DEUTSCHE WINDGUARD

Status of Onshore Wind Energy Development in Germany

First Half of 2023

On behalf of

BWE Bundesverband WindEnergie

VDMA Power Systems

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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 an installed capacity of 100 kW and less are not included in the analysis.

The publication of the Status of Onshore Wind Energy Development takes place before the reporting deadline for commissioning in the first half of 2023. 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.

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Photo on Title Page

Contact

Deutsche WindGuard GmbH
Oldenburger Straße 65 A
26316 Varel, Germany
Phone +49 (4451) 9515-0
Fax +49 (4451) 9515-29
Email info@windguard.de
URL http://www.windguard.com/

Wind Energy Development and Status

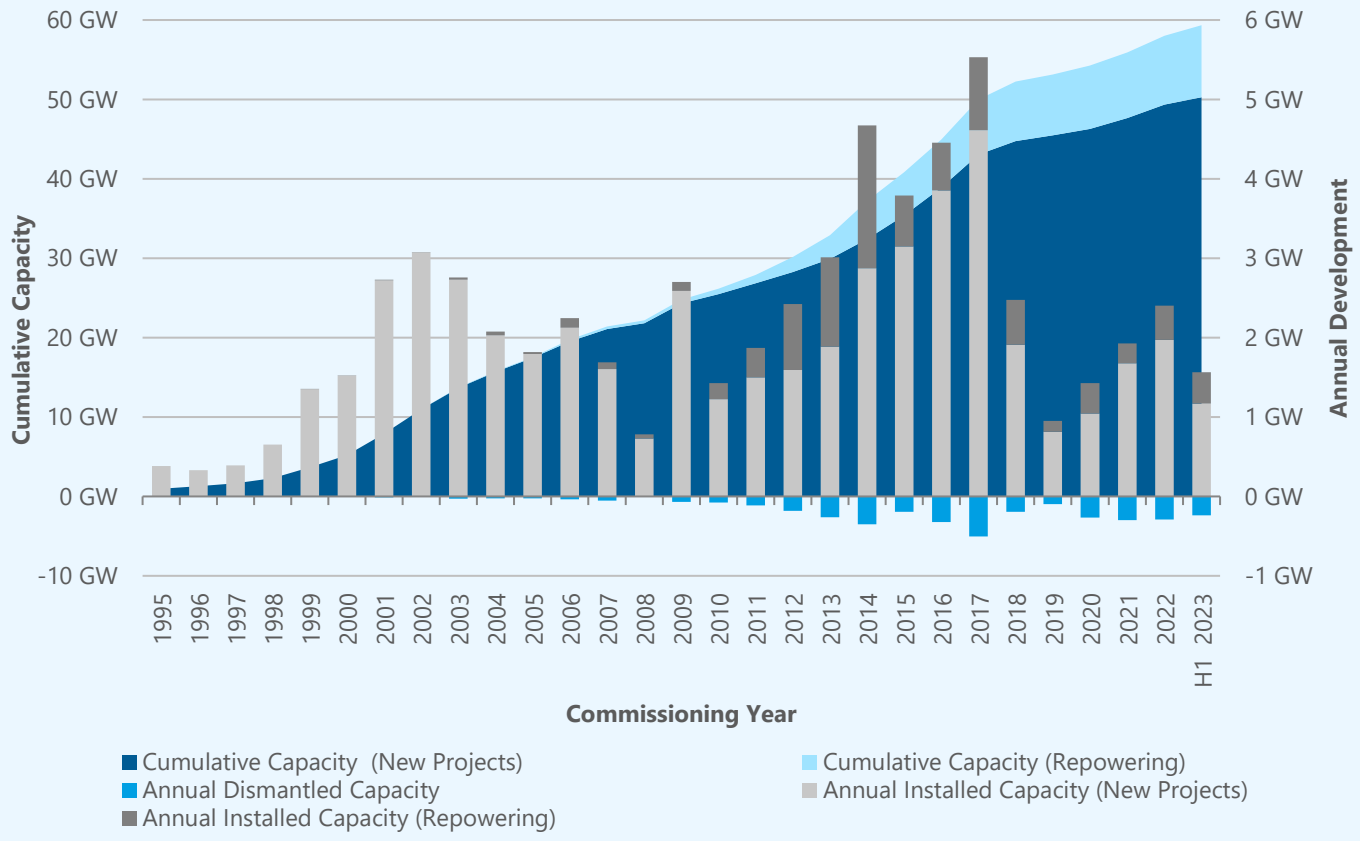
In the first half of 2023, 331 new onshore wind turbines (WT) with a combined capacity of 1,565 MW were installed in Germany. By the end of June 2023, the new installed capacity had already reached 65 % of the total installed capacity of the previous year.

80 of the new wind turbines with 396 MW were installed as part of repowering projects. The decommissioning of 198 old wind turbines with a combined capacity of 239 MW was recorded in the first half of 2023.

Gross additions and decommissioning resulted in a net addition of 1,325 MW. As of June 30, 2023, this results in a cumulative portfolio of 28,517 wind turbines with a total capacity of 59,343 MW.

Status of Onshore Wind Energy Development

		Capacity	Turbines
Development H1 2023	Gross installations	1,565 MW	331 WT
	Repowering share	396 MW	80 WT
	Decommissioning	239 MW	198 WT
	Net installations	1,325 MW	133 WT
Cumulative 2023-06-30	Cumulative	59,343 MW	28,517 WT



