

Status of Onshore Wind Energy Development in Germany

Year 2024



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Notes

The analysis within the scope of the Status of Onshore Wind Energy Development is based on the data of the core energy market data register (German: Marktstammdatenregister or MaStR) of the Federal Network Agency (German: Bundesnetzagentur or BNetzA) as well as on the announcements of the BNetzA regarding the tenders for onshore wind energy. The data was partially validated and corrected with regard to various details and supplemented with unrecorded dismantling and repowering properties of projects. Only wind turbines with an installed capacity of over 100 kW are included in the analysis.

The publication of the Status of Onshore Wind Energy Development takes place before the reporting deadline for commissioning in the year of 2024. Further reports increasing the quantity added and decommissioned as well as permits are possible. Furthermore, changes or subsequent reporting of existing turbines to the MaStR may result in deviations from the cumulative portfolio shown.

Some of the figures in the text and illustrations are rounded values. Their addition may therefore result in slight deviations from the total values.

Photo on Title Page

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Wind Energy Development and Status

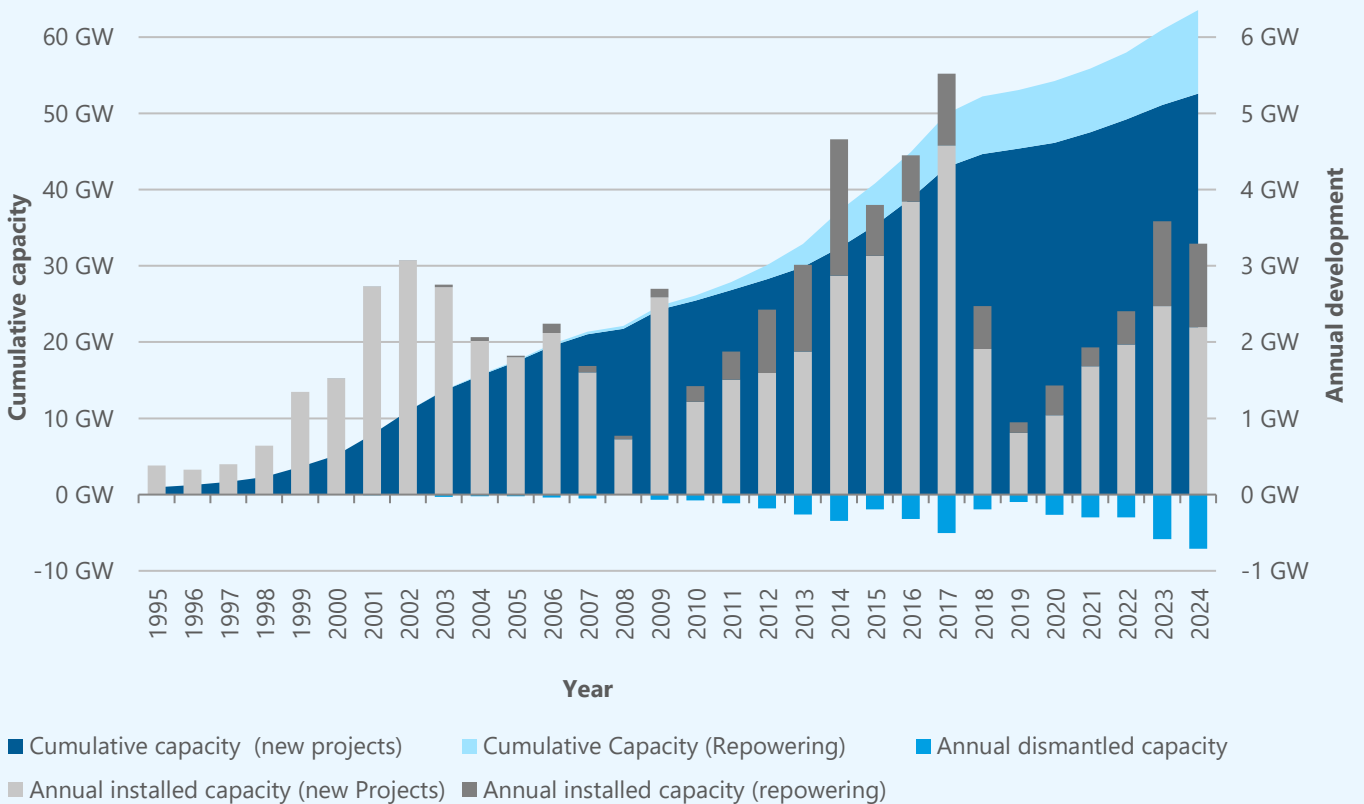
In 2024, 644 new onshore wind turbines (WT) were installed in Germany. Overall, these turbines add up to an installed capacity of 3,292 MW. The annual expansion in 2024 is therefore 8% below the expansion figures for 2023, with the expansion from new projects primarily declining, while the expansion realized as part of repowering projects is at a similar level to the previous year. The additions are offset by the dismantling of 557 wind turbines with a capacity of 712 MW. 2024 is therefore the year with the largest decommissioned capacity to date. The net additions in 2024 will therefore amount to 2,580 MW.

At the end of 2024, the cumulative total of wind turbines amounts to 28,717 with a total capacity of 63,551 MW. The cumulative capacity has thus increased by 4% over the course of 2024. The total

number of installed turbines has also risen slightly by 87 WTGs in comparison to the end of 2023.

Status of onshore wind energy development

		Capacity	Turbines
Cumulative 2023-12-31	Cumulative 2023	60,971 MW	28,630 WT
	Development Year 2024		
Development Year 2024	Gross installations	3,292 MW	644 WT
	Repowering share	1,096 MW	207 WT
	Decommissioning	712 MW	557 WT
	Net installations	2,580 MW	87 WT
Cumulative 2024-12-31	Cumulative 2024	63,551 MW	28,717 WT



