installed capacity is to be increased to at least 40 GW by 2035. The current plan is to exceed the legally defined expansion target and to install 50 GW by 2035.

Development status of offshore wind energy capacity with expansion targets by 2030, 2035 and 2045 (Database: own surveys, MaStR, WindSeeG 2023, FEP 2023, preliminary draft update FEP 2023)

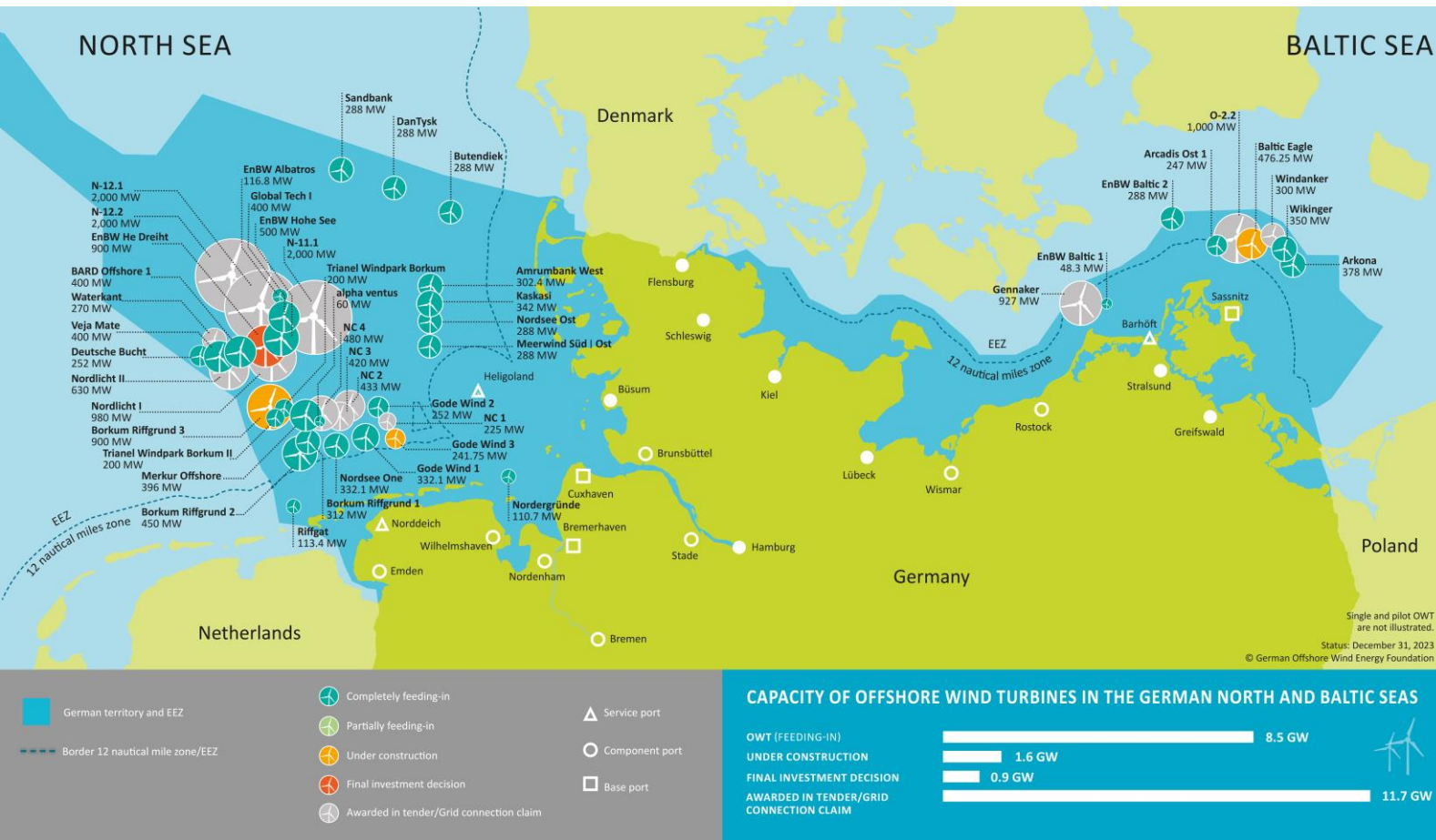
Activities in Offshore Wind Energy Projects

By the end of 2023, 29 offshore wind energy projects in Germany were fully operational. Construction work on the Arcadis Ost 1 project was finished in the second half of the year and the entire project was successfully completed in November 2023. In the Baltic Eagle project, the installation of the foundations began in the first half of 2023 and was completed by the end of the year. In the Gode Wind 3 and Borkum Riffgrund 3 projects, foundation installation started in the second half of 2023. The erection of the wind turbines in all three projects is scheduled for 2024. In the OWP EnBW He Dreih, the final investment decision was made in spring 2023 and construction is expected to start at the beginning of 2024. Other projects have been awarded or have a claim for grid connection and are still in the early stages of project planning.

