

Status of Offshore Wind Energy Development in Germany

Year 2022



On behalf of



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Notes

The data was obtained through surveys with industry representatives as well as through additional research (sources e.g. BNetzA and BSH). 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 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

Rotor blade assembly at RWE's OWP Kaskasi

© RWE AG | Matthias Ibeler

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Offshore Wind Energy Development

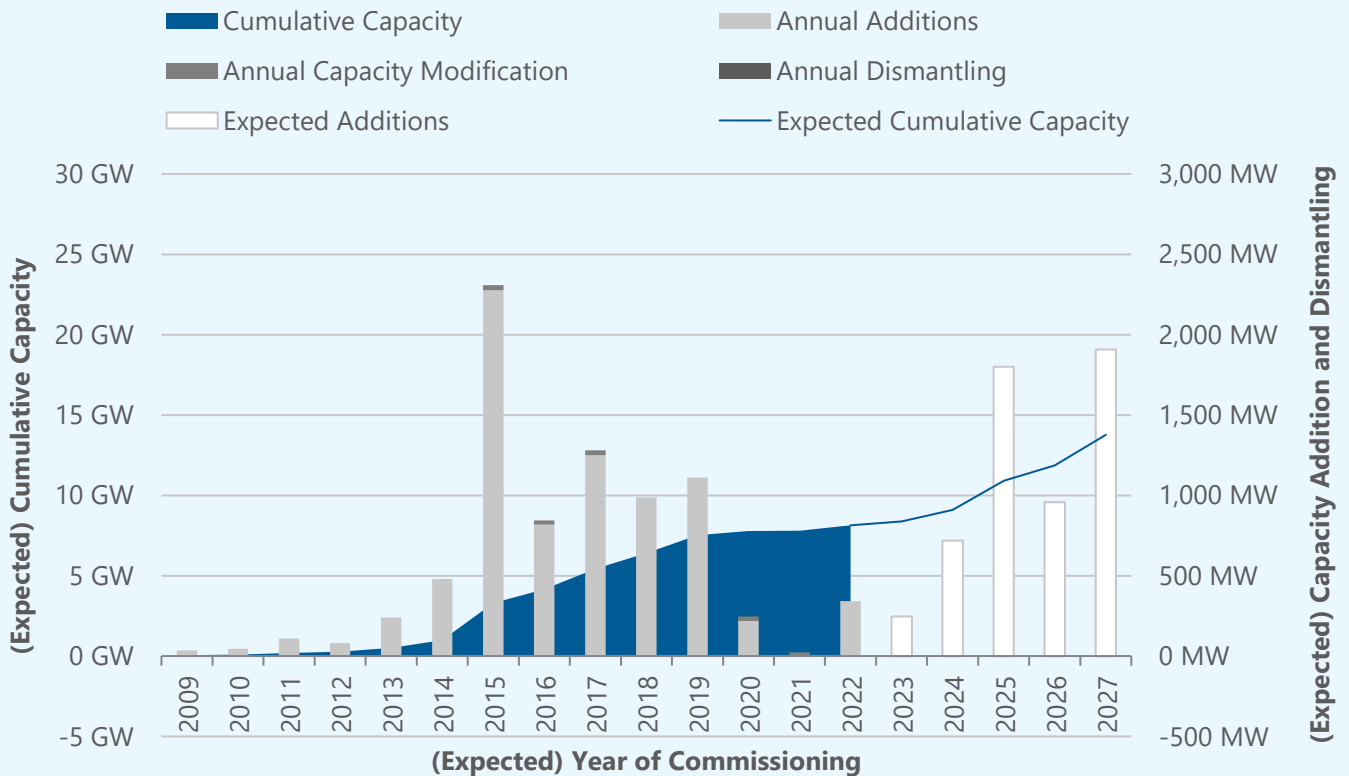
As of December 31, 2022, 1,539 offshore wind turbines (OWT) with a total capacity of 8.1 GW were in operation in Germany. Of these, 38 turbines with a total capacity of 342 MW fed into the electricity grid for the first time in 2022. Additional foundations and turbines were installed.

The construction and commissioning activities in the course of 2022 marked the start of the implementation phase of the projects, which were awarded in the tender rounds of the transitional system in 2017 and 2018. For the first time since 2020, an offshore wind energy project was commissioned in Germany. By 2025, all projects from the transitional system are expected to be commissioned. Further projects with awards from tender rounds in 2021/2022 and with grid connection claim in accordance with the Energy Industry Act (German: Energiewirtschaftsgesetz or EnWG) are to be realised by 2027. If these projects

are fully realised, the installed capacity can be increased to almost 13.8 GW by the end of 2027.

