

Status of Onshore Wind Energy Development in Germany

Year 2020



On behalf of



Power Systems

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Notes

The data from 2012 onwards was obtained through surveys with manufacturers and other industry representatives, as well as through additional research. Analyses of the DEWI serve as the data basis for the years 1992 - 2011. Data corrections based on the MaStR were made. The MaStR and the publications of the awards by the BNetzA serve as a data basis for the analysis of the permit situation and the tender results.

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

The cumulative data may be overestimated due to the incomplete capture of dismantling.

Analyses that rely on deviating data bases (i.e. MaStR) exhibit a deviating data inventory.

Photo on Title Page

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Gross and Net Wind Energy Additions

Over the course of 2020, 420 onshore wind turbine generators (WTG) with a total capacity of 1,431 MW were installed in Germany. Compared to the record low in the previous year, an increase of about 46% was achieved.

Status of Onshore Wind Energy Development

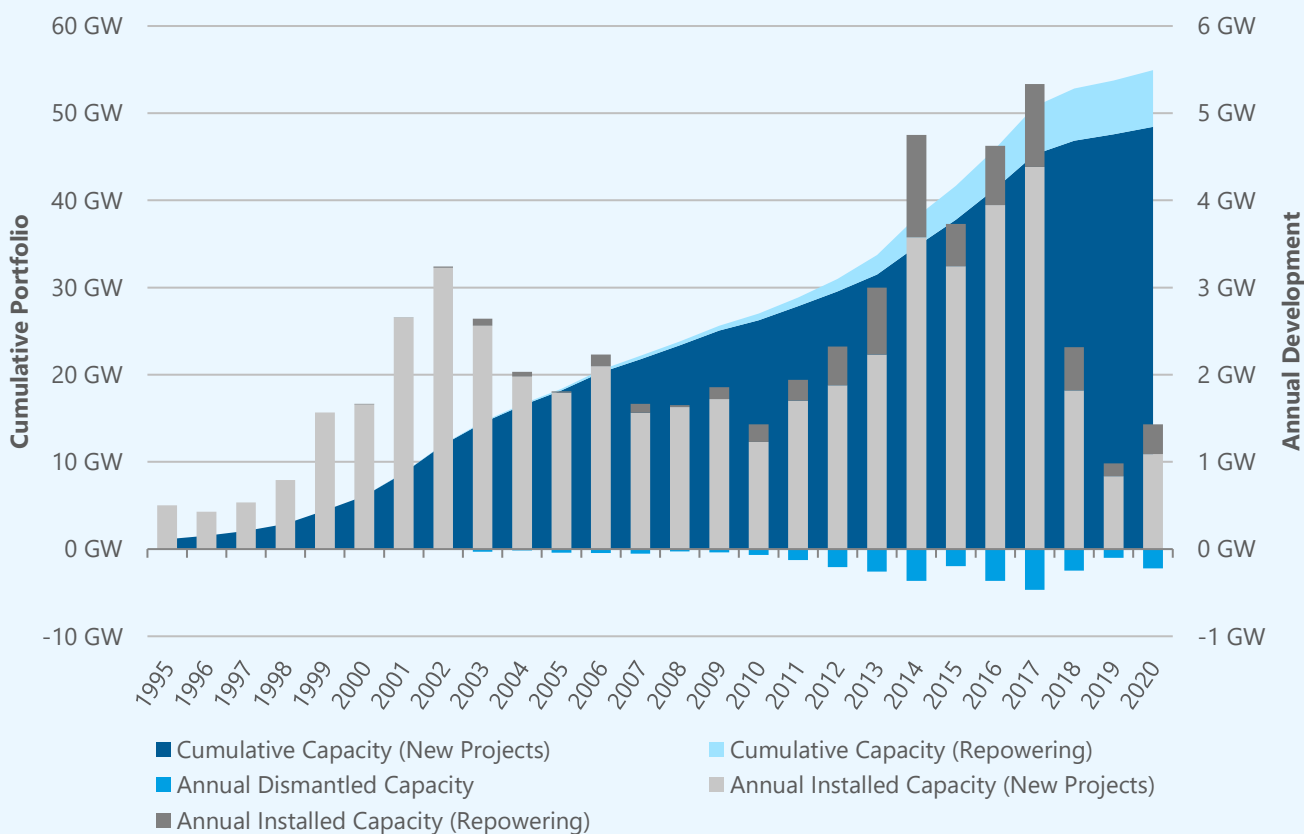
		Capacity	Number
Development Year 2020	Gross additions	1,431 MW	420 WTG
	Repowering share	339 MW	102 WTG
	Dismantling (incl. subsequent registration) (non-binding)	222 MW	203 WTG
	Net additions	1,208 MW	217 WTG
Cumulative 2020-12-31	Cumulative WTG portfolio (non-binding)	54,938 MW	29,608 WTG

Expansion Target for Onshore Wind Energy

	Year	Cumulative Capacity
Target according to EEG 2021	2022	57,000 MW
	2024	62,000 MW
	2026	65,000 MW
	2028	68,000 MW
	2030	71,000 MW

Within the same period, the dismantling of 203 WTG with a total capacity of 222 MW was recorded. The net increase in capacity amounts to 1,208 MW in 2020.

The cumulative WTG portfolio thus increases to 29,608 WTG as of December 31, 2020. The total installed capacity increases by around 2% to 54,938 MW. The Renewable Energy Sources Act 2021 (German: Erneuerbare-Energien-Gesetz or EEG), which was passed at the end of 2020, provides for an expansion target of 71 GW by 2030. To achieve this target, it is necessary to increase the cumulative capacity (net additions) by about 30% over the next 10 years.



