

Status of Onshore Wind Energy Development in Germany

Year 2022



On behalf of



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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. Turbines with 100 kW and below are not included in the analysis.

The publication of the status of onshore wind energy takes place before the reporting deadline for commissioning in the first half of 2022. Further reports increasing the amount added and withdrawn as well as permits are possible. Further reports that increase the installed capacity are possible. Furthermore, changes or subsequent reporting of existing turbines to the MaStR may result in deviations from the 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 2022, 551 onshore wind turbines (WT) were installed in Germany. In total, the new turbines have a capacity of 2,403 MW. The previous year's installations were thus exceeded by 25% and the upward trend of the years since 2019 has continued. Nonetheless, the installation of new capacity remains well below that of the record years 2014 - 2017.

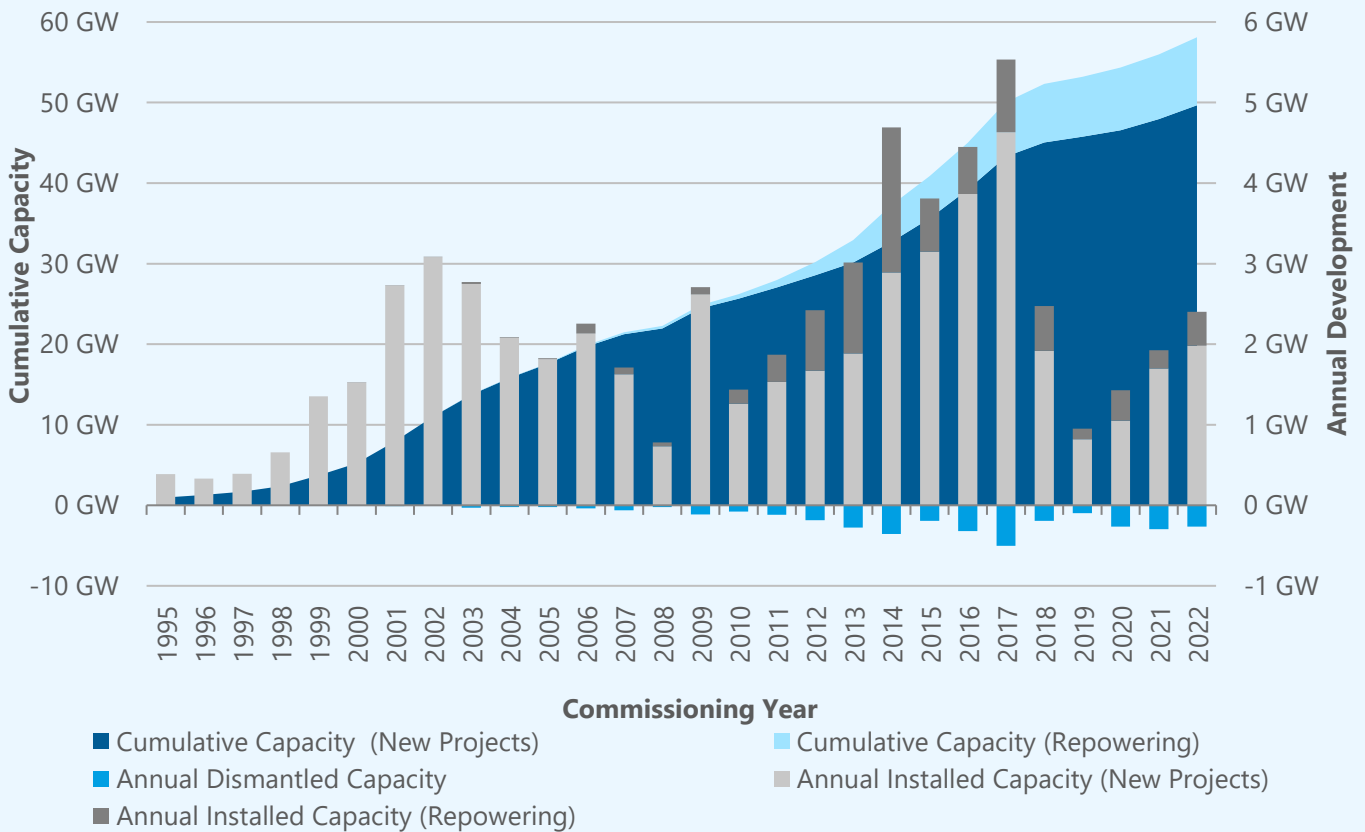
In the course of 2022, 246 wind turbines with a capacity of 266 MW were dismantled. These mostly old turbines with low capacity were partially replaced by the 103 repowering turbines installed. A net installation of 2,137 MW thus contributes to the achievement of the expansion targets.

The cumulative installed base at the end of 2022 amounts to 28,443 wind turbines with a total capacity of 58,106 MW. Compared to the previous

year, the cumulative capacity has increased by 4.3%. The target set in the EEG 2021 of 57 GW in 2022 was achieved.

Status of Onshore Wind Energy Development

		Capacity	Turbines
Development Year 2022	Gross installations	2,403 MW	551 WT
	Repowering share	423 MW	103 WT
	Decommissioning	266 MW	246 WT
	Net installations	2,137 MW	305 WT
Cumulative 2022-12-31	Cumulative	58,106 MW	28,443 WT



Annual Development Onshore Wind Energy Capacity in Germany

Decommissioning, Continued Operation and Repowering

During the year 2022, 246 wind turbines were decommissioned. The average age of all decommissioned turbines was 21 years.