Status of the Offshore Wind Energy Development

		Capacity	Number
Additions Year 2022	OWT (feeding in)	342 MW	38 OWT
	Installed OWT (no feed-in)	86 MW	9 OWT
	Foundations w/o OWT		18 Foundations
Cumulative 2022-12-31	OWT (feeding in)	8,136 MW	1,539 OWT
	Installed OWT (no feed-in)	86 MW	9 OWT
	Foundations w/o OWT		18 Foundations



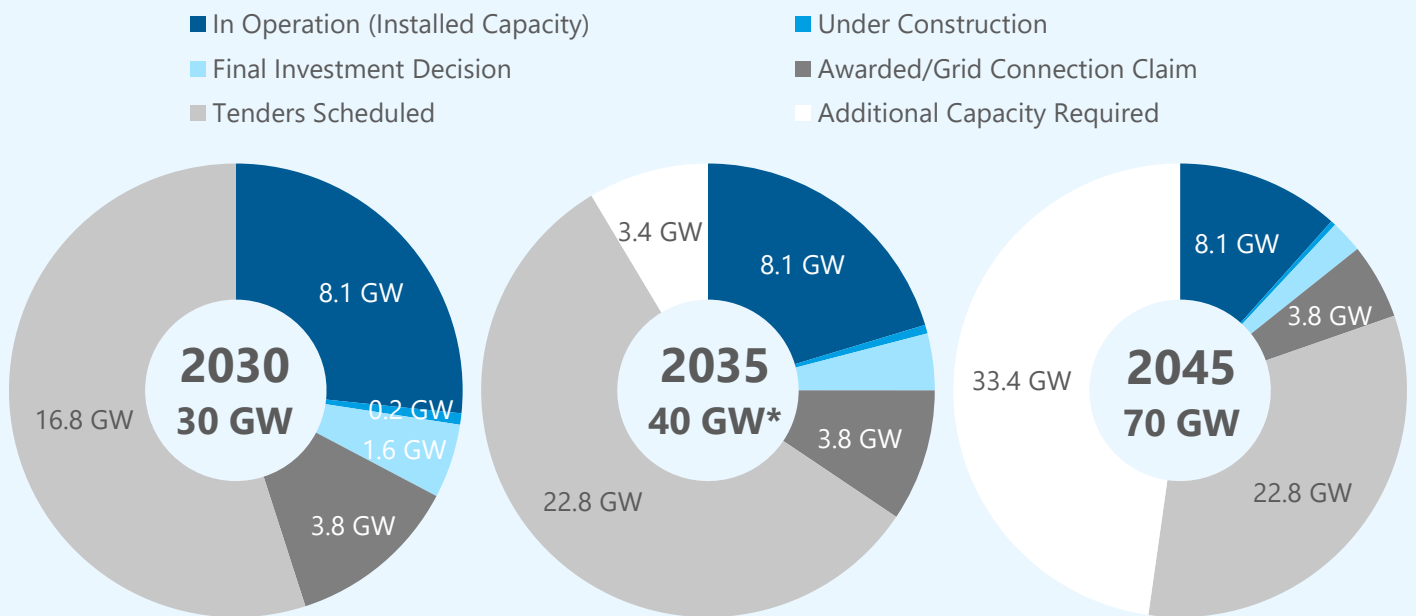
(Expected) Development of the Offshore Wind Energy in Germany
(Database: own surveys, MaStR, BNetzA)

Expansion Targets Offshore Wind Energy

The increase in the expansion targets for offshore wind energy was legally anchored in the amendment to the Offshore Wind Energy Act (German: Windenergie-auf-See-Gesetz or WindSeeG) in summer 2022. The European Commission approved this amendment in December 2022, so that the changes could come into force as planned on January 1, 2023. The increased targets provide for the installed capacity of offshore wind turbines connected to the grid to be raised to a total of at least 30 GW by 2030, to at least 40 GW by 2035 and to 70 GW by 2045. As of December 31, 2022, the installed capacity of offshore wind energy projects in operation was 8.1 GW. One project with a total capacity of 0.2 GW was under construction. In addition, a final investment decision has already been reached for several projects with a total capacity of 1.6 GW by the end of 2022. Further projects with a total capacity of 3.8 GW have been awarded in the

tenders for offshore wind energy or have a grid connection claim in accordance with the Energy Industry Act (German: Energiewirtschaftsgesetz or EnWG). However, these projects did not yet report a final investment decision.