Annual Development Onshore Wind Energy Capacity in Germany

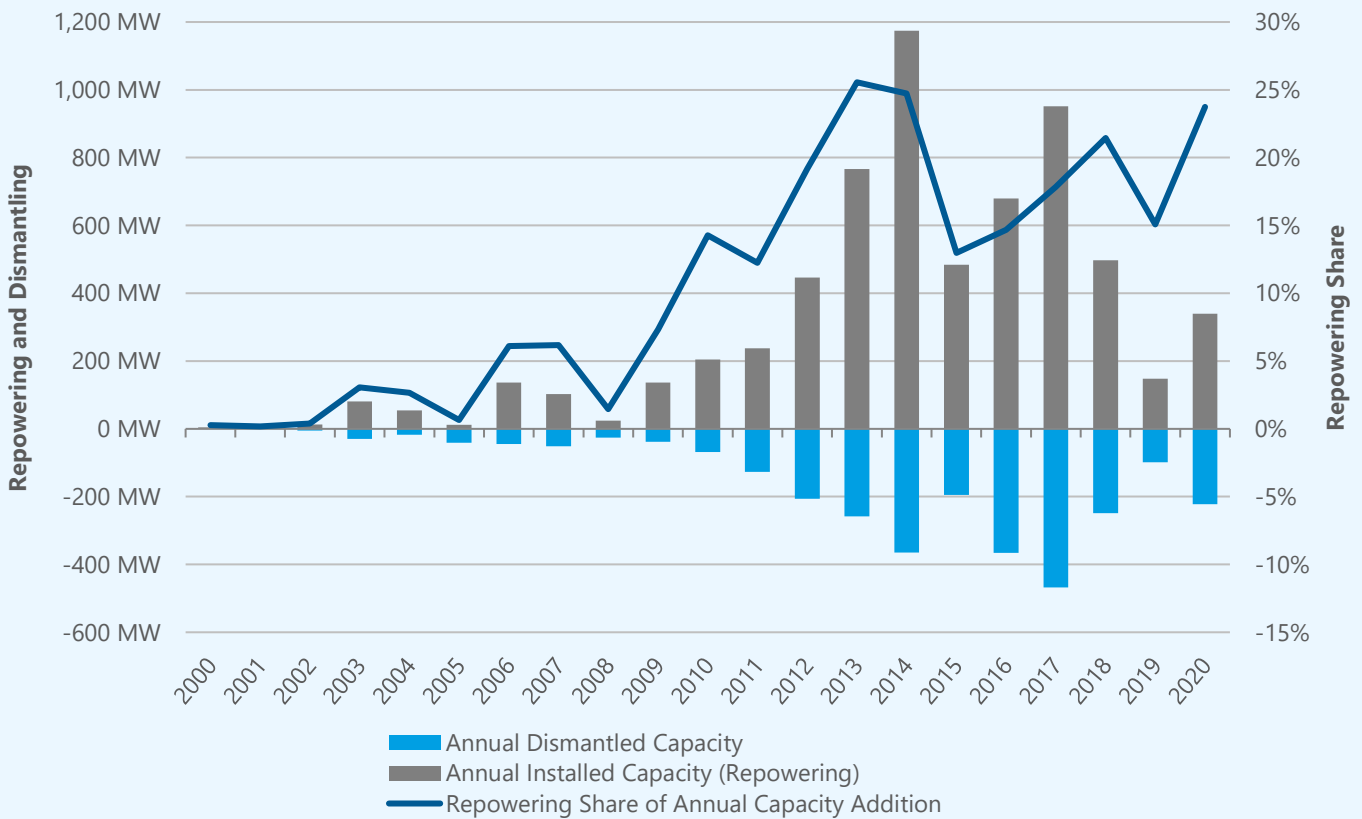
Dismantling and Repowering

In 2020, 102 wind turbine generators (WTG) with 339 MW were identified as repowering WTG. The repowering share in the 2020 gross capacity additions is thus 24%. Not all 203 dismantled WTG with 222 MW have been taken down for the purpose of repowering. The EEG remuneration period for turbines commissioned in or before 2000, which expired for the first time on December 31, 2020, may reduce the incentive to continue operating old turbines. If turbines can no longer be operated or repaired economically, they are usually dismantled.

The new EEG 2021 provides regulations to prevent the substantial dismantling of turbines without replacement for which the EEG remuneration period has ended. These old turbines are entitled to receive a transitional remuneration. According to the EEG 2021, the feed-in tariff corresponds to

the monthly market value for onshore wind energy, plus a surcharge that decreases over the course of 2021 (initially 1 ct/kWh, 0.25 ct/kWh at the end of 2021) and minus marketing costs.

This transitional regulation is to be replaced in 2021 by a special tender system for turbines for which the EEG remuneration period has ended. Tenders are to be used to award a feed-in tariff until the end of 2022 to turbines that continue operation. The key points for this tender system are regulated by a so-called ordinance authorization. Particularly specified is that only those operators may participate whose turbine is located on an area where repowering is not permitted under planning regulations. The volume of the tenders is limited to 1.5 GW in 2021 and 1 GW in 2022. The upper limit for the bid value is set between 3 ct/kWh and 3.8 ct/kWh.



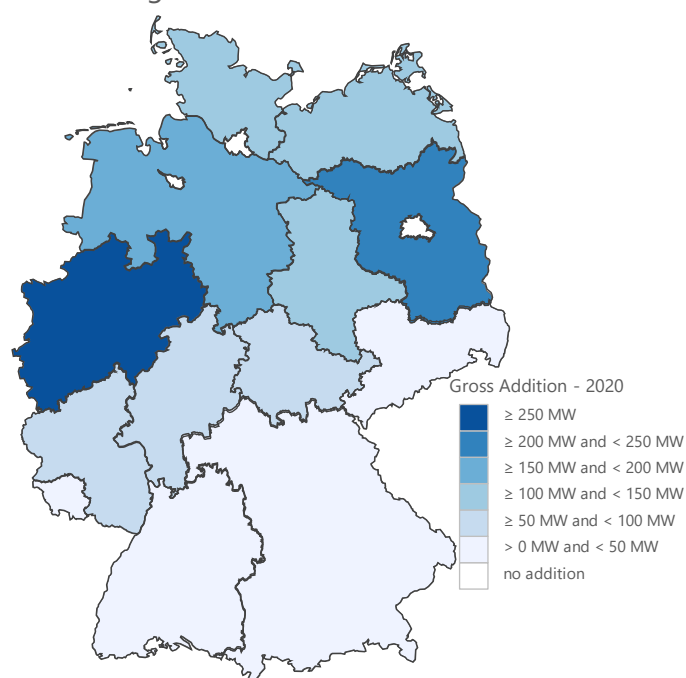
Development of Annual Dismantled Capacity, Annual Installed Repowering Capacity and Repowering Share

Regional Distribution of Wind Energy Additions

The German federal state of North Rhine-Westphalia accounts for the largest share of new capacity in 2020, with 22% of gross capacity additions. It is followed by the states in the north of Germany. Apart from the city states without any additions, the southern federal states are at the bottom of the list in terms of gross capacity added per state in 2020. If dismantling is taken into account to determine net capacity additions, the ranking of the federal states changes slightly, but all states report positive numbers for net additions.

Dismantling activities in 2020 are also more concentrated in the northern states when compared to the southern part of Germany. This is primarily due to a larger number of old turbines in the north. A part of the dismantled turbines could be replaced by new wind turbines at the original location. Most of the repowering turbines were installed in North Rhine-Westphalia. It is followed

by Saxony-Anhalt, Schleswig-Holstein and Brandenburg.



