DEUTSCHE WINDGUARD

Status of Offshore Wind Energy Development in Germany

Year 2024

On behalf of

BWE Bundesverband WindEnergie

BWO Bundesverband Windenergie Offshore e.V.

FOUNDATION OFFSHORE WIND ENERGY

VDMA Power Systems

wab It's only possible with wind

WindEnergy Network

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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 may be less or higher than 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

Iberdrola OWP Baltic Eagle

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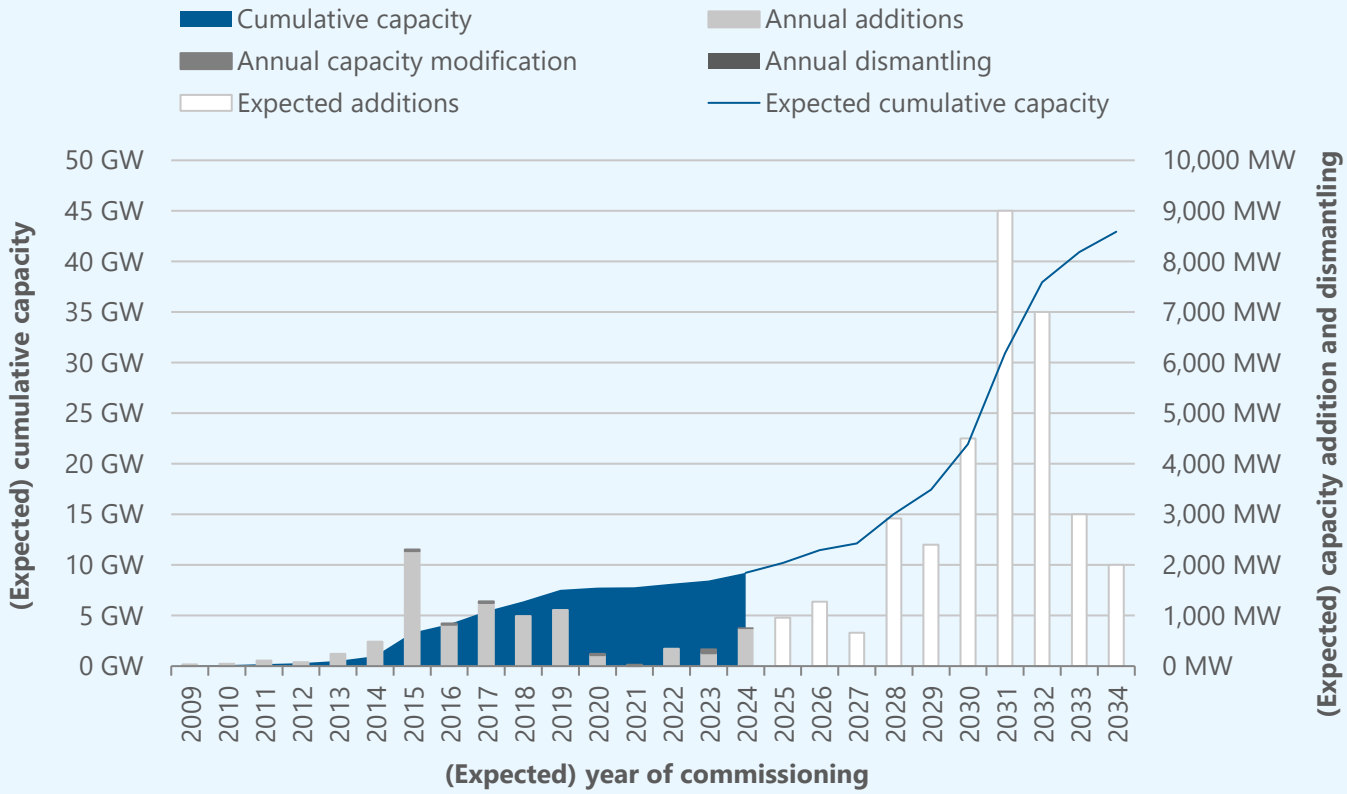
Offshore Wind Energy Development

As of December 31, 2024, 1,639 offshore wind turbines (OWT) with a total capacity of around 9.2 GW are in operation in German waters. Over the course of the year 2024, 73 of these turbines with a total capacity of 742 MW fed into the electricity grid for the first time and 78 existing turbines underwent capacity modifications. At the end of 2024, 81 turbines had also been installed but had not yet fed into the grid for the first time. In addition, 66 foundations have been installed in the seabed, but the associated wind turbines had not yet been erected by the end of 2024.
In the coming years, a similar level of additions as in 2024 is predicted. Significantly higher annual expansion rates are expected towards the end of the decade, which will lead to a considerable increase in total installed offshore wind energy capacity in Germany.