Annual Development Onshore Wind Energy Capacity in Germany

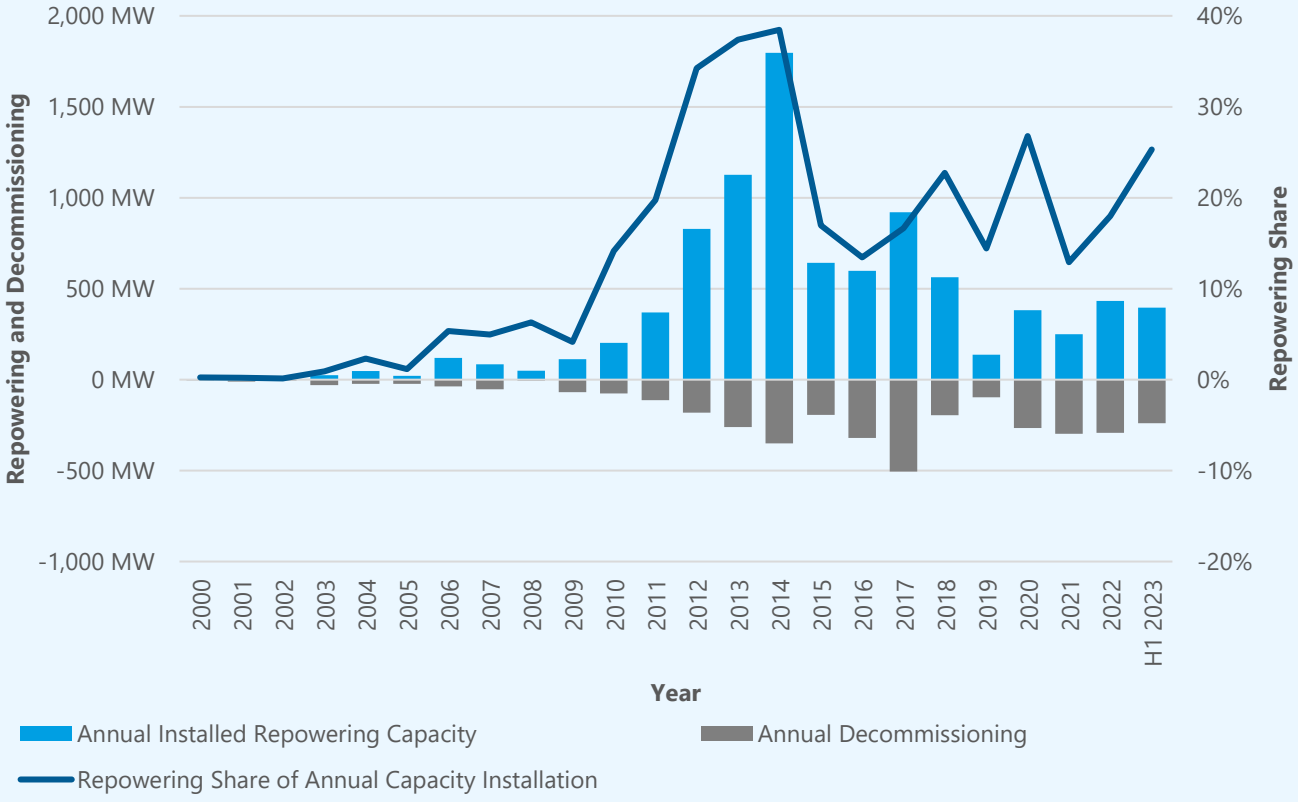
Decommissioning, Continued Operation and Repowering

198 wind turbines with a combined capacity of 239 MW were decommissioned in the first half of 2023. An average turbine decommissioned during the half-year has a capacity of about 1,2 MW. The average decommissioning age is approximately 21 years. Some of the decommissioned turbines are replaced by new ones as part of repowering projects. Through the realization of repowering projects, the areas for wind energy utilization are preserved. Often, several small, old wind turbines are dismantled and replaced by a smaller number of large, new turbines. In the first half of 2023, 80 turbines with 396 MW were identified as such repowering turbines. This corresponds to a repowering share of 25 % of the gross installations.

Turbines that were installed in 2002 or before and have not yet been decommissioned are currently operating without financial subsidies. As of June 30, 2023, this affects 7,796 turbines with a combined capacity of 8 GW. During the next 5 years, another 5,850 wind turbines (10 GW) if not decommissioned before, will lose their entitlement to a subsidized remuneration.

Age of dismantled and operating Wind Turbines

Age	Decommissioned H1 2023		In Operation 2023-06-30	
	Capacity	Turbines	Capacity	Turbines
>20 Years, no funding claim (COD ≤ 2002)	144 MW	137 WT	8,007 MW	7,796 WT
15 - 20 Years (COD 2003 - 2007)	72 MW	50 WT	10,046 MW	5,850 WT
10 - 15 Years (COD 2008 - 2012)	14 MW	7 WT	9,100 MW	4,333 WT
5 - 10 Years (COD 2013 - 2017)	9 MW	4 WT	21,442 MW	7,705 WT
0 - 5 Years (COD 2018 - 2023)	0 MW	0 WT	10,748 MW	2,833 WT
Total	**239 MW**	**198 WT**	**59,343 MW**	**28,517 WT**

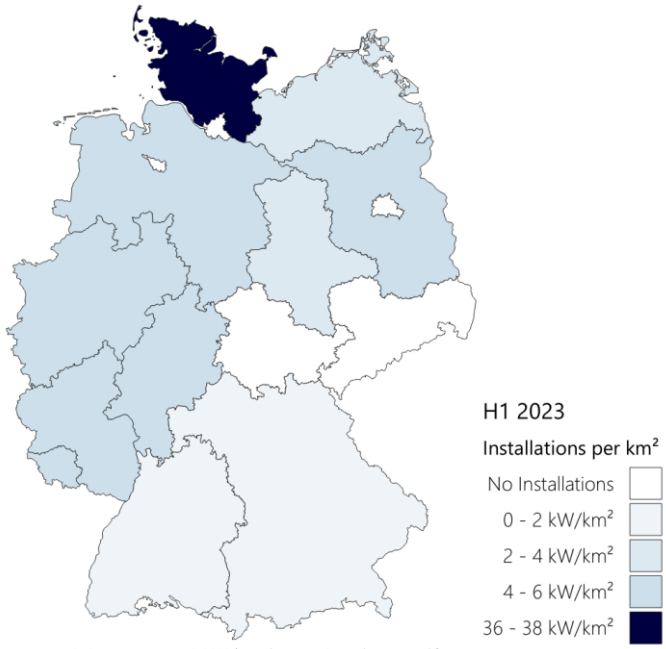


Development of Annual Decommissioning, Annual Installed Repowering Capacity and Repowering Share

Regional Distribution of Wind Energy Installation

Schleswig-Holstein has installed 38 % of the new capacity in the first half of the year 2023, and is thus the undisputed front-runner in terms of current wind energy development. In this northernmost German federal state, 125 wind turbines with 597 MW were erected. Lower Saxony follows at a clear distance in second place: 52 turbines with a total of 267 MW were installed. North Rhine-Westphalia achieved an addition of 204 MW, putting it in third place. In Brandenburg, 148 MW were newly installed. In the four previously mentioned states and in Saxony-Anhalt, the repowering share is the highest.

The remaining German federal states added less than 100 MW each. In addition to the city states, no new installations were recorded in Thuringia and Saxony in the first half of 2023. Due to the dismantling of 3 turbines, the net addition in Saxony is negative.