Regional Distribution of Gross Capacity Additions

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

Position	Year 2020 State	Gross Additions			Dismantling and Net Additions			Repowering		
		Capacity Addition	Number Added WTG	Share*	Capacity Dismantling	Number Dismantled WTG	Net Additions	Capacity Repowering	Number Repowering WTG	Repowering-Share**
1	North Rhine-Westphalia	317 MW	93 WTG	22%	33 MW	33 WTG	283 MW	83 MW	27 WTG	26%
2	Brandenburg	238 MW	70 WTG	17%	33 MW	43 WTG	205 MW	53 MW	14 WTG	22%
3	Lower Saxony	167 MW	48 WTG	12%	48 MW	34 WTG	118 MW	30 MW	8 WTG	18%
4	Saxony-Anhalt	140 MW	42 WTG	10%	26 MW	36 WTG	114 MW	53 MW	15 WTG	37%
5	Schleswig-Holstein	122 MW	35 WTG	9%	52 MW	30 WTG	70 MW	50 MW	15 WTG	41%
6	Mecklenburg-Western Pomerania	110 MW	33 WTG	8%	1 MW	1 WTG	110 MW	19 MW	7 WTG	17%
7	Rhineland-Palatinate	89 MW	26 WTG	6%	3 MW	2 WTG	87 MW	8 MW	2 WTG	9%
8	Hesse	88 MW	27 WTG	6%	3 MW	5 WTG	85 MW	7 MW	2 WTG	7%
9	Thuringia	60 MW	16 WTG	4%	13 MW	11 WTG	47 MW	32 MW	9 WTG	53%
10	Baden-Württemberg	37 MW	12 WTG	3%	7 MW	4 WTG	30 MW	0 MW	0 WTG	0%
11	Bavaria	32 MW	8 WTG	2%	0 MW	0 WTG	32 MW	1 MW	1 WTG	3%
12	Saarland	22 MW	7 WTG	2%	0 MW	0 WTG	22 MW	0 MW	0 WTG	0%
13	Saxony	8 MW	3 WTG	1%	3 MW	4 WTG	5 MW	5 MW	2 WTG	57%
	Berlin	0 MW	0 WTG	0%	0 MW	0 WTG	0 MW	0 MW	0 WTG	
	Bremen	0 MW	0 WTG	0%	0 MW	0 WTG	0 MW	0 MW	0 WTG	
	Hamburg	0 MW	0 WTG	0%	0 MW	0 WTG	0 MW	0 MW	0 WTG	
	Germany	1,431 MW	420 WTG		222 MW	203 WTG	1,208 MW	339 MW	102 WTG	24%

* Share of gross capacity additions per federal state in total gross capacity additions

** Share of repowering capacity per federal state in gross capacity addition per federal state

Average Wind Turbine Generator Configuration

The average configuration of wind turbine generators is described by the parameters of the turbine capacity, the rotor diameter, and the hub height. Additional indicators are the tip height and the specific power that in turn can be derived from the main parameters.

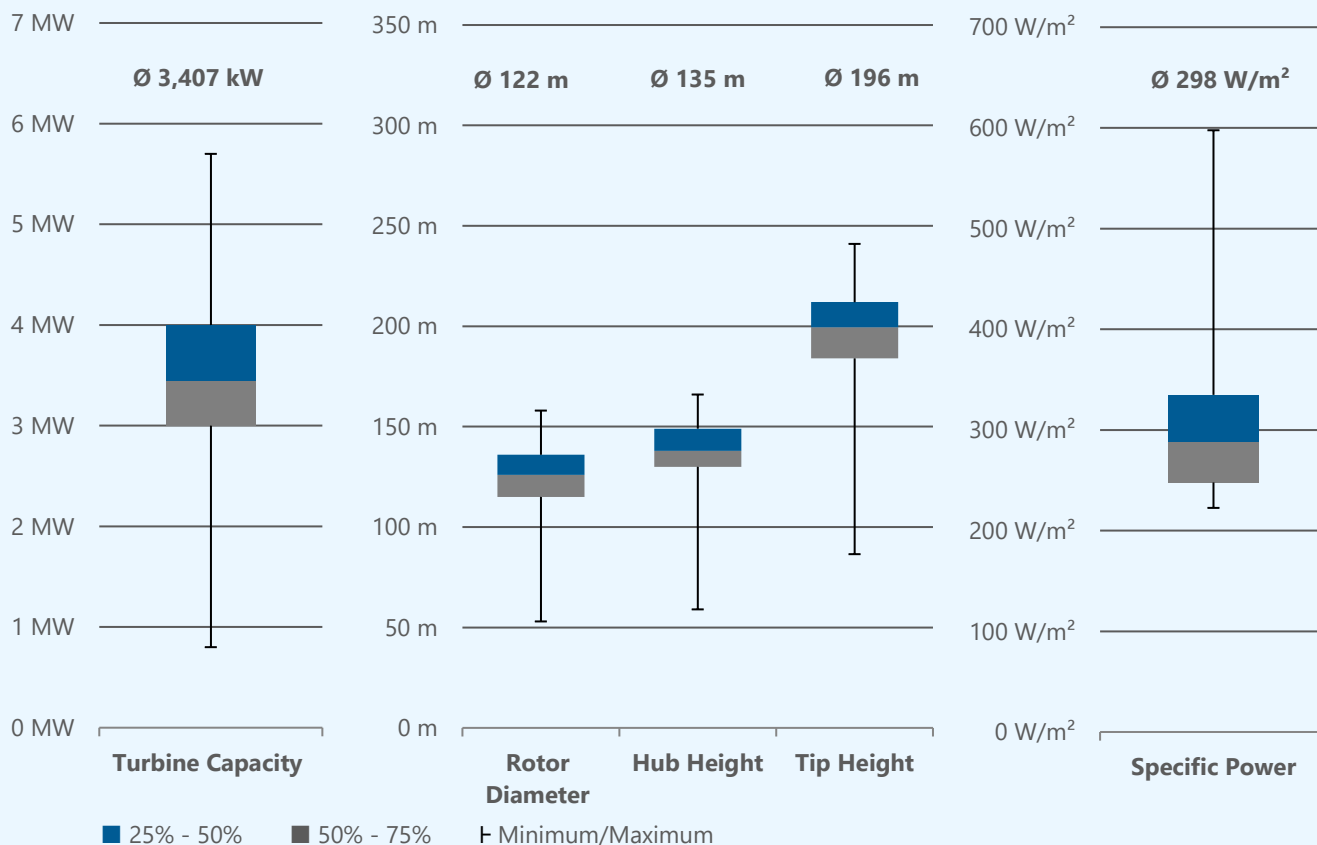
The technology of the newly installed turbines in 2020 largely corresponds to the technology used in the previous year. The average turbine capacity of 3.4 MW remains unchanged compared to 2019. The rotor diameter, averaging 122 m, and the hub height, averaging 135 m, are also at the previous year's level. The WTG installed in 2020 have an average total height of 196 m and an average specific power of 298 W/m². These values are also similar to those of 2019.

The average turbine configuration provides good insight into the overall development of turbine

technology. In addressing the specific requirements for each project site, a wide range of individual installed configurations can be observed.