Status of the offshore wind energy development

		Capacity	Number
Additions Year 2024	OWT (feeding in)	742 MW	73 OWT
	Capacity modifications of existing OWT	16 MW	78 OWT
	Installed OWT (no feed-in)	936 MW	81 OWT
	Foundations w/o OWT		66 Foundations
Cumulative 2024-12-31	OWT (feeding in)	9,222 MW	1,639 OWT
	Installed OWT (no feed-in)	936 MW	81 OWT
	Foundations w/o OWT		66 Foundations



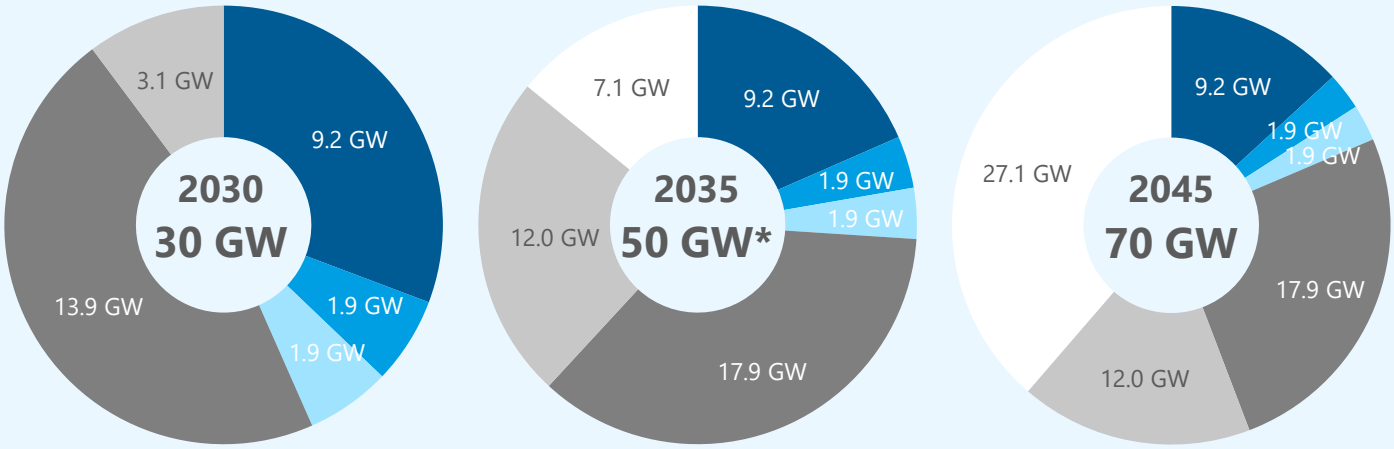
(Expected) development of the offshore wind energy capacity in Germany
(Database: own surveys, MaStR, FEP 2025)

Expansion Targets Offshore Wind Energy

The 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 Offshore Realisation Agreement from November 2022 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 Federal Maritime and Hydrographic Agency (German: Bundesamt für Seeschifffahrt und Hydrographie or BSH) is constantly designating new sites for future expansion in the Site Development Plan (German: Flächenentwicklungsplan or FEP). The FEP 2025, which was published by the BSH in January 2025, provides for specifications for wind energy sites and grid connection systems up to the year 2034. Further specifications, e.g. those already included in the draft FEP (June 2024), are to be included in a future update and are presented in the informative annex of the FEP 2025.

The legally defined expansion target of 30 GW for 2030 is expected to be achieved with a delay of around one year. The WindSeeG target for 2035 of 40 GW can already be achieved in 2034 according to the plans of the FEP 2025, provided that all sites planned for this are tendered, awarded and realised as planned. In order to achieve the increased expansion target of 50 GW for 2035, further specifications are required. This also applies to achieving the long-term legally defined expansion target of at least 70 GW offshore wind energy capacity by 2045.



Development status (2024-12-31)

- In operation
- Under construction
- Final investment decision
- Awarded/grid connection claim
- Tenders scheduled
- Additional specifications required

* According to the WindSeeG, the installed capacity is to be increased to at least 40 GW by 2035. The Offshore Realisation Agreement from November 2022 between the federal government, the federal states of Hanseatic City of Bremen, Hanseatic City of Hamburg, Mecklenburg-Western Pomerania, Lower Saxony, North Rhine-Westphalia and Schleswig-Holstein and the transmission system operators 50Hertz, Amprion and TenneT aims to exceed the WindSeeG expansion target and install 50 GW by 2035.