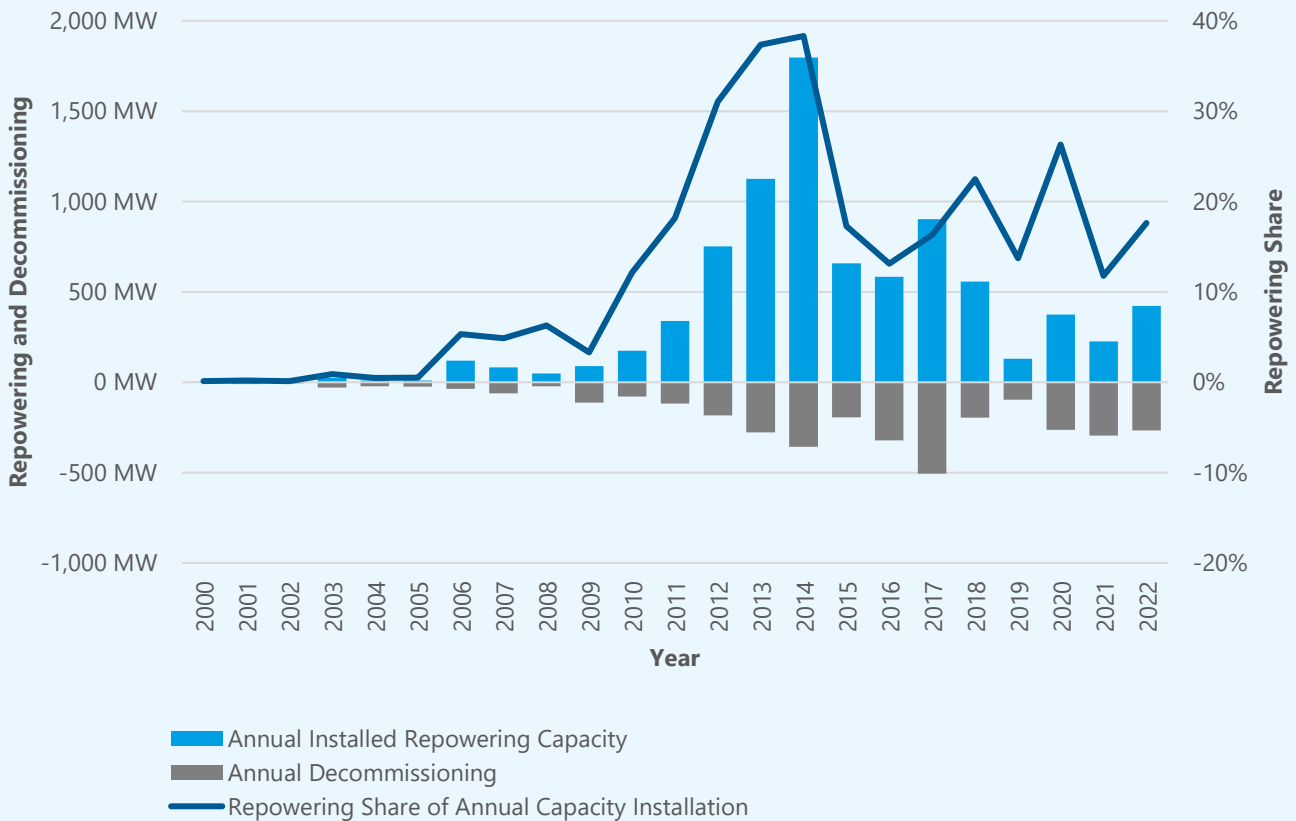
More than half of these turbines had already lost their claim to subsidies under the EEG and were still in operation at the time of decommissioning. At the end of the year, further 5,999 turbines (5,447 MW) were in operation without entitlement to subsidies. This age category represents 9% of the capacity stock. Turbines commissioned in 2002 will also lose their claim to subsidies as of January 1, 2023. As long as they are not decommissioned for technical or economic reasons or replaced by new turbines in the course of repowering, these turbines can continue to operate.

In 2022, 103 wind turbines with 423 MW were installed as part of repowering projects. This corresponds to 18% share of gross installations.

The majority of the new installations in 2022 were new projects or park expansions.

Age of dismantled and existing Wind Turbines

Age	Decommissioned Year 2022		In Operation 2022-12-31	
	Capacity	Turbines	Capacity	Turbines
>20 Years, no funding claim (COD ≤ 2001)	145 MW	145 WT	5,447 MW	5,999 WT
15 - 20 Years (COD 2002 - 2006)	94 MW	88 WT	11,214 MW	6,995 WT
10 - 15 Years (COD 2007 - 2011)	23 MW	12 WT	8,363 MW	4,212 WT
5 - 10 Years (COD 2012 - 2016)	3 MW	1 WT	18,367 MW	6,874 WT
0 - 5 Years (COD 2017 - 2022)	0 MW	0 WT	14,716 MW	4,363 WT
Total	266 MW	246 WT	58,106 MW	28,443 WT

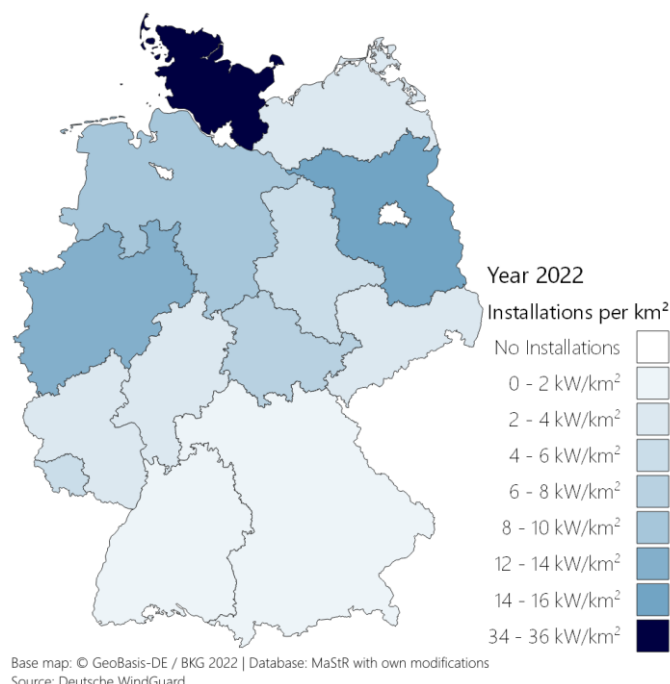


Development of Annual Decommissioning, Annual Installed Repowering Capacity and Repowering Share

Regional Distribution of Wind Energy Installation

Schleswig-Holstein, Lower Saxony, Brandenburg and North Rhine-Westphalia account for 77% of new installations. Due to the small area, Schleswig-Holstein stands out in particular for the high level of new installations, doubling the amount of new installations compared to the previous year. Lower Saxony and Brandenburg maintain the level of the previous year, and North Rhine-Westphalia is able to increase new installations by almost a quarter. All other states install less than 5% of gross new capacity.

Apart from the city states, where no new turbines were installed, Bavaria, Baden-Württemberg and Saarland come in last in the ranking of new installations. The two southernmost states, Bavaria and Baden-Württemberg, are installing particularly little new capacity in relation to the area of the state. As in previous years, a north-south divide in new installations remains visible.