Overview of future offshore wind energy projects

OWP	Status	Expected commissioning	Expected capacity*
Baltic Eagle	Under construction	2024	476 MW
Gode Wind 3	Under construction	2024	242 MW
Borkum Riffgrund 3	Under construction	2025	900 MW
EnBW He Dreih	FID	2025	900 MW
Windanker	Awarded	2026	300 MW
NC 1 (N-3.7)	Awarded	2027	225 MW
NC 2 (N-3.8)	Awarded	2027	433 MW
Nordlicht I	Awarded	2028	980 MW
Nordlicht II (N-6.6)	Awarded	2028	630 MW
Gennaker	Grid connection claim	2028	927 MW
Waterkant (N-6.7)	Awarded	2028	270 MW
NC 3 (N-3.5)	Awarded	2029	420 MW
NC 4 (N-3.6)	Awarded	2029	480 MW
N-11.1	Awarded	2030	2,000 MW
N-12.1	Awarded	2030	2,000 MW
N-12.2	Awarded	2030	2,000 MW
O-2.2	Awarded	2030	1,000 MW

* grid connection capacity



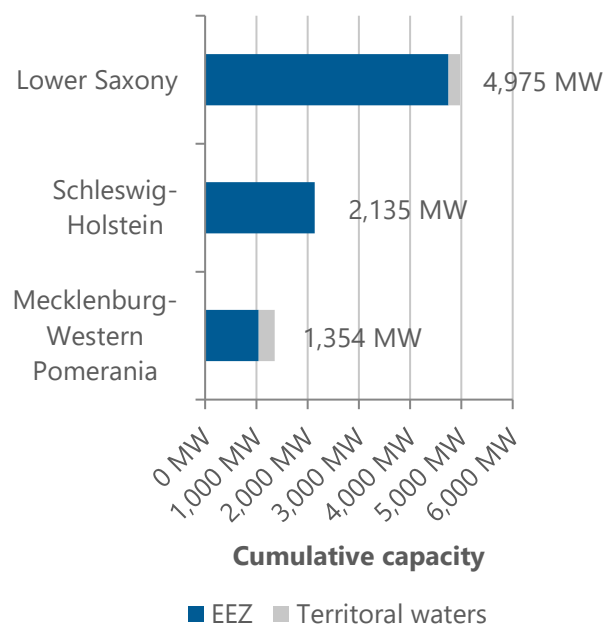
Overview map of offshore wind energy in Germany (© German Offshore Wind Energy Foundation)

Distribution across Federal States and North and Baltic Sea

At the end of 2023, the installed capacity of German offshore wind turbines feeding into the grid is mainly located in the North Sea (7.1 GW). The Baltic Sea accounts for significantly less capacity (1.4 GW). Although commissioning activities in 2023 took place exclusively in the Baltic Sea, the future expansion of offshore wind energy will focus much stronger on the North Sea. In both the North Sea and the Baltic Sea, offshore wind turbines are predominantly installed in the Exclusive Economic Zone (EEZ; German: Ausschließliche Wirtschaftszone or AWZ) (8 GW). Significantly fewer turbines are installed in the territorial waters (0.5 GW).

Based on the location of the respective grid connection point, the capacity installed at sea can be allocated to the federal states. The installed capacity in the North Sea is divided between Lower Saxony (5 GW) and Schleswig-Holstein (2.1 GW). The installed capacity of 1.4 GW in the

Baltic Sea is entirely attributable to Mecklenburg-Western Pomerania.