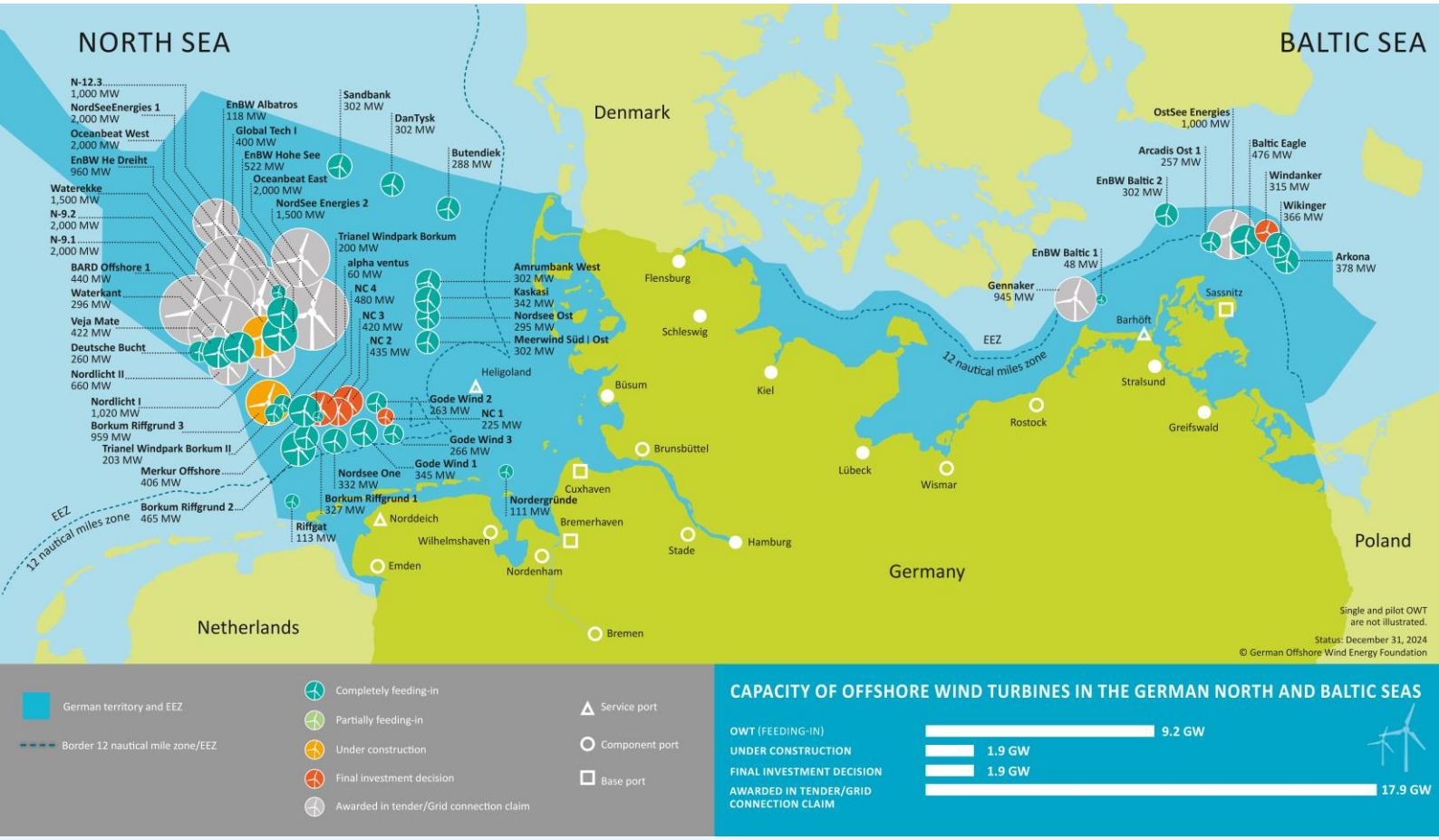
Development status of offshore wind energy capacity with expansion targets by 2030, 2035 and 2045 (Database: own surveys, MaStR, FEP 2025)

Activities in Offshore Wind Energy Projects

At the end of 2024, 31 offshore wind energy projects (OWP) are fully operational in Germany. In the two projects Gode Wind 3 and Baltic Eagle, all turbines were commissioned in the course of 2024. In the project Borkum Riffgrund 3, the foundation installations were started at the end of 2023 and completed in the second half of 2024. The construction of the offshore wind turbines has progressed steadily since summer 2024 and was largely completed by the end of 2024. In the EnBW He Dreiht OWP, all foundations were installed over the course of 2024, but the wind turbines have not yet been erected. The final investment decisions (FID) for the North Sea cluster (NC 1-4) and Windanker projects were made in the spring of 2024. A further 13 projects had an award/claim for grid connection at the end of December 2024.

Overview of future offshore wind energy projects

OWP	Status	Expected commissioning	Expected capacity
EnBW He Dreiht	Under Construction	2025	960 MW
Borkum Riffgrund 3	Under Construction	2026	959 MW
Windanker (O-1.3)	FID	2026	315 MW
NC 1 (N-3.7)	FID	2027	225 MW
NC 2 (N-3.8)	FID	2027	435 MW
Gennaker	Grid connection claim	2028	945 MW
Nordlicht I (N-7.2)	Awarded	2028	1,020 MW
Nordlicht II (N-6.6)	Awarded	2028	660 MW
Waterkant (N-6.7)	Awarded	2028	296 MW
NC 3 (N-3.5)	FID	2029	420 MW
NC 4 (N-3.6)	FID	2029	480 MW
Waterekke (N-9.3)	Awarded	2029	1,500 MW
NordSee Energies 1 (N-12.1)	Awarded	2030	2,000 MW
Oceanbeat West (N-12.2)	Awarded	2030	2,000 MW
N-12.3	Awarded	2031	1,000 MW
N-9.1	Awarded	2031	2,000 MW
NordSee Energies 2 (N-11.2)	Awarded	2031	1,500 MW
OstSee Energies (O-2.2)	Awarded	2031	1,000 MW
N-9.2	Awarded	2032	2,000 MW
Oceanbeat East (N-11.1)	Awarded	2032	2,000 MW

