WIND ENERGY MARKET | 24th Edition

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German Wind Energy Association

Yearbook Wind Energy 2014

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LOOKING AHEAD ⊕ Standards & guidelines ⊕ Research ⊕ Technology, trends and turbine overview

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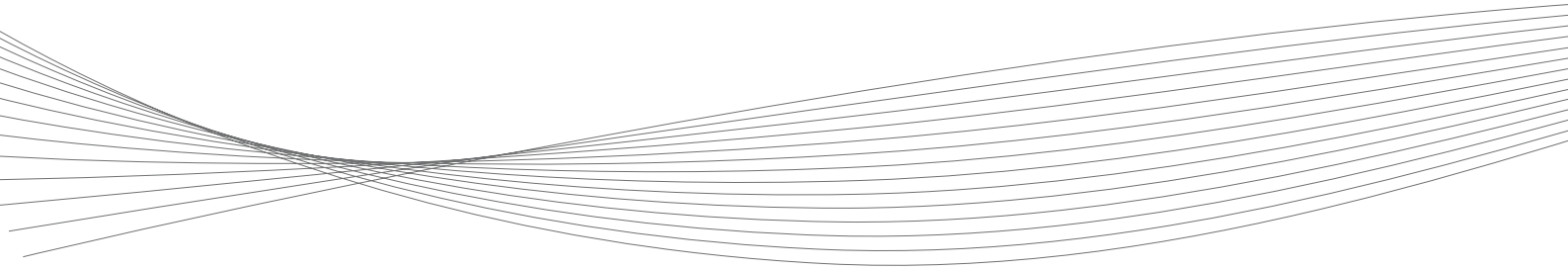

Yearbook Wind Energy 2014

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24th Edition

Imprint

Publisher:
German Wind Energy
Association (BWE), Berlin
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24th Edition, April 2014

Editorial

The change in energy policy has led to a genuine innovative advance in our country. Engineers and scientists everywhere are devising solutions for a new electricity market. Savvy small and medium-sized businesses recognize new opportunities and are placing their bets on the emergent technologies. As an innovative industry with a workforce of 118,000 the wind industry is representative of the success that comes from being "Made in Germany."

In the next few years Germany will be able to prove that the change in energy policy can be made possible with affordable electricity prices for households, trade and industry in a country of advanced technology. It requires political courage to set this course for the future. Despite the many debates, there has been a noticeable lack of spirited initiative on the part of policymakers when it comes to designing a new electricity market. At the same time, a new market design that establishes a flexible range of products and services on the basis of solar energy, wind and biomass is essential for successfully advancing the change in energy policy. In this energy market of the future, even flexible gas-fired power stations and public utilities will be presented with new opportunities. However, fair debates with regard to overall costs cannot be held as long as this new market remains unforeseeable and external costs are left out of the equation.

In spite of a difficult political environment the German market for onshore wind energy plants is experiencing stable growth. Of the 2,998 megawatts in newly installed output in 2013 (1,154 wind energy plants), just under sixty percent were attributable to central and southern Germany. Advances in the development of wind energy are being made especially onshore. With a total of more than forty percent northern Germany remains an anchor of stability when it comes to wind energy. However, developments are also progressing offshore. Last year a total of 48 new offshore wind energy plants (OWEP) were connected to the grid with an output of 240 megawatts.

With low remuneration tariffs wind energy already contributes to the overall stabilization of electricity prices. Without onshore wind energy, successful implementation of the change in energy policy will remain a dream. The continued shutdown of nuclear power plants starting in 2015 will require additional energy production capacities, as will the dismantling of older wind energy plants. If enough power is to be provided in a clean and inexpensive way, onshore wind energy must surely

play its part. Inexpensive wind energy is and remains the engine that drives the change in energy policy.

More than 20,000 members are organized into the German Wind Energy Association [BWE], including 2,100 operator companies, 1,100 manufacturers, suppliers and service providers as well as 15,000 investors. Thus the BWE is one of the world's largest associations for renewable energies and represents the entire value chain of the industry. Germany sets the standard for technology, efficiency and system compatibility worldwide. With a current export share of 67 percent, the wind industry ensures that Germany remains a business location for innovation and industry. And as a pool of technical experts, we promote this technological development in our advisory committees and working groups. We stand for the successful change in energy policy!

Sylvia Pilarsky-Grosch
President of the registered German Wind Energy Association

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OFFSHORE

Guarded optimism

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The prevailing mood in the offshore sector has significantly brightened over the course of 2013. The reason for this is not least the current number of completed wind farms or wind farms under construction. General conditions also seem to be stabilising, and heading in the right direction – albeit with a few trade-offs.

SERVICE

Continued growth in the service market

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The service market is growing continuously and the sector is confident about the immediate future. However it is not yet possible to discern any clear tendency as to the future development of the market.

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BWE SERVICE SURVEY

The customer the king

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Turbine manufacturers are regaining lost ground in the service business. In the latest BWE service survey they confirmed last year's good performance for repairs and maintenance. The run on independent servicing has stopped for the time being.

Global Service Protocol (GSP)

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The Global Service Protocol provides a common data format for the exchange of maintenance data.

