2016

DEUTSCHE WINDGUARD

STATUS OF LAND-BASED WIND ENERGY DEVELOPMENT IN GERMANY

On behalf of:

BWE Bundesverband WindEnergie

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STATUS OF LAND-BASED WIND ENERGY DEVELOPMENT

The additions that occurred in 2016, the cumulative turbine portfolio as of 31 December 2016, along with the portrayal of major aspects such as average turbine configuration, regional distribution and select evaluations with regard to the new regulations of the German Renewable Energy Law (EEG) 2017 are analyzed in this factsheet on the Status of land-based wind energy in Germany.

NET AND GROSS ADDITIONS

The gross addition of wind turbine generators (WTG) in 2016 in Germany came to a total of 1 624 machines with an overall capacity of 4 625 MW. Included in this total are 238 repowered turbines with a capacity of 679 MW. Subtracting 366 MW in capacity generated by the 336 turbines dismantled during 2016 from the total results in a net addition of 1 288 WTG generating 4 259 MW. In gross, an additional 24% in capacity was added in 2016 compared to 2015. The gross of the record year of 2014 with 4 750 MW was not reached.

	Status of Land-based Wind Energy Development	Capacity [MW]	Number of WTG
Development Year 2016	Net additions during 2016	4 259.17	1 288
	Gross additions during 2016	4 625.25	1 624
	Repowering share (non-binding)	679.25	238
	Dismantling in 2016 (incl. subsequent registration) (non-binding)	366.09	336
Cumulative 2016-12-31	Cumulative WTG portfolio Status:2016-12-31 non-binding)	45 910.67	27 270

Table 1: Status of Land-based Wind Energy Development (2016-12-31)

By 2016-12-31, the number of WTG in the cumulative portfolio had increased to 27 270 generating 45 911 MW. This is equivalent to a 10% increase of the cumulative capacity compared to the value of the previous year. The development of land-based wind energy with regard to installed, dismantled and cumulative capacity per year over time is depicted in Figure 1.

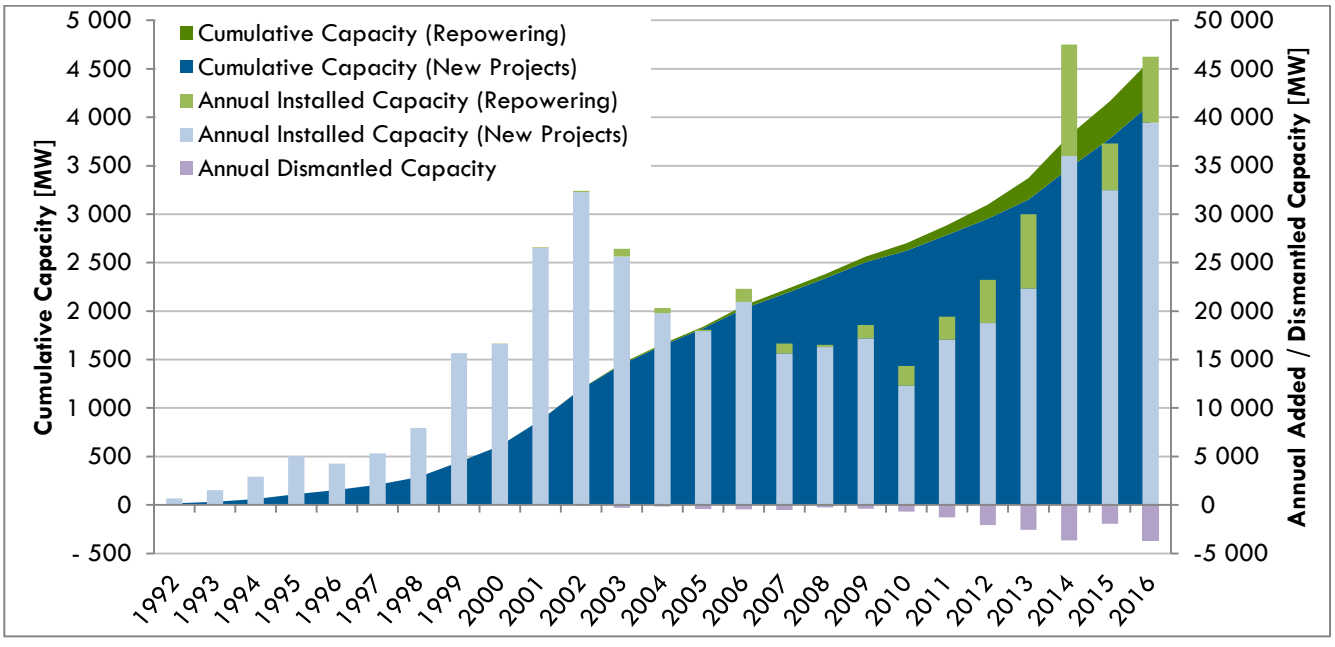

Figure 1: Development of Installed, Dismantled and Cumulative Land-based Wind Energy Capacity [MW] per Year in Germany Including Repowering and Dismantling, Status: 2016-12-31

From 2012 onward, data was determined using industry player questionnaires and additional research.