Annual development onshore wind energy capacity in Germany

Decommissioning, Continued Operation and Repowering

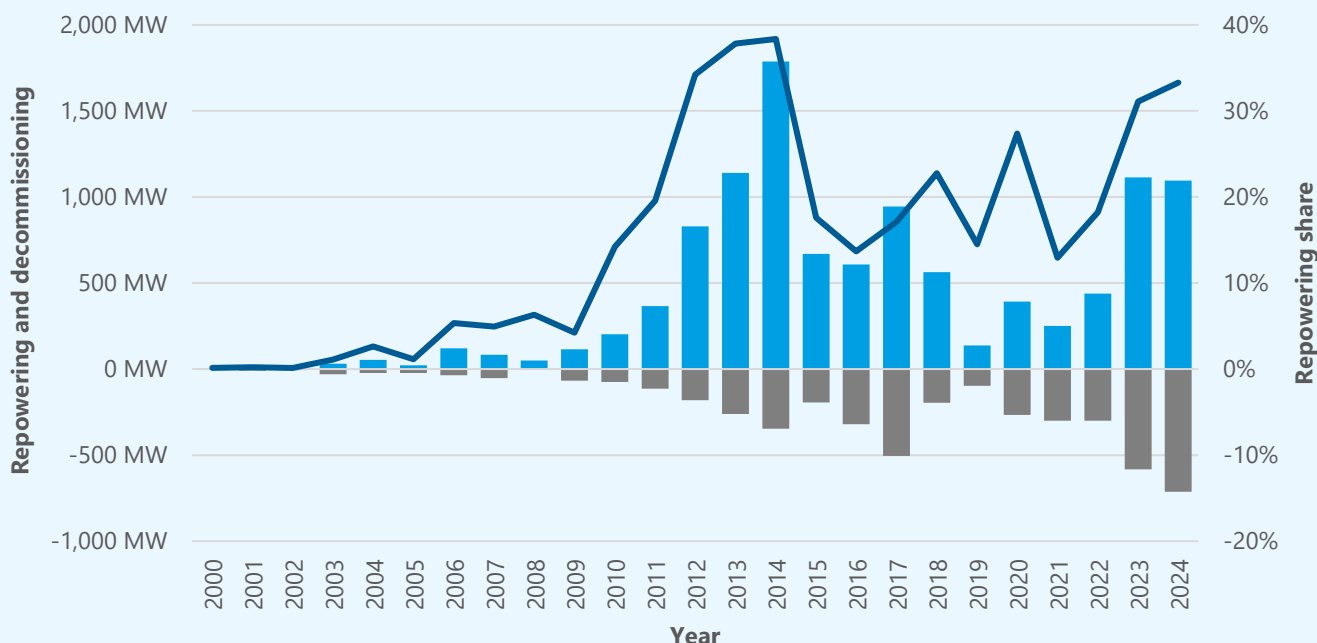
In the course of 2024, 557 wind turbines with a total capacity of 712 MW were decommissioned in Germany. The average operating life of the wind turbines that were dismantled was 22 years. The repowering share of the turbines added in 2024 is 33% and is similar to the level in 2023.

After 20 years of subsidized operation, wind energy plants that have neither been repowered nor decommissioned will continue to operate without subsidies, as they are no longer entitled to subsidies under the EEG. This applies to 8,749 wind turbines with a capacity of just under 9.8 GW in 2024.

For wind turbines that were commissioned in 2004, the entitlement for a subsidy under the EEG will expire at the end of 2024. This affects over 1,000 wind turbines with a capacity of 1.8 GW, which will no longer receive a market premium from 2025 on. The entitlement to subsidies will also gradually lapse for turbines that were commissioned from 2005 onwards.

Age of dismantled and operating wind turbines

Age	Decommissioning Year 2024		Cumulative 2024-12-31	
	Capacity	Turbines	Capacity	Turbines
>20 Years, no funding claim (COD ≤ 2003)	516 MW	449 WT	9,752 MW	8,749 WT
15 - 20 Years (COD 2004 - 2008)	130 MW	78 WT	8,054 MW	4,472 WT
10 - 15 Years (COD 2009 - 2013)	63 MW	29 WT	11,265 MW	5,058 WT
5 - 10 Years (COD 2014 - 2018)	3 MW	1 WT	20,892 MW	7,309 WT
0 - 5 Years (COD 2019 - 2024)	0 MW	0 WT	13,588 MW	3,129 WT
Total	712 MW	557 WT	63,551 MW	28,717 WT



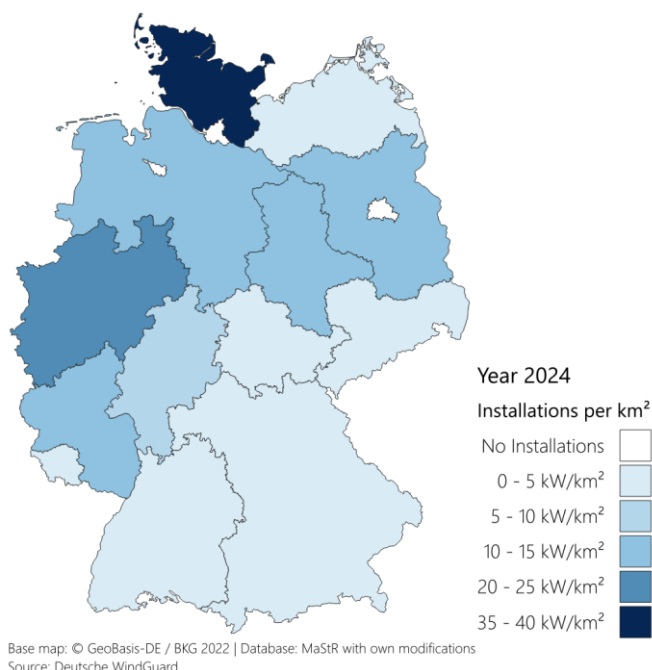
■ Annual installed repowering capacity ■ Annual decommissioning — Repowering share of annual capacity installation

Development of annual decommissioning, annual installed repowering capacity and repowering share

Regional Distribution of Wind Energy Installation

In a comparison between the federal states, North Rhine-Westphalia leads with an addition of 756 MW in 2024, followed by Lower Saxony with an addition of 697 MW and Schleswig-Holstein with 574 MW. Together, these three federal states account for 62% of the total gross additions in 2024. Schleswig-Holstein has thus been ousted from the top spot in terms of absolute annual additions after two years, but is still well ahead of the other federal states in terms of additions per square kilometer of land area. Brandenburg, Saxony-Anhalt and Rhineland-Palatinate are also among the federal states with the highest expansion rates in 2024 and together account for a quarter of the newly installed capacity. Only the three city states will remain without any new wind energy installations in 2024. In Bavaria, Thuringia, Saxony and Saarland, fewer than 10 wind turbines were added in each case. These federal states each contribute a maximum share of

2% to the expansion of onshore wind energy in Germany.



Regional distribution of gross capacity installation

Gross installation, dismantling, net installation and repowering in German federal states

Year 2024		Gross installations			Dismantling and net installation			Repowering		
Position	Federal state	Capacity Installation	Number of new turbines	Share*	Capacity Dismantling	Number of dismantled Turbines	Net Installation	Capacity Repowering	Number of repowering turbines	Repowering-share**
1	North Rhine-Westphalia	756 MW	156 WT	23%	124 MW	118 WT	632 MW	194 MW	38 WT	26%
2	Lower Saxony	697 MW	132 WT	21%	255 MW	166 WT	443 MW	355 MW	68 WT	51%
3	Schleswig-Holstein	574 MW	113 WT	17%	111 MW	73 WT	464 MW	208 MW	38 WT	36%
4	Brandenburg	360 MW	69 WT	11%	33 MW	26 WT	327 MW	56 MW	10 WT	15%
5	Saxony-Anhalt	262 MW	48 WT	8%	73 MW	58 WT	189 MW	139 MW	27 WT	53%
6	Rhineland-Palatinate	206 MW	42 WT	6%	51 MW	39 WT	154 MW	42 MW	7 WT	20%
7	Hesse	119 MW	22 WT	4%	10 MW	18 WT	109 MW	26 MW	4 WT	22%
8	Baden-Württemberg	111 MW	24 WT	3%	5 MW	3 WT	105 MW	21 MW	4 WT	19%
9	Mecklenburg-Western Pomerania	89 MW	16 WT	3%	17 MW	24 WT	73 MW	21 MW	4 WT	24%
10	Bavaria	50 MW	9 WT	2%	4 MW	4 WT	46 MW	0 MW	0 WT	0%
11	Thuringia	35 MW	6 WT	1%	13 MW	9 WT	22 MW	17 MW	3 WT	49%
12	Saxony	24 MW	5 WT	1%	15 MW	18 WT	9 MW	13 MW	3 WT	53%
13	Saarland	10 MW	2 WT	0%	2 MW	1 WT	8 MW	4 MW	1 WT	43%
	Berlin	0 MW	0 WT	0%	0 MW	0 WT	0 MW	0 MW	0 WT	-
	Hamburg	0 MW	0 WT	0%	0 MW	0 WT	0 MW	0 MW	0 WT	-
	Bremen	0 MW	0 WT	0%	0 MW	0 WT	0 MW	0 MW	0 WT	-
	Germany	3,292 MW	644 WT		712 MW	557 WT	2,580 MW	1,096 MW	207 WT	33%