Regional Distribution of Gross Capacity Installation

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

H1 2023		Gross Installations			Dismantling and Net Installation			Repowering		
Position	Federal State	Capacity Instal-lation	Number of new Turbines	Share*	Capacity Dis-mantling	Number of Dismantled Turbines	Net Instal-lation	Capacity Repo-wering	Number of Repo-wering Turbines	Repo-wering-Share**
1	Schleswig-Holstein	597 MW	125 WT	38%	55 MW	64 WT	542 MW	199 MW	40 WT	33%
2	Lower Saxony	267 MW	52 WT	17%	69 MW	48 WT	198 MW	69 MW	14 WT	26%
3	North Rhine-Westphalia	204 MW	45 WT	13%	54 MW	45 WT	149 MW	55 MW	13 WT	27%
4	Brandenburg	148 MW	28 WT	9%	8 MW	6 WT	140 MW	51 MW	9 WT	35%
5	Rhineland-Palatinate	90 MW	22 WT	6%	10 MW	4 WT	80 MW	0 MW	0 WT	0%
6	Hesse	89 MW	19 WT	6%	0 MW	0 WT	89 MW	0 MW	0 WT	0%
7	Saxony-Anhalt	58 MW	11 WT	4%	21 MW	15 WT	37 MW	22 MW	4 WT	39%
8	Mecklenburg-Western Pomerania	49 MW	12 WT	3%	18 MW	11 WT	32 MW	0 MW	0 WT	0%
9	Baden-Württemberg	31 MW	8 WT	2%	1 MW	1 WT	30 MW	0 MW	0 WT	0%
10	Bavaria	18 MW	5 WT	1%	2 MW	1 WT	17 MW	0 MW	0 WT	0%
11	Saarland	14 MW	4 WT	1%	0 MW	0 WT	14 MW	0 MW	0 WT	0%
	Thuringia	0 MW	0 WT	0%	0 MW	0 WT	0 MW	0 MW	0 WT	-
	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	-
	Saxony	0 MW	0 WT	0%	3 MW	3 WT	-3 MW	0 MW	0 WT	-
	Germany	**1,565 MW**	**331 WT**		**239 MW**	**198 WT**	**1,325 MW**	**396 MW**	**80 WT**	**25%**

* Share of gross capacity Installations per federal state in total gross capacity installation

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

Average Turbine Configuration and Regional Differences

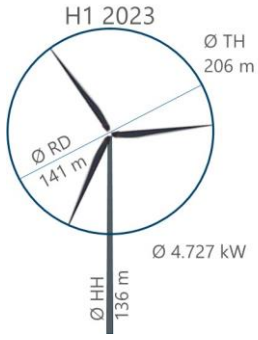
The average capacity of a wind turbine installed in the first half of 2023 has once again increased significantly and, at about 4,7 MW, is 8 % above the previous year's average. The rotor diameter of currently 141 m on average has also increased compared to the previous year. Due to the approximately 1 % lower hub height, the average total height remains unchanged compared to 2022.

With an average capacity of over 5 MW, the most powerful turbines have been installed in Brandenburg, Saxony-Anhalt, and Lower Saxony in the first half of 2023. The average capacity of the turbines installed in Baden-Württemberg, Bavaria and Saarland is significantly lower (below 4 MW).

The average rotor diameter in the federal states ranges from 131 m in Saarland to 151 m in Lower Saxony. The average hub height is by far the lowest in Schleswig-Holstein, where turbines with an average hub height of 110 m are installed, while in many other states the average is above 150 m. This is also the reason for the low tip height in Schleswig-Holstein, where turbines with an average tip height of 179 m are built.

Average Wind Turbine Configuration

Installations H1 2023	Change compared to prior year
Turbine Capacity	+8%
Rotor Diameter	+3%
Hub Height	-1%
Tip Height	+0%

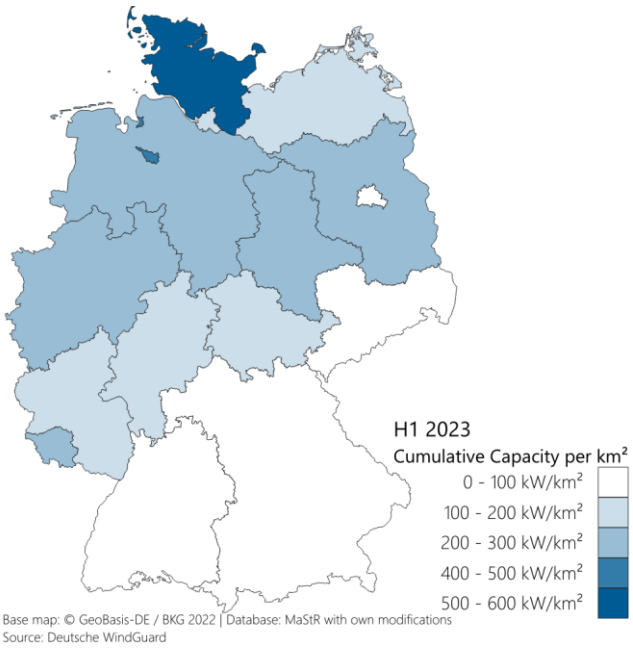


Average Turbine Configuration of newly installed Wind Turbines in German Federal States

Installations H1 2023		Average Configuration of newly installed Turbines			
State	Number of Turbines	Turbine Capacity	Rotor Diameter	Hub Height	Tip Height
Schleswig-Holstein	125 WT	4,774 kW	138 m	110 m	179 m
Lower Saxony	52 WT	5,128 kW	151 m	153 m	228 m
North Rhine-Westphalia	45 WT	4,525 kW	140 m	146 m	216 m
Brandenburg	28 WT	5,288 kW	148 m	156 m	230 m
Rhineland-Palatinate	22 WT	4,075 kW	134 m	145 m	212 m
Hesse	19 WT	4,695 kW	141 m	156 m	227 m
Saxony-Anhalt	11 WT	5,264 kW	149 m	158 m	233 m
Mecklenburg-Western Pomerania	12 WT	4,108 kW	139 m	155 m	224 m
Baden-Württemberg	8 WT	3,825 kW	134 m	152 m	219 m
Bavaria	5 WT	3,660 kW	136 m	155 m	223 m
Saarland	4 WT	3,600 kW	131 m	134 m	200 m
Thuringia	0 WT	-	-	-	-
Berlin	0 WT	-	-	-	-
Bremen	0 WT	-	-	-	-
Hamburg	0 WT	-	-	-	-
Saxony	0 WT	-	-	-	-
Germany	**331 WT**	**4,727 kW**	**141 m**	**136 m**	**206 m**

Regional Distribution of the Cumulative Portfolio

At mid-year 2023, a total of 28,517 wind turbines with a combined capacity of approx. 59 GW are in operation. Lower Saxony has the highest share of the total capacity with 21 %. Lower Saxony is followed by the federal states of Brandenburg (14 %), Schleswig-Holstein (13 %) and North Rhine-Westphalia (12 %). However, due to the different state sizes, the informative value of the installed capacity is limited. If the installed capacity is viewed in relation to the area of the state, Schleswig-Holstein is in the lead with a capacity density of over 500 kW/km². It is closely followed by the small city state of Bremen. The states of Berlin, Bavaria, Baden-Württemberg and Saxony, on the other hand, have a particularly low capacity density of less than 100 kW/km².