In October 2022, the Federal Maritime and Hydrographic Agency (German: Bundesamt für Seeschifffahrt und Hydrographie or BSH) published the second draft of the updated Site Development Plan (German: Flächenentwicklungsplan or FEP). This draft contains further tender dates for sites that are to be put into operation by 2032: Sites with an installed capacity of in total 16.8 GW are to be commissioned by 2030, with a further 6 GW in total to follow in 2031 and 2032. Based on these plans, the expansion target of 30 GW could be reached by 2030. In order to achieve the expansion targets for 2035 and 2045, additional designations by the Site Development Plan are still required.



* According to the Offshore Realisation Agreement 2022, the target of at least 40 GW by 2035 can be significantly exceeded through increased legal tender volumes, so that an expansion to 50 GW can be achieved by 2035.

Development Status of Offshore Capacity with Expansion Targets by 2030, 2035 and 2045 (Database: own surveys, MaStR, WindSeeG 2023, 2. Draft FEP)

Activities in Offshore Wind Energy Projects

At the end of 2022, 28 offshore wind energy projects (OWP) were fully operational in Germany. The Kaskasi project was the first project from the transitional system to be commissioned in December 2022. In the Arcadis Ost 1 project, construction activities have continued to progress in the second half of 2022: The foundation work was completed and the installation of the turbines has started. The commissioning of the project is scheduled for 2023. At the OWP Baltic Eagle, the installation of the turbine foundations is expected to start in the first half of 2023. In the Gode Wind 3 and Borkum Riffgrund 3 projects, installation of the foundations is expected to begin in summer 2023. At the OWP EnBW He Dreiht, construction is expected to start at the beginning of 2024. Six other projects that have been awarded or are entitled to be connected to the grid are preparing for commissioning until 2027.

Overview of future projects until 2027

OWP	Status	Expected Commissioning	Capacity**
Kaskasi*	Completely feeding-in	2022	342 MW
Arcadis Ost 1	Under Construction	2023	247 MW
Baltic Eagle	FID	2024	476.25 MW
Gode Wind 3	FID	2024	241.75 MW
Borkum Riffgrund 3	FID	2025	900 MW
EnBW He Dreiht	Awarded	2025	900 MW
N-3.7	Awarded	2026	225 MW
Nordsee Two	Awarded	2026	433 MW
Windanker	Awarded	2026	300 MW
N-7.2	Awarded	2027	980 MW
Gennaker	Grid connection claim	2027	927 MW

* incl. pilot OWT

** grid connection capacity



Overview Map of Offshore Wind Energy in Germany (© German Offshore Wind Energy Foundation)

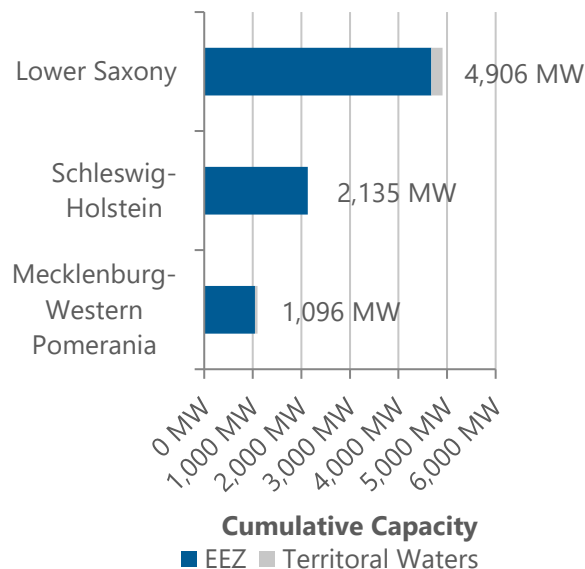
Distribution across Federal States and North and Baltic Sea

In Germany, the installed capacity of offshore wind turbines feeding into the grid is mainly located in the North Sea (7.0 GW), while the Baltic Sea accounts for 1.1 GW. Based on the location of the respective grid connection point, the offshore installed capacity can be allocated to the German federal states. The installed capacity in the North Sea is distributed between Lower Saxony with 4.9 GW and Schleswig-Holstein with 2.1 GW. The 1.1 GW of installed capacity in the Baltic Sea is entirely assigned to Mecklenburg-Western Pomerania.

With regard to the distribution of installed capacity between the Exclusive Economic Zone (EEZ; German: Ausschließliche Wirtschaftszone or AWZ) and the territorial waters, the share installed in the EEZ (7.8 GW) clearly exceeds that in territorial waters (0.3 GW).