Database 1992 – 2011: DEWI

DISMANTLING

Based on research, reconciliation of decommissionings logged in the WTG register, as well as taking late registrations for the previous year into consideration, a total of 336 WTG with a capacity of 366 MW could be identified as dismantled in 2016. The capacity determined as dismantled exceeded the value of the previous year by 88 %. The average capacity of a WTG dismantled in 2016 was 1 090 kW.

WTG are dismantled if their operation is no longer economically feasible, their technological condition prohibits continued operation or the pressure to free up the space occupied by the WTG for alternative use(s) is very high. All WTG currently in operation receive at least the base remuneration as WTG installed prior to 2000 were guaranteed to be eligible for this remuneration until 2020.

REPOWERING

Of the 1 624 WTG erected in 2016, 238 could be identified as repowered WTG. The overall capacity of these repowered WTG is 679 MW, which constitutes a share of 15 % of the gross additions. The capacity added in the framework of repowering projects increased by 40% compared to the previous year.

The definition of repowering WTG in Germany is unclear. Prior to the 2014 amendment to the EEG, each WTG replacing at least one old WTG in the same or an adjacent county received the repowering bonus and was thus identified as a repowered WTG. Without this bonus, interpretation of the term "repowering" changes in the sense that a new, modern WTG replaces an old machine in direct spatial relation. Subsequently, WTG are no longer classified as repowered WTG, if the dismantling of old WTG in an adjacent county is unrelated to a new project, for example.

CUMULATOVE PORTFOLIO

The cumulative capacity increased by 10% to 45 911 MW compared to the previous year. By the end of 2016, a total of 27 270 WTG had been installed. It must be noted that the cumulative values are non-binding and may be overestimated due to an underestimation of dismantled WTG from previous years.

With the establishment of the central WTG register as required by the 2014 amendment to the EEG, it is mandatory for WTG operators to report permissions and commissionings of WTG, as well as their repowering and dismantling, so they can be captured in the register. As a result, since August 2014, the quality of the available repowering and dismantling database has improved. WTG that were dismantled prior to the EEG 2014 going into effect are not captured retroactively. It must be noted that in the register the "commissioning" of WTG is used as the allocation criteria for a particular year. In comparison, the development statistic at hand captures the "erection" of WTG. Since a certain amount of time passes between the erection and the commissioning of WTG, the capturing of part of the WTG into the WTG register ends up getting pushed into the following year. This, along with possible late registrations to the register, is one of the reasons for the differences between the data sets.

AVERAGE WIND TURBINE GENERATOR CONFIGURATION

On average, a WTG erected in Germany in 2016 had a nominal capacity of 2 848 kW, which is an increase of 4% compared to 2015. With an average rotor diameter of 109 meters and an average hub height of 128 meters, both values increased by 4%. The average specific power, resulting from the ratio of WTG capacity and the area swept by the rotor, decreased by 4 % from 326 W/m² to 314 W/m². The trend observed since 2012 to WTG with a large rotor sweep area compared to their capacity is thus continuing. The summary of the average WTG configuration values can be found in Table 2. The development of the average capacity of WTG erected in a particular year is shown in Figure 2. The figure also shows the increase of the average WTG capacity in relation to the overall WTG portfolio in Germany. With an increase of 5% compared to the preceding year, the average capacity in the cumulative WTG portfolio increased to 1 684 kW in 2016.