Average Wind Turbine Generator Configuration

Average Configuration	Additions Year 2020	Changes compared to prior year
Turbine Capacity	3,407 kW	0%
Rotor Diameter	122 m	0%
Hub Height	135 m	0%
Tip Height	196 m	0%
Specific Power	298 W/m ²	+1%



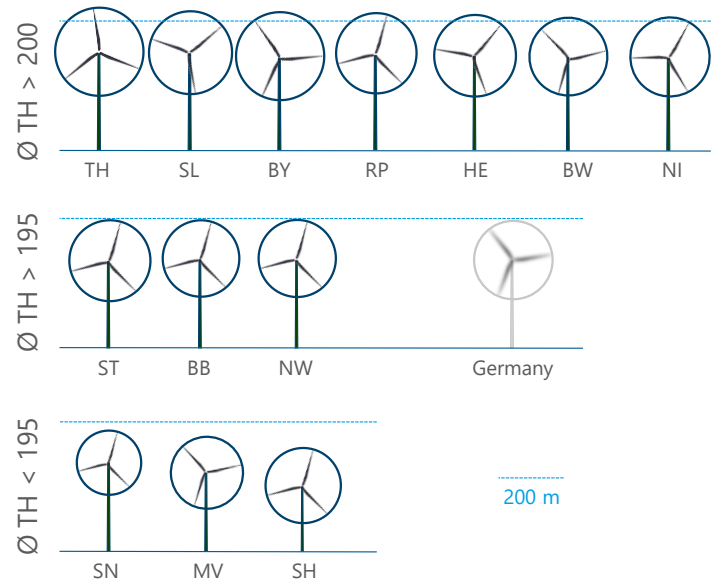
Range of Configuration Values of newly installed WTG

Regional Differences in Wind Turbine Generator Configuration

With regard to the average turbine configuration of new turbines installed in 2020, there are regional differences – for example, in the tip height (TH) that results from adding half the rotor diameter to the hub height. In 2020, the tallest turbines on average, with a tip height of 218 m, were installed in Thuringia. Also, in Saarland, Bavaria, Rhineland-Palatinate, Hesse, Baden-Württemberg and Lower Saxony, turbines with an average tip height of over 200 m were installed. In the German federal states of Saxony-Anhalt, Brandenburg and North Rhine-Westphalia, new turbines have a total height of just below 200 m. In Saxony, Mecklenburg-Western Pomerania and Schleswig-Holstein, the average total height of new installations in 2020 is significantly lower than the 200 m mark.

However, due to the low number of newly installed turbines in some federal states in 2020, the average configuration is in part strongly

influenced by individual projects. On a national average, the tip height is just below 200 m due to the stronger influence of the federal states with a high number of newly installed WTG.



Turbine Configuration of newly installed WTG in German Federal States

Average Installed Turbine Configuration in German Federal States

State	WTG-Number	Average Configuration of newly installed WTG				
		Turbine Capacity	Rotor Diameter	Hub Height	Specific Power	Tip Height
North Rhine-Westphalia	93 WTG	3,406 kW	120 m	135 m	301 W/m ²	196 m
Brandenburg	70 WTG	3,401 kW	119 m	137 m	310 W/m ²	196 m
Lower Saxony	48 WTG	3,474 kW	123 m	143 m	298 W/m ²	204 m
Saxony-Anhalt	42 WTG	3,338 kW	126 m	134 m	275 W/m ²	197 m
Schleswig-Holstein	35 WTG	3,486 kW	117 m	100 m	336 W/m ²	159 m
Mecklenburg-Western Pomerania	33 WTG	3,342 kW	112 m	121 m	343 W/m ²	177 m
Rhineland-Palatinate	26 WTG	3,431 kW	125 m	146 m	284 W/m ²	209 m
Hesse	27 WTG	3,268 kW	127 m	145 m	254 W/m ²	209 m
Thuringia	16 WTG	3,772 kW	137 m	149 m	260 W/m ²	218 m
Baden-Württemberg	12 WTG	3,100 kW	121 m	144 m	270 W/m ²	205 m
Bavaria	8 WTG	3,963 kW	137 m	142 m	268 W/m ²	210 m
Saarland	7 WTG	3,129 kW	129 m	149 m	242 W/m ²	213 m
Saxony	3 WTG	2,700 kW	100 m	137 m	355 W/m ²	187 m
Berlin	0 WTG					
Bremen	0 WTG					
Hamburg	0 WTG					
Germany	420 WTG	3,407 kW	122 m	135 m	298 W/m²	196 m

Results of Tender Rounds

In 2020, a total volume of 3,860 MW was put out to tender in seven rounds for onshore wind energy. Projects with a capacity of 2,672 MW received an award. Approximately 32% of the tender volume remained without award. Compared to the previous year, when only half of the tendered volume (1,847 MW) was awarded, this represents a significant increase in participation.

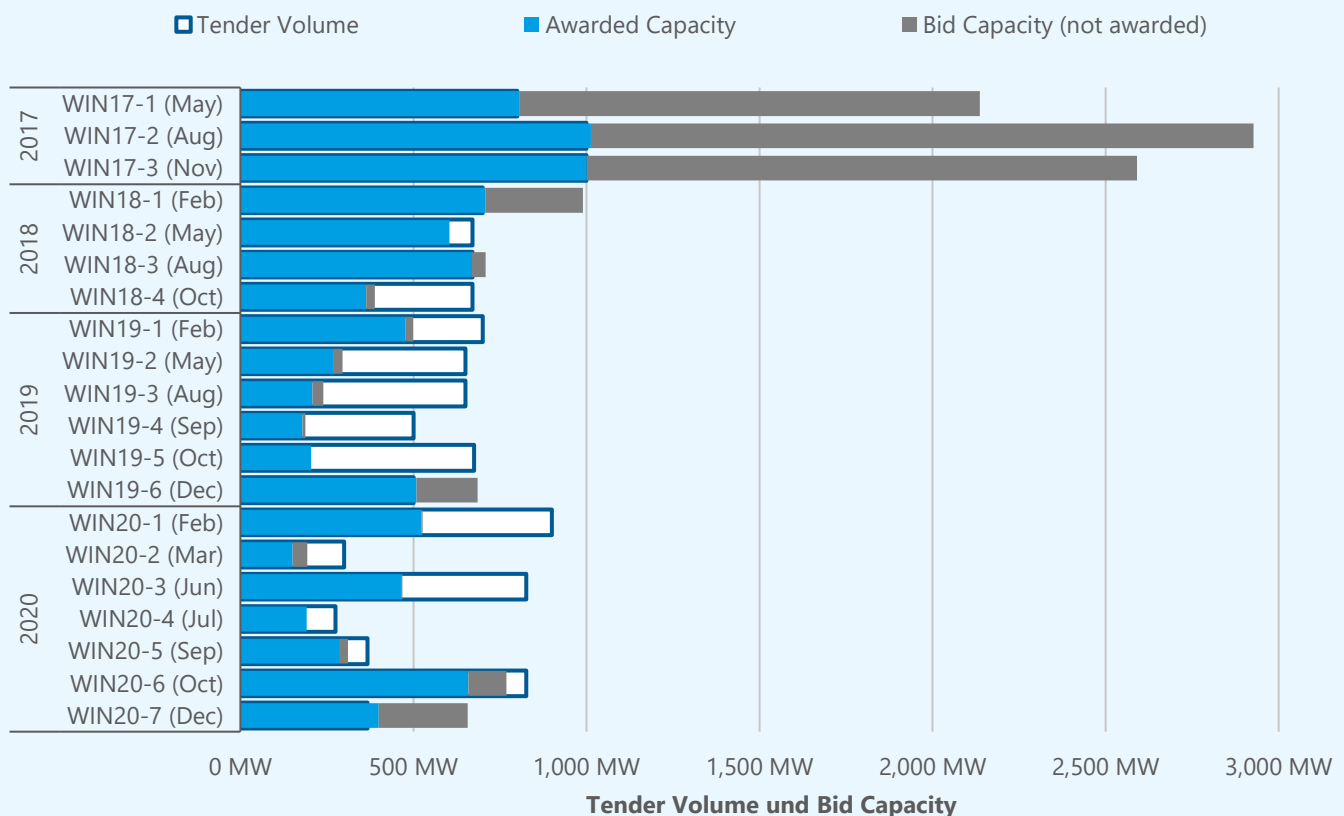
In addition to the low participation in the first six tender rounds, some turbines could not be awarded due to the exclusion of the bid from the tender process (e.g. due to formal errors) or due to the full exhaustion of the volume for the grid expansion area. Projects with a capacity of 237 MW could not yet secure an entitlement for EEG remuneration due to the high participation in the last tender round in December (WIN20-7).