Distribution of cumulative capacity of OWT (feeding in) across the federal states and maritime areas

Distribution across the North and Baltic Sea

		North Sea		Baltic Sea	
		Capacity	Number	Capacity	Number
Additions 2023	OWT (feeding in)	0 MW	0 OWT	257 MW	27 OWT
	Capacity modifications of existing OWT	70 MW	212 OWT	2 MW	10 OWT
	Installed OWT (no feed-in)	0 MW	0 OWT	0 MW	0 OWT
	Foundations w/o OWT		24 Foundations		50 Foundations
Cumulative 2023-12-31	OWT (feeding in)	7,110 MW	1,307 OWT	1,354 MW	259 OWT
	Installed OWT (no feed-in)	0 MW	0 OWT	0 MW	0 OWT
	Foundations w/o OWT		24 Foundations		50 Foundations

Turbine Configuration

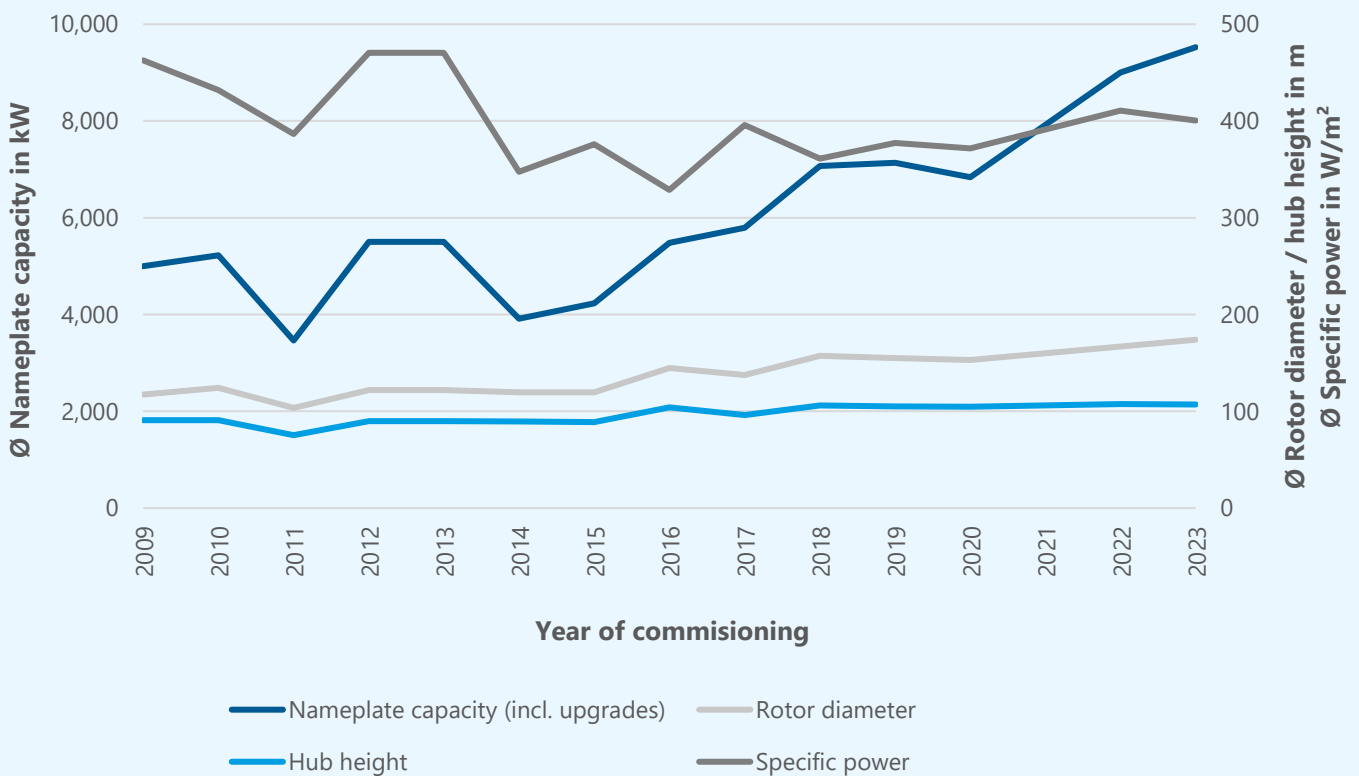
At 9.5 MW each, the turbines commissioned in 2023 are the most powerful offshore wind turbines in Germany to date. For the entire portfolio of all turbines in operation at the end of 2023, the average capacity rose to 5.4 MW. Many of the offshore wind turbines in operation have undergone additional capacity increases during their operating period; these are not structural changes to the turbine, but rather so-called software upgrades.

The installation of turbine types with 9.5 MW and 11 MW is planned for 2024. In 2025, a 15 MW offshore wind turbine is to be commissioned in Germany for the first time. Current plans for future projects up to 2025 also envisage significant increases in rotor diameter and hub height compared to existing turbines in 2023. Depending on the project, rotor diameters of between 174 m

and 236 m and hub heights of between 107 m and 145 m are planned.