Table 2: Average Configuration of WTG Erected in 2016, Status: 2016-12-31

	Average Land-based Turbine Configuration, Erected 2016	
Year 2016	Average WTG Capacity	2 848 kW
	Average Rotor Diameter	109 m
	Average Hub Height	128 m
	Average Specific Power	314 W/m²

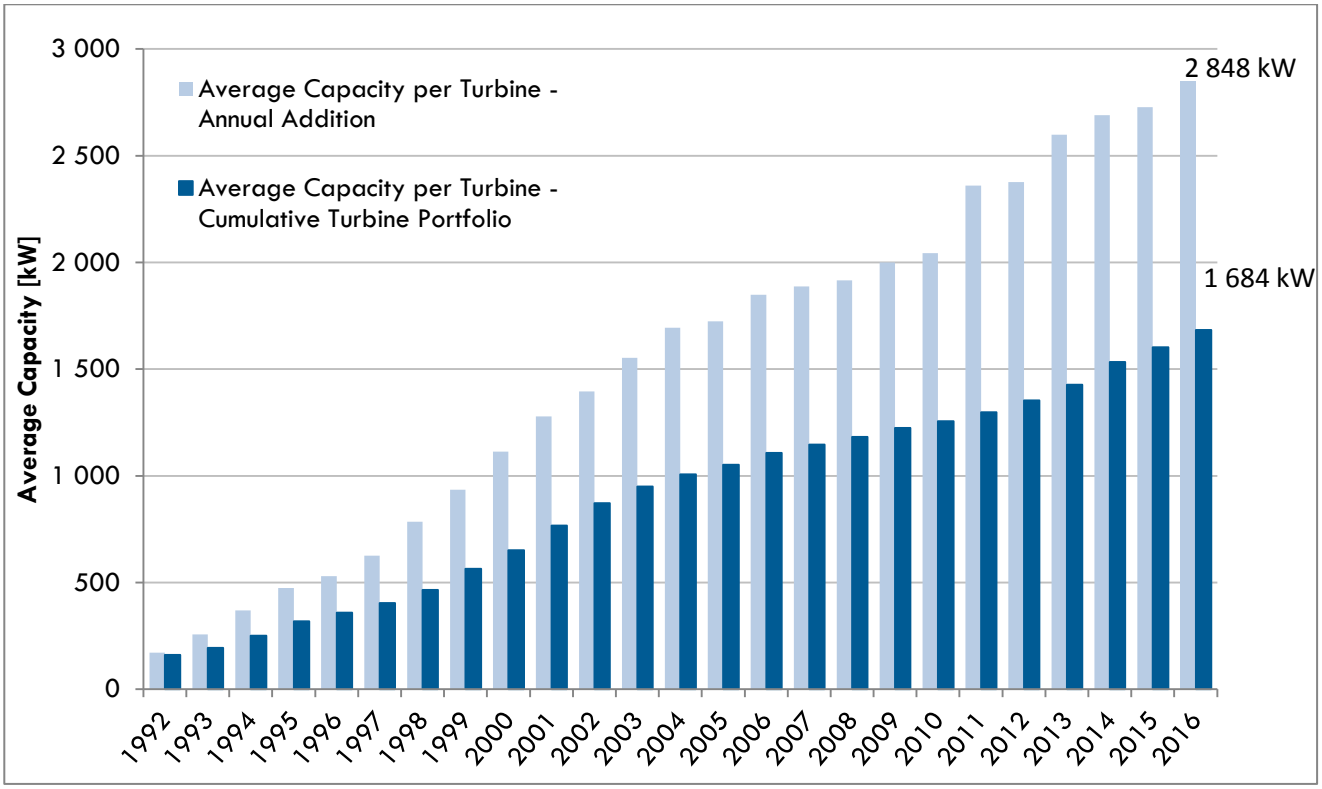

Figure 2: Average Capacity Development of Land-based WTGs Newly Installed and Cumulatively Present in the German Turbine Portfolio, Status: 2016-12-31

From 2012 onward, data was determined using industry player questionnaires and additional research.

Database 1992 – 2011: DEWI

On behalf of: BWE Bundesverband WindEnergie, VDMA Power Systems

REGIONAL DISTRIBUTION OF WIND ENERGY ADDITIONS

The largest number of new WTG were erected in the state of Lower Saxony with a total of 312 machines and a respective capacity of 900 MW. The gross addition within that state more than doubled from 2015 and with that it replaces Schleswig-Holstein, with its 217 WTG and a capacity of 651 MW, after three consecutive years in first place in the German federal state comparison. North Rhine-Westphalia is a close third with 211 WTG and 564 MW in new additions. Brandenburg maintains its fourth place with an addition of 494 MW and Baden-Wuerttemberg moved up the ranks rapidly with a gross addition of 141% to 347 MW, subsequently installing slightly more capacity than Bavaria (340 MW). In the regional comparison of additions, the northern German states claim 38.6%, the central states 41.5% and the southern states 21.9% of the gross additions.