Average Turbine Configuration and Regional Differences

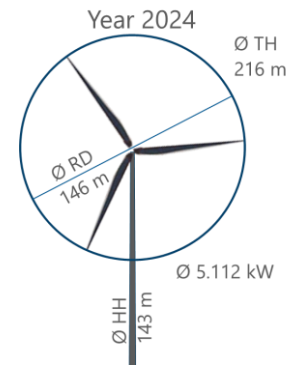
On average, the wind turbines installed in 2024 have a rated power of 5,112 kW and a total height of 216 m. Compared to the average turbine configuration of the previous year 2023, both the turbine output has increased by 7% and the total height by 5%, continuing the trend towards ever more powerful and larger wind turbines. The average rotor diameter is 146 m and the hub height is 143 m. The specific power averages 302 W/m².

The range of average rated power per federal state is between 4.6 and 5.8 MW. The turbines with the lowest average capacity were installed in Baden-Württemberg in 2024, while the new wind turbines with the highest average capacity are located in Thuringia. The total height of new wind turbines in

Schleswig-Holstein in 2024 is also well below average at 179 m on average. The highest turbines on average (over 240 m) were erected in Bavaria, Thuringia and Hesse.

Average wind turbine configuration

Installations Year 2024	Change compared to prior year
Rated power	+7%
Rotor Diameter	+4%
Hub Height	+5%
Tip Height	+5%



Average turbine configuration of newly installed wind turbines in German federal states

Installations Year 2024	Average configuration of newly installed turbines					
	State	Number of turbines	Rated power	Rotor diameter	Hub height	Tip height
North Rhine-Westphalia	156 WT	4,845 kW	144 m	140 m	212 m	293 W/m ²
Lower Saxony	132 WT	5,281 kW	149 m	147 m	222 m	299 W/m ²
Schleswig-Holstein	113 WT	5,082 kW	139 m	109 m	179 m	331 W/m ²
Brandenburg	69 WT	5,219 kW	151 m	162 m	237 m	292 W/m ²
Saxony-Anhalt	48 WT	5,458 kW	152 m	159 m	235 m	299 W/m ²
Rhineland-Palatinate	42 WT	4,900 kW	143 m	149 m	220 m	306 W/m ²
Hesse	22 WT	5,396 kW	153 m	165 m	242 m	293 W/m ²
Baden-Württemberg	24 WT	4,616 kW	141 m	155 m	226 m	295 W/m ²
Mecklenburg-Western Pomerania	16 WT	5,579 kW	152 m	148 m	224 m	309 W/m ²
Bavaria	9 WT	5,542 kW	156 m	166 m	244 m	288 W/m ²
Thuringia	6 WT	5,817 kW	156 m	165 m	243 m	302 W/m ²
Saxony	5 WT	4,772 kW	145 m	154 m	227 m	289 W/m ²
Saarland	2 WT	4,900 kW	144 m	163 m	235 m	298 W/m ²
Bremen	0 WT	-	-	-	-	-
Hamburg	0 WT	-	-	-	-	-
Berlin	0 WT	-	-	-	-	-
Germany	644 WT	5,112 kW	146 m	143 m	216 m	302 W/m²

Turbine Manufacturers and Types

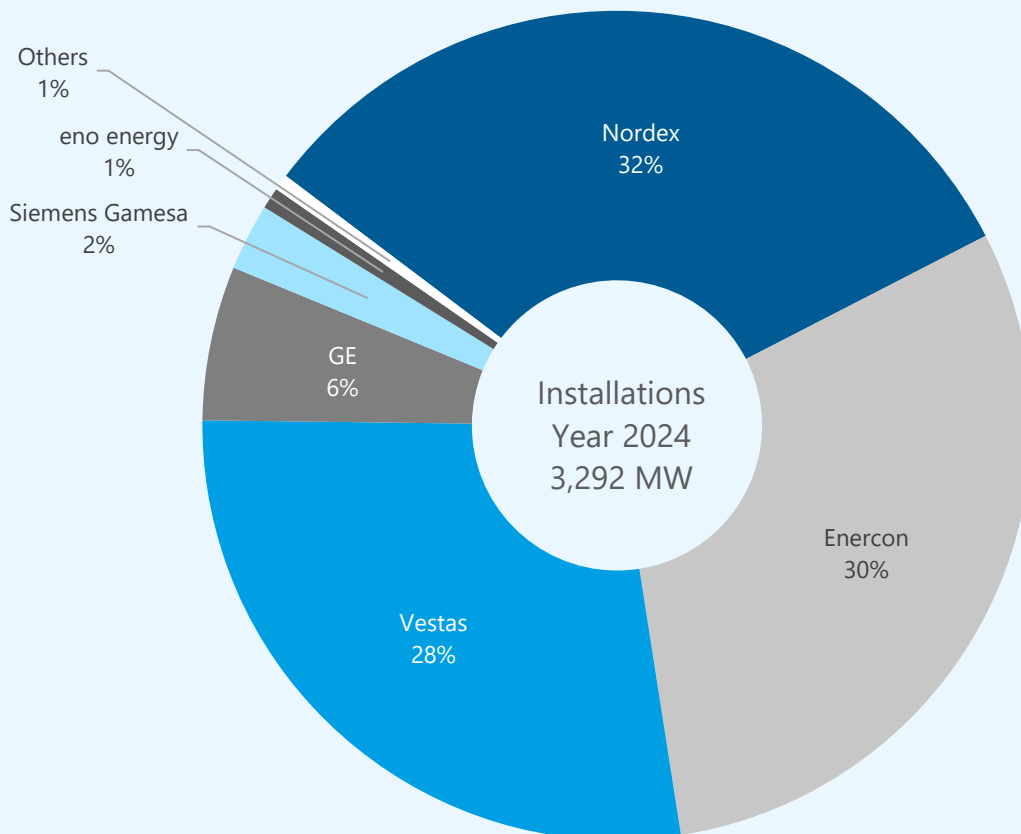
In 2024, the wind turbine manufacturers Nordex, Enercon and Vestas held a total of 90% of the market share of capacity additions in Germany. Nordex achieved the largest market share with 32%, resulting from capacity additions of 1,059 MW. Enercon follows with 30% and Vestas with 28%, meaning that the dominant manufacturers can each claim similarly high market shares. GE follows in fourth place with a market share of 6%. Siemens Gamesa and eno energy can be assigned 2% and 1% of the market volume in 2024 respectively.