Average offshore wind turbine configuration

Average Configuration	Cumulative 2023-12-31	Additions 2023
Nameplate capacity (incl. upgrades)	5,405 kW	9,525 kW
Rotor diameter	134 m	174 m
Hub height	95 m	107 m
Specific power	377 W/m ²	401 W/m ²



Turbine configuration over course of time

Water Depth and Distance to Shore

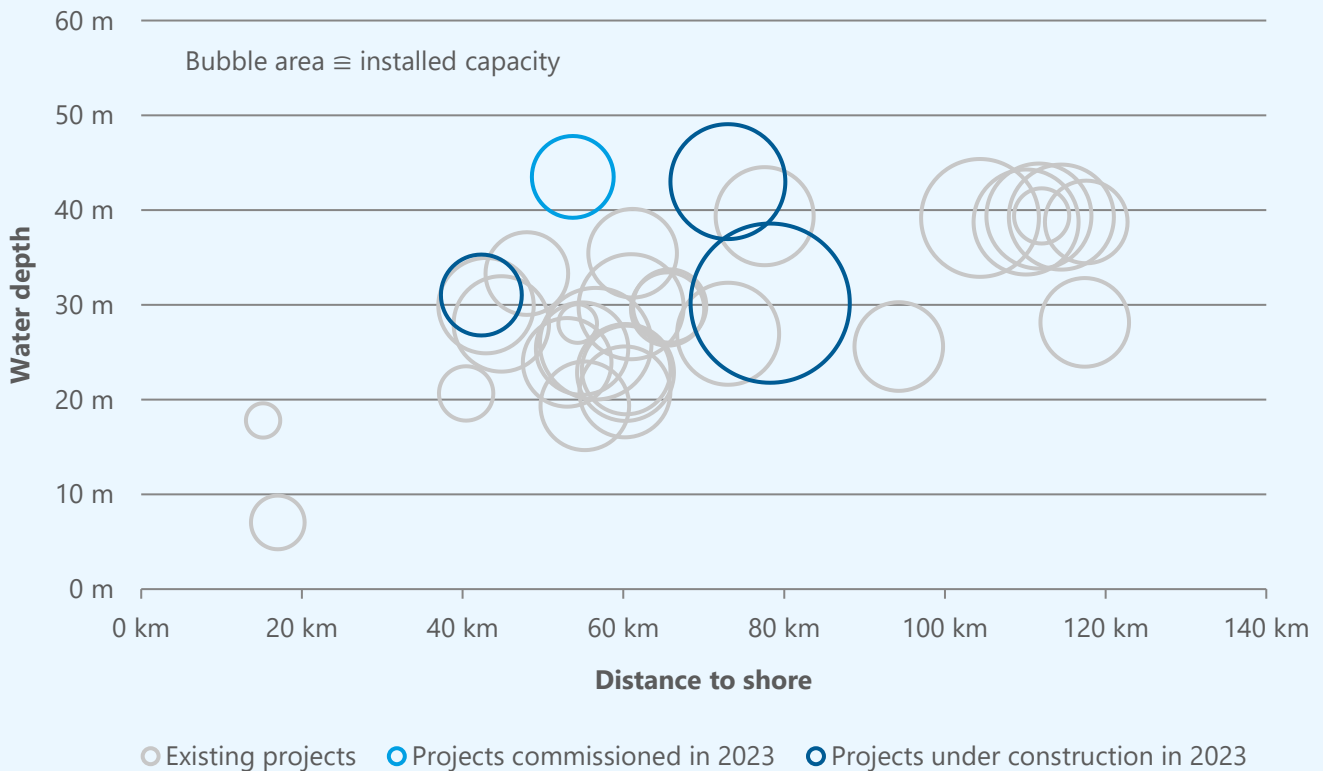
The majority of offshore wind energy projects off the German coast are located at least 40 km from the shore in water depths of 20 m or more. Only a few projects are located in shallow waters close to the coast. Some of the projects are installed at locations over 120 km from shore and in water depths of up to 44 m. On average, the existing projects have a water depth of approx. 30 m and a distance from the shore of approx. 75 km.

The project with commissioning in 2023 was installed on a site with comparatively large water depths. The three projects in the North Sea under construction in the course of 2023 also have a greater water depth than the average existing project but are located slightly closer to the coast. The future projects are being planned in areas that are increasingly further away from the shore. In terms of foundation type, the monopile foundation has established as the most commonly

used type in Germany. All foundations installed in 2023 were monopiles and also future offshore wind energy projects have already announced the installation of monopile foundations. The dimensions of monopile foundations are increasing in parallel with the growing dimensions of wind turbines.