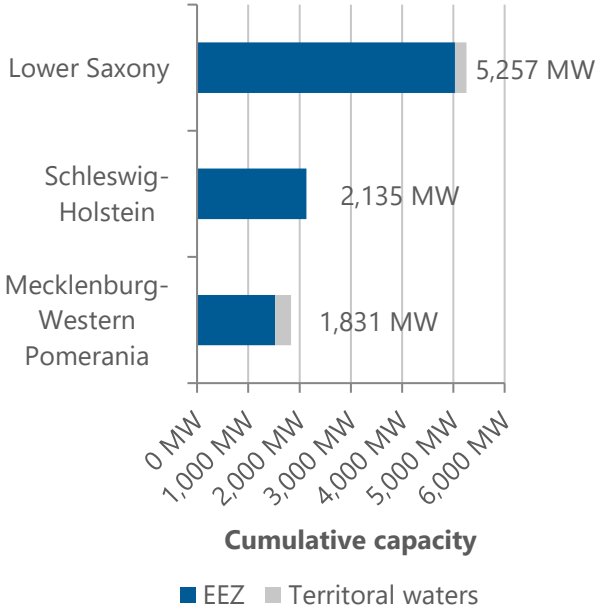


Overview map of offshore wind energy in Germany (© German Offshore Wind Energy Foundation)

Distribution across Federal States and North and Baltic Sea

The expansion of offshore wind energy in Germany is primarily focussed on the Exclusive Economic Zone (EEZ) of the North Sea. Accordingly, as of 31 December 2024, the installed capacity of German offshore wind turbines with grid feed-in is largely located in the North Sea (7.4 GW). The Baltic Sea accounts for significantly less capacity (1.8 GW). Commissioning activities over the course of 2024 took place in both the North Sea and the Baltic Sea. The offshore wind turbines in the North Sea and Baltic Sea are predominantly installed in the EEZ (8.7 GW), with significantly fewer turbines installed in the territorial waters (0.5 GW).

The capacity installed at sea can be allocated to the federal states based on the location of the respective grid connection point. Lower Saxony accounts for around 5.3 GW of the installed capacity in the North Sea and Schleswig-Holstein for 2.1 GW. The installed capacity of 1.8 GW in the Baltic Sea is fully connected in 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 Year 2024	OWT (feeding in)	266 MW	23 OWT	476 MW	50 OWT
	Capacity modifications of existing OWT	16 MW	78 OWT	0 MW	0 OWT
	Installed OWT (no feed-in)	936 MW	81 OWT	0 MW	0 OWT
	Foundations w/o OWT		66 Foundations		0 Foundations
Cumulative 2024-12-31	OWT (feeding in)	7,391 MW	1,330 OWT	1,831 MW	309 OWT
	Installed OWT (no feed-in)	936 MW	81 OWT	0 MW	0 OWT
	Foundations w/o OWT		66 Foundations		0 Foundations