Regional Distribution of Gross Capacity Installation

Gross Installation, Dismantling, Net Installation and Repowering in German Federal States

Position	Year 2022 Federal State	Gross Installations			Dismantling and Net Installation			Repowering		
		Capacity Installation	Number of new Turbines	Share*	Capacity Dismantling	Number of Dismantled Turbines	Net Installation	Capacity Repowering	Number of Repowering Turbines	Repowering-Share**
1	Schleswig-Holstein	545 MW	132 WT	23%	75 MW	56 WT	470 MW	131 MW	34 WT	24%
2	Lower Saxony	462 MW	99 WT	19%	36 MW	31 WT	425 MW	71 MW	16 WT	15%
3	Brandenburg	425 MW	91 WT	18%	37 MW	37 WT	387 MW	49 MW	12 WT	12%
4	North Rhine-Westphalia	420 MW	98 WT	17%	30 MW	31 WT	390 MW	80 MW	19 WT	19%
5	Thuringia	105 MW	23 WT	4%	3 MW	2 WT	102 MW	13 MW	3 WT	12%
6	Saxony-Anhalt	104 MW	25 WT	4%	64 MW	70 WT	40 MW	46 MW	12 WT	44%
7	Rhineland-Palatinate	71 MW	17 WT	3%	3 MW	3 WT	68 MW	14 MW	3 WT	20%
8	Hesse	63 MW	14 WT	3%	7 MW	7 WT	56 MW	0 MW	0 WT	0%
9	Saxony	59 MW	11 WT	2%	1 MW	1 WT	58 MW	16 MW	3 WT	28%
10	Mecklenburg-Western Pomerania	57 MW	15 WT	2%	8 MW	6 WT	50 MW	0 MW	0 WT	0%
11	Bavaria	44 MW	14 WT	2%	0 MW	0 WT	44 MW	0 MW	0 WT	0%
12	Baden-Württemberg	38 MW	9 WT	2%	0 MW	0 WT	38 MW	0 MW	0 WT	0%
13	Saarland	12 MW	3 WT	0%	3 MW	2 WT	9 MW	3 MW	1 WT	29%
	Berlin	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	-
	Hamburg	0 MW	0 WT	0%	0 MW	0 WT	0 MW	0 MW	0 WT	-
	Germany	2,403 MW	551 WT		266 MW	246 WT	2,137 MW	423 MW	103 WT	18%

Average Turbine Configuration and Regional Differences

The average capacity of a newly installed wind turbine in 2022 was around 4.4 MW, 10% higher than in the previous year.

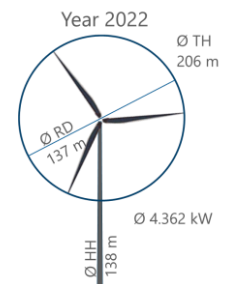
The average total height of the turbines remains almost unchanged compared to the previous year. The 3% larger rotor diameters on average are offset by 2% lower hub heights on average.

Schleswig-Holstein is the only federal state in which the average turbine is well below 200 m in height. The relatively low hub heights in the northernmost state are also the reason for the decreasing hub heights in the national average. Due to the below-average rotor diameters, Mecklenburg-Western Pomerania achieves an average total height of just under 200 m.

The highest wind turbines on average were erected in Saarland, Thuringia and Hesse. The average rotor diameter in these states is over 140 m and the average hub height over 160 m.

Average Wind Turbine Configuration

Installations Year 2022	Change compared to prior year
Turbine Capacity	+10%
Rotor Diameter	+3%
Hub Height	-2%
Tip Height	0%



Average Turbine Configuration of newly installed Wind Turbines in German Federal States

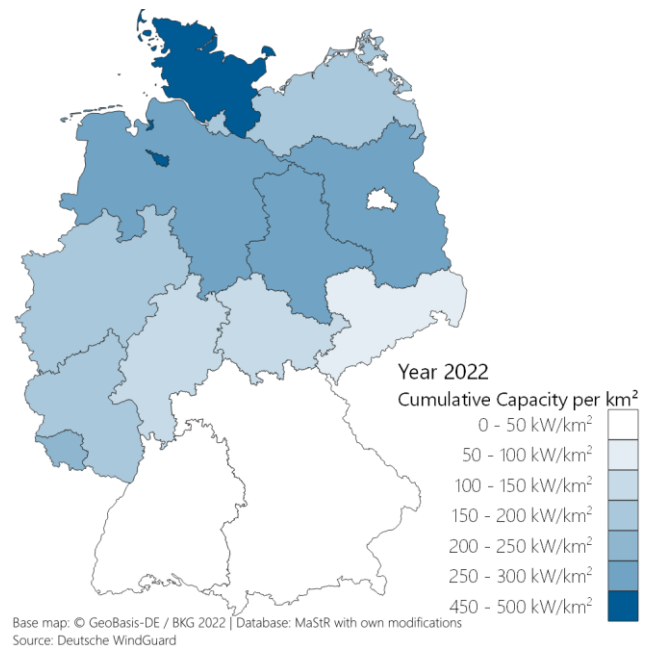
Installations Year 2022	State	Number of Turbines	Average Configuration of newly installed Turbines			
			Turbine Capacity	Rotor Diameter	Hub Height	Tip Height
	Schleswig-Holstein	132 WT	4,125 kW	128 m	109 m	173 m
	Lower Saxony	99 WT	4,666 kW	142 m	142 m	213 m
	Brandenburg	91 WT	4,665 kW	142 m	146 m	217 m
	North Rhine-Westphalia	98 WT	4,281 kW	136 m	144 m	212 m
	Thuringia	23 WT	4,550 kW	148 m	159 m	233 m
	Saxony-Anhalt	25 WT	4,152 kW	137 m	160 m	228 m
	Rhineland-Palatinate	17 WT	4,203 kW	140 m	150 m	220 m
	Hesse	14 WT	4,484 kW	148 m	161 m	235 m
	Saxony	11 WT	5,355 kW	150 m	154 m	229 m
	Mecklenburg-Western Pomerania	15 WT	3,827 kW	117 m	139 m	198 m
	Bavaria	14 WT	3,171 kW	125 m	145 m	208 m
	Baden-Württemberg	9 WT	4,167 kW	139 m	145 m	215 m
	Saarland	3 WT	3,950 kW	145 m	166 m	239 m
	Berlin	0 WT	-	-	-	-
	Bremen	0 WT	-	-	-	-
	Hamburg	0 WT	-	-	-	-
Germany		551 WT	4,362 kW	137 m	138 m	206 m

Regional Distribution of the Cumulative Portfolio

The total number of wind turbines in Germany at the end of 2022 was 28,443, with a combined capacity of 58.1 GW. With 12.1 GW, Lower Saxony accounts for more than one-fifth of the total capacity. Brandenburg, Schleswig-Holstein and North Rhine-Westphalia each have more than 10% of the total capacity installed.

In relation to the respective state area, Schleswig-Holstein and Bremen have the highest power density with over 470 kW/km².

With 200 to 300 kW/km², Brandenburg, Saxony-Anhalt, Lower Saxony and Saarland follow at some distance. North Rhine-Westphalia, Rhineland-Palatinate, Hamburg, Mecklenburg-Western Pomerania, Hesse and Thuringia have a power density of 100 to 200 kW/km². With the lowest area-based stock, Saxony, Baden-Württemberg, Bavaria and Berlin have the greatest need to catch up in order to meet the planned expansion path.