Average water depth and distance to shore

Average location	Existing projects	Projects with commissioning in 2023	Projects under construction in 2023
Water depth	30 m	44 m	34 m
Distance to shore	75 km	54 km	71 km



Water depth and distance to shore of existing projects, projects commissioned in 2023 and projects under construction in 2023

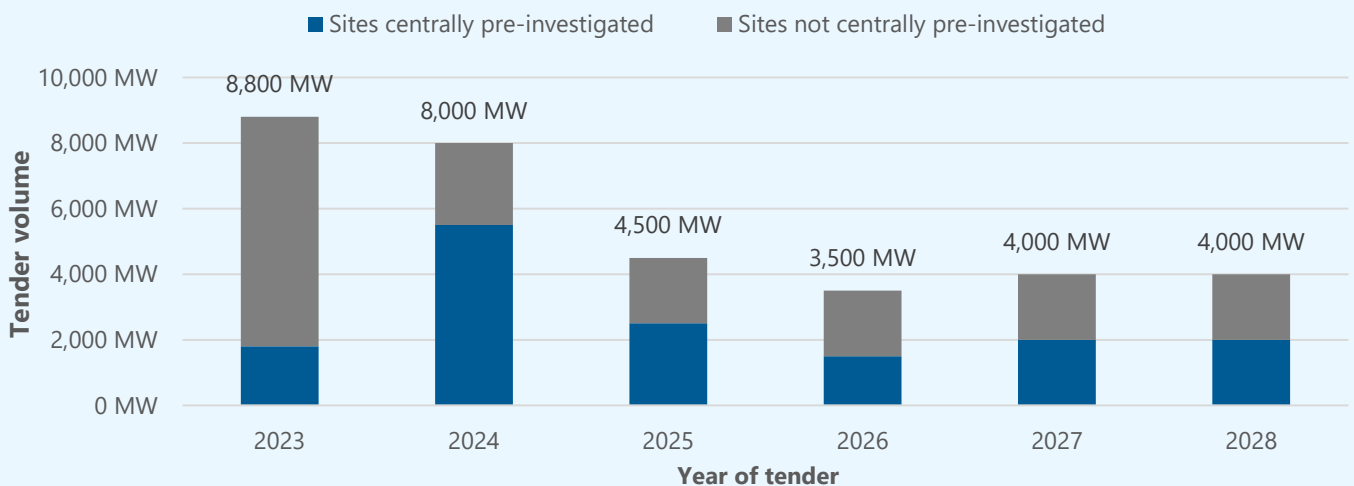
Tenders for Offshore Wind Energy

The amendment to the WindSeeG, which came into force at the beginning of 2023, introduces a modified tender system for tender rounds from 2023 onwards. In addition to the sites centrally pre-investigated by the BSH, sites that have not been centrally pre-investigated will be tendered. The award procedure differs depending on status (centrally pre-investigated or not centrally pre-investigated) of the site.

In June 2023, the first tender round with a total tender volume of 7 GW was held for not centrally pre-investigated sites. Four sites (N-11.1, N-12.1, N-12.2, O-2.2) were awarded. For all sites several bidders submitted 0-cent bids, meaning that the dynamic bidding procedure had to be carried out for the first time. The bidders with the highest willingness to pay were awarded. The awards for the site N-11.1 and N-12.2 were won by BP.

Total Energies won the awards for sites N-12.1 and O-2.2. The total payments offered by the two winning bidders amount to approx. 12.6 billion euros.

In August 2023, the tender round for four centrally pre-investigated sites (N-3.5, N-3.6, N-6.6, N-6.7) with a total volume of 1.8 GW took place. The centrally pre-investigated sites are being awarded on the basis of various criteria. These include financial (bid for a payment) and non-financial criteria (e.g. contribution to decarbonisation and securing qualified employees). RWE was awarded for the sites N-3.5 and N-3.6 (NC 3 and NC 4). RWE was also awarded for the site N-6.6 (Nordlicht II), but Vattenfall exercised its right of entry. Luxcara secured the award for site N-6.7 (Waterkant). The total payments from this tender round amount to 784 million euros.