The future projects that have been awarded in the tender rounds and projects entitled to be

connected to the grid account for approx. 3.7 GW in the North Sea and just under 2 GW in the Baltic Sea.



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 2022	OWT (feeding in)	342 MW	38 OWT	0 MW	0 OWT
	Installed OWT (no feed-in)	0 MW	0 OWT	86 MW	9 OWT
	Foundations w/o OWT		No Foundations		18 Foundations
Cumulative 2022-12-31	OWT (feeding in)	7,040 MW	1,307 OWT	1,096 MW	232 OWT
	Installed OWT (no feed-in)	0 MW	0	86 MW	9 OWT
	Foundations w/o OWT		No Foundations		18 Foundations
Future Additions	Awarded projects and projects with grid connection claim (Commissioning until 2027)	3,680 MW		1,950 MW	

Turbine Configuration

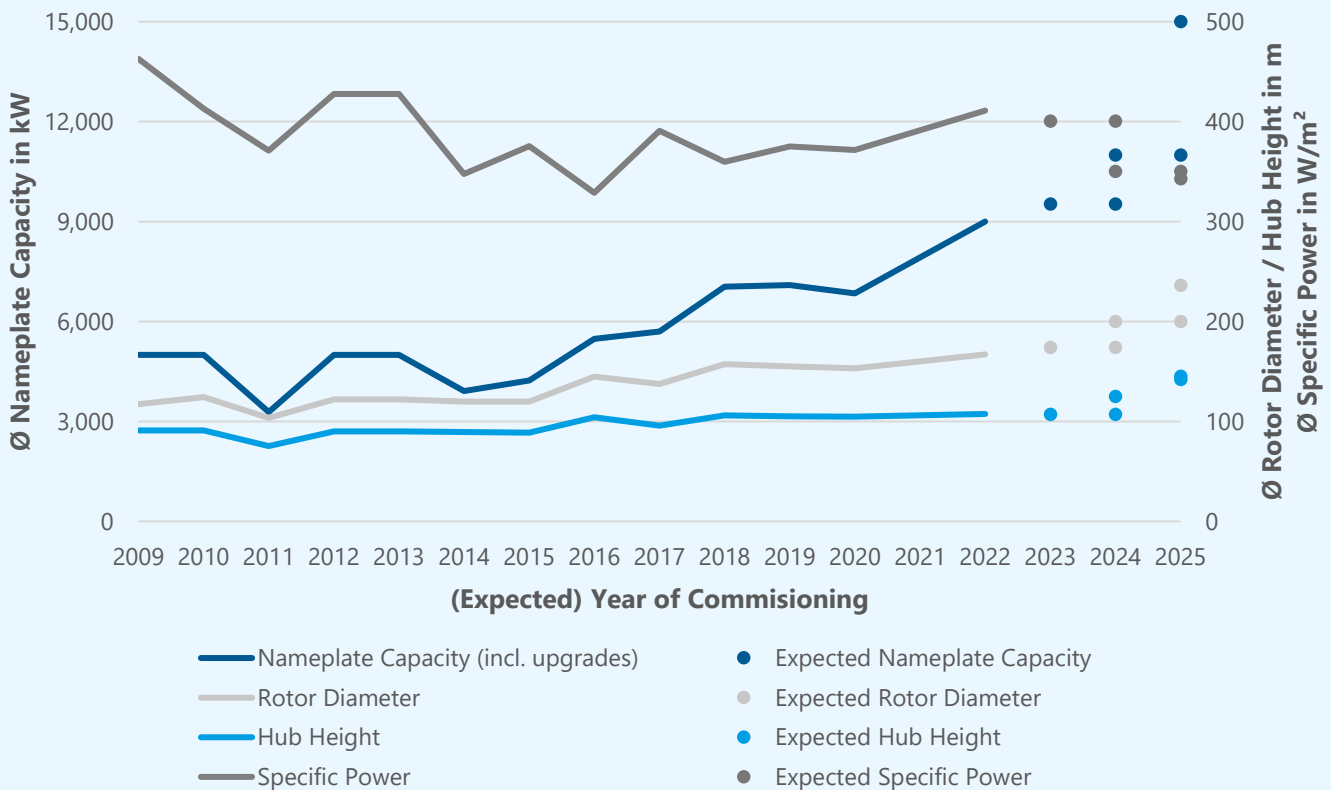
With the advancing expansion of offshore wind energy, the turbine technology has also further developed. With 9 MW each, the turbines commissioned in 2022 represent the most powerful offshore wind turbines in Germany to date. For the entire portfolio of all turbines in operation at the end of 2022, the average capacity is just under 5.3 MW.