The upper limit for bid values in all 2020 tender rounds, which may not be exceeded by the

bidders, was set at 6.2 ct/kWh. Weighted by capacity throughout all tender rounds, an average award value of 6.11 ct/kWh was achieved in 2020. In the December 2020 tender round, an average capacity-weighted award value of less than 6 ct/kWh was achieved for the first time since the beginning of 2018.

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

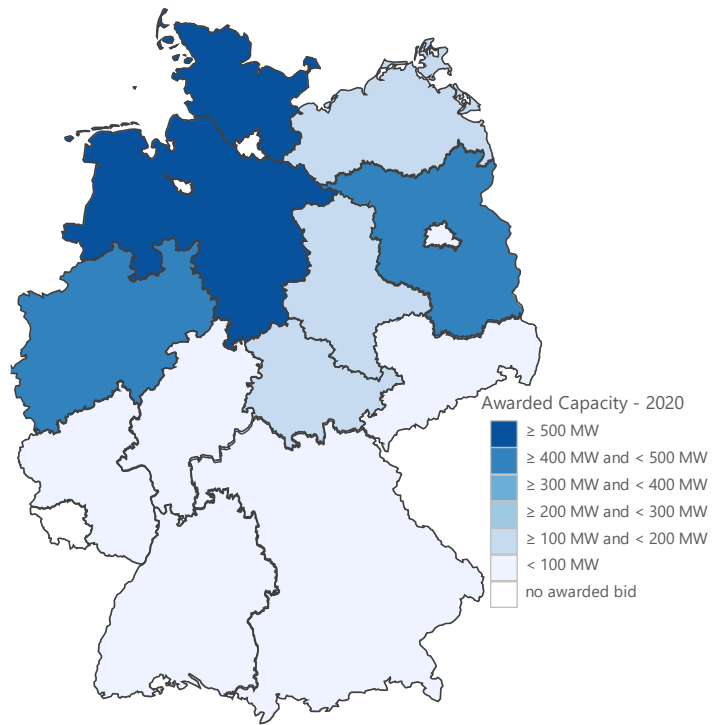
	Year	Bid Limit	Capacity-weighted award value
Year of Tender	2017	7.00 ct/kWh	4.53 ct/kWh
	2018	6.30 ct/kWh	5.63 ct/kWh
	2019	6.20 ct/kWh	6.14 ct/kWh
	2020	6.20 ct/kWh	6.11 ct/kWh



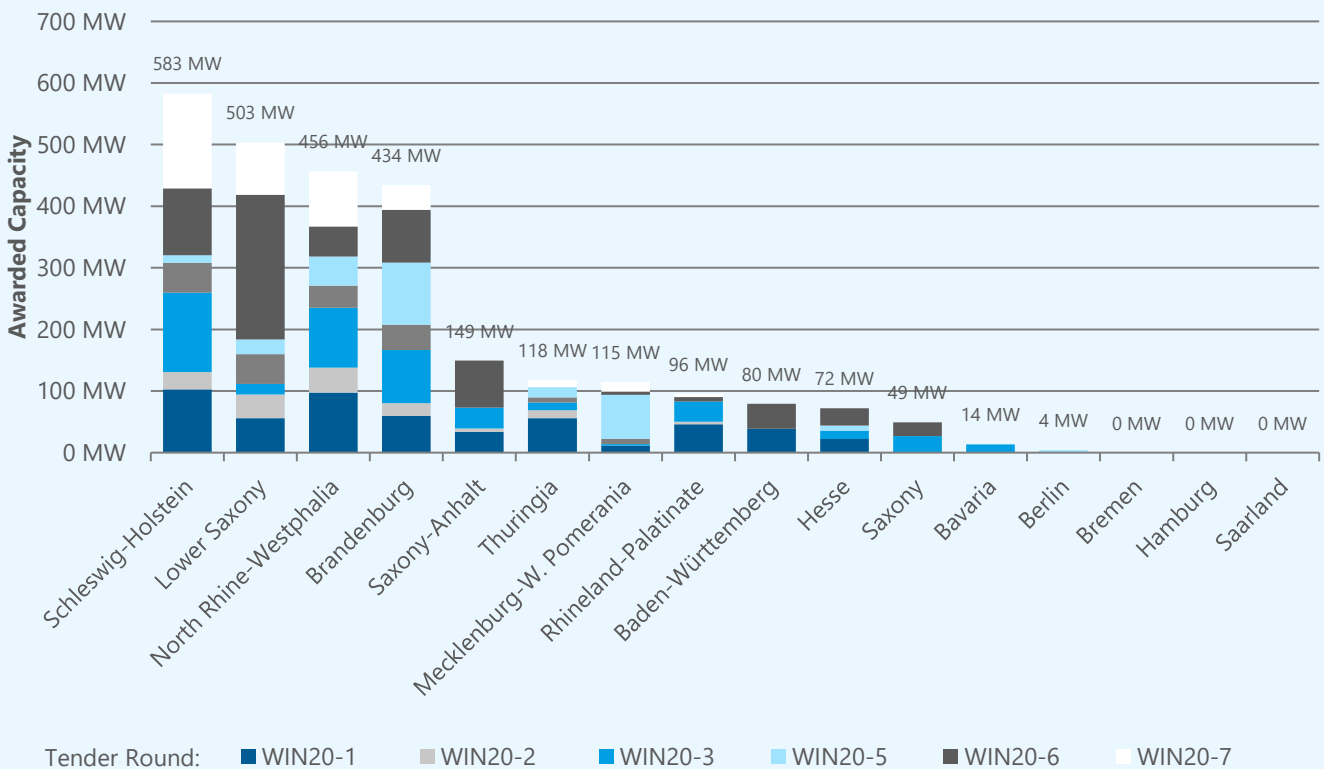
Competitive Situation in Tender System for Onshore Wind Energy (Database: BNetzA)

Regional Distribution of Awarded Bids

The capacity of 2,672 MW awarded in all tender rounds in 2020 is largely distributed among four German federal states with an award volume of over 400 MW each: Schleswig-Holstein, Lower Saxony, North Rhine-Westphalia and Brandenburg. Together, these states account for 74% of the total awarded capacity in 2020. Saxony-Anhalt, Thuringia and Mecklenburg-Western Pomerania follow at a considerable distance, each with an awarded capacity of between 100 MW and 150 MW, they thus hold the middle positions in the federal state ranking. In the German federal states Rhineland-Palatinate, Baden-Württemberg, Hesse, Saxony, Bavaria and Berlin, the awarded capacity from all tender rounds in 2020 is less than 100 MW each – this means that only a low awarded capacity is allocated to the center and the south of Germany. Projects from Saarland, Bremen and Hamburg did not participate in the 2020 tender rounds.