Table 3: Addition (gross) to Wind Energy in the German States in 2016, Status: 2016-12-31

		Gross Additions in 2016				Average WTG Configuration			
Rank	State	Gross Capacity Addition [MW]	Gross-Number of Added WTG	Share in the Gross Capacity Addition	Development of the Gross Addition compared to the previous Year	Average WTG Capacity [kW]	Average Rotor Diameter [m]	Average Hub Height [m]	Average Specific Power [W/m²]
1	Lower Saxony	900.40	312	19.5%	+118%	2 886	105	125	353
2	Schleswig-Holstein	651.20	217	14.1%	-27%	3 001	105	99	357
3	North Rhine-Westphalia	564.45	211	12.2%	+34%	2 675	104	127	328
4	Brandenburg	493.80	173	10.7%	+24%	2 854	113	135	294
5	Baden-Wuerttemberg	346.70	124	7.5%	+141%	2 796	118	142	257
6	Bavaria	339.80	124	7.3%	-9%	2 740	116	140	261
7	Saxony-Anhalt	323.00	116	7.0%	+22%	2 784	109	128	302
8	Hesse	316.70	112	6.8%	+52%	2 828	118	142	261
9	Rhineland-Palatinate	235.65	79	5.1%	+17%	2 983	113	139	301
10	Mecklenburg-Western Pomerania	217.45	73	4.7%	+13%	2 979	105	130	348
11	Thuringia	138.15	48	3.0%	+80%	2 878	112	134	296
12	Saarland	42.95	16	0.9%	-33%	2 684	112	131	277
13	Saxony	34.90	12	0.8%	-49%	2 908	110	118	333
14	Hamburg	13.70	5	0.3%	+71%	2 740	105	127	321
15	Berlin	3.40	1	0.1%	-28%	3 400	104	128	400
16	Bremen	3.00	1	0.1%	-35%	3 000	115	149	289
	Total	**4 625.25**	**1 624**	**100%**	**+24%**	**2 848**	**109**	**128**	**314**

Among the territorial states, the WTG with the highest average capacity of 3 001 kW were installed in Schleswig-Holstein. The on average smallest generators with a capacity of 2 675 kW were installed in North Rhine-Westphalia. This state also had the smallest average rotor diameter of 104 meters, compared to Baden-Wuerttemberg and Hesse with the highest diameter of 118 meters. With an average hub height of 99 meters, Schleswig-Holstein trails all other federal states that have at least an average hub height of 118 meters.

REGIONAL DISTRIBUTION OF THE CUMULATIVE TOTAL PORTFOLIO

With 5 857 WTG generating 9 324 MW, the largest amount of turbines in Germany is found in Lower Saxony, followed by Schleswig-Holstein with 3 581 WTG producing 6 449 MW.

The largest cumulative capacity in central Germany and third largest in Germany is found in Brandenburg, where 3 630 WTG and 6 337 MW are installed. The south of Germany is led by Rhineland-Palatinate with 1 612 WTG and 3 159 MW. Contained in Table 4 are the cumulative capacities and number of WTG broken down among German federal states and regions.

Table 4: Cumulative Capacity and Number of WTG in the German Federal States, Status: 2016-12-31

	Region / State	Cumulative Capacity Status: 2016-12-31 [MW]	Cumulative Number Status: 2016-12-31 [WTG]
North	Lower Saxony	9 324	5 857
	Schleswig-Holstein	6 449	3 581
	Mecklenburg Western Pomerania	3 091	1 844
	Bremen	174	85
	Hamburg	72	51
Central	Brandenburg	6 337	3 630
	Saxony-Anhalt	4 914	2 804
	North Rhine-Westphalia	4 604	3 345
	Hesse	1 703	998
	Thuringia	1 333	793
	Saxony	1 156	880
	Berlin	12	5
South	Rhineland-Palatinate	3 159	1 612
	Bavaria	2 233	1 061
	Baden-Württemberg	1 041	572
	Saarland	310	152
		45 911	27 270

At the end of 2016, 41.6% of the installed capacity in Germany was located in the north, 43.7% in Central Germany and the remaining 14.7% in the south. Compared to the previous year, the cumulative capacity in the north has decreased, whereas the share of the central German states remained virtually unchanged. The southern states gained in cumulative capacity from 2015. Shown in Figure 3 is the distribution development of cumulative capacities across the regions over time.