The list of the most popular turbine types is accordingly dominated by the market leaders. Enercon provides the most frequently erected turbine type E 138 EP3 E2 with a turbine output of 4.2 MW and 85 new wind turbines. The only turbine type in the top ten that is not produced by

the three dominant turbine manufacturers is the turbine type GE 5.5-158, provided by GE, which reaches 6th place.

Most popular turbine types

Rank	Manufacturer	Type
1	Enercon	E-138 EP3 E2 4,2 MW
2	Nordex	N149/5.X
3	Enercon	E-160 EP5 E3
4	Vestas	V162-6.2 MW
5	Vestas	V150-6.0 MW
6	GE	GE 5.5-158
7	Nordex	N163/6.X
8	Nordex	N133/4.8
9	Nordex	N149/4.X
10	Enercon	E-115 EP3 E3 4,2 MW



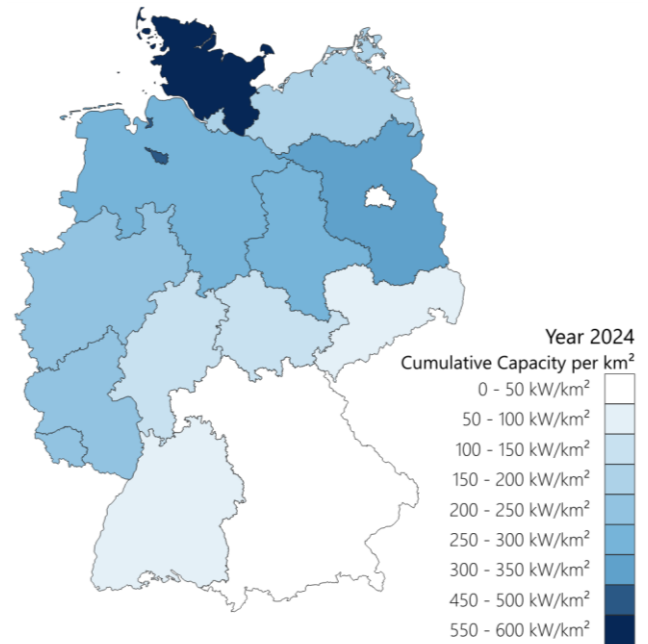
Manufacturers' market share of onshore capacity additions in Germany

Regional Distribution of the Cumulative Portfolio

The cumulative total in 2024 is 28,717 wind turbines with a total capacity of 63.6 GW. At around 13 GW, Lower Saxony has the highest total installed capacity and thus accounts for 20% of the total nationwide capacity, followed by the federal states of Brandenburg and Schleswig-Holstein, which each contribute 14% of the total capacity. North Rhine-Westphalia contributes 12% and Saxony-Anhalt 9% to the total capacity.

In terms of capacity per state area, Schleswig-Holstein is well ahead of the other federal states with 568 kW/km². Bremen also makes a comparatively large contribution of 483 kW/km² in view of its small area. Brandenburg follows at a considerable distance with 303 kW/km², as do Lower Saxony and Saxony-Anhalt, whose power density is between 250 and 300 kW/km². Both Bavaria and Berlin have a particularly low power density of less than 50 kW/km², while Baden-

Württemberg and Saxony also have low values of between 50 and 100 kW/km².



Base map: © GeoBasis-DE / BKG 2022 | Database: MaStR with own modifications
Source: Deutsche WindGuard

Regional distribution of cumulative capacity

Cumulative capacity and number of wind turbines in the German federal states

Cumulative portfolio* (2024-12-31)				
Federal state	Cumulative capacity	Cumulative number	Share	Capacity per area
Lower Saxony	12,967 MW	6,123 WT	20%	272 kW/km ²
Brandenburg	8,992 MW	4,079 WT	14%	303 kW/km ²
Schleswig-Holstein	8,984 MW	3,266 WT	14%	568 kW/km ²
North Rhine-Westphalia	7,800 MW	3,650 WT	12%	229 kW/km ²
Saxony-Anhalt	5,512 MW	2,734 WT	9%	269 kW/km ²
Rhineland-Palatinate	4,158 MW	1,781 WT	7%	209 kW/km ²
Mecklenburg-Western Pomerania	3,795 MW	1,844 WT	6%	163 kW/km ²
Bavaria	2,679 MW	1,152 WT	4%	38 kW/km ²
Hesse	2,644 MW	1,184 WT	4%	125 kW/km ²
Baden-Württemberg	1,896 MW	800 WT	3%	53 kW/km ²
Thuringia	1,855 MW	867 WT	3%	114 kW/km ²
Saxony	1,371 MW	858 WT	2%	74 kW/km ²
Saarland	553 MW	219 WT	1%	215 kW/km ²
Bremen	203 MW	87 WT	0%	483 kW/km ²
Hamburg	125 MW	67 WT	0%	166 kW/km ²
Berlin	17 MW	6 WT	0%	19 kW/km ²
Germany	63,551 MW	28,717 WT		178 kW/km²