Regional Distribution of the Cumulative Capacity

Cumulative Capacity and Number of Wind Turbines in the German Federal States

Cumulative Portfolio* (2022-12-31)					
Federal State	Cumulative Capacity	Cumulative Number	Share	Capacity per area	Turbines per area
Lower Saxony	12,084 MW	6,156 WT	21%	253 kW/km ²	0.13 WT/km ²
Brandenburg	8,273 MW	3,992 WT	14%	279 kW/km ²	0.13 WT/km ²
Schleswig-Holstein	7,456 MW	3,110 WT	13%	472 kW/km ²	0.20 WT/km ²
North Rhine-Westphalia	6,755 MW	3,603 WT	12%	198 kW/km ²	0.11 WT/km ²
Saxony-Anhalt	5,344 MW	2,800 WT	9%	261 kW/km ²	0.14 WT/km ²
Rhineland-Palatinate	3,891 MW	1,761 WT	7%	196 kW/km ²	0.09 WT/km ²
Mecklenburg-Western Pomerania	3,573 MW	1,837 WT	6%	153 kW/km ²	0.08 WT/km ²
Bavaria	2,613 MW	1,143 WT	4%	37 kW/km ²	0.02 WT/km ²
Hesse	2,389 MW	1,150 WT	4%	113 kW/km ²	0.05 WT/km ²
Thuringia	1,797 MW	863 WT	3%	111 kW/km ²	0.05 WT/km ²
Baden-Württemberg	1,745 MW	776 WT	3%	49 kW/km ²	0.02 WT/km ²
Saxony	1,326 MW	880 WT	2%	72 kW/km ²	0.05 WT/km ²
Saarland	520 MW	212 WT	1%	202 kW/km ²	0.08 WT/km ²
Bremen	201 MW	87 WT	0%	479 kW/km ²	0.21 WT/km ²
Hamburg	122 MW	67 WT	0%	161 kW/km ²	0.09 WT/km ²
Berlin	17 MW	6 WT	0%	19 kW/km ²	0.01 WT/km ²
Germany	58,106 MW	28,443 WT		162 kW/km²	0.08 WT/km²

* with a minimum turbine capacity of > 100 kW

Results of Tender Rounds

In the course of 2022, four bidding rounds for onshore wind energy were carried out. The originally planned tender for the year was 5,190 MW in three regular rounds and one catch-up round. After deductions for installed pilot turbines and, in particular, the reduction in volume due to the threat of lack of competition in the December tender, the remaining tender volume was 4,572 MW.

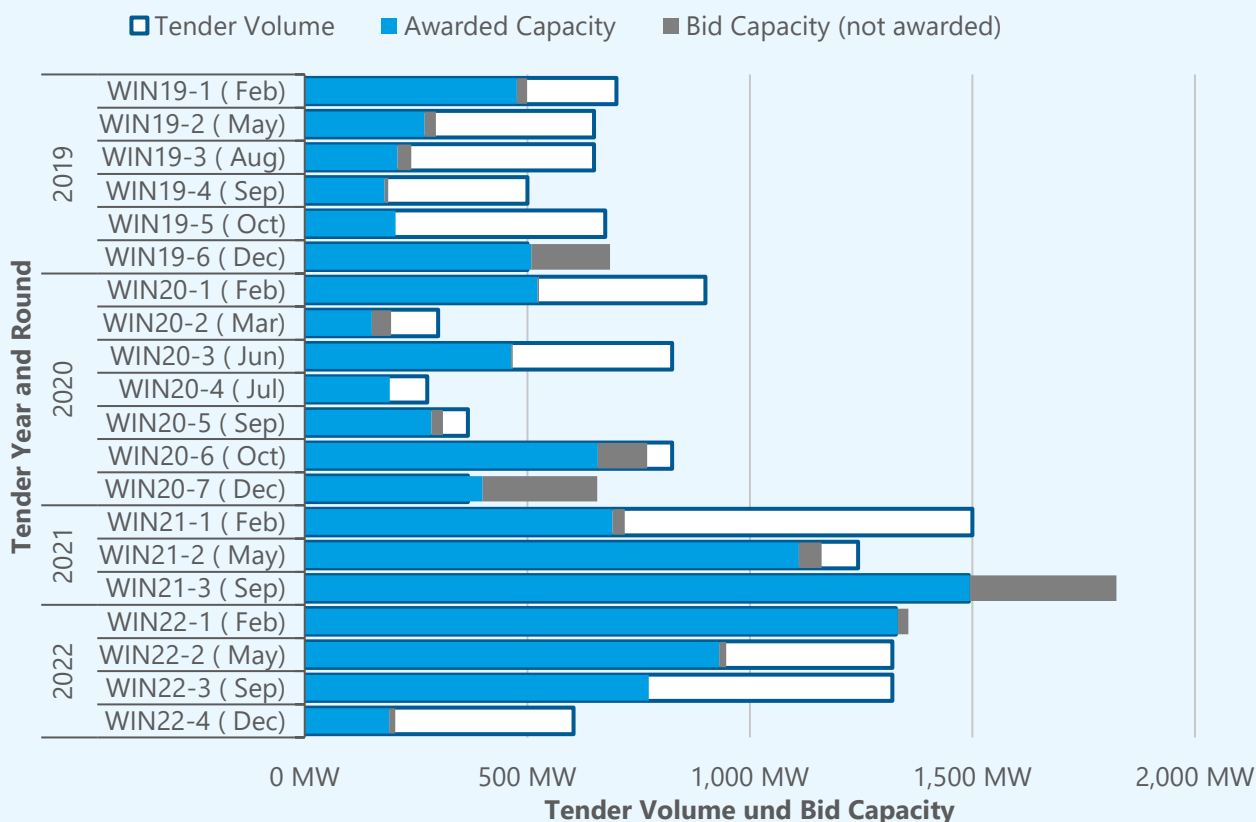
Of this, only a total of 3,225 MW was awarded in the 2022 bidding rounds. In the first round in February, a slight surplus was achieved, but in the following rounds the participation ratio decreased steadily, so that in the last round in December, despite the reduction in volume, the participation ratio was only 31%.

At 5.88 ct/kWh, the maximum permissible value in 2022 was only slightly above the average capacity-weighted award value of 5.81 ct/kWh.

In 2023, the maximum permissible value will rise to 7.35 ct/kWh for the first time since the introduction of the tendering procedure, after the Federal Network Agency was granted the authority to increase it.