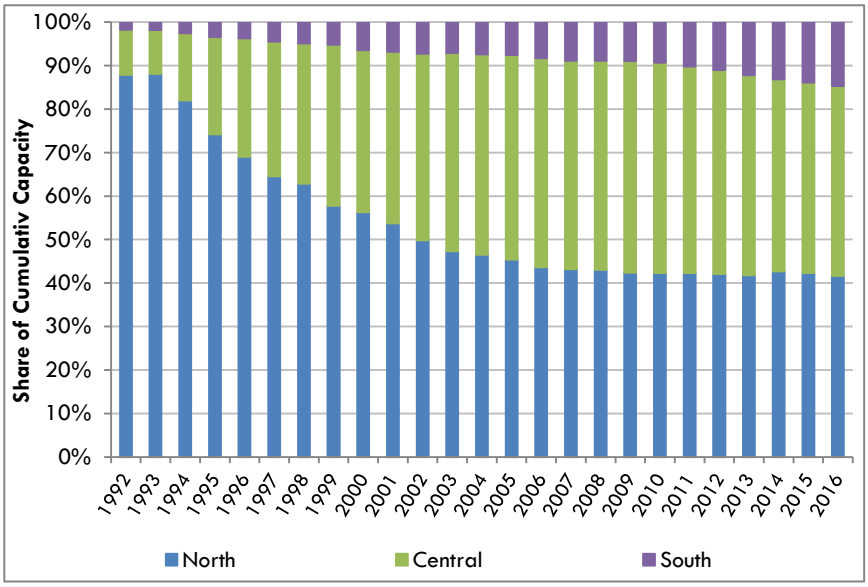

Figure 3: Germany-wide Installed Cumulative Capacity Distribution across the Regions, Status: 2016-12-31

From 2012 onward, data was determined using industry player questionnaires and additional research.

Database 1992 – 2011: DEWI

On behalf of: BWE VDMA

PROJECTION OF MONTHLY POWER GENERATION FROM WIND ENERGY

The actual monthly generation of electricity from wind energy for 2016 is not yet known, but will be published at some point in 2017. At this moment, the projection data from transmission system operators (TSO) can be utilized for an initial overview of electricity production in the past year. This data deviates from the actual values published in the future, as these are calculated by the individual TSOs. This is done by projecting production data from measured reference WTG to the sum of all WTG. The projection data primarily allow an overview of the expected wind energy production distribution across the various months and a first evaluation of the estimated production level.

According to the TSO projection for 2016, the amount of about 65 TWh in electricity was fed into the grids by WTG, which is equivalent to about 11% of the gross electricity consumption. The average capacity factor (the ration between the amount of electricity produced and the overall installed capacity) was 17%. Depicted in Figure 4 are the monthly electricity production numbers from wind energy according to the projection data from TSOs. The individually achieved monthly capacity factors are depicted as supplemental information. February was the strongest month in 2016, in which about 8.7 TWh was produced from wind energy. This is equivalent to an average capacity factor of about 30%. In the month with the least amount of wind, June, 2.8 TWh were generated.