Site name (planned commissioning and capacity)	Not centrally pre-investigated (■)					
	2023	2023	2023	2023	2024	2025
	N-11.1 (2030, 2,000 MW)	N-11.2 (2031, 1,500 MW)	N-9.4 (2032, 2,000 MW)	N-12.4 (2033, 2,000 MW)	N-12.5 (2034, 2,000 MW)	N-9.5 (2035, 2,000 MW)
	N-12.1 (2030, 2,000 MW)	N-12.3 (2031, 1,000 MW)				
	N-12.2 (2030, 2,000 MW)					
	O-2.2 (2030, 1,000 MW)					
	N-3.5 (2029, 420 MW)	N-9.1 (2029, 2,000 MW)	N-10.2 (2030, 500 MW)	N-13.1 (2031, 500 MW)	N-6.8 (2032, 2,000 MW)	N-14.1 (2033, 2,000 MW)
	N-3.6 (2029, 480 MW)	N-9.2 (2029, 2,000 MW)	N-10.1 (2030, 2,000 MW)	N-13.2 (2031, 1,000 MW)		
	N-6.6 (2028, 630 MW)	N-9.3 (2029, 1,500 MW)				
	N-6.7 (2028, 270 MW)					

Offshore sites for tenders 2023 to 2028 (Database: own surveys, FEP 2023, preliminary draft update FEP 2023)

Overview of Grid Connection Capacities

In Germany, a total of 19 grid connection systems with a total capacity of approx. 9.4 GW were fully operational as of December 31, 2023. Of these, 13 grid connection systems with approx. 8 GW are located in the North Sea and six grid connection systems with approx. 1.3 GW in the Baltic Sea. Further grid connection systems in the North and

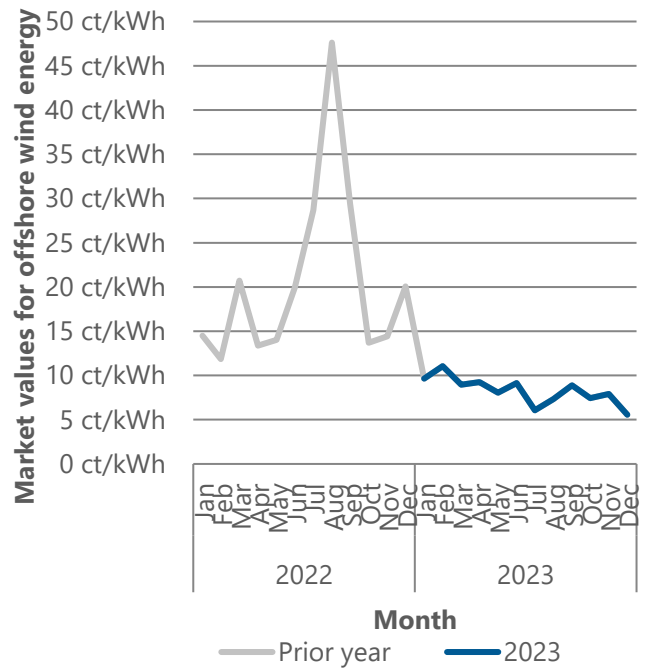
Baltic Sea were under construction or in planning at the end of 2023. In addition, the necessary grid connection capacities for future offshore wind energy projects in the 2030s are currently being identified by updating the site development plan and the grid development plan.

Installed and planned grid connections (to converter station or bundling point) in the North and Baltic Seas
(Database: Grid Development Plan Electricity 2037/2045 (Version 2023, 2nd draft), TSOs, additional research)