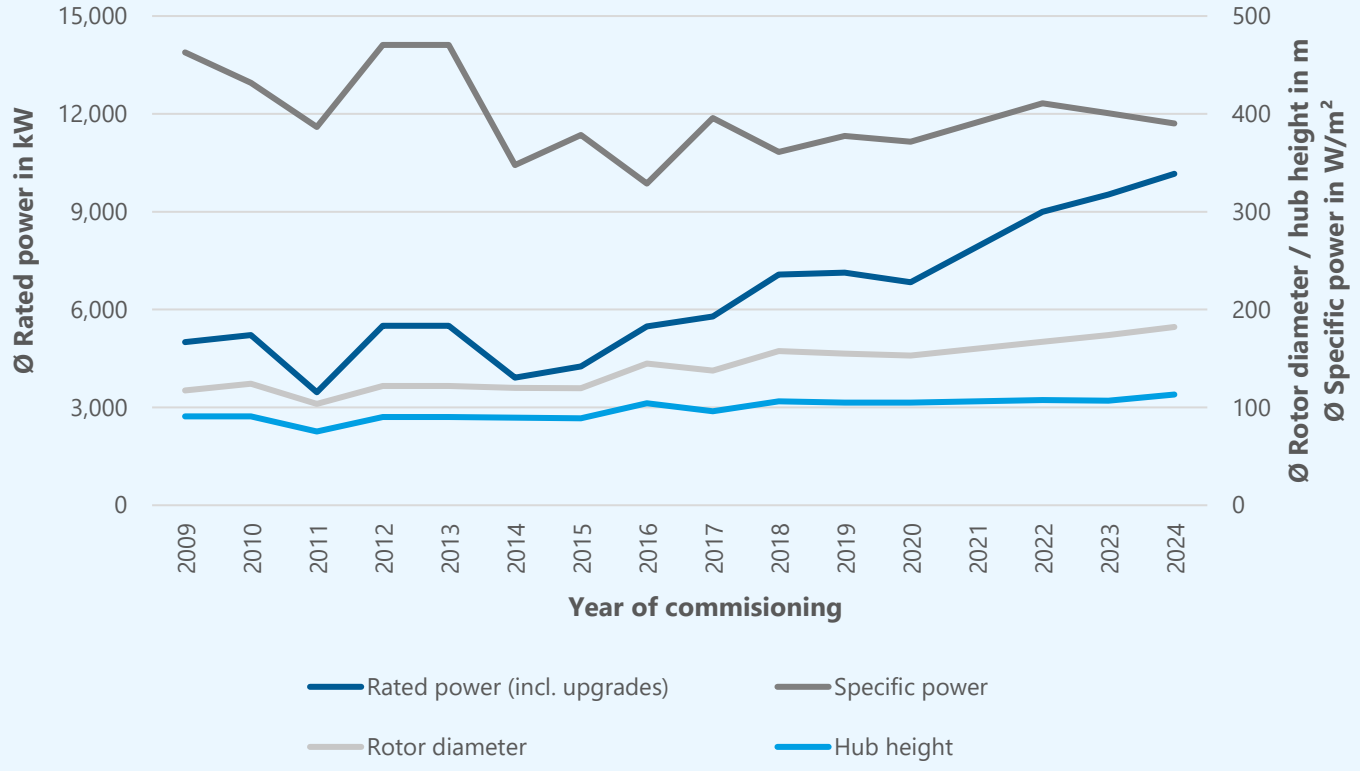
Turbine Configuration

In the course of 2024, offshore wind turbines with an average rated power of 10.2 MW were commissioned. This corresponds to an increase of 7% compared to the previous year. The trend towards ever more powerful offshore wind turbines is continuing. The average rotor diameter of the turbines commissioned over the course of 2024 also increased by 5% to 182 m. This results in a reduction of the specific power to 390 W/m². The average hub height increases in 2024 by 6% to 113 m.

After the first offshore wind turbines with a rated power of 11 MW was put into operation in Germany in 2024, the 15 MW mark is expected to be reached in 2025. The 15 MW turbines will also contribute to further significant increases in size compared to existing turbines in terms of rotor diameter and hub height. For projects to be realised in the coming years, turbines with a rated power of 15 MW to 18.5 MW are planned.

Average offshore wind turbine configuration

Average Configuration	Cumulative 2024-12-31	Additions Year 2024
Rated power (incl. upgrades)	5,627 kW	10,163 kW
Rotor diameter	136 m	182 m
Hub height	96 m	113 m
Specific power	378 W/m²	390 W/m²