Development of Awarded Bids of Tender Rounds for Onshore Wind Energy (Database: BNetzA)

	Year	Maximum Permissible Value	Average capacity-weighted Award Value
Tender Year	2019	6.20 ct/kWh	6.14 ct/kWh
	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

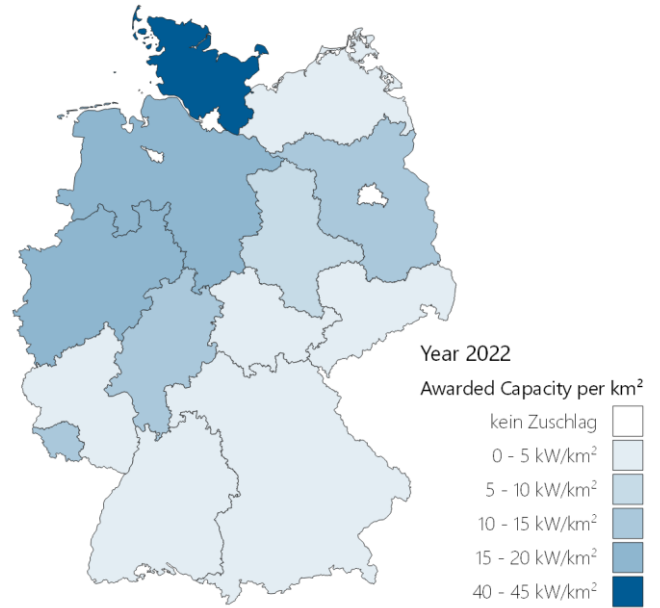


Competitive Situation in Tender System for Onshore Wind Energy (Database: BNetzA)

Regional Distribution of Awarded Bids

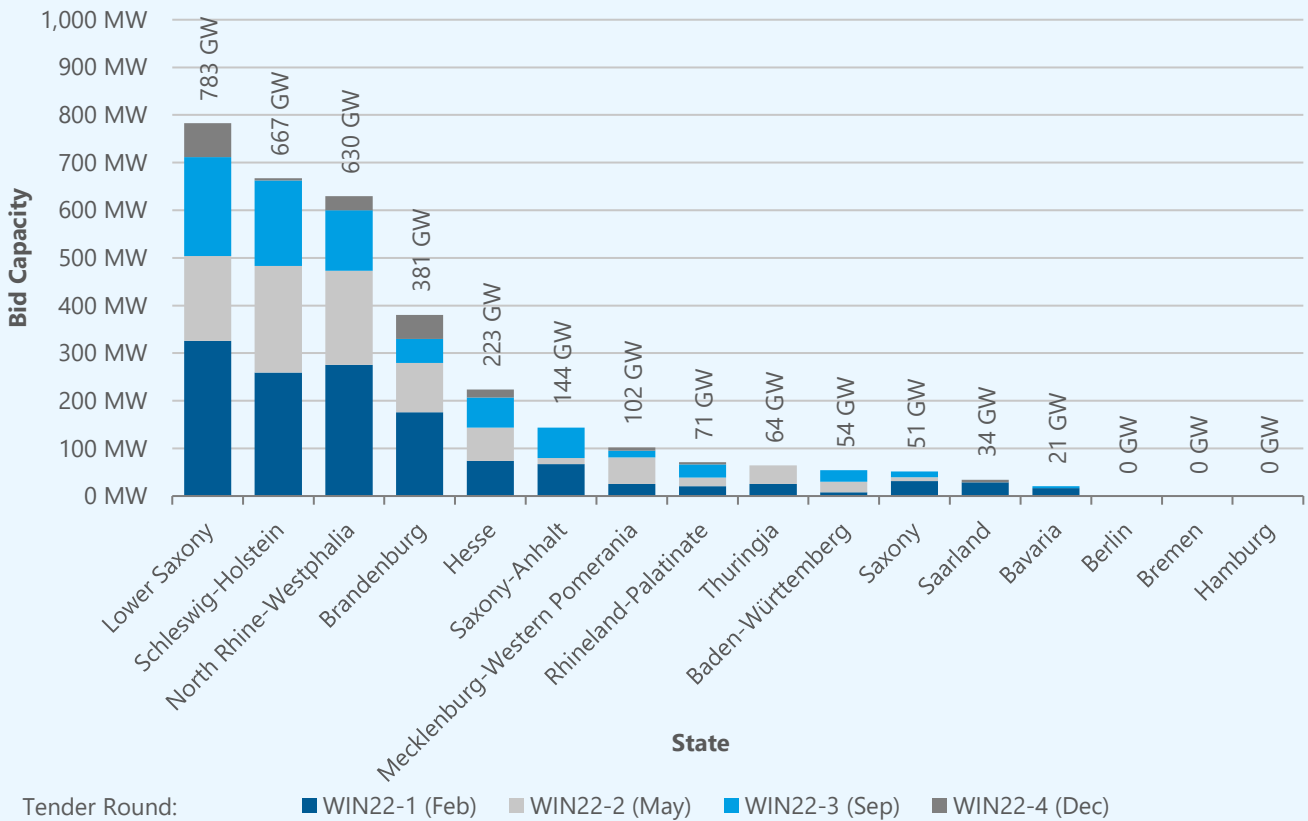
The largest award volume in 2022 was awarded to turbines from Lower Saxony. Projects from Schleswig-Holstein and North Rhine-Westphalia were also successfully placed with a volume of over 600 MW. The three states in the northwest together accounted for 64% of the capacity awarded. Brandenburg (12%), Hesse (7%) and Saxony-Anhalt (4%) also achieved relevant shares of awarded volumes. In terms of area, Saarland is also in the middle of the field.

Mecklenburg-Western Pomerania, Rhineland-Palatinate, Thuringia, Baden-Württemberg, Saxony and Bavaria achieve the lowest successes in the tenders in relation to the state area and have less than 5 kW/km of awarded capacity per square kilometer of the state area. No contracts were awarded to the city states.



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

Regional Distribution of Awarded Capacity
(Database: BNetzA)



Regional Distribution of Awarded Capacity across the German Federal States (Database: BNetzA)

Development Status of Awarded Turbines

Since the introduction of tendering procedure for onshore wind energy in 2017, 16.2 GW have been awarded. By the end of 2022, 6.8 GW of the awarded capacity has been successfully realized. At 11%, the realization rate of the awards from 2017 was particularly poor. At that time, many citizens' energy companies received awards for turbines without a permit. By the end of 2022 the awarded volume from 2018 was realized to 80%, the awards from 2019 were realized to as much as 92%. The realization period for the surcharges from 2020 is still ongoing. For the 2020 awards, realization is also already well advanced with a rate of 83%. The implementation of the turbines awarded in 2021 is only just beginning, and hardly any turbines from the 2022 tender year have been commissioned to date.