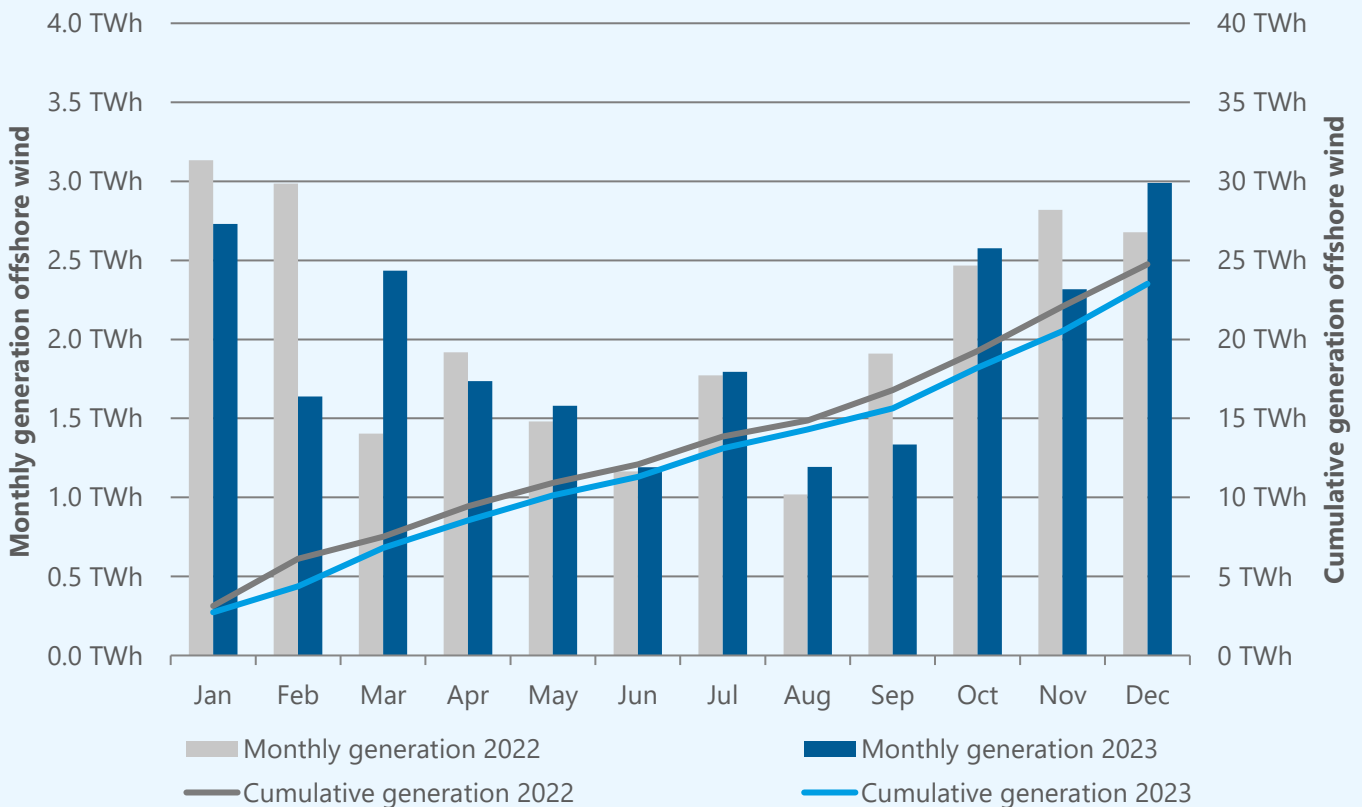
Grid connection system	Status	(Expected) commissioning	(Expected) capacity	(Preliminary) assigned offshore wind energy projects and sites
North Sea				
NOR-2-1 (Alpha Ventus)	In Operation	2009	62 MW	alpha ventus
NOR-6-1 (BorWin1)	In Operation	2010	400 MW	BARO Offshore 1
NOR-0-1 (Riffgat)	In Operation	2014	113 MW	Riffgat
NOR-2-2 (DolWin1)	In Operation	2015	800 MW	Borkum Riffgrund 1, Trianel Windpark Borkum, Trianel Windpark Borkum II
NOR-4-1 (HelWin1)	In Operation	2015	576 MW	Meerwind Süd Ost, Nordsee Ost
NOR-4-2 (HelWin2)	In Operation	2015	690 MW	Amrumbank West, Kaskasi
NOR-5-1 (SylWin1)	In Operation	2015	864 MW	Butendiek, DanTysk, Sandbank
NOR-6-2 (BorWin2)	In Operation	2015	800 MW	Deutsche Bucht, EnBW Albatros, Veja Mate
NOR-3-1 (DolWin2)	In Operation	2016	916 MW	Gode Wind 1, Gode Wind 2, Nordsee One
NOR-0-2 (Nordergründe)	In Operation	2017	111 MW	Nordergründe
NOR-2-3 (DolWin3)	In Operation	2018	900 MW	Borkum Riffgrund 2, Merkur Offshore
NOR-8-1 (BorWin3)	In Operation	2019	900 MW	EnBW Hohe See, Global Tech I
NOR-3-3 (DolWin6)	In Operation	2023	900 MW	Gode Wind 3, NC 1, NC 2
NOR-1-1 (DolWin5)	Under Construction	2025	900 MW	Borkum Riffgrund 3
NOR-7-1 (BorWin5)	Under Construction	2025	900 MW	EnBW He Dreihit
NOR-7-2 (BorWin6)	Under Construction	2027	980 MW	Nordlicht I
NOR-3-2 (DolWin4)	Under Construction	2028	900 MW	NC 3, NC 4
NOR-6-3 (BorWin4)	Under Construction	2028	900 MW	Nordlicht II, Waterkant
NOR-9-1 (BalWin1)	Planned	2029	2,000 MW	N-9.1
NOR-9-2 (BalWin3)	Planned	2031	2,000 MW	N-9.2
NOR-9-3 (BalWin4)	Planned	2029	2,000 MW	N-9.3, N-10.2
NOR-10-1 (BalWin2)	Planned	2030	2,000 MW	N-10.1
NOR-11-1 (LanWin3)	Planned	2030	2,000 MW	N-11.1
NOR-12-1 (LanWin1)	Planned	2030	2,000 MW	N-12.1
NOR-12-2 (LanWin2)	Planned	2030	2,000 MW	N-12.2
NOR-11-2 (LanWin4)	Planned	2031	2,000 MW	N-11.2, N-13-1
NOR-13-1 (LanWin5)	Planned	2031	2,000 MW	N-12.3, N-13.2
NOR-6-4 (BorWin7)	Planned	2032	2,000 MW	N-6.8
Baltic Sea				
OST-3-1 (Baltic 1)	In Operation	2011	51 MW	EnBW Baltic 1
OST-3-2 (Baltic 2)	In Operation	2015	288 MW	EnBW Baltic 2
OST-1-1 (Ostwind 1)	In Operation	2018	250 MW	Wikinger
OST-1-2 (Ostwind 1)	In Operation	2019	250 MW	Arkona
OST-1-3 (Ostwind 1)	In Operation	2019	250 MW	Arkona, Wikinger
OST-2-1 (Ostwind 2)	In Operation	2023	250 MW	Arcadis Ost 1
OST-2-2 (Ostwind 2)	Under Construction	2024	250 MW	Baltic Eagle
OST-2-3 (Ostwind 2)	Under Construction	2024	250 MW	Baltic Eagle
OST-1-4 (Ostwind 3)	Under Construction	2026	300 MW	Windanker
OST-2-4 (Ostwind 4)	Planned	2030	1,000 MW	O-2.2
OST-6-1 (Gennaker)	Planned		927 MW	Gennaker
OST-T-1 (Test Field)			300 MW	Test Field