Turbine configuration over course of time

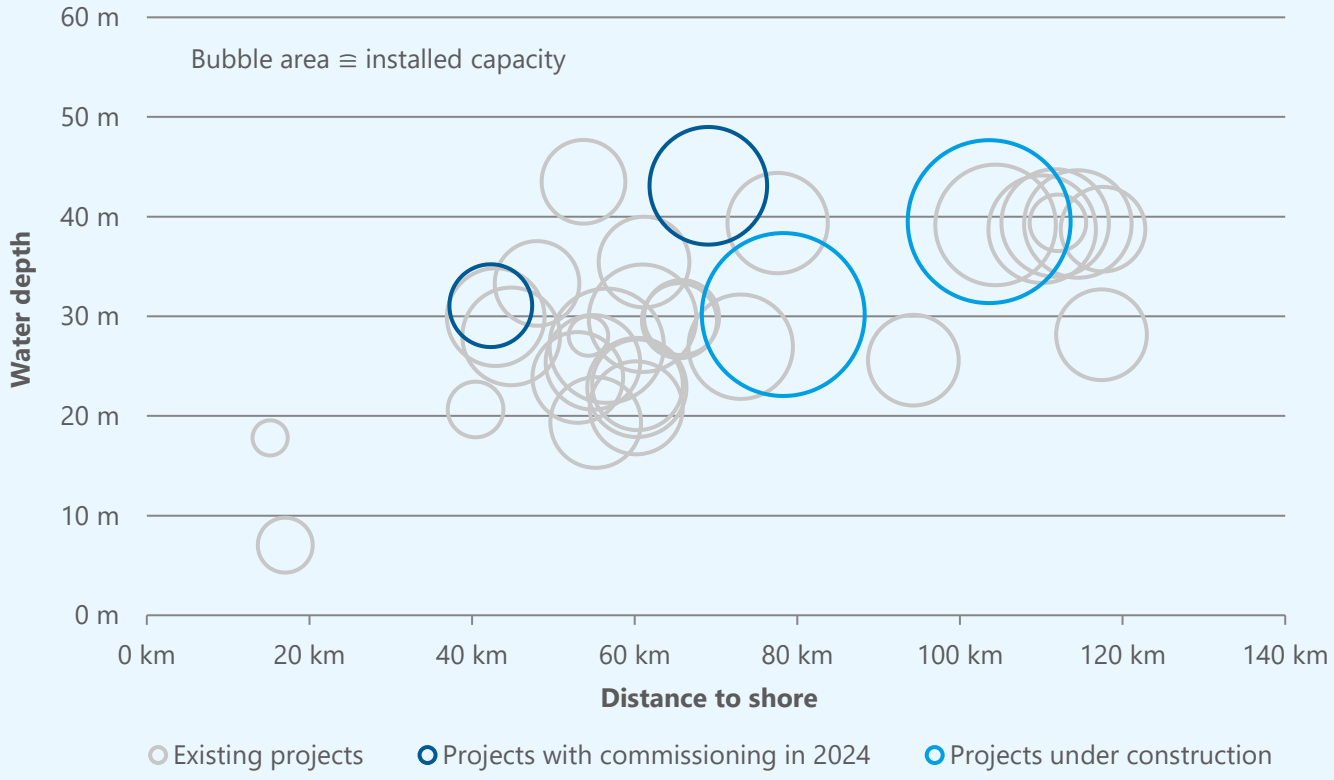
Water Depth and Distance to Shore

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 up to 120 km from the shore and in water depths of over 40 m. On average, the existing projects have a water depth of approx. 31 m and a distance from the coast of approx. 70 km. The two projects that became fully operational in 2024 have a greater average water depth but are located somewhat closer to the shore than the existing projects. The two projects under construction at the end of the year 2024 are on average located much further out in the German EEZ with a comparable water depth to the existing projects.

In terms of foundation type, the monopile foundation has been established as the most commonly used type in Germany. No other foundation type has been installed since the year 2019. Accordingly, all foundations installed in the course of 2024 were monopiles. Parallel to the growing dimensions of offshore wind turbines, the dimensions of monopile foundations are also constantly increasing.

Average water depth and distance to shore

Average location	Existing projects	Projects with commissioning in 2024	Projects under construction
Water depth	31 m	39 m	35 m
Distance to shore	70 km	59 km	91 km



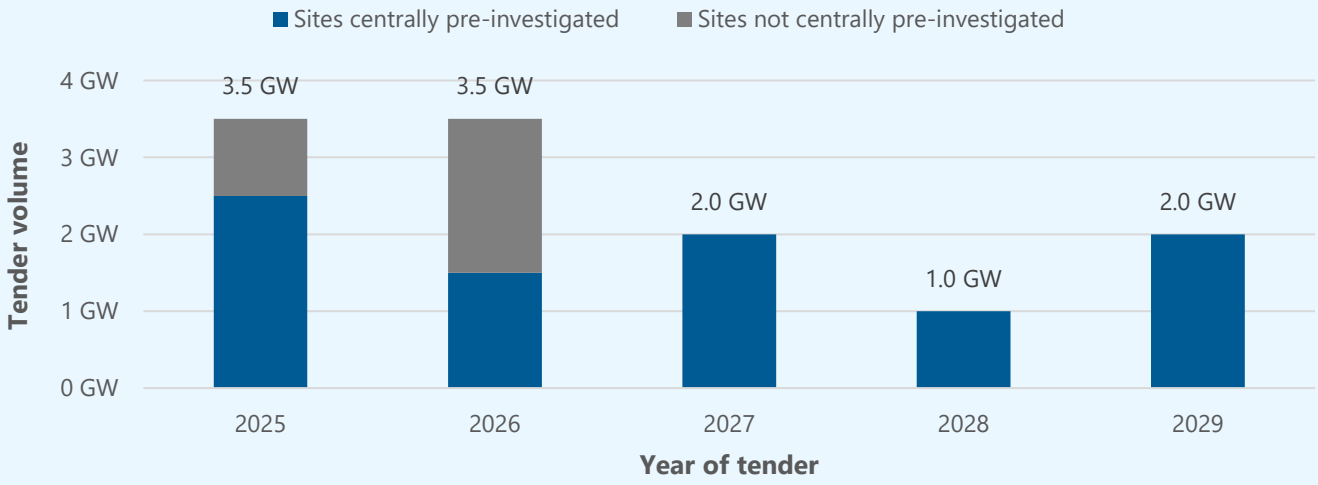
Water depth and distance to shore of existing projects, projects with commissioning in 2024 and projects under construction

Tenders for Offshore Wind Energy

Since the year 2023, the Federal Network Agency (German: Bundesnetzagentur or BNetzA) conducts two tender rounds per year. A distinction is made between tenders for sites that have not been centrally pre-investigated and tenders for sites that have been centrally pre-investigated by the BSH. The tendering procedure differs depending on the type of site.