Regional Distribution of the Cumulative Capacity

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

Cumulative Portfolio* (2023-06-30)					
Federal State	**Cumulative Capacity**	**Cumulative Number**	**Share**	**Capacity per area**	**Turbines per area**
Lower Saxony	12,268 MW	6,149 WT	21%	257 kW/km²	0.13 WT/km²
Brandenburg	8,403 MW	4,010 WT	14%	283 kW/km²	0.14 WT/km²
Schleswig-Holstein	7,987 MW	3,158 WT	13%	505 kW/km²	0.20 WT/km²
North Rhine-Westphalia	6,901 MW	3,598 WT	12%	202 kW/km²	0.11 WT/km²
Saxony-Anhalt	5,372 MW	2,790 WT	9%	263 kW/km²	0.14 WT/km²
Rhineland-Palatinate	3,956 MW	1,769 WT	7%	199 kW/km²	0.09 WT/km²
Mecklenburg-Western Pomerania	3,599 MW	1,835 WT	6%	154 kW/km²	0.08 WT/km²
Bavaria	2,629 MW	1,149 WT	4%	37 kW/km²	0.02 WT/km²
Hesse	2,462 MW	1,162 WT	4%	117 kW/km²	0.06 WT/km²
Thuringia	1,797 MW	863 WT	3%	111 kW/km²	0.05 WT/km²
Baden-Württemberg	1,774 MW	783 WT	3%	50 kW/km²	0.02 WT/km²
Saxony	1,321 MW	875 WT	2%	72 kW/km²	0.05 WT/km²
Saarland	535 MW	216 WT	1%	208 kW/km²	0.08 WT/km²
Bremen	201 MW	87 WT	0%	479 kW/km²	0.21 WT/km²
Hamburg	122 MW	67 WT	0%	161 kW/km²	0.09 WT/km²
Berlin	17 MW	6 WT	0%	19 kW/km²	0.01 WT/km²
Germany	**59,343 MW**	**28,517 WT**		**166 kW/km²**	**0.08 WT/km²**

* with a minimum turbine capacity of > 100 kW

Results of Tender Rounds

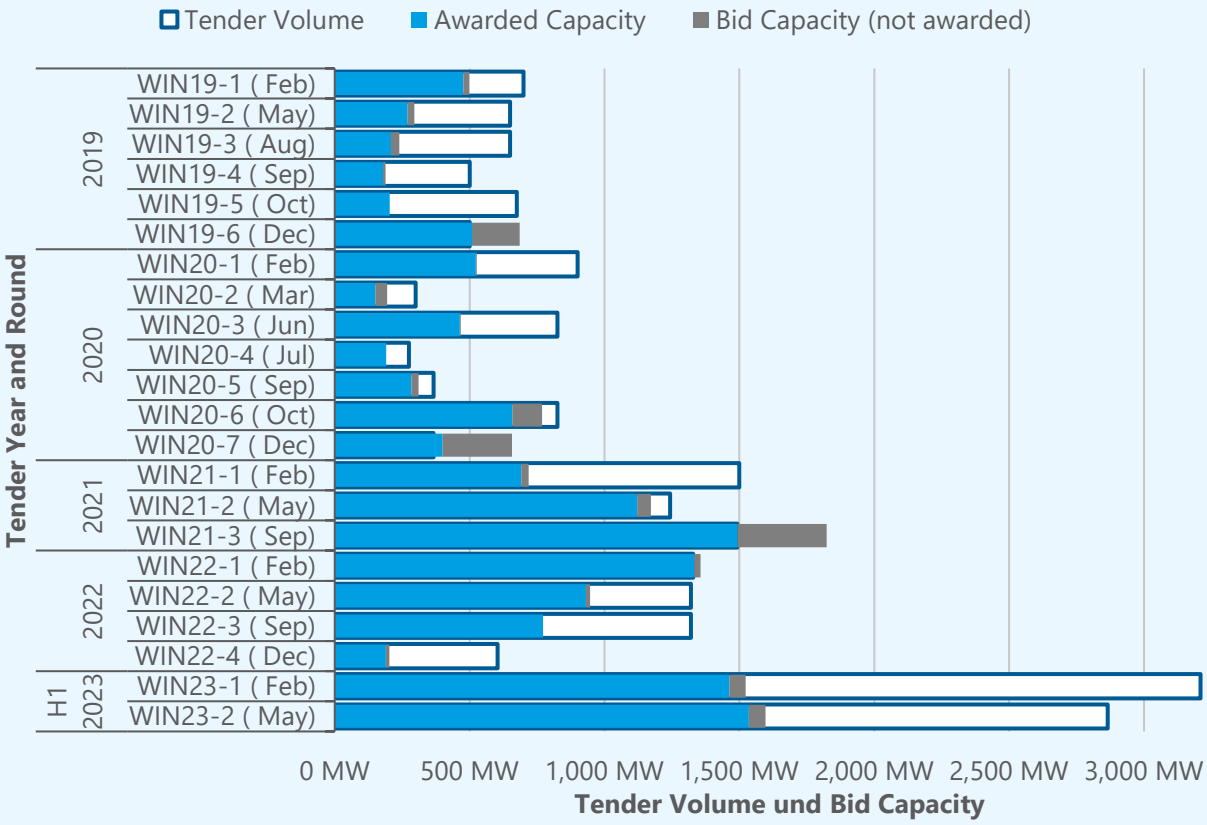
The tender rounds for onshore wind energy in 2023 entail some changes compared to the tender rounds in previous years. Not only were the tender volumes significantly increased due to the higher political development targets, furthermore the maximum permissible bid values were increased from 5,88 ct/kWh to 7,35 ct/kWh to compensate for the rising costs in the previous year.