Power Generation and Market Values

After 2022 was characterised by record values, the level of electricity market prices stabilised from the beginning of 2023. The monthly market value for electricity from offshore wind energy ranged from a maximum of 11.05 ct/kWh (February 2023) to a minimum of 5.56 ct/kWh (December 2023) over the course of 2023. The volume-weighted average monthly market value for offshore wind energy in 2023 was 8.19 ct/kWh, which is significantly lower than the average value for 2022 of 18.35 ct/kWh. Offshore wind energy contributed 5.2 % to electricity generation in Germany in 2023. In the course of 2023, 23.5 TWh of electricity was generated. Electricity generation from offshore wind energy was at a lower level compared to the previous year. Around 4.9 % less electricity was generated than in 2022 (24.7 TWh).



Monthly market values for offshore wind energy (Database: Netztransparenz)



Power generation offshore wind (Database: Bundesnetzagentur | SMARD.de)

About Deutsche WindGuard

In the complex energy market, Deutsche WindGuard is committed to providing unbiased, manufacturer-independent consulting and comprehensive scientific, technical and operational services.

About the German Windenergy Association (BWE)

The German Windenergy Association (BWE) is partner to over 3,000 companies in the wind energy industry and represents the interests of about 20,000 members. The entire know-how of a multifaceted industry is pooled through BWE.

About the German Offshore Wind Energy Association (BWO)

The aim of the BWO is to represent the political interests of the offshore wind industry in Germany. The BWO acts as central point of contact for politicians and authorities at federal and state level for all questions relating to offshore wind energy.

About the German Offshore Wind Energy Foundation

The non-profit organization's overall purpose is to consolidate the role of offshore wind energy in the energy mix of the future in Germany and Europe and to promote its expansion in the interests of environmental and climate protection. Since 2005, it has been established as a non-partisan, supra-regional and cross-sector think tank as well as an independent communication platform for the entire offshore wind energy industry.

About VDMA Power Systems

The trade association VDMA Power Systems and its working groups represent the interests of manufacturers and suppliers of power and heat generation plants.

About WAB e.V.

The WAB is the nationwide contact for the offshore wind industry, the onshore network in the Northwest and promotes the production of green hydrogen from wind power. Wind Industry and Hydrogen Association WAB e.V. includes around 250 smaller and larger companies as well as institutes from all areas of the wind industry, the maritime industry, the emerging hydrogen economy and science.

About WindEnergy Network e.V. (WEN)

The WEN is the leading company network for wind energy in the northeast region with currently approx. 100 member companies. The aim is to promote the expansion of companies and supply chains in order to enhance regional value creation in the future sector renewable energies. The key topics are windenergy on- and offshore, maritime technologies in connection with offshore wind as well as the development of green hydrogen.