Regional Distribution of Awarded Capacity (Database: BNetzA)



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

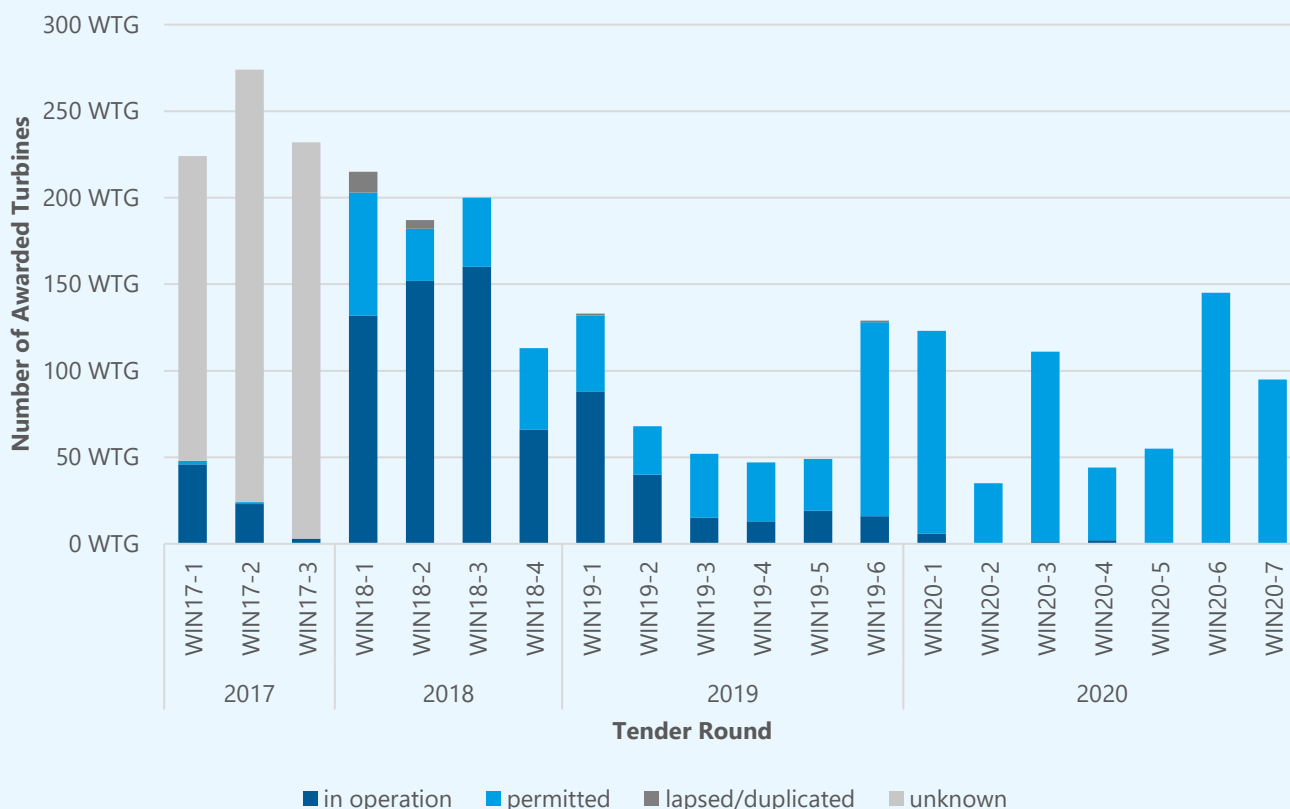
Development Status of Awarded Turbines*

With the exception of pilot and small-scale turbines, wind energy turbines that have been put into operation since the beginning of 2019 (after the end of the transition period) have received their EEG remuneration entitlement by means of a successful participation in a tender. After receiving an award, the realization period begins that remains for the project developers until their award expires. The respective period is between 30 and 54 months and can be extended, e.g. in the case of a legal action against the turbine's permit. The development status of the turbines that were awarded without permit in 2017 is largely unknown. For turbines with permits, which were mainly awarded from 2018 onwards, the development status could be estimated based on the Core Energy Market Data Register (German: Marktstammdatenregister or MaStR). For the

2018 tender year, 71% of the awarded capacity was classified as "in operation". This corresponds to an installed capacity of approximately 1.7 GW. Of the capacity awarded in 2019, 37% (about 0.7 GW) has already been put into operation. The share of awards issued in 2020 that has already been put into operation amounts to 31 MW, or 1% of the awarded capacity. The capacity of projects that have not yet been put into operation is thus about 2.6 GW from tender year 2017 and 4.5 GW from the tender years 2018-2020.

More than half (56%) of the additions in 2020 resulted from awards issued in the 2018 tender rounds. Awards from 2019 account for another 39%. The tender rounds in 2017 and 2020 account for only a very small share of the new capacity added in 2020.

* 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 Turbines (Database: BNetzA, MaStR, own research and assumptions)

Permitted Capacity and Future Tender Rounds

For 2020, permits with a total volume of around 3.3 GW were reported in the MaStR. Compared to 2019, the permit situation has improved again and the previous year's volume of around 1,9 GW has been exceeded.