In the two tender rounds conducted so far this year, 2,999 MW were awarded. Both tender rounds were significantly undersubscribed, yet almost as much capacity was awarded in the first half of 2023 as in the entire previous year. The amount of bids submitted per round, which had fallen massively over the course of 2022, returned to the level observed at the end of 2021 and beginning of 2022.

The award values in the first half of 2023 are close to the permissible maximum value. On average, they are 26 % higher than the award values achieved in 2022.

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	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
	H1 2023	7.35 ct/kWh	7.34 ct/kWh



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

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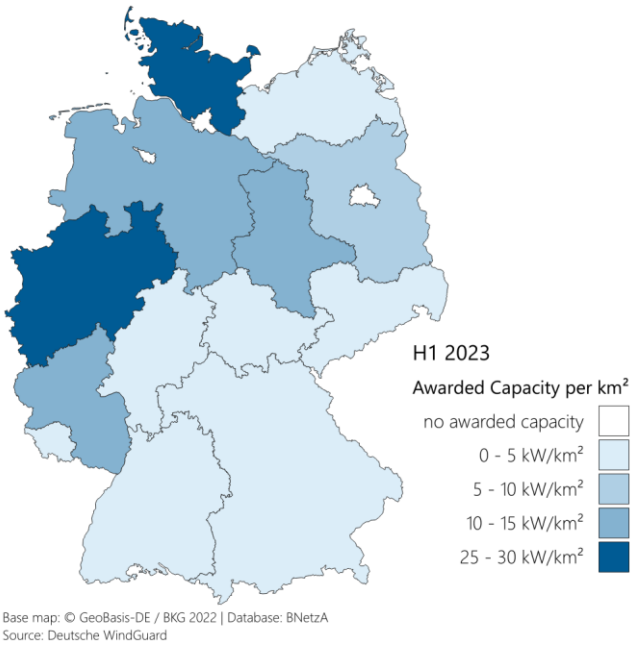
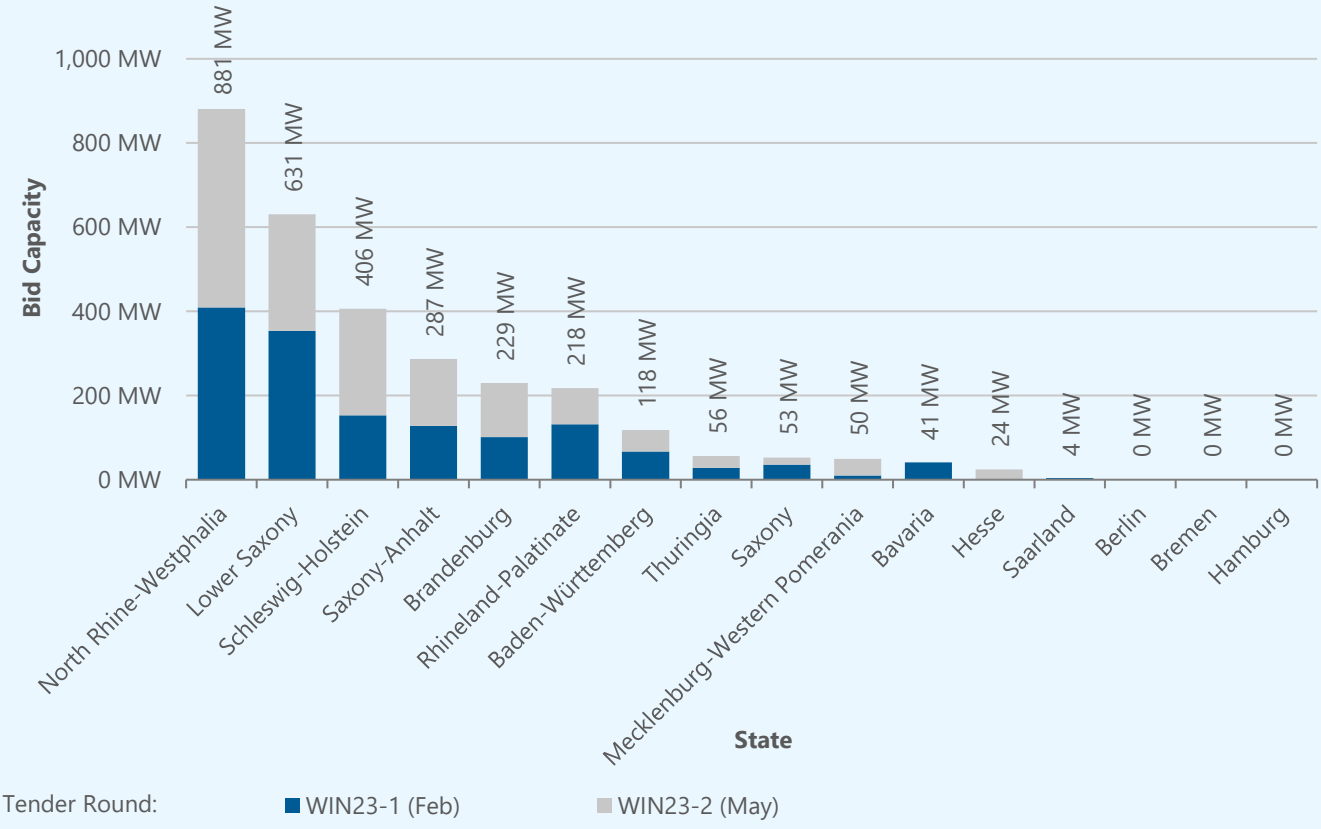
Regional Distribution of Awarded Bids

The awards made in the first half of 2023 are distributed across 13 of 16 German federal states. With the exception of the three city states, at least one bid was awarded in each federal state. The largest capacity was awarded in North Rhine-Westphalia (29 % of the total volume awarded). At mid-year, more capacity had already been awarded in North Rhine-Westphalia than in the entire previous year. Lower Saxony came second with 21 % of the total volume awarded. Although only 12 % of the total volume was awarded to wind energy projects in Schleswig-Holstein, in relation to the area of the state, the amount awarded corresponds to that of North Rhine-Westphalia (26 kW/km² in each case). Saxony-Anhalt, Lower Saxony and Rhineland-Palatinate achieved an award density of over 10 kW/km².