In the projects that will be commissioned in 2023, 2024 and 2025, turbine types with at least 9.5 MW and up to 15 MW are planned. This results in an average turbine capacity of more than 11 MW for the expected additions of new turbines by 2025. The current plans for the future projects also provide for significant increases in rotor diameter and hub height by 2025 compared to the existing turbines. According to the project plans, rotor diameter and hub height will be between 174 m and 236 m (rotor diameter) and between 107 m and 145 m (hub height), depending on the project.

The specific power (ratio of turbine capacity to rotor area) remains at a level comparable to previous years and will range between 340 W/m² and 410 W/m² in the future projects until 2025.

Average Turbine Configuration

Average Configuration	Additions Year 2022	Cumulative 2022-12-31	Expected additions until 2025
Nameplate Capacity (incl. upgrades)	9,000 kW	5,286 kW	11,577 kW
Rotor Diameter	167 m	134 m	201 m
Hub Height	108 m	95 m	130 m
Specific Power	411 W/m ²	373 W/m ²	364 W/m ²



* Illustration of expected turbine configuration by project and year of commissioning

(Expected*) Turbine Configuration over Course of Time

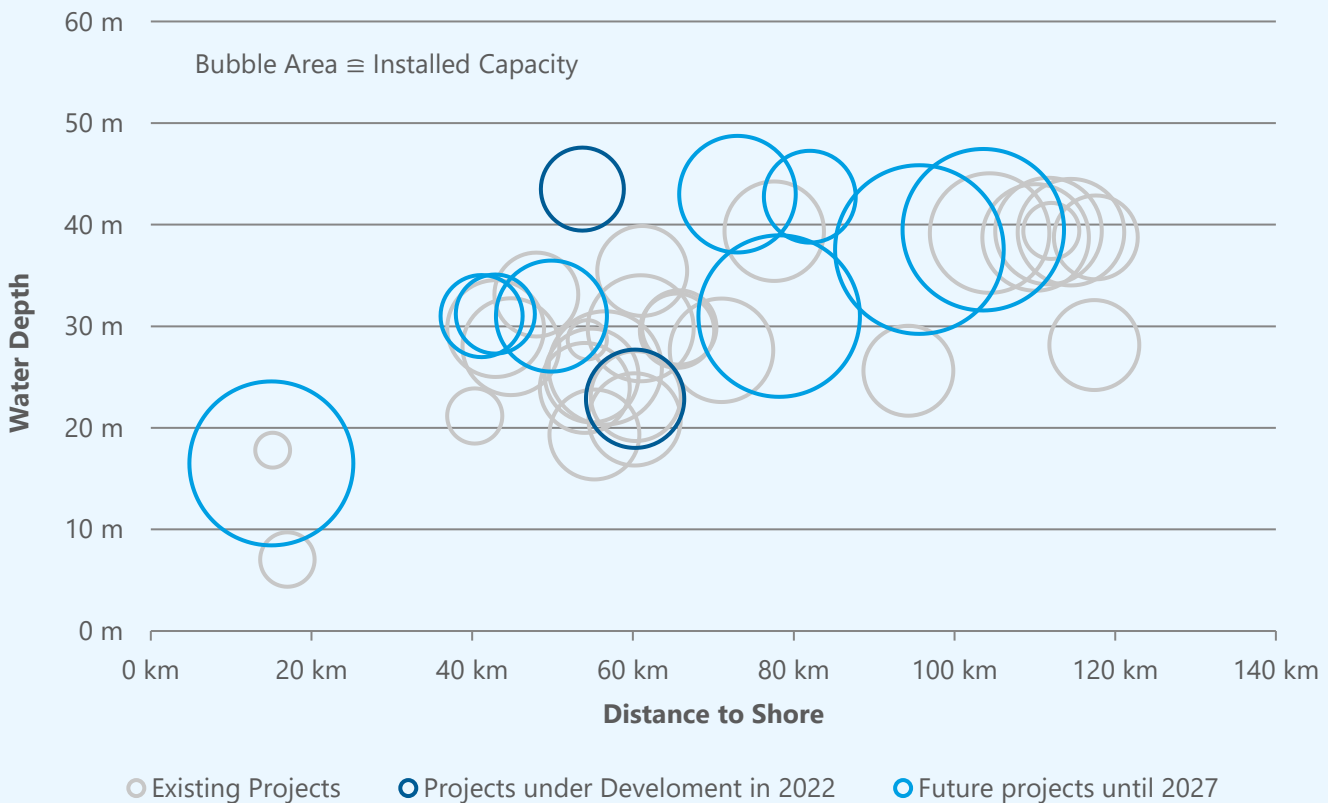
Water Depth and Distance to Shore

Offshore wind energy projects in German waters differ in terms of water depth and distance to shore. Only a few of the offshore wind turbines installed in Germany are located in shallow waters close to the coast; the majority is located at least 40 km from the coast in water depths of 20 m and more. Some of the turbines are installed at locations with a distance to the shore of more than 120 km and water depths of up to 44 m. On average, the existing projects have a water depth of about 30 m and a distance to the shore of 75 km. The two projects under development in 2022 have a similar average water depth but are located slightly closer to the coast. The future projects, which are to be realised by 2027, are also distributed at locations with different conditions. On average, however, their water depth and distance to shore do not differ much from those of the existing projects.

With regard to the type of foundation, the monopile foundation has become the most commonly used type in Germany. All of the foundations installed during the course of 2022 were monopiles, and many future projects have already announced the installation of monopile foundations likewise.

Average Water Depth and Distance to Shore

Average Location	Water Depth	Distance to Shore
Existing Projects	30 m	75 km
Projects under Development in 2022	32 m	58 km
Future Projects until 2027	33 m	69 km



Water Depth and Distance to Shore of Existing Projects, Projects under Development and Future Projects

Tenders for Offshore Wind Energy