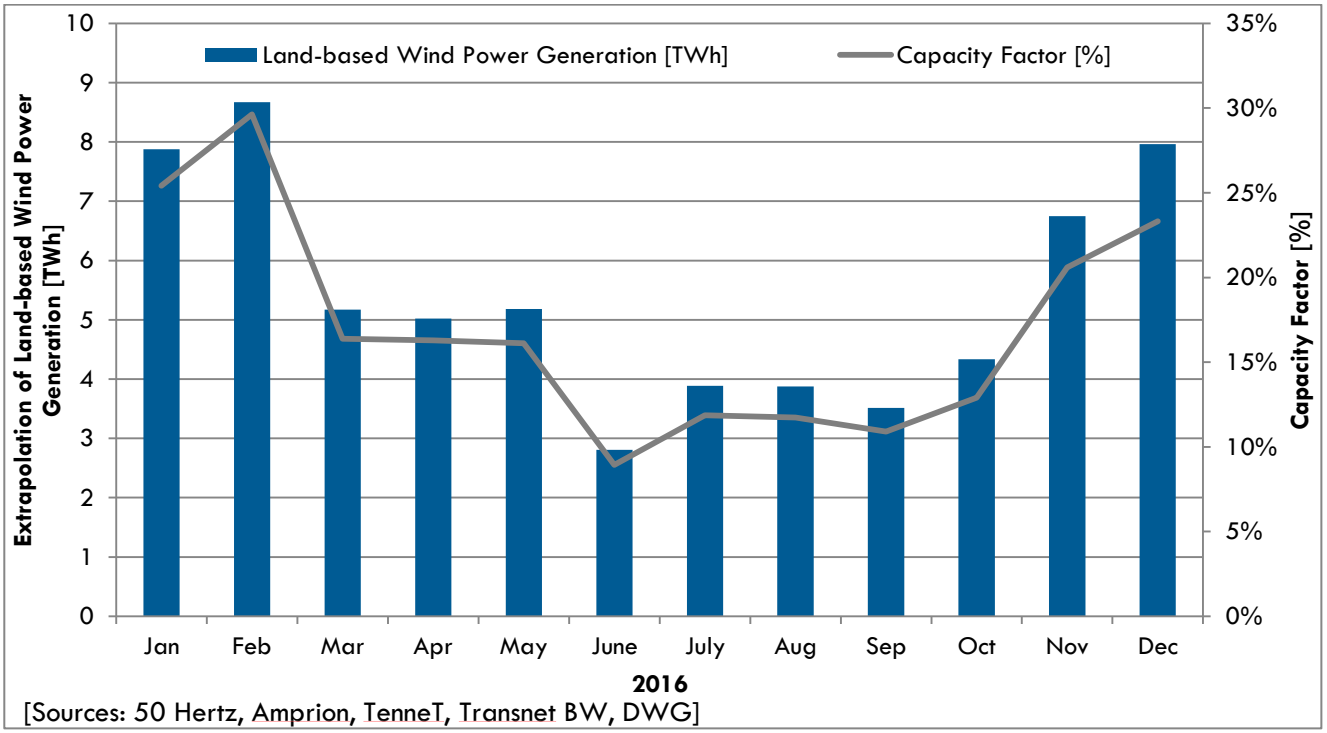

Figure 4: TSO Projection of Electricity Production by Land-based WTG and Resulting Monthly Capacity Factor of the Overall WTG Portfolio

From 2012 onward, data was determined using industry player questionnaires and additional research.

Database 1992 – 2011: DEWI

INTRODUCTION OF TENDERING

As announced in the last amendment, the 2017 iteration of the EEG introduces tendering for land-based wind energy projects in Germany. For the first time, wind energy projects in Germany will be competing with each other. The EEG defines concrete tender amounts and differentiates between additions inside and outside the so-called grid expansion area. Permissible additions within the grid expansion area are limited. For WTG that had received approval by the end of December 2016 may remain in the remuneration system according to the EEG 2014 and their participation in the tender system is optional. The industry is in the process of adjusting to the new framework. A multitude of new features and reforms must be taken into account during the development of strategies. This factsheet provides an overview of the interdependencies of the new framework below.

ADDITION AND TENDER AMOUNTS

The annual tender amount for land-based wind energy between 2017 and 2019 is 2,800 MW. From 2020, 2,900 MW (gross) are to be tendered per annum. The annual tender amount will be awarded in several rounds throughout the year. Table 5 provides and overview of the planned tender dates and amounts along with their respective registration deadlines.

Table 5: Tender Dates and Amounts and Registration Deadlines

Tender Date	Tender Amount	Registration Deadline Authorization
2017-05-01	800 MW	2017-04-10
2017-08-01	1 000 MW	2017-07-11
2017-11-01	1 000 MW	2017-10-11
2018-02-01	700 MW	2018-01-11
2018-05-01	700 MW	2018-04-10
2018-08-01	700 MW	2018-07-11
2018-10-01	700 MW	2018-09-10
2019-02-01	700 MW	2019-01-11
2019-05-01	700 MW	2019-04-10
2019-08-01	700 MW	2019-07-11
2019-10-01	700 MW	2019-09-10
2020-02-01	1 000 MW	2020-01-11
2020-05-01	950 MW	2020-05-11
2020-10-01	950 MW	2020-09-10

Operators that end up winning a tender are allowed 2.5 years to realize the individual project after which the award expires. An extension may be granted under specific circumstances. If the project is a citizen's wind project that has participated in the tender without construction permit, the implementation period is 4.5 years. These varying periods clearly show that the annual tender amount can be realized over several years and thus not be translated directly into an annual addition. By the end of 2018, transitional WTG will be realized in parallel following the remuneration system of the EEG 2014.

ADDITIONS DIVIDED ACCORDING TO THE GRID EXPANSION AREA

Starting in 2017, additions within the so called grid expansion area are limited with the introduction of the tendering system. According to the draft Grid Expansion Area Ordinance (GEAO) (German "Netzausbaugebietsverordnung" (NAGV)) of 2017-01-13, the grid expansion area is defined as the German federal states of Schleswig-Holstein, Mecklenburg-Western Pomerania, as well as the northern part of Lower Saxony and the city-states of Bremen and Hamburg. In Lower Saxony, the counties of Cuxhaven, Harburg, Luneburg, Osterholz, Rotenburg (Wuemme), Stade, Ammerland, Aurich, Cloppenburg, Emsland, Friesland, Leer, Oldenburg, Vechta, Wesermarsch and Wittmund, as well as the independent cities of Delmenhorst, Emden, Oldenburg and Wilhelmshaven are involved. The geographic placement of the grid expansion area is shown in Figure 5. In the future, the additions in the grid expansion area are to be curbed. The EEG 2017 defines that in the future only 58% of the installed capacity that was commissioned between 2013 and 2015on an annual average in this area may be awarded per year. No more than 902 MW can thus possibly be awarded in the grid expansion area in the tendering system. To give an overview of the wind energy additions within the newly defined grid expansion area up to this point, the additions that occurred between 2013 and 2016 are shown in Figure 6.