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



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

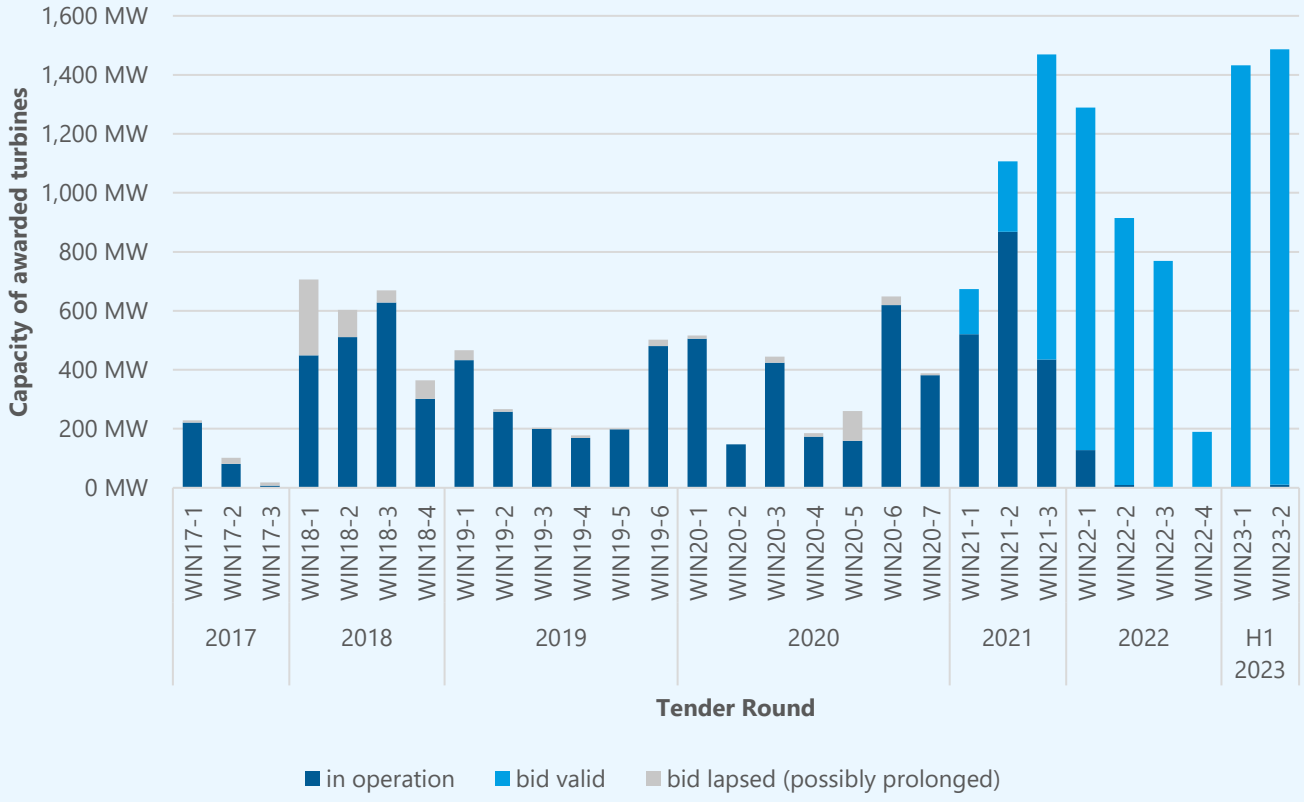
Development Status of Awarded Turbines

Since the introduction of the tenders in 2017, wind energy projects with a total capacity of 19.2 GW have been awarded. At the end of the first half of 2023, 8.3 GW of this have been realized. Capacity amounting to approximately 3.4 GW has already lost the award due to lapsed realization period, unless an extension has been requested. Most of the lapsed bids originate from the year 2017, in which primarily turbines without approval were awarded. Awarded turbines with a capacity of around 7.6 GW still need to be realized. Turbines awarded in 2020 have largely been implemented, with a realization rate of 90 %. More than half of the capacity awarded in 2021 (55 %) has already been put into operation. Implementation of the awards of 2022 and the first half of 2023 is still in the early stages.

Realized Capacity* of Tenders for Onshore Wind Energy in Germany

	Year	Realized Capacity	Realization Rate
Year of Tender	2017	309 MW	11%
	2018	1,891 MW	81%
	2019	1,738 MW	94%
	2020	2,411 MW	90%
	2021	1,823 MW	55%
	2022	138 MW	4%
	H1 2023	15 MW	1%

* 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)

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Permitted Capacity and Future Tender Rounds

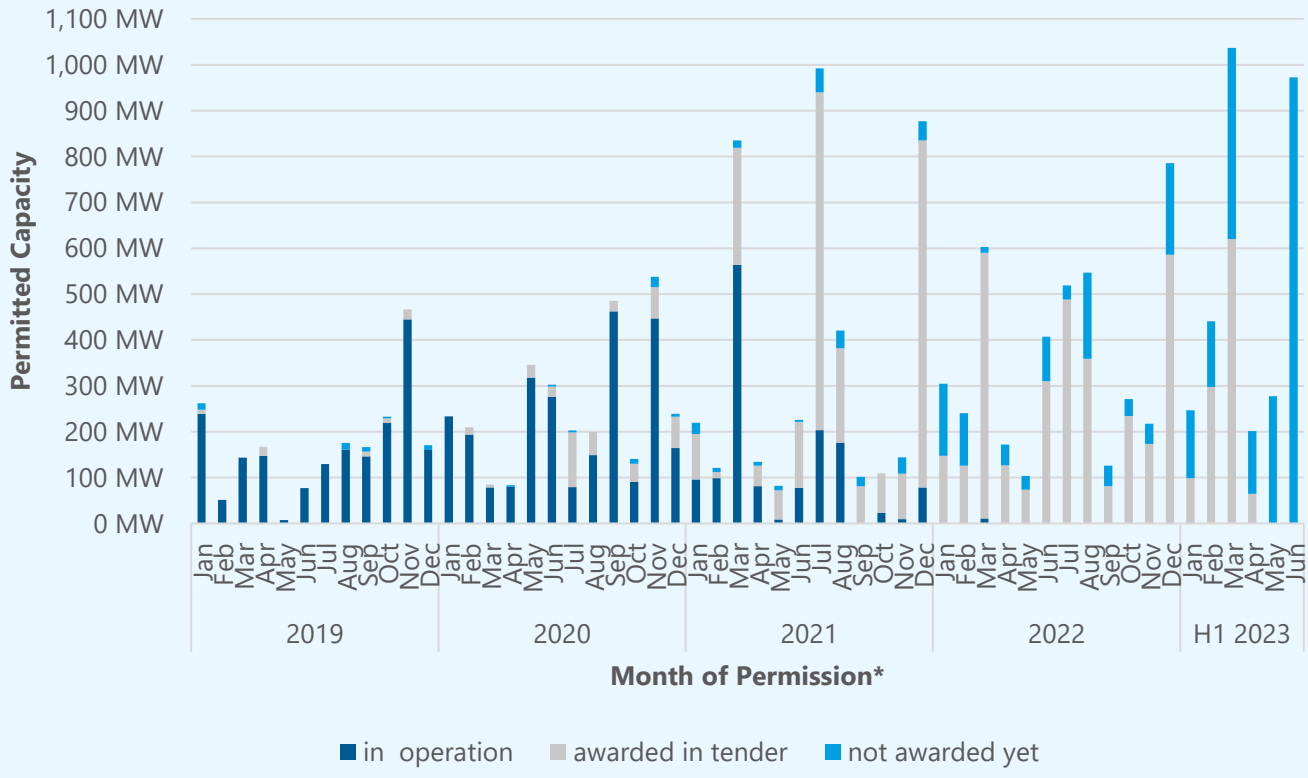
In the first half of 2023, permits were issued for 585 new wind turbines with a combined capacity of 3,175 MW. Compared to the previous year, there is already a significant increase - by the middle of 2023, the volume of permitted capacity already amounts to three quarters of the new approvals issued in 2022 as a whole.