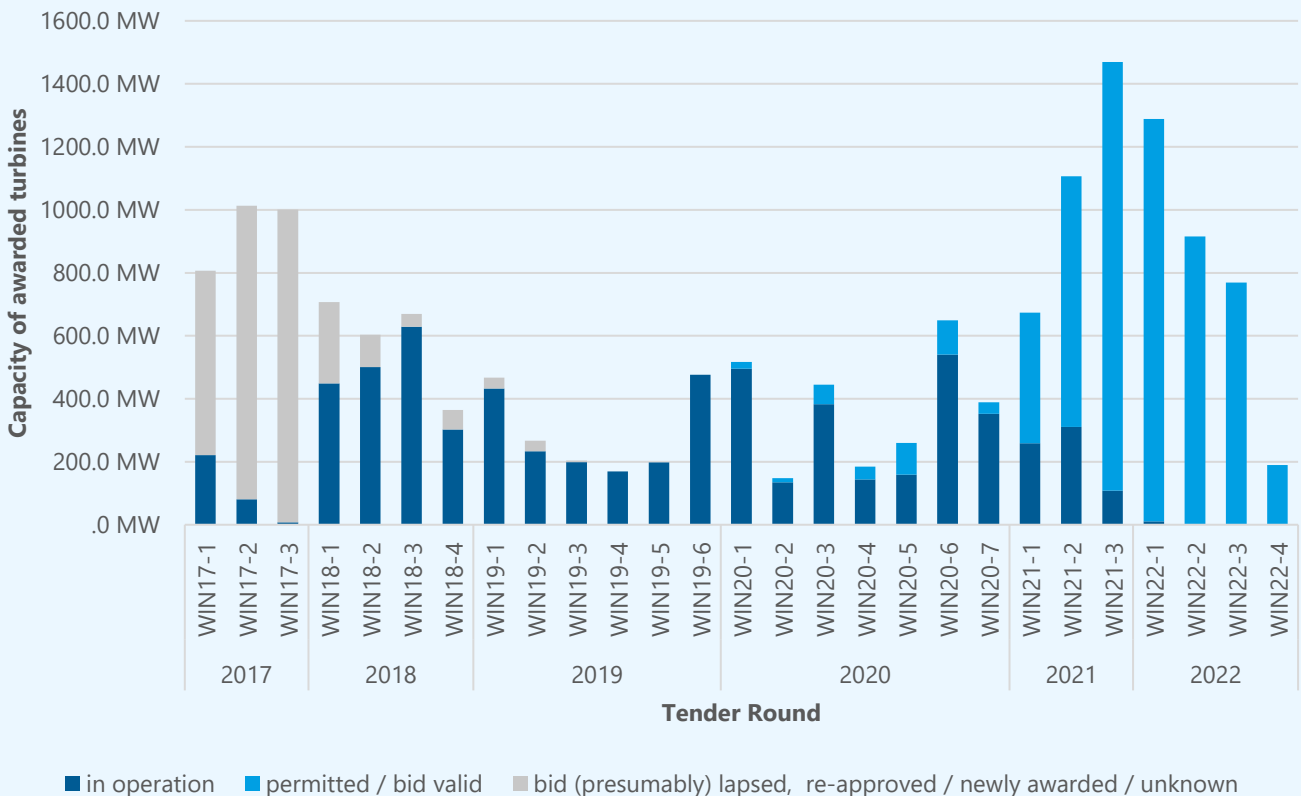
The period between the award and commissioning has increased since the

introduction of the tendering procedure. For turbines commissioned in 2022, an average of 22 months passed until commissioning. The average is thus only just within the penalty-free implementation period of 24 months.

Realized Capacity* of Tenders for Onshore Wind Energy in Germany

	Year	Realized Capacity	Realization Rate
Year of Tender	2017	309 MW	11%
	2018	1,881 MW	80%
	2019	1,708 MW	92%
	2020	2,208 MW	83%
	2021	678 MW	21%
	2022	10 MW	0%

* 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 Future Tender Rounds

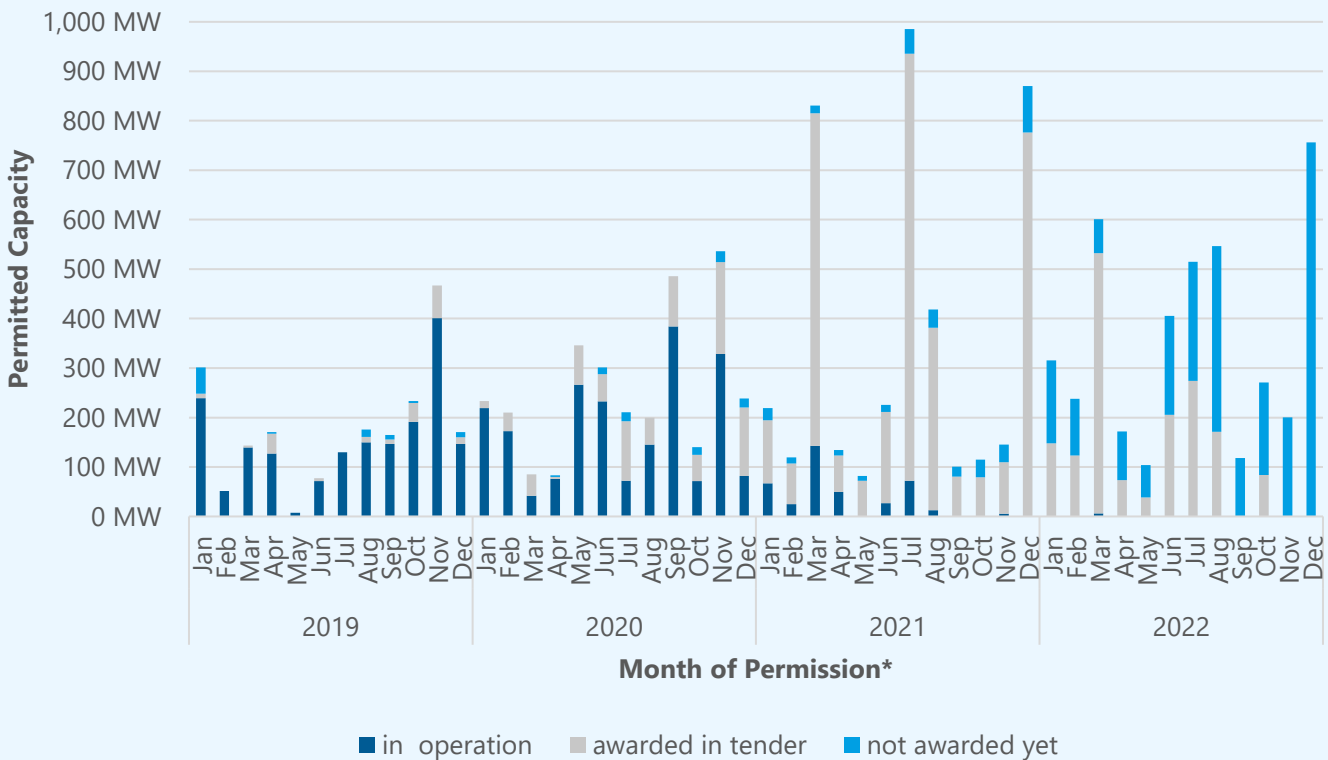
Permits for 842 new wind turbines were issued during 2022. Together, these turbines have a capacity of 4,243 MW. This means that the level of permits issued in the previous year will be reached again. The upward trend observed in recent years is stagnating. The current annual level of approvals is not sufficient to fulfill the large tender volumes in the coming rounds. In 2023, a record of 12.84 GW will be put out to tender, followed by 10 GW per year in subsequent years.