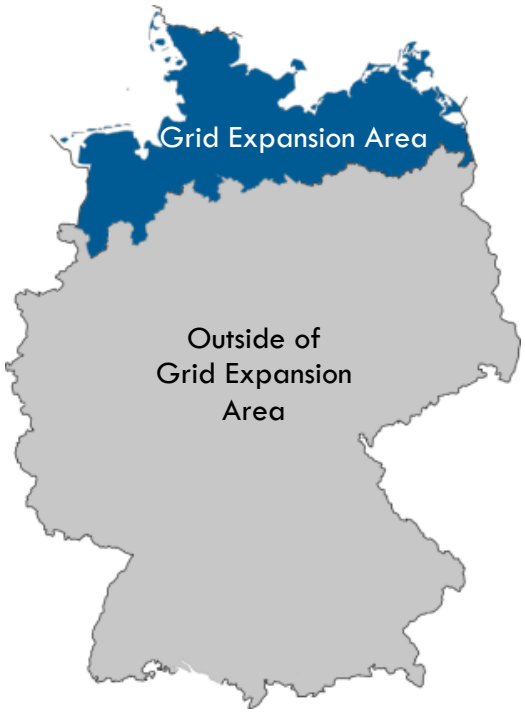

Figure 5: Geographic Placement of the Grid Expansion Area According to the Draft GEAO (NAGV) of 2017-01-13

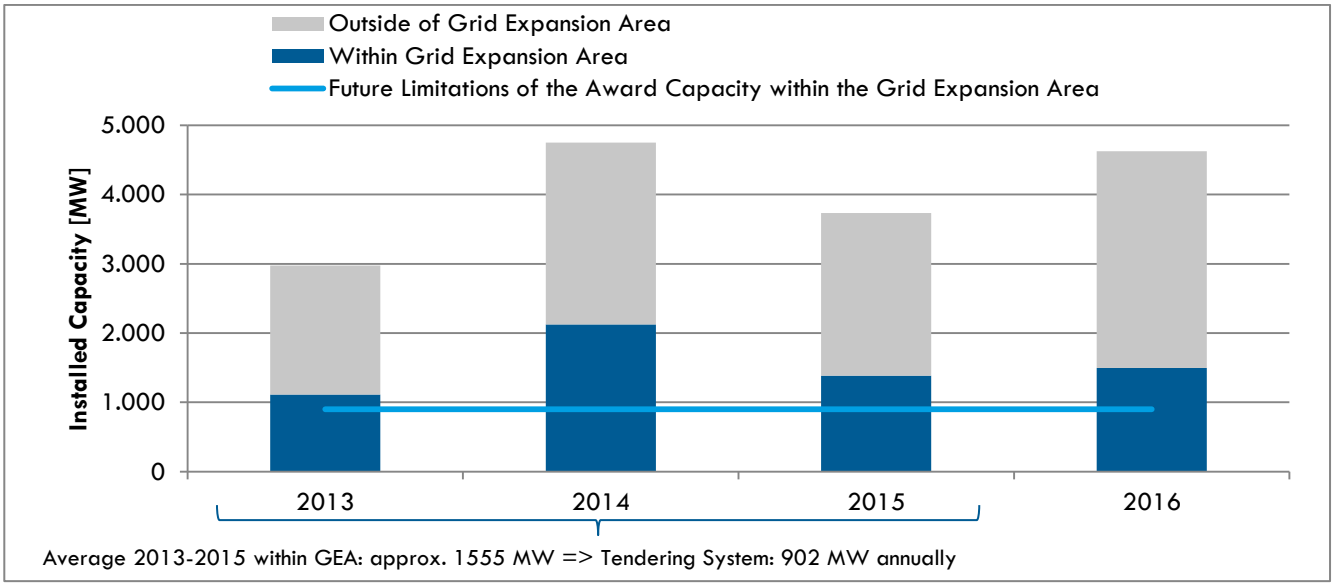

Figure 6: Distribution of Additions between 2013 and 2016 across the Areas as defined in the Draft GEAO (NAGV) of 2017-01-13 and Future Limitations of the Award Capacity within the Grid Expansion Area

APPROVED PROJECTS ACCORDING TO THE WTG REGISTER OF THE GERMAN FEDERAL NETWORK AGENCY

Wind turbine generators that received approval according to the Federal Emissions Control Act (BImSchG) by 2016-12-31 and that will be commissioned prior to 2017-12-31 do not have to participate in the tendering process and, following the EEG 2017, may be erected under the current remuneration system. A voluntary participation in the tendering system is possible if a notification to do so is received by 2017-02-28. In view of the developments in the next several years, the question of how many of these transitional machines there are is thus of great relevance.