* with a minimum turbine capacity of > 100 kW

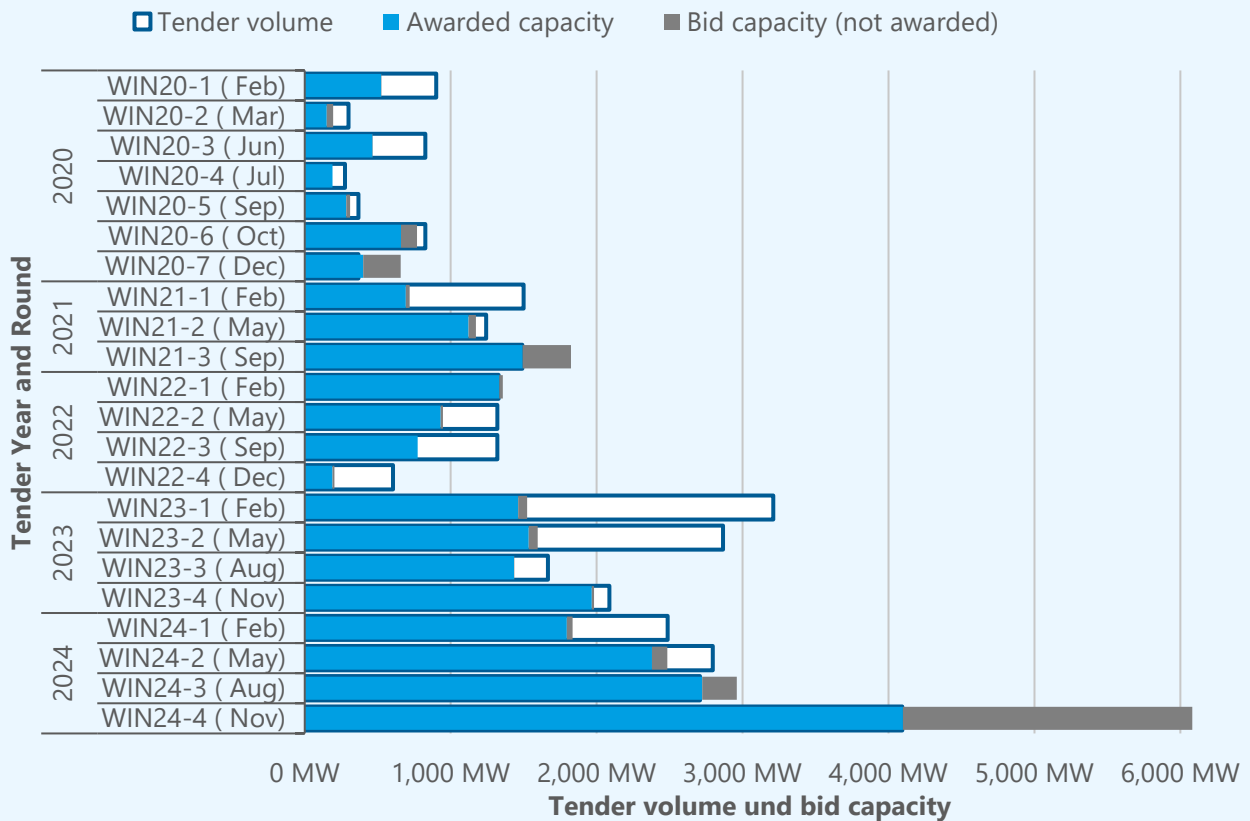
Results of Tender Rounds

The Federal Network Agency (German: Bundesnetzagentur or BNetzA) conducted four tendering rounds for onshore wind energy in 2024. The number of bids increased with each round over the course of the year, with the result that competition in the tenders returned for the first time in the second half of the year. In the fourth tendering round of the year, an oversubscription of almost 50% was achieved despite full tendering of the planned capacity. The capacity awarded in 2024 amounts to 11.0 GW and represents a new record in German tenders. The average award value of the tender rounds in 2024 is 7.26 ct/kWh and thus below the average award value of the previous year. The maximum permissible value for bids in the tenders has been

7.35 ct/kWh since 2023 and has also been set at this value for the tenders in the coming year 2025.

Development of awarded bids of tender rounds for onshore wind energy in Germany (Database: BNetzA)

	Year	Maximum permissible value	Average capacity-weighted award value
Tender Year	2020	6.20 ct/kWh	6.11 ct/kWh
	2021	6.00 ct/kWh	5.88 ct/kWh
	2022	5.88 ct/kWh	5.81 ct/kWh
	2023	7.35 ct/kWh	7.33 ct/kWh
	2024	7.35 ct/kWh	7.26 ct/kWh



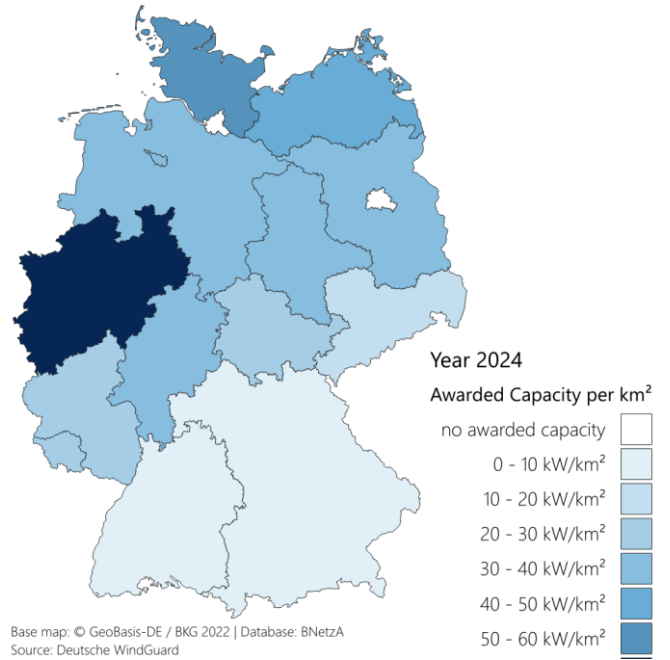
Competitive situation in tender system for onshore wind energy (Database: BNetzA)

Regional Distribution of Awarded Bids

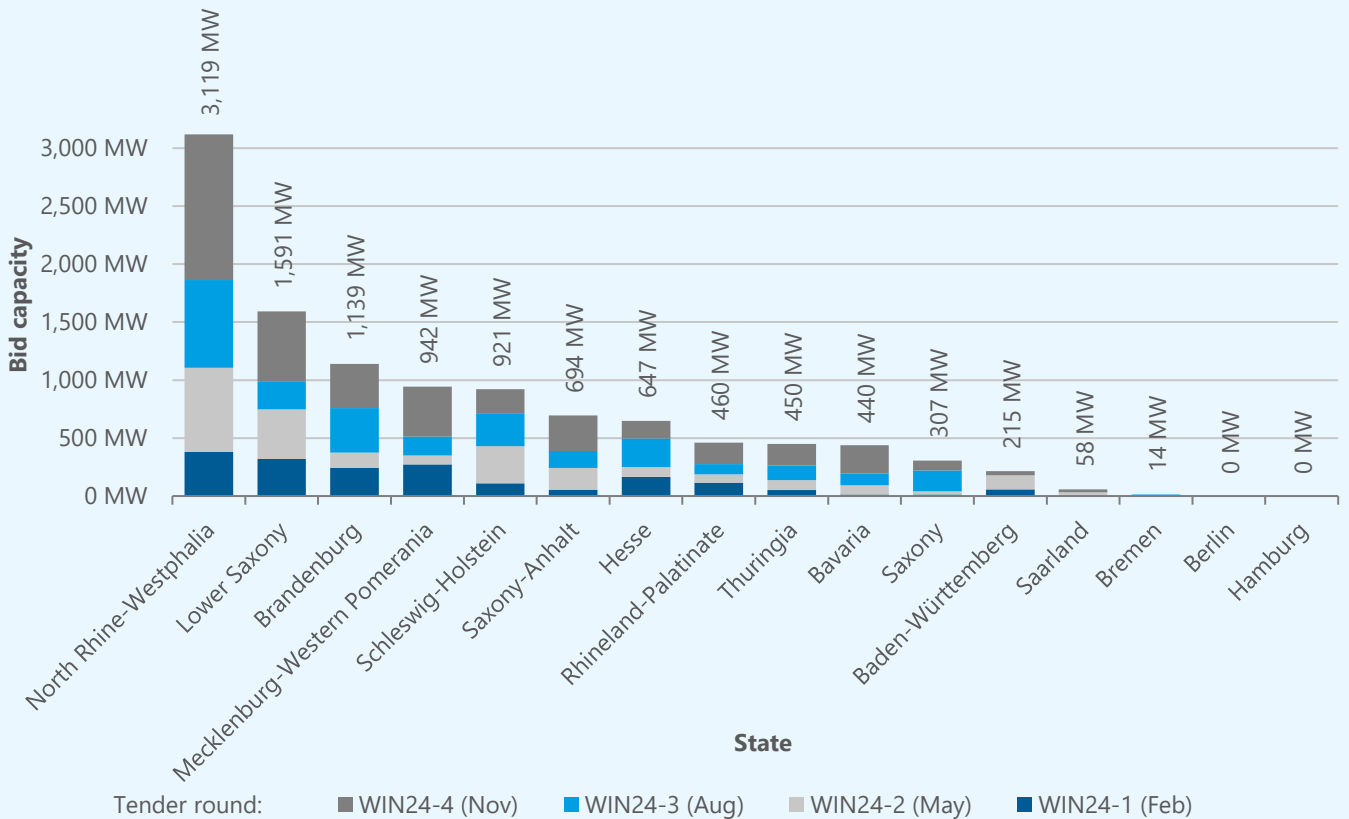
In 2024, wind turbines from all federal states apart from Hamburg and Berlin were awarded in at least one of the four tendering rounds. With 3.1 GW, North Rhine-Westphalia has the largest award volume, which is almost twice as large as that of the federal state with the second-largest volume. This corresponds to 28% of the total awarded capacity. North Rhine-Westphalia is also clearly ahead of the other federal states in terms of the amount added per state area.