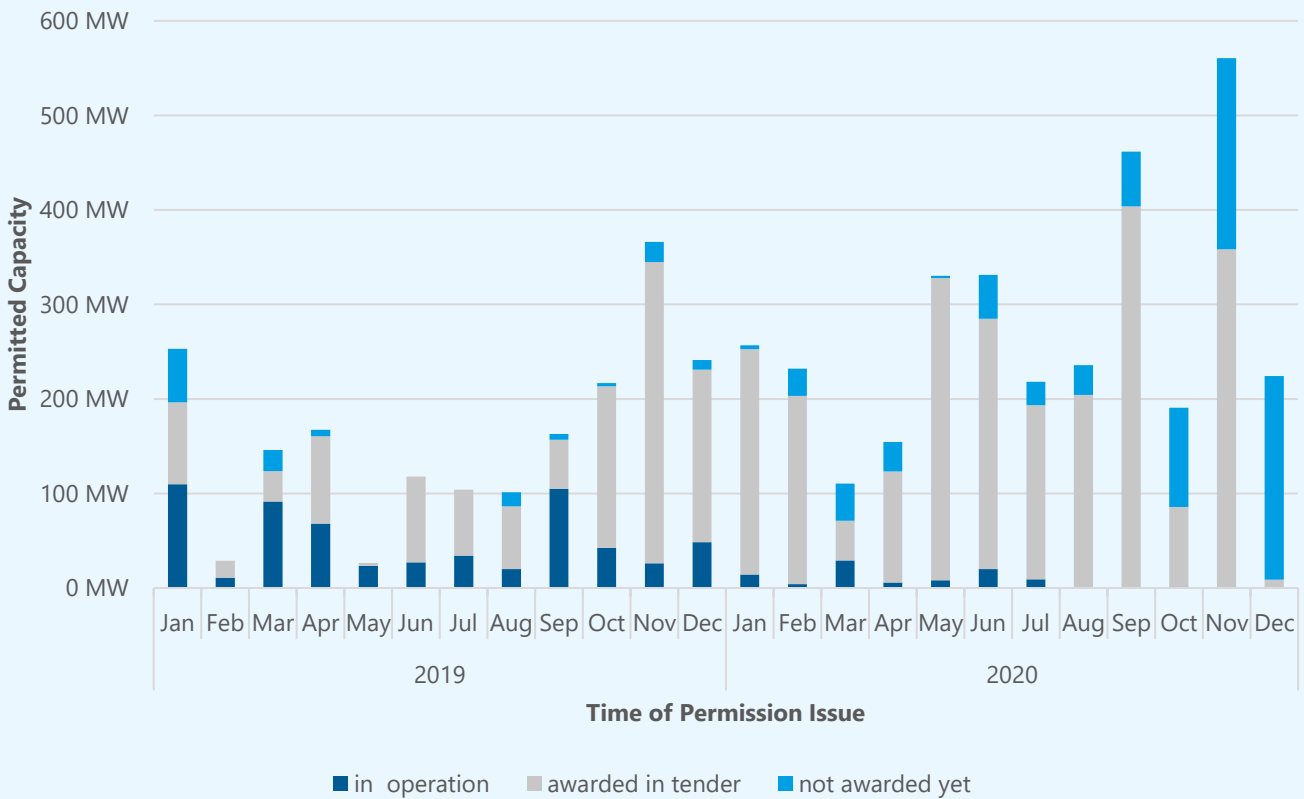
In order to participate in a tender, modern wind energy turbines need a permit in accordance to the Federal Immission Control Act (German: Bundes-Immissionsschutzgesetz or BImSchG). The permit is registered in the MaStR. Of the projects permitted in 2019 and 2020 (5.2 GW), around 0.7 GW are already in operation and another 3.6 GW have been awarded but have not yet been put into operation. The turbines with 0.9 GW that have not yet been awarded, as well as all turbines permitted before and in the future, can secure an entitlement for EEG remuneration in future tenders. In 2021, tenders for onshore wind energy with a volume of 4.5 GW are planned. The bid limit will fall to 6 ct/kW, which is slightly lower than in

2020, and the grid expansion area, which previously limited new capacity additions in the north, will no longer apply. Wind energy turbines, e.g. in combination with storage facilities, can also participate in the innovation tenders, in which a volume of 500 MW will be tendered in 2021.

Tender volume 2021 to 2028 (according to EEG)

Year	Tenders for	
	Onshore Wind Energy	Innovations*
2021	4,500 MW	500 MW
2022	2,900 MW	550 MW
2023	3,000 MW	600 MW
2024	3,100 MW	650 MW
2025	3,200 MW	700 MW
2026	4,000 MW	750 MW
2027	4,800 MW	800 MW
2028	5,800 MW	850 MW

* excluding the capacity reserved for special solar plants (50 MW in 2022)



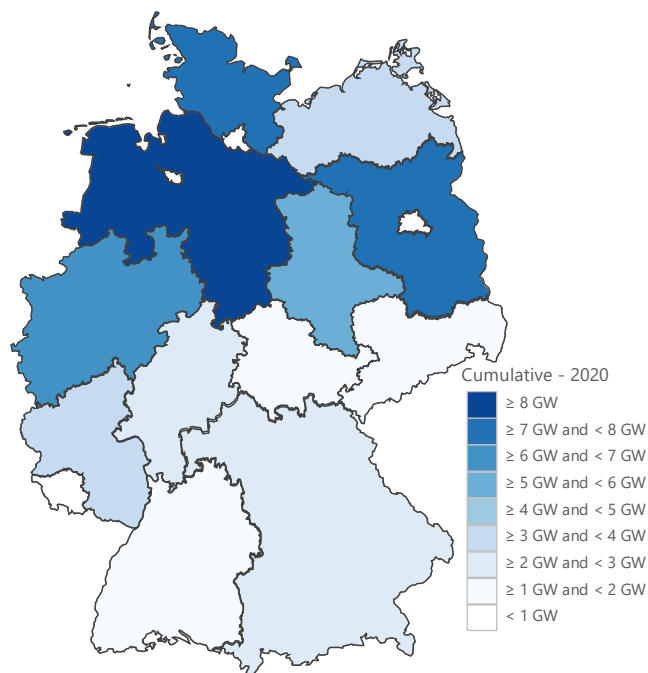
Monthly Permitted Capacity including Status

Regional Distribution of the Cumulative Portfolio

The regional distribution of the total number of WTG in Germany shows a clear north-south divide. Although the remuneration system provides stronger support for areas with less wind, which occur more frequently in the south, the share is lowest in the south with 15% of the cumulative capacity. In the tenders from 2022 onwards, the south should therefore be supported by the newly defined award quota. Projects located in the southern region are to receive preferred awards up to a certain share (15% in 2022/2023 and 20% from 2024) of the volume. At the end of 2020, the coastal states accounted for around 41% of the cumulative installed capacity and the states in central Germany for around 44%.

Different data are available on the actual cumulative installed portfolio. Due to different definition and counting systems, the sources differ from each other. The MaStR, in which operators must register their turbines, is still under development and is to be filled with all existing

turbines by the end of January 2021. Until then, the sources (DWG statistics, MaStR and, in some cases, country data) will be maintained in parallel.



Regional Distribution of the Cumulative Capacity

Cumulative Capacity and Number of WTG in the German Federal States

		Cumulative Portfolio (2020-12-31)					
Region	State	Cumulative Capacity			Cumulative Number		
		DWG Statistics	MaStR*	State Data**	DWG Statistics	MaStR*	State Data**
North	Lower Saxony	11,430 MW	11,327 MW		6,352 WTG	6,214 WTG	
	Schleswig-Holstein	7,064 MW	6,891 MW	6,780 MW	3,673 WTG	3,335 WTG	3,021 WTG
	Mecklenburg-Western Pomerania	3,556 MW	3,461 MW		1,965 WTG	1,887 WTG	
	Bremen	198 MW	201 MW		91 WTG	93 WTG	
	Hamburg	128 MW	122 MW		65 WTG	71 WTG	
Central	Brandenburg	7,478 MW	7,501 MW		3,900 WTG	3,898 WTG	
	North Rhine-Westphalia	6,174 MW	6,171 MW		3,818 WTG	3,503 WTG	
	Saxony-Anhalt	5,281 MW	5,295 MW		2,870 WTG	2,890 WTG	
	Hesse	2,295 MW	2,240 MW		1,179 WTG	990 WTG	
	Thuringia	1,657 MW	1,743 MW		870 WTG	933 WTG	
	Saxony	1,272 MW	1,290 MW		907 WTG	965 WTG	
	Berlin	12 MW	12 MW		4 WTG	10 WTG	
South	Rhineland-Palatinate	3,757 MW	3,759 MW		1,791 WTG	1,732 WTG	
	Bavaria	2,559 MW	2,570 MW		1,172 WTG	1,241 WTG	
	Baden-Württemberg	1,573 MW	1,648 MW		735 WTG	779 WTG	
	Saarland	505 MW	527 MW		216 WTG	215 WTG	
Germany		54,938 MW	54,759 MW		29,608 WTG	28,756 WTG	