In June 2024, the tendering round for sites not centrally pre-investigated took place. Two sites (N-11.2 and N-12.3) with a total capacity of 2.5 GW were put out to tender. Several bidders submitted 0-cent-bids for both sites, which means that they do not receive funding, and a dynamic bidding procedure had to be carried out. The bidders with the highest willingness to pay were awarded. The award for site N-11.2 was won by Total Energies for €1.305 million/MW. EnBW was awarded for site N-12.3 at a bid value of €1.065 million/MW. The total payments offered amount to approximately €3 billion, most of which is to be paid during the operating period of the offshore wind energy project. In August 2024, the tender round took place for three centrally pre-investigated sites (N-9.1, N-9.2 and N-9.3) with a total volume of 5.5 GW, which were awarded on the basis of a bidding process with qualitative criteria (including contribution to decarbonisation and securing skilled workers). The awards for the two sites N-9.1 and N-9.2 were both won by RWE and the right to develop site N-9.3 was awarded to Luxcara. The total payments offered in this tender round were not published by the BNetzA.

Future tenders with a volume of 12 GW have so far been scheduled in the FEP 2025. These will take place between 2025 and 2029.



Site name (planned commissioning and capacity)	2025	2026	2027	2028	2029
Not centrally pre-investigated (■)	N-9.4 (2032, 1 GW)	N-12.4 (2033, 1 GW)			
		N-12.5 (2033, 1 GW)			
Centrally pre-investigated (■)	N-10.1 (2031, 2 GW)	N-13.1 (2031, 0.5 GW)	N-6.8 (2032, 2 GW)	N-9.5 (2033, 1 GW)	N-12.6 (2034, 2 GW)
	N-10.2 (2030, 0.5 GW)	N-13.2 (2031, 1 GW)			

Offshore sites for tenders 2025 to 2029 (Database: FEP 2025)

Overview of Grid Connection Capacities

In Germany, a total of 21 grid connection systems with a total capacity of approximately 9.8 GW were operational at the end of 2024. Of the grid connection systems realised to date, 13 are in the North Sea and 8 in the Baltic Sea. Further grid connection systems, which are scheduled to be commissioned by 2028, are under construction at the end of 2024. The implementation of the grid connection systems in accordance with the new 2 GW standard is planned from 2029.

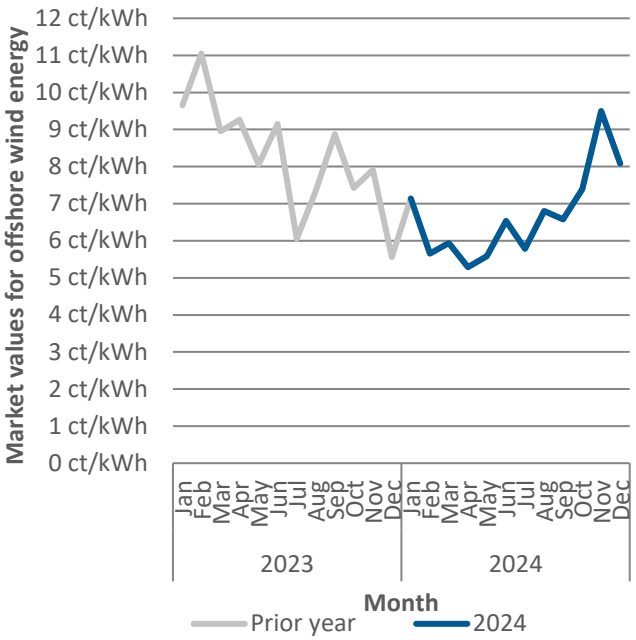
Installed and planned grid connections (to converter station or bundling point) in the North and Baltic Seas (Database: Confirmation of Grid Development Plan Electricity 2037/2045, FEP 2025, TSOs, additional research)

Grid connection system	Status	(Excpected) 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	BARD 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 Dreiht
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-9-3 (BalWin4)	Planned	2029	2,000 MW	Waterekke, N-10.2
NOR-9-1	Planned	2030	2,000 MW	N-9.1
NOR-12-1	Planned	2030	2,000 MW	NordSee Energies 1
NOR-12-2	Planned	2030	2,000 MW	Oceanbeat West
NOR-9-2	Planned	2031	2,000 MW	N-9.2
NOR-10-1	Planned	2031	2,000 MW	N-10.1
NOR-11-2	Planned	2031	2,000 MW	NordSee Energies 2, N-13.1
NOR-13-1	Planned	2031	2,000 MW	N-12.3, N-13.2
NOR-6-4	Planned	2032	2,000 MW	N-6.8
NOR-9-4	Planned	2032	2,000 MW	N-9.4, N-9.5
NOR-11-1	Planned	2032	2,000 MW	Oceanbeat East
NOR-12-3	Planned	2033	2,000 MW	N-12.4, N-12.5
NOR-12-4	Planned	2034	2,000 MW	N-12.6
Baltic Sea				
OST-3-1 (Baltic 1)	In operation	2011	50,6 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)	In operation	2024	250 MW	Baltic Eagle
OST-2-3 (Ostwind 2)	In operation	2024	250 MW	Baltic Eagle
OST-1-4 (Ostwind 3)	Under construction	2026	300 MW	Windanker
OST-6-1 (Gennaker)	Planned	2028	900 MW	Gennaker
OST-2-4 (Ostwind 4)	Planned	2031	2,000 MW	OstSee Energies