Of the capacity permitted in the first half of the year, 34 % has already been awarded in a tender round. The remaining 66 % will have their first or renewed opportunity to secure an EEG subsidy claim in the next tender round on August 1, 2023. Around 1 GW of permits issued in 2022 has not yet been awarded in a tender round.

For the remaining month of the year, two more tender rounds with 3,2 GW tender volume each (possibly subject to a reduction by the BNetzA) are planned. The permits issued to date are not yet sufficient to fill this volume.

Annual Permitted Capacity

	Year	Permitted Capacity	Permitted Wind Turbines
Year of Permission	2019	2,051 MW	513 WT
	2020	3,065 MW	691 WT
	2021	4,261 MW	888 WT
	2022	4,296 MW	853 WT
	H1 2023	3,175 MW	585 WT



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

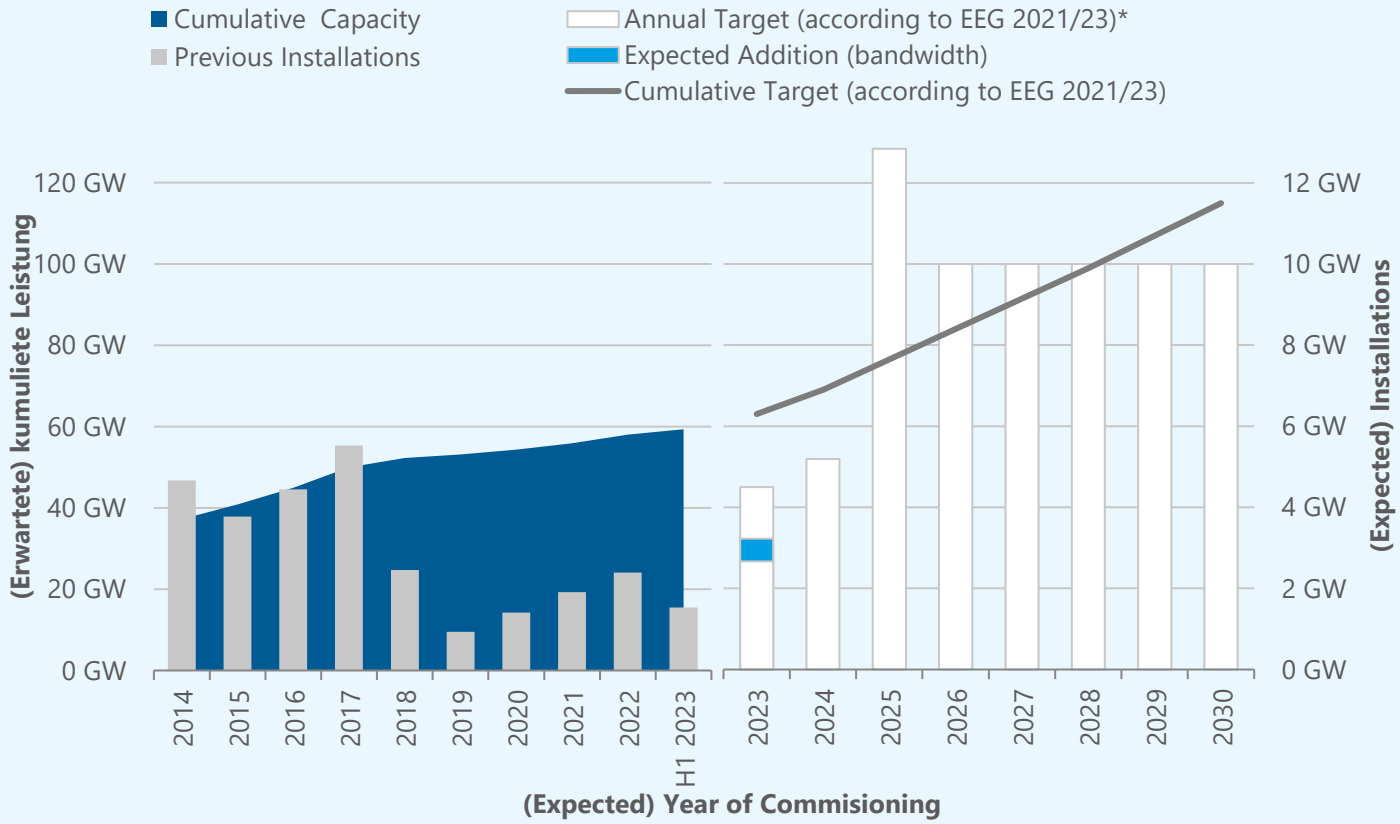
Monthly Permitted Capacity including Status

Expected Development and Political Target

The EEG 2023 sets out the targeted expansion path for onshore wind energy. In 2024, for example, 69 GW of installed capacity is to be reached. In 2030, a total installed capacity of 115 GW is to be reached. At the end of the first half of 2023, about 59 GW is in operation. A 16 % increase in the total installed capacity is required to reach the 2024 target within the next year and a half.