The WTG register of the German Federal Network Agency (BNetzA) lists 2 053 WTG with a capacity of 6 128 MW that have been registered by 2016-12-31 as approved but are not yet in operation. About 34% of this capacity is located inside the grid expansion area (according to the draft GEAO (NAGV) of 2017-01-13) and consequently 66% is located outside of this area. The BNetzA explicitly points out that the register as currently published only contains WTG reported up to and including 2016-12-31. Due to reporting deadlines, late registrations of commissionings and approvals are expected. Therefore, as of the time of publication of this factsheet the number and capacity of machines approved by the end of 2016 that can still be erected within the transitional system is not conclusively known. How the currently known approvals according to the WTG register are distributed among the German federal states is shown in Figure 7. Additionally depicted in this figure is the share of the approved capacity located within the grid expansion area.

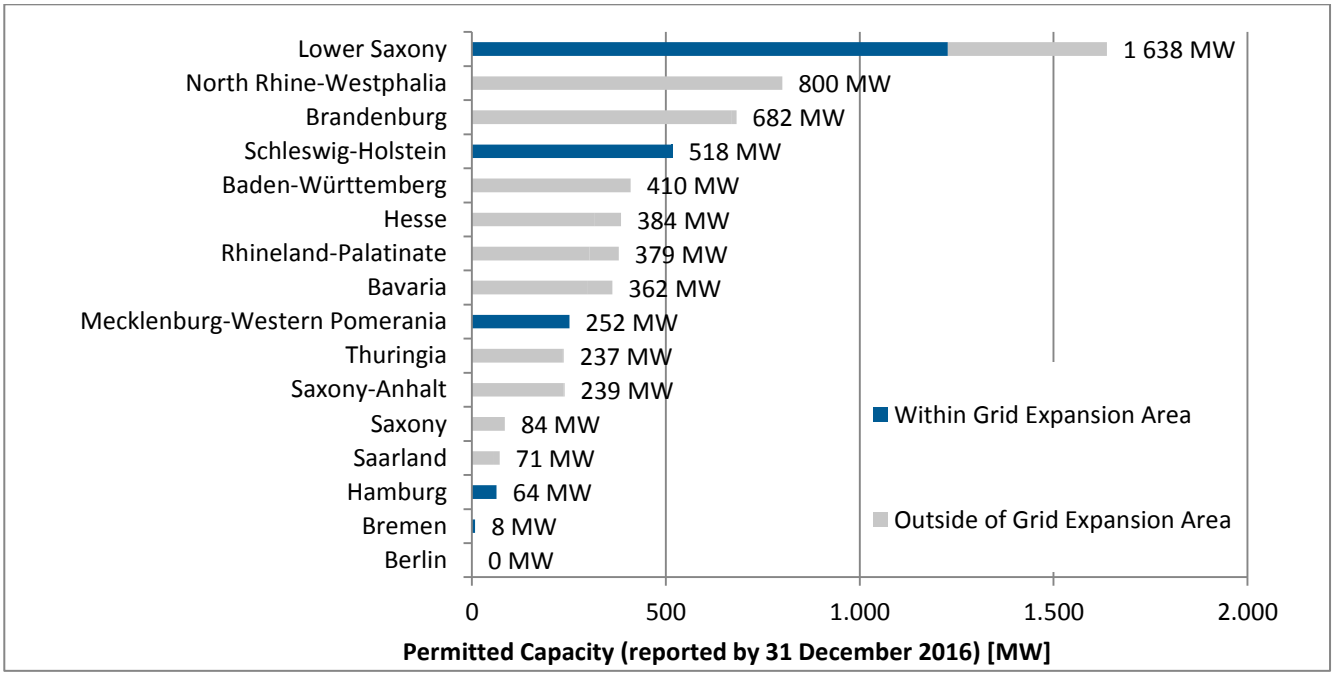

Figure 7: Permits for WTG (≥ 500 kW) According to the WTG Register 12/16 of BNetzA [Source: WTG Register of BNetzA, own evaluation]

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