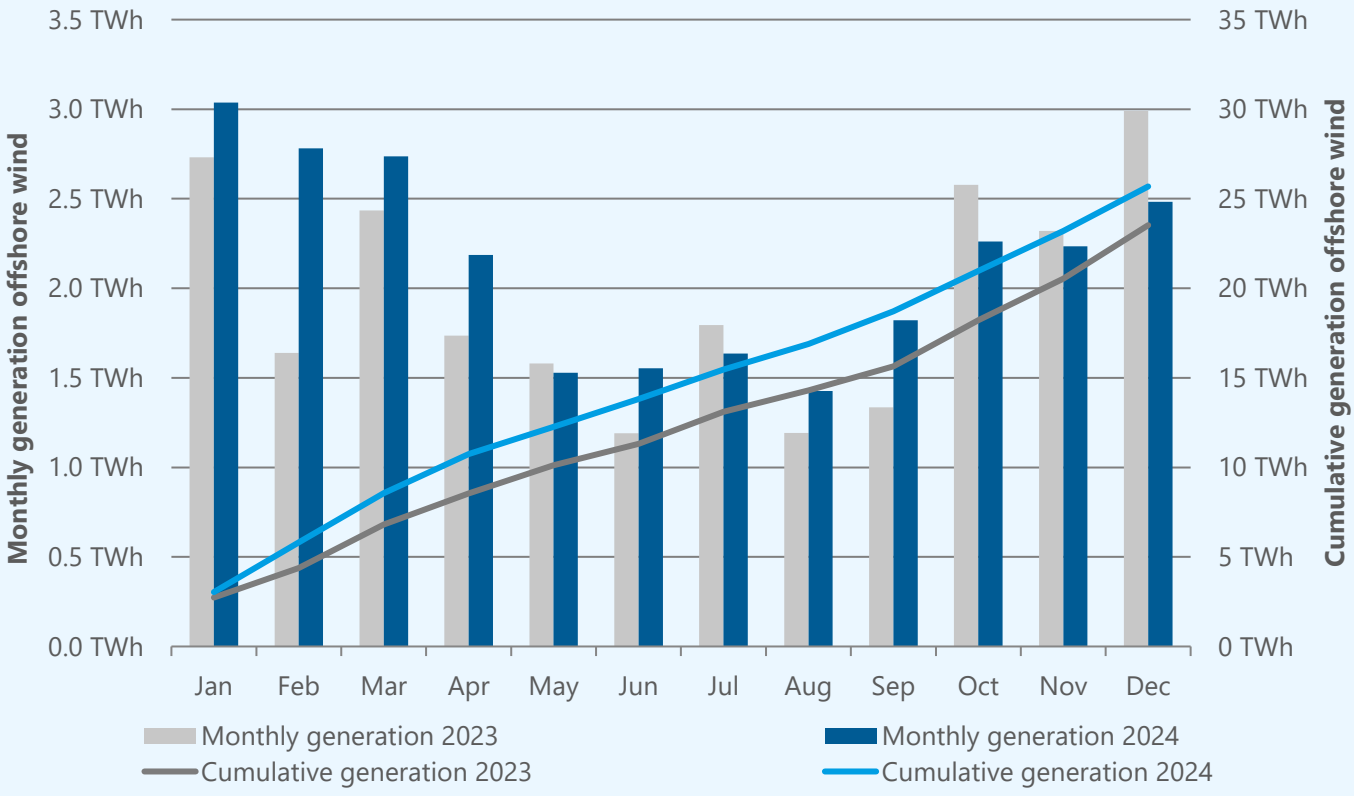
Power Generation and Market Values

The monthly market values for electricity from offshore wind energy ranged from a minimum of 5.29 ct/kWh (April 2024) to a maximum of 9.50 ct/kWh (November 2024) over the course of the year 2024. Overall, the monthly market values in 2024 were at a lower level than in the previous year. While the annual market value in 2023 was 8.19 ct/kWh, the value in 2024 was 17% lower at 6.78 ct/kWh.

Offshore wind energy generated a total of 25.7 TWh of electricity in 2024. The highest generation of just over 3 TWh was achieved in January 2024 and the lowest generation of 1.4 TWh was recorded in August 2024. Overall, electricity generation was at a higher level than in the same period of the previous year. Offshore wind energy accounted for 5.9% of German electricity generation in 2024.



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 Wind Energy Association (BWE) is a partner to more than 3.000 companies in the wind industry sector and represents the interests of its approximately 17.000 members. BWE pools the combined know-how of a diverse industry sector.

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

VDMA Power Systems is the association for the power plant engineering. It represents the interests of manufacturers and suppliers of electricity and heat generation systems in Germany and abroad. These include wind energy, photovoltaic and hydropower plants, engines and thermal power plants as well as storage and sector coupling technologies.

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. The association 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 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 windenergy as well as the development of green hydrogen.