After the first tender round in the central model for the sites N-3.7, N-3.8 and O-1.3 in 2021, the Federal Network Agency (German: Bundesnetzagentur or BNetzA) announced the results of the second round in the central model in September 2022. The pre-investigated site N-7.2 in the North Sea with 980 MW was tendered at a maximum bid value of 6.4 ct/kWh. The award was given to a subsidiary of RWE with an award value of 0.0 ct/kWh. However, the company Vattenfall made use of its right of entry, so that the award was transferred to Vattenfall.

The amendment to the WindSeeG provides for changes of the tender system in the future. In order to achieve the increased expansion targets, sites that have not been centrally pre-investigated will also be tendered in addition to the sites that have been centrally pre-investigated by the BSH. The award procedure differs depending on the

site. The centrally pre-investigated sites are to be 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). For sites that have not been centrally pre-investigated, the current award procedure will be supplemented by a dynamic regulation in the case of several 0-cent bids. According to these legal changes, two tender rounds are taking place in 2023:

- June 1, 2023: sites not centrally pre-investigated with a total volume of 7,000 MW
- August 1, 2023: sites centrally pre-investigated with a total volume of 1,800 MW

In addition, a site for other offshore energy generation (SEN-1) is to be tendered for the first time; the date is not yet announced.

Envisioned Offshore Sites for Tenders until 2027 (Database: 2. Draft FEP, additional research)

Site	Tender Round	Expected Commissioning	Expected Capacity	Size of Site	Preliminary Investigation	Status Preliminary Investigation
N-3.5	2023	2028	420 MW	ca. 29 km ²	central	Suitability determined (2. WindSeeV)
N-3.6	2023	2028	480 MW	ca. 33 km ²	central	Suitability determined (2. WindSeeV)
N-6.6	2023	2028	630 MW	ca. 44 km ²	central	Ongoing (Draft 3. WindSeeV)*
N-6.7	2023	2028	270 MW	ca. 16 km ²	central	Ongoing (Draft 3. WindSeeV)*
N-11.1	2023	2030	2,000 MW	ca. 205 km ²	not central	
N-12.1	2023	2030	2,000 MW	ca. 193 km ²	not central	
N-12.2	2023	2030	2,000 MW	ca. 187 km ²	not central	
O-2.2	2023	2030	1,000 MW	ca. 92 km ²	not central	
N-9.1	2024	2029	2,000 MW	ca. 158 km ²	central	Ongoing
N-9.2	2024	2029	2,000 MW	ca. 157 km ²	central	Ongoing
N-9.3	2024	2029	1,500 MW	ca. 106 km ²	central	Ongoing
N-11.2	2024	2031	1,500 MW	ca. 156 km ²	not central	
N-12.3	2024	2031	1,000 MW	ca. 80 km ²	not central	
N-10.1	2025	2030	2,000 MW	ca. 151 km ²	central	Ongoing
N-10.2	2025	2030	500 MW	ca. 31 km ²	central	Ongoing
N-13.1	2026	2031	500 MW	ca. 50 km ²	central	
N-13.2	2026	2031	1,000 MW	ca. 91 km ²	central	
N-21.1	2027	2032	2,000 MW	ca. 242 km ²	central	
SEN-1				ca. 95 km ²		

* Suitability was determined with the 3rd WindSeeV coming into force on January 12, 2023.