Lower Saxony achieves a share of 14% of the awarded volume; Brandenburg reaches 10%. In the other federal states, the share of the added capacity in 2024 is 9% or less.

The federal states in the south of Germany are in the lower half of the ranking both in terms of absolute values and in terms of area-related surcharge volumes. This continues the north-south divide that has existed for years.



Regional distribution of awarded capacity across the federal states (Database: BNetzA)



Regional distribution of awarded capacity across the German federal states (Database: BNetzA)

Development Status of Awarded Turbines

Of the 26.6 GW of wind energy capacity that has been awarded since 2020, 9.6 GW has been realized by the end of 2024. The deadline for realizing the unused awards of around 0.8 GW has already expired. If the deadline has not been extended, these awards will expire and the turbines in question can participate in the tenders again.

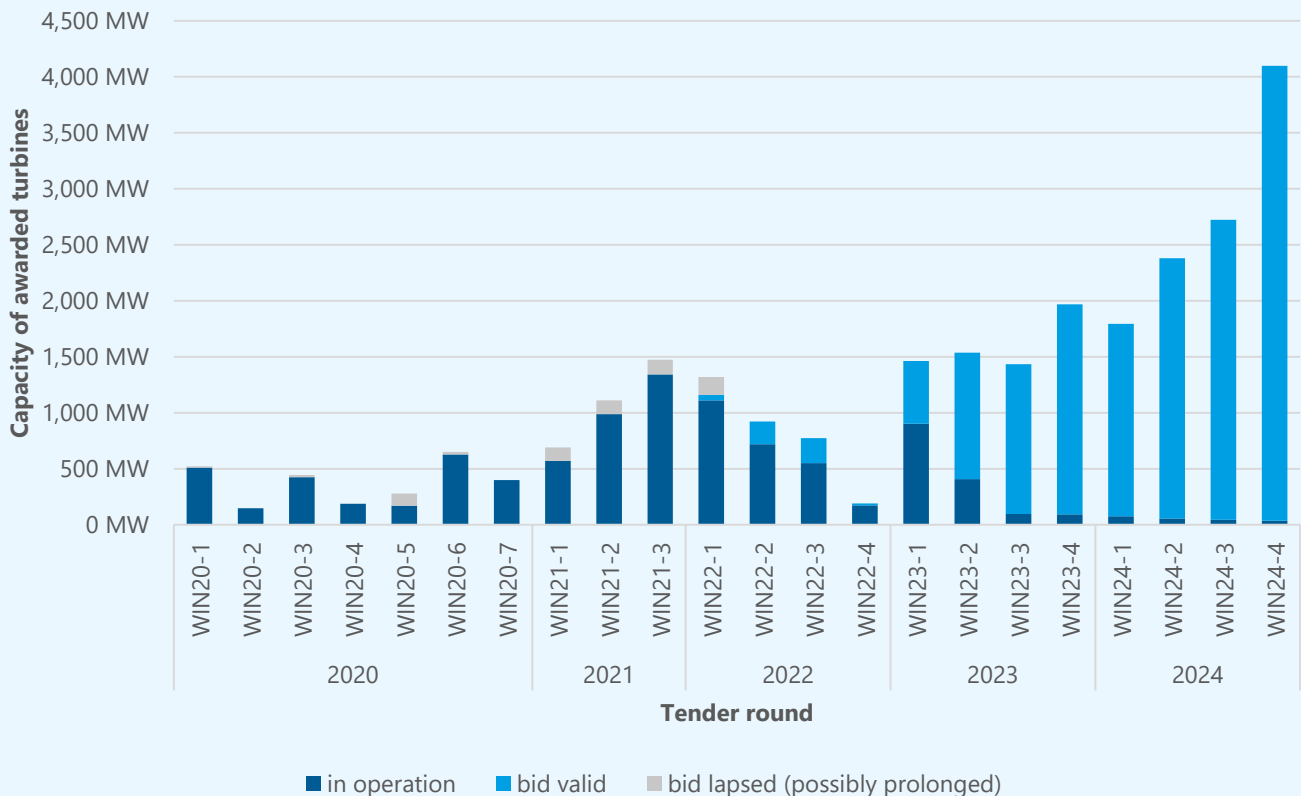
In the tender years 2020 to 2022, the realization rates are well above the realized awards of the last two years with an average of 86%. The realization rate for the award year 2020 is 92%, 88% in 2021 and 79% in 2022. In contrast, the realization rate for the volume awarded in 2023 is 23% and 2% for the volume awarded in 2024. The low realization rates in 2023 and 2024 can be explained by the fact that the realization of these awarded wind turbines is only just beginning. On average, the

period between the award and commissioning of the wind turbines commissioned in 2024 is 20 months.

Realized capacity* of tenders for onshore wind energy in Germany

	Year	Realized capacity*	Realization rate
Year of tender	2020	2,468 MW	92%
	2021	2,899 MW	88%
	2022	2,554 MW	79%
	2023	1,498 MW	23%
	2024	213 MW	2%

* The evaluations represent an assessment of the development status based on an analysis of the MaStR and the awards issued by BNetzA. Deviations from actually allocated awards are possible. It was assumed that the award volume corresponds to the permitted/installed capacity.



Development status* of awarded capacity (Database: BNetzA, MaStR, own research and assumptions)