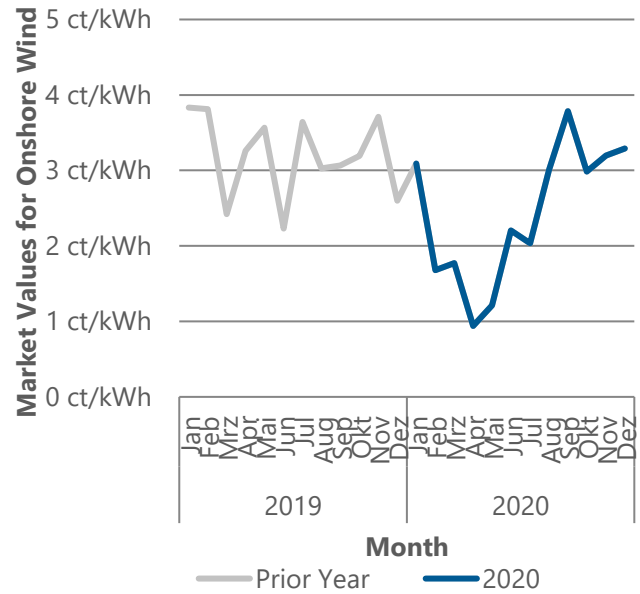
* Turbine Portfolio (incl. small turbines) based on WTG reported as in operation according to the Core Energy Market Data Register (MaStR)

** Turbine Portfolio subject to permit according to LLUR Schleswig-Holstein as of December 16, 2020

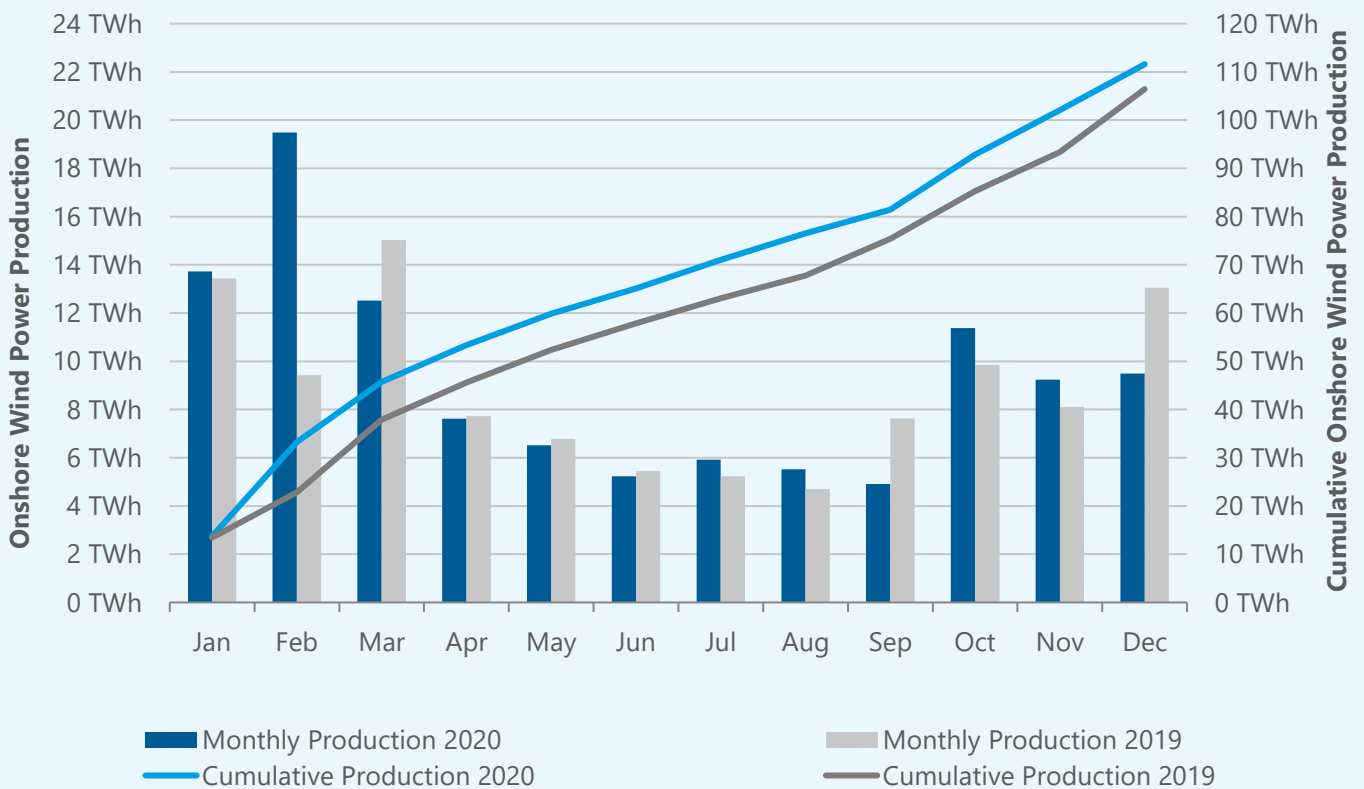
Monthly Power Production and Market Values

According to the projection data of the Transmission System Operators (TSO; German: Übertragungsnetzbetreiber or ÜNB), onshore wind energy turbines in Germany produced 112 TWh of power in 2020, which is 5% more than in the previous year. With almost 20 TWh, February 2020 was by far the month with the highest power production of the entire year.

The monthly market values that could be called at the power exchange for electricity from onshore wind energy dropped to 0.9 ct/kWh in connection with the effects of the COVID-19 pandemic in spring 2020. In August, the market value returned to the previous year's level. Nevertheless, the volume-weighted average market value for onshore wind energy in 2020 is only 2.4 ct/kWh, which is 25% lower than in the previous year.



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



Projection of Power Production by Onshore WTG (Database: Netztransparenz Projection Data)

About Deutsche WindGuard

In the complex energy market, Deutsche WindGuard is committed to providing independent, manufacturer-neutral consulting and comprehensive scientific, technical and operational services. The wide range of services creates extensive synergy effects. Whether due diligence, market analysis, contract consulting or feasibility studies: each of them contains the 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 industry. Members of BWE include the mechanical engineering industry's suppliers and manufacturers; project developers; specialist jurists; the financial sector; companies from the fields of logistics, construction, service/maintenance and storage technology; electricity traders; network operators; and energy suppliers. As a result, BWE is the primary contact for politics and business, science and the media.

About VDMA Power Systems

VDMA Power Systems is an association of the Mechanical Engineering Industry Association (VDMA). It represents the interests of manufacturers of wind energy and hydroelectric plants, fuel cells, gas/steam turbines and systems and engine systems in Germany and abroad. For all of these manufacturers, VDMA Power Systems serves as an information and communication platform for all topics within the industry, such as energy policy, legislation, market analyses, trade fairs, standardization, and press and public relations.