Overview of Grid Connection Capacities

In Germany, a total of 17 grid connection systems with a total capacity of 8.2 GW were in operation at the end of 2022. Of these, twelve grid connections systems with approx. 7.1 GW are located in the North Sea and five grid connection systems with approx. 1.1 GW in the Baltic Sea. This capacity is used by the offshore wind energy

projects in operation. No new grid connection system was completed in 2022. However, several grid connection systems were under construction in the North Sea and Baltic Sea at the end of 2022, which will provide the necessary grid connection capacities for future offshore wind energy projects.

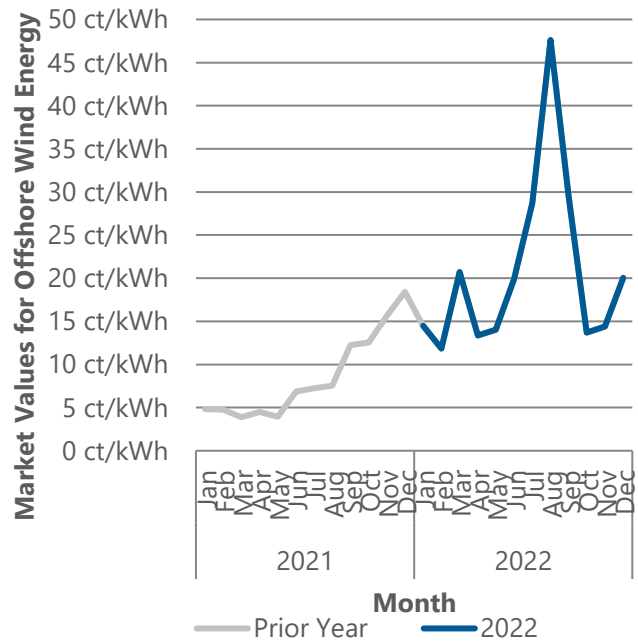
Installed and Planned Grid Connections (to Converter Station or Bundling Point) in the North and Baltic Seas (Database: 2. Draft FEP, Offshore Realisation Agreement 2022, TSOs, additional research)

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	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 incl. Pilotanlagen
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)	Under Construction	2023	900 MW	Gode Wind 3, N-3.7, Nordsee Two
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	N-7.2
NOR-3-2 (DolWin4)	Under Construction	2028	900 MW	N-3.5, N-3.6
NOR-6-3 (BorWin4)	Under Construction	2028	900 MW	N-6.6, N-6.7
NOR-9-1	Planned	2029	2,000 MW	N-9.1
NOR-9-2	Planned	2029	2,000 MW	N-9.2
NOR-9-3	Planned	2029	2,000 MW	N-9.3, N-10.2
NOR-10-1	Planned	2030	2,000 MW	N-10.1
NOR-11-1	Planned	2030	2,000 MW	N-11.1
NOR-12-1	Planned	2030	2,000 MW	N-12.1
NOR-12-2	Planned	2030	2,000 MW	N-12.2
NOR-11-2	Planned	2031	2,000 MW	N-11.2, N-13-1
NOR-13-1	Planned	2031	2,000 MW	N-12.3, N-13.2
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)	Under Construction	2023	250 MW	Arcadis Ost 1
OST-2-2 (Ostwind 2)	Under Construction	2023	250 MW	Baltic Eagle
OST-2-3 (Ostwind 2)	Under Construction	2024	250 MW	Baltic Eagle
OST-1-4 (Ostwind 3)	Approval Procedure	2026	300 MW	Windanker
OST-6-1 ("Gennaker")	Preparation of planning and approval procedures		927 MW	Gennaker
OST-2-4 (Ostwind 4)	Planned	2030	1,000 MW	O-2.2
OST-T-1 (Test Field)				