Permitted Capacity and Development Status

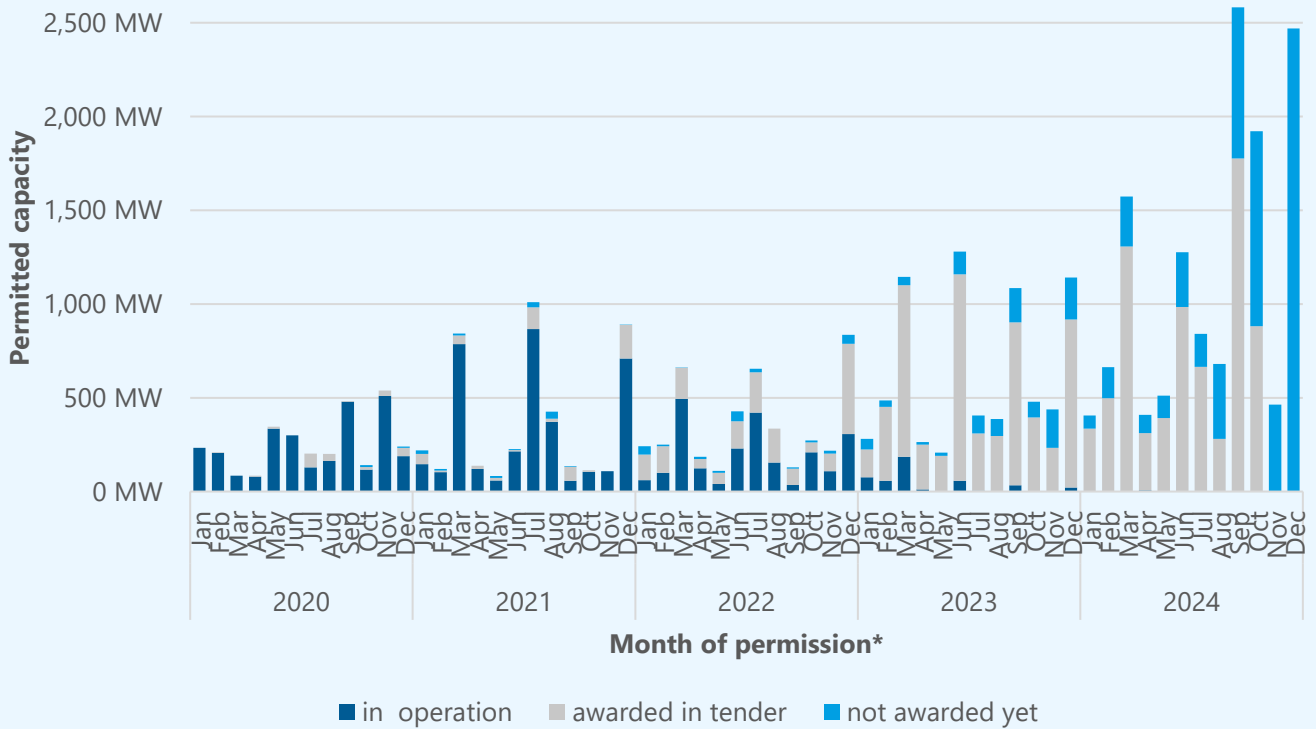
In 2024, 2,344 wind turbines with a total capacity of 13.8 GW were permitted. Compared to the previous year 2023, this represents an increase in permit capacity of 82%. The approved volume in 2024 is more than three times as high as in 2021 and 2022 and more than four times as high the permitted volume in 2020.

In the course of 2024, 54% of the newly approved wind turbines have already been awarded funding under the EEG in the tenders. Permits issued in November and December 2024 have not yet been able to participate in a tender. In addition, other turbines with permits from previous years have not yet been awarded a contract. This means that almost 7.9 GW of approved capacity is already available for the tender rounds in 2025.

Only a few of the wind turbines permitted in 2020 and 2021 are not yet in operation. The realization of the approved wind turbines in 2022 is also well advanced, while the realization of the approved wind turbines in 2023 is just starting. Only a few wind turbines that were permitted in 2024 have been in operation by the end of 2024.

Annual permitted capacity

	Year	Permitted capacity	Permitted wind turbines
Year of permission	2020	3,062 MW	688 WT
	2021	4,314 MW	887 WT
	2022	4,324 MW	836 WT
	2023	7,597 MW	1,379 WT
	2024	13,797 MW	2,344 WT



* Permits with an updated permit date have been dated back to the date of the first registration in MaStR.

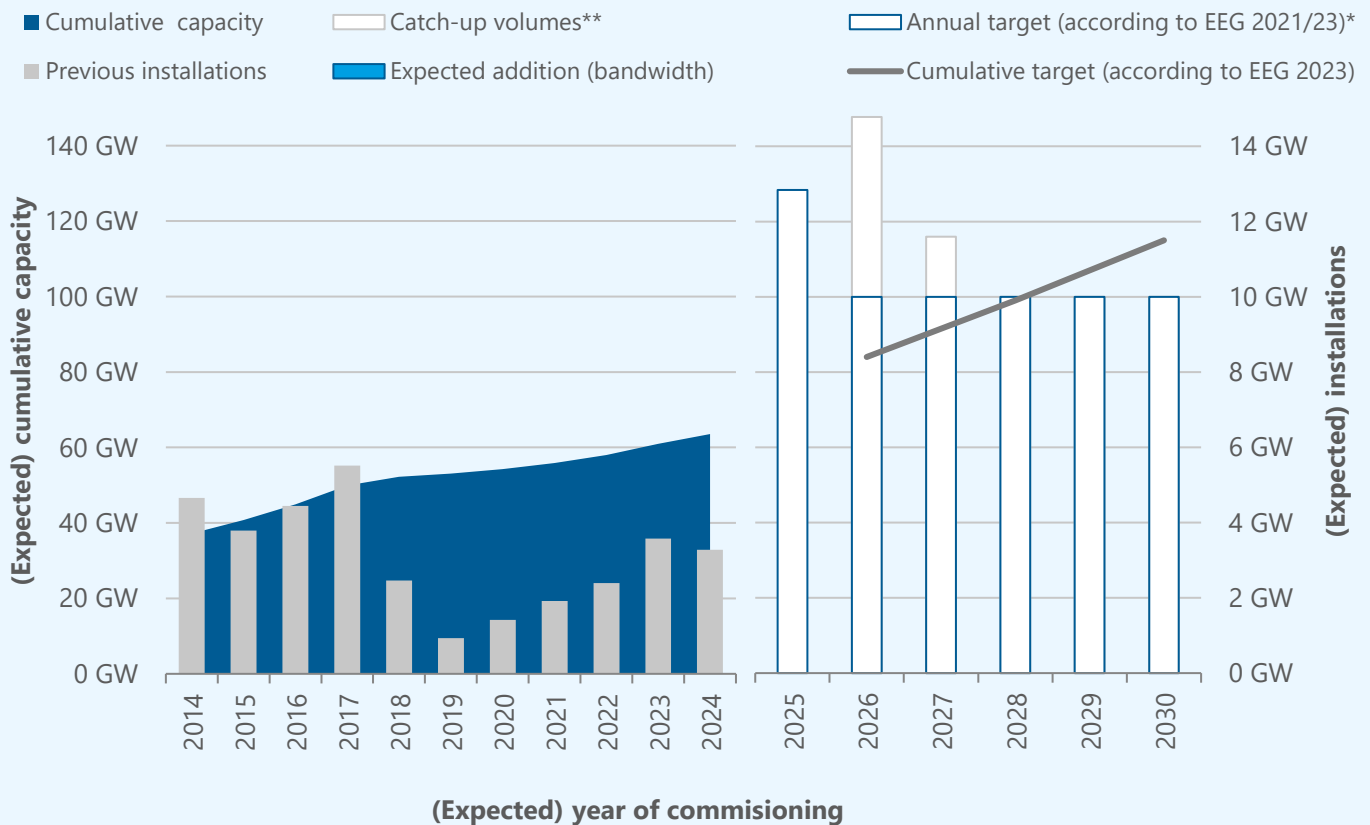
Monthly permitted capacity including status

Political Target and Future Tender Rounds

The EEG 2023 defines the development path for onshore wind energy. For the year 2024, a cumulative total of 69 GW was planned to achieve the statutory target. Of this, 63.5 GW was achieved. The next interim target defined in the law is set for 2026 and amounts to 84 GW. In the next two years, a net addition of over 20 GW will be required to achieve this. According to the EEG 2023, the total capacity across Germany is to increase steadily to 115 GW by 2030.