Based on the tender volumes also defined in the EEG, it is possible to derive the annual addition volume aimed for, in order to achieve the targets. Assuming that around 2 years elapse between the tender and the realization of the capacities, 12,8 GW are supposed be commissioned in 2025 and 10 GW annually in the future. The annual expansion targets for 2023 and 2024 are derived from tender volumes in the EEG 2021 and are lower.

In the past, however, it was often not possible to fill the tender volumes. Accordingly, the actual expected expansion is below the political targets. At the beginning of the year, an addition of 2.7 GW to 3.2 GW was forecasted for 2023. By mid-year, the upper forecast range is expected to be reached. Effects, such as further delays in the supply chains or economic problems resulting from high inflation or decreasing realization times due to changes in framework conditions, could influence the achievable additions.



Expected installations in 2023 and political targets according to EEG 2021/23

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

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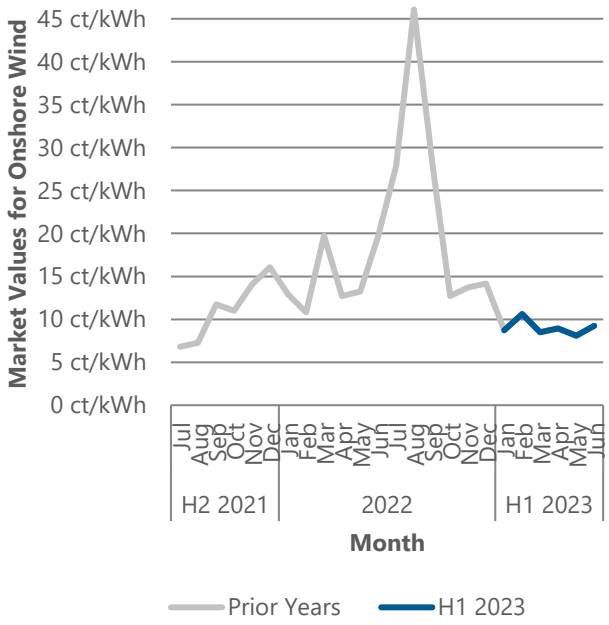
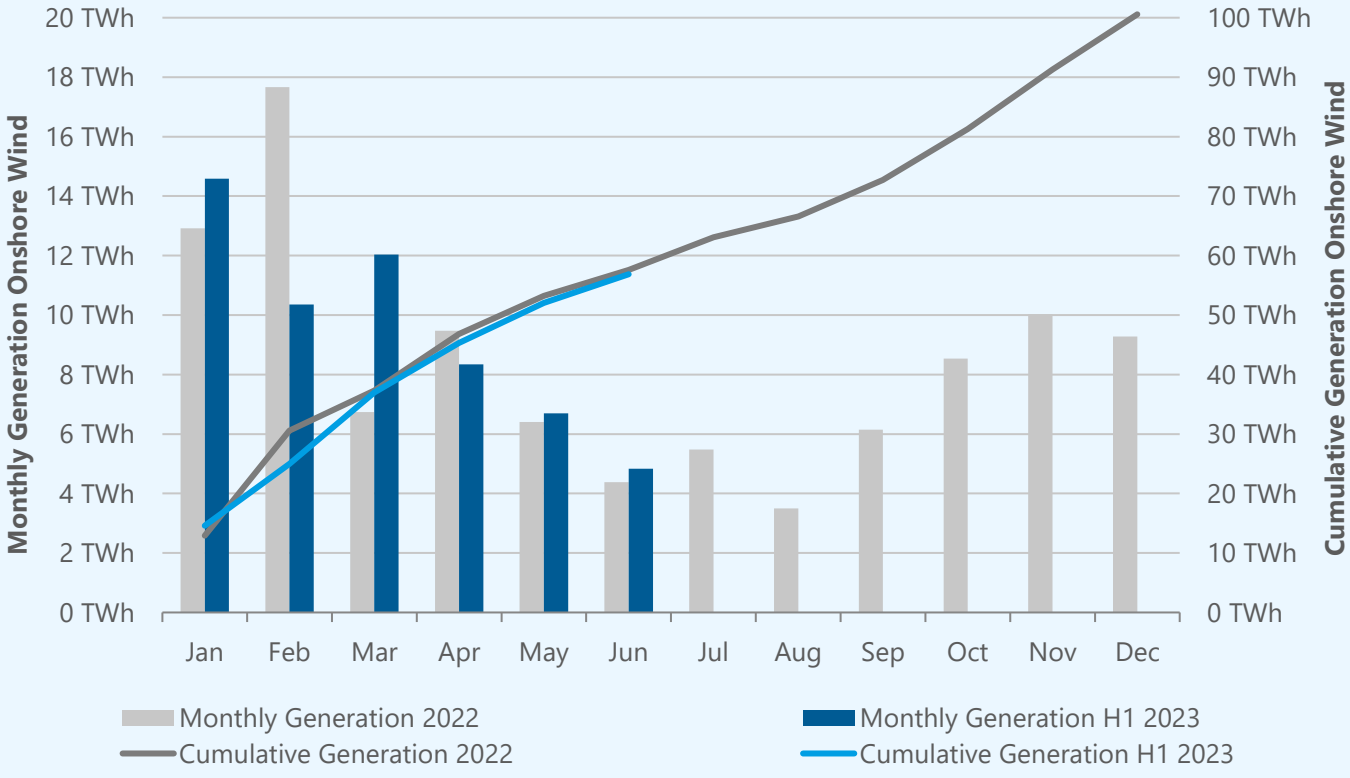
Power Generation and Market Values

In the first half of 2023, 56,9 TWh of electricity was generated from onshore wind energy in Germany. Although the distribution among the individual months differs, the generation roughly corresponds to the amount of electricity achieved in the first half of the previous year. The highest generation of the year so far was achieved in January, with the volume generated falling in the summer months as expected. Around 25 % of total generation in the first half of 2023 is attributable to onshore wind energy. Renewables as a whole account for 54 %.

After reaching unprecedented maximum values on the electricity market in 2022 with considerable fluctuations, the market value settled back at a more stable level in the first half of 2023. On average, the market value for onshore wind energy in the first six months of the year was 9,03 ct/kWh, 45 % below the prior-year average.



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, manufactuer-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 the association of the energy plant manufacturers. It 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 as well as press and public relations. VDMA Power Systems is a trade association within the German Engineering Federation VDMA e.V.