39% of the capacity permitted in 2022 has already been awarded in the tenders. The remaining 2.6 GW may participate in the February 2023 tender, provided that the approval has been reported to the core energy market data register (MaStR) by January 4, 2023. There are also some permits from previous years that have not been awarded.

In addition to the February tender, three further rounds will be held in 2023, each with a tender volume of up to 3,210 MW. Adjustments to the tender volumes in the individual rounds could be made by the BNetzA, for example in case of expected lack of competition.

Annual Permitted Capacity

	Year	Permitted Capacity	Permitted Wind Turbines
Year of Permission	2019	2,092 MW	526 WT
	2020	3,069 MW	691 WT
	2021	4,245 MW	890 WT
	2022	4,243 MW	842 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

Expected Development and Political Target

The EEG 2023 defines the tender volumes for the years 2023 to 2028 and thus provides an indication of the politically targeted expansion path*. In 2023, the tender volume will at first increase to 12.84 GW, from 2024 onwards, 10 GW will be tendered annually. The EEG specifies a penalty-free implementation period of 24 months, which means that the desired annual expansion from 2025 - two years after the respective tender - is around twice as high as the expansion in the previous record year of 2017.

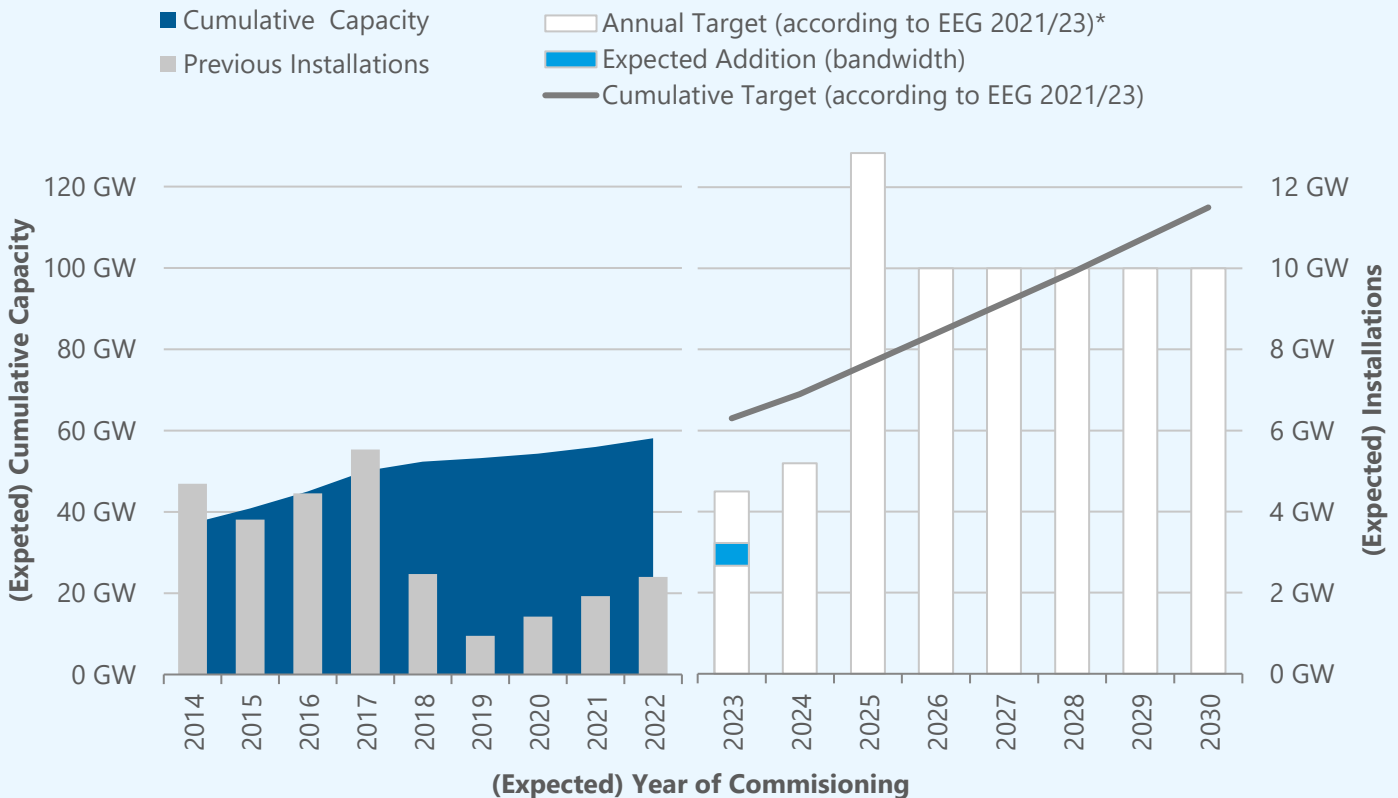
For the years 2023 and 2024, targets can also be derived from the anticipated tender volumes of the previous years. However, from the awards in the tenders in the past and the actual realization

times observed so far, it can already be deduced that the expansion for 2023 will be below the assumed target value.

The turbines put out to tender in 2022 took an average of around 22 months from the time of the award notice to commissioning. In addition, not all of the wind turbines that have been awarded to date were commissioned on time, so that it must be assumed that some of the awards will also be invalidated in the future.

Assuming no change in the speed of implementation, the expected increase in capacity for 2023 is between 2.7 GW and 3.2 GW. The target (4.5 GW) set by the tender volumes in the EEG 2021 will probably not be achieved.

*The expansion target of the EEG was derived from the planned tender volumes in the year before the previous year.