The tendering volumes defined in the EEG determine the annual gross additions required to compensate for the expected dismantling. The EEG stipulates that tender volumes that are not awarded at the specified time can be put out to

tender again in the following year as so-called catch-up volumes. As a result, competition-related reductions in tender volumes and the signing of tender rounds automatically increase demand in the following years - until the targets can be met. The first tendering round in 2025 (WIN25-1) was already subject to an increase for catch-up volumes from 2023. Due to the lack of participating volumes in the of tenders in the first half of 2024, the designation of catch-up volumes is also expected for the four subsequent tender rounds (WIN25-2 to WIN26-1). The specific distribution will be announced by the Federal Network Agency in spring 2025.



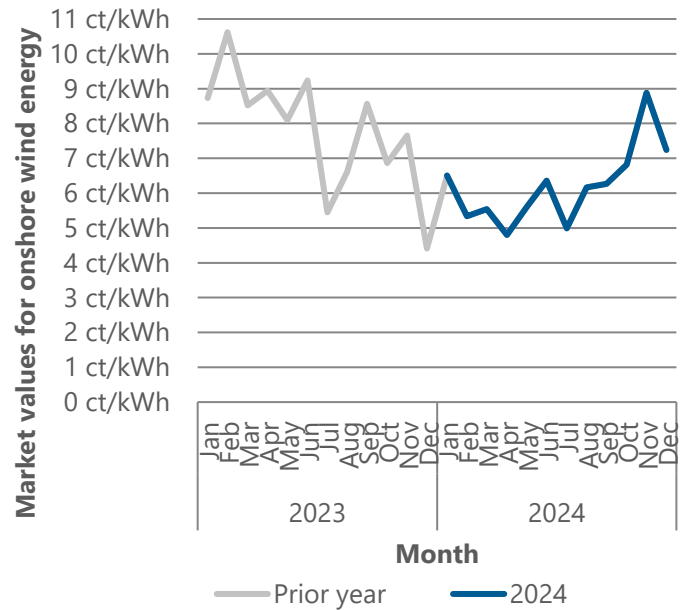
Expected installations in 2024 and political targets according to EEG 2021/23

**derived from the (planned) tender quantities in the year before the previous year
 **Tender volume corrected in accordance with § 28 EEG

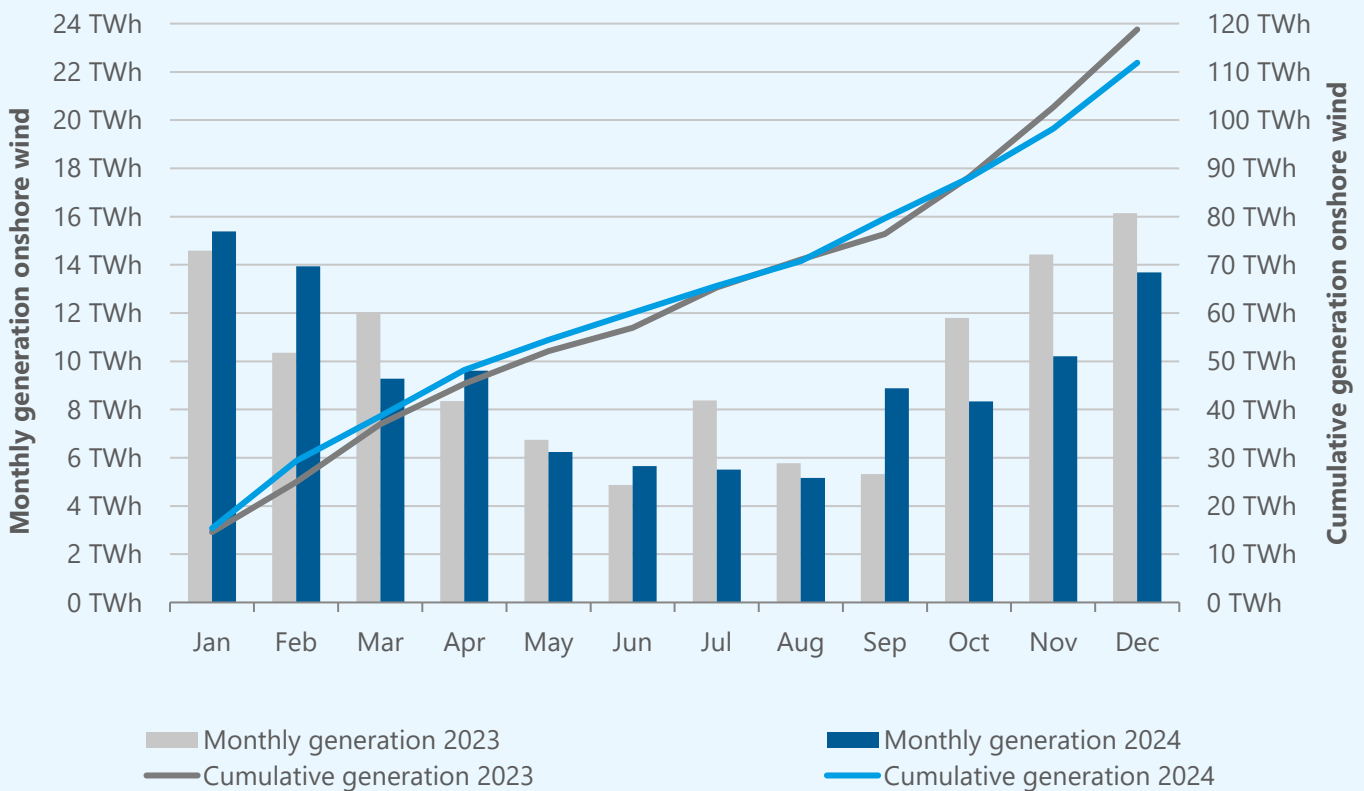
Power Generation and Market Values

In 2024, the onshore wind turbines installed in Germany generated 112 TWh of electricity. Compared to 2023, electricity generation from onshore wind energy is thereby 6% lower than in the previous year. With a share of 25.9% of total generation, onshore wind energy is still the most important energy source for electricity generation in Germany.

The market value of onshore wind energy fell overall over the course of 2023. The annual market value averaged 7.62 ct/kWh. In December 2023, the value fell below 5 ct/kWh for the first time since spring 2021. In contrast to 2023, an upward trend in the market value of onshore wind energy was observed again in 2024. However, at 6.29 ct/kWh, the average annual market value in 2024 was 17% below the annual market value in 2023.



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



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

Deutsche WindGuard – The Wind Professionals

Deutsche WindGuard is one of the leading independent service providers in the wind energy industry. It offers comprehensive services and consulting along the entire value chain of a wind energy project.

One key area of activity is advising federal and state governments on issues relating to onshore and offshore wind energy as well as preparing market, cost and value creation analyses for various associations and other stakeholders in the wind energy sector and politics.

Further business activities include technical inspections and management, site assessment, measurements on wind turbines, wind tunnel measurements, offshore, consulting and certification. In the complex energy market, Deutsche WindGuard is committed to providing unbiased, manufacturer-independent consulting and comprehensive scientific, technical, and operational services.

Deutsche WindGuard was founded in 2000. With the headquarters in Varel and subsidiaries in Germany, the United States, China and India, it employs more than 200 experienced experts.