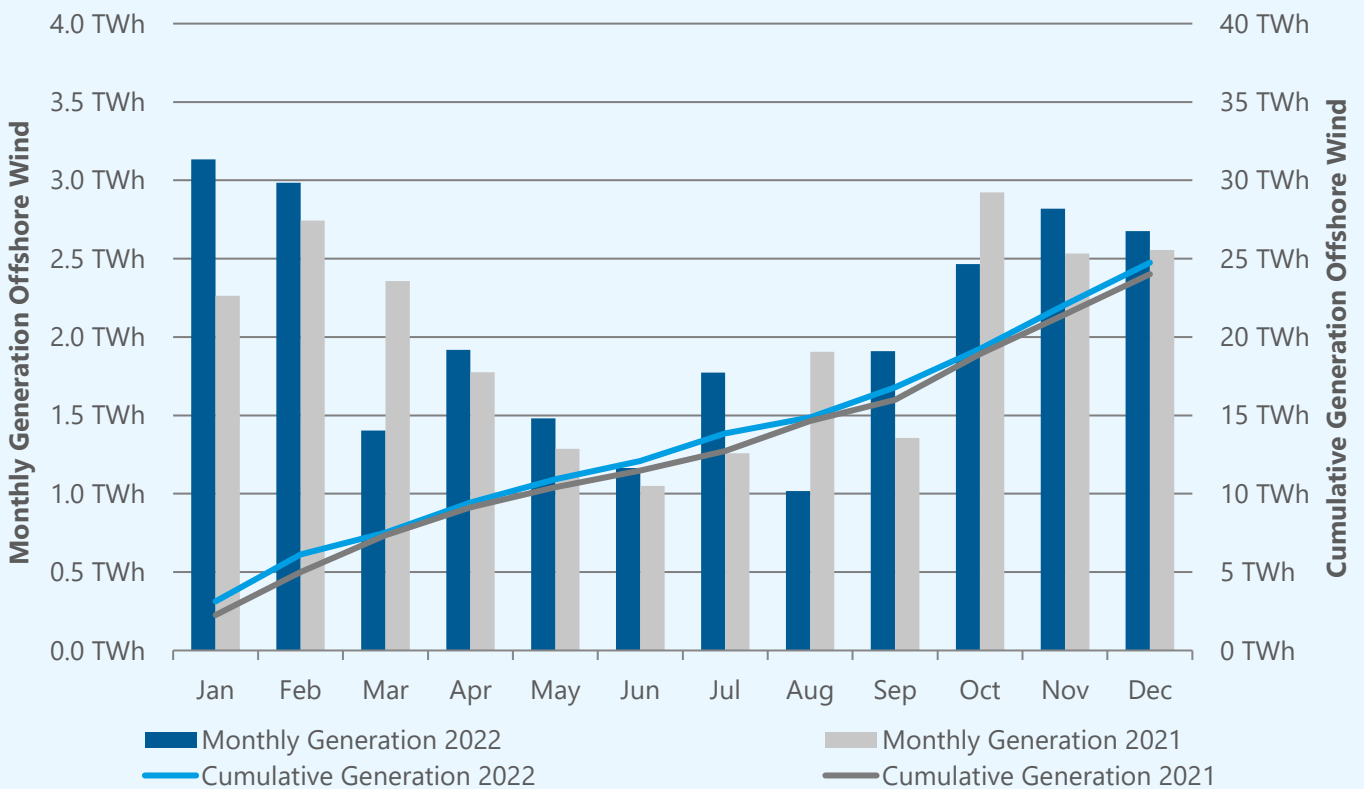
Power Generation and Market Values

The year 2022 was characterised by strong distortions on the energy markets, especially since the beginning of the Ukraine war. The monthly market values for electricity from offshore wind energy reached a high price level throughout 2022. On average, the volume-weighted monthly market value for offshore wind energy in 2022 was 18.35 ct/kWh, about twice as high as the average value in 2021 (9.02 ct/kWh). In August 2022, the record value of 47.61 ct/kWh was achieved, the highest monthly market value for offshore wind energy to date.

Power generation by offshore wind turbines during 2022 was at a similar level as in 2021. A total of 24.7 TWh was generated, about 3% more than in 2021 (24.0 TWh). In the course of 2022, generation was highest in the months of January, February and November.



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 Bundesverband der Windparkbetreiber Offshore e.V. (BWO)

The association of German offshore wind farm operators (BWO) represents all companies that plan, construct and operate offshore wind farms in Germany. The BWO is the central contact on all questions concerning offshore wind energy.

About the German Foundation OFFSHORE WIND ENERGY

The foundation is a leading non-partisan, supra-regional and independent ThinkTank for the development of offshore wind energy in Germany and Europe. It serves as a communication platform for stakeholders from the political, industrial and research sector, enables knowledge exchange and serves as driver of ideas.

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.

Bremerhaven-based WAB is the nationwide contact partner for the offshore wind industry in Germany and the leading business network for onshore wind energy in the north-west region. The association fosters the production of "green" hydrogen from wind energy. It comprises some 250 SMEs as well as institutes from all sectors of the wind and maritime industry as well as research.

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.