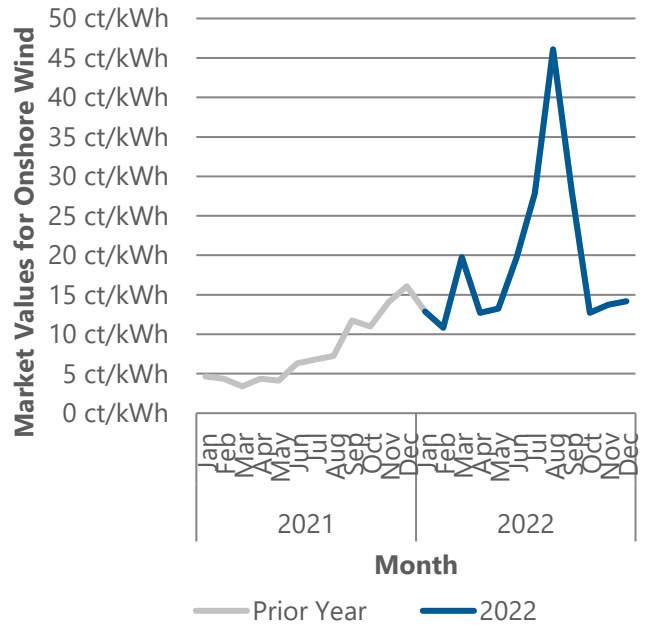


Expected expansion in 2022 and expansion targets according to EEG 2021/23

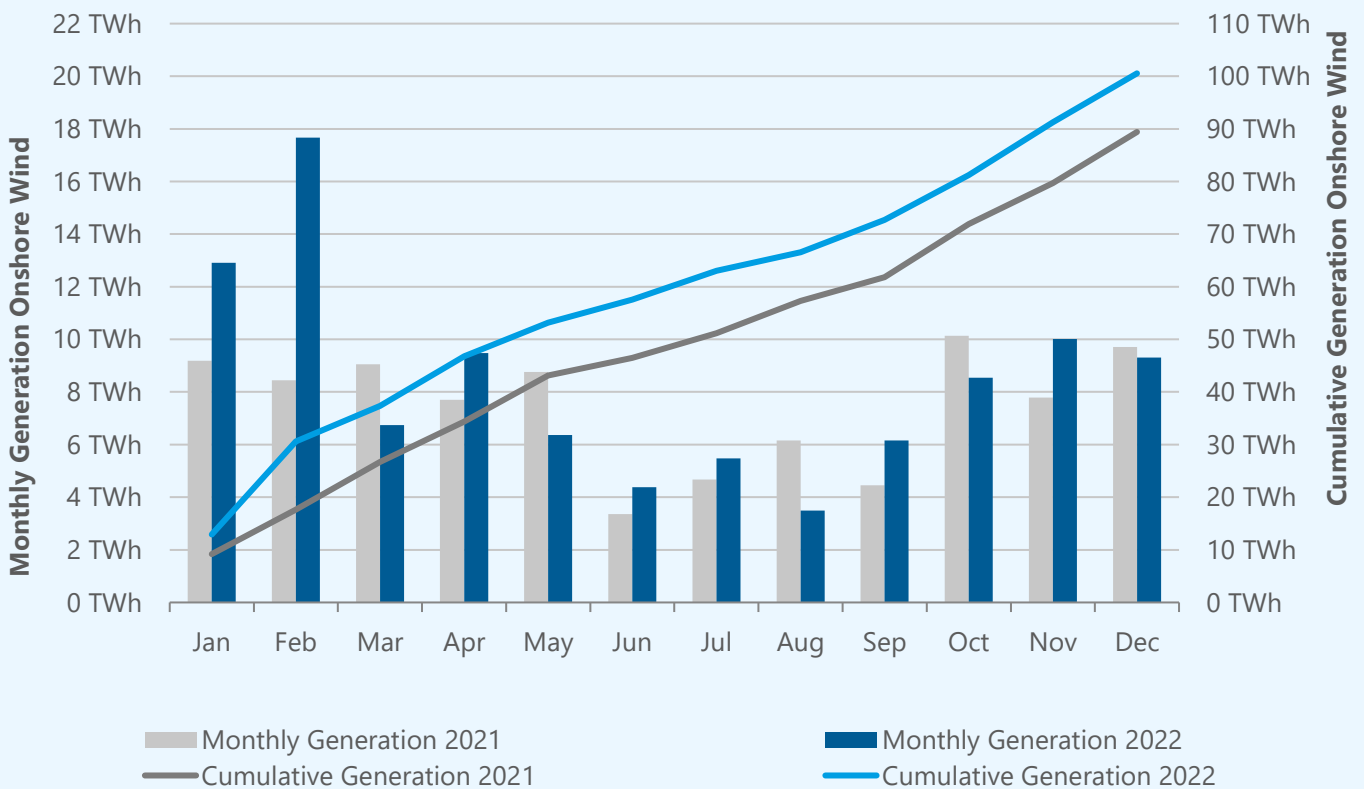
Power Generation and Market Values

In 2022, onshore wind turbines in Germany generated 100.5 TWh of RE electricity. Compared to the previous year, this corresponds to an increase of 12%. January and especially February 2022 stand out with particularly high feed-in. Onshore wind energy makes a significant contribution of 19.8% to Germany's electricity generation.

The distortions caused by the corona pandemic and the Ukraine war on the energy market are also reflected in the market values. The already high price level on the electricity exchange reached new record levels in the summer of 2022, rising to 46.1 ct/kWh in August 2022. In September, market values fell back to the same level as at the beginning of the year. The generation-weighted average market value for onshore wind energy pre-doubles (+107%) compared to 2021 and is 16.27 ct/kWh in 2022.



Monthly Market Values for Onshore Wind Energy (Database: Netztransparenz)



Power Generation Onshore 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. The broad portfolio creates extensive synergy effects: Whether due diligence, market analysis, contract consulting or feasibility studies – each of them contains expertise and know-how of the entire WindGuard group. Deutsche WindGuard has been publishing the semi-annual statistics on wind energy development since 2012.

About Bundesverband Windenergie e.V. [German Wind Energy Association (BWE)]

BWE, a member of Bundesverband Erneuerbare Energie [German Renewable Energy Federation (BEE)] with more than 20,000 members, represents the entire wind industry in Germany. Members of BWE range from industry suppliers in the fields of mechanical engineering and manufacturing over project developers to legal experts, the financial sector, electricity traders, network operators, energy suppliers, and companies specialized in logistics, construction, service/maintenance, and storage technologies. Its broad membership makes of BWE the primary point of contact for politics, business, science, and the media in all matters linked to wind energy.

About VDMA Power Systems

VDMA Power Systems is a trade association of the German Engineering Federation VDMA e.V. The trade association represents the interests of manufacturers of wind energy and hydropower plants, fuel cells, thermal plants and storage systems in Germany and abroad. For them, VDMA Power Systems serves as an information and communication platform for all industry topics such as energy policy, legislation, market analyses, trade fairs, standardisation and press and public relations.