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Wind turbines – sorted by **name (A – Z)**

Wind turbines – sorted by **rated power (kW)**

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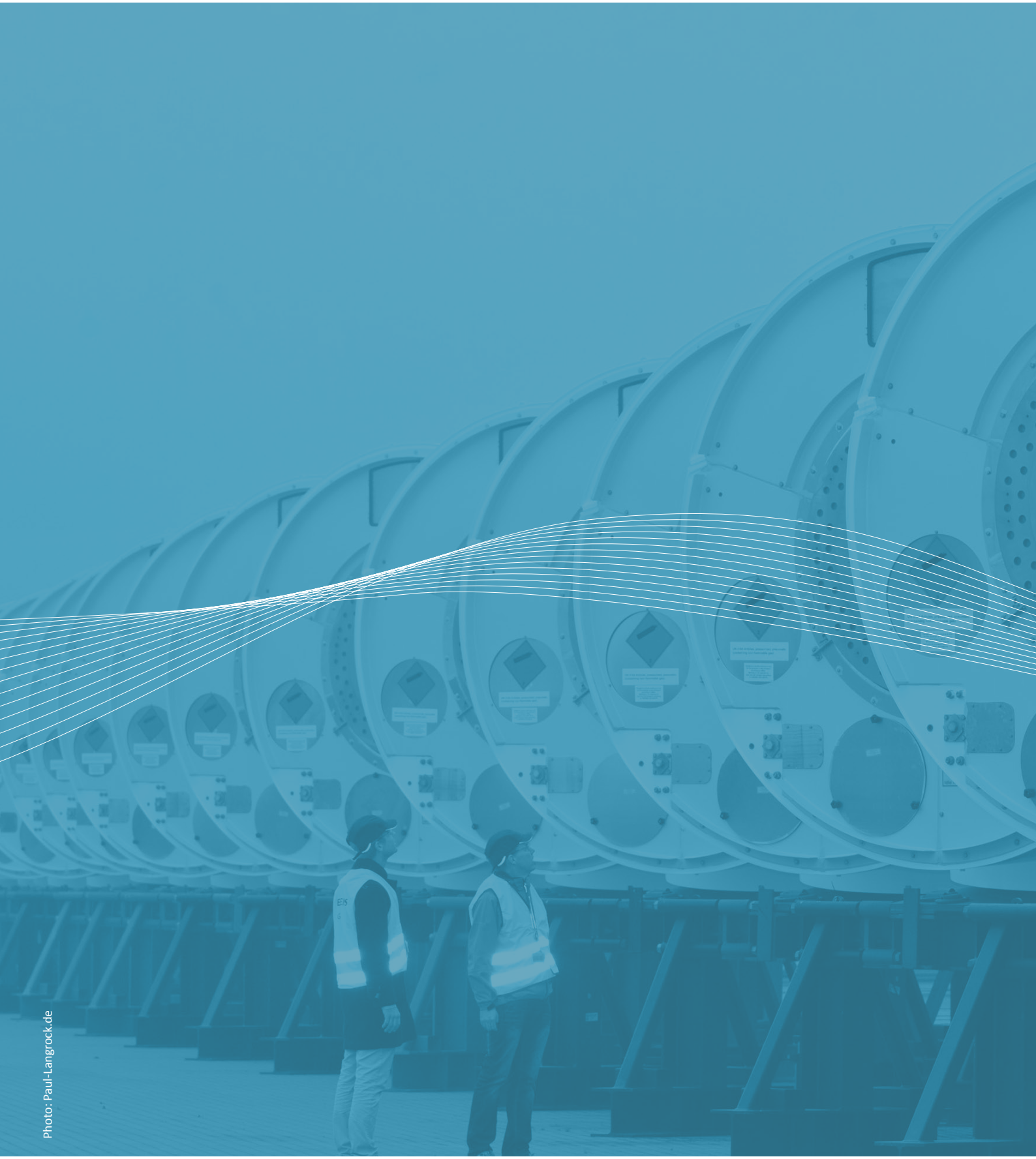


Photo: Paul-Langrock.de

Wind Energy Market

Morning mist surrounding an Enercon E-126 in Altenwerder. Photo: U. Mertens

Potentially record-breaking despite uncertain future

In 2013 the land-based wind energy sector experienced its greatest growth for 11 years. But uncertainty has also increased in relation to the coming framework conditions, which will have a serious impact on developments over the short term.

With 1,154 new onshore wind energy plants last year, the German wind energy sector achieved a level of capacity growth not exceeded since 2002. This is evident in the 2013 expansion figures compiled by Deutsche WindGuard on behalf of German Wind Energy Association (BWE) and VDMA Power Systems (VDMA PS). A total of 2,998 MW were installed, which meant that at the start of 2014 23,645 wind turbines were feeding into the German grid with a combined power output of around 33,730 MW. Taking into account the removal of 416 turbines with a combined power output of some 258 MW, the net additional power capacity for onshore wind energy is currently 2,740.5 MW.

Robust expansion not a surprise

The above figures show an increase of 29 per cent compared with the previous year – also a record high since expansion figures began being recorded in 1992. It was hardly surprising that the extremely windy year 2013 would be an impressive year given the planning periods for wind energy projects. According to BWE President Sylvia Pilarsky-Grosch, "Many projects were completed in 2013 which had been initiated following the nuclear catastrophe in Fukushima and the ensuing energy transition it inspired. Now, two years later, the expansion figures are showing the first tangible results of this policy change." She goes on to say that, "some of these projects were expedited in light of the debate surrounding the electricity price slow-down."

Record values in the field of re-powering

After a number of re-powering projects in the previous year had already contributed around 18 per cent to the expansion of onshore plant, this figure has now risen to over 25 per cent. The 269 re-powered plants recorded for the previous year produce a combined power output of around 766 MW, which represents an increase of 77 percent compared to the year before. "What this shows," says the BWE President, "is that the re-powering framework conditions anchored within the German Renewable Energy Act (EEG), have already shown positive results. It is now all the more important to ensure that reliable framework conditions for re-powering projects are also given going forward."

The average power performance of a re-powered wind turbine in 2013 was just under 2.85 MW. By contrast the average power output of the turbines that were dismantled during the same period was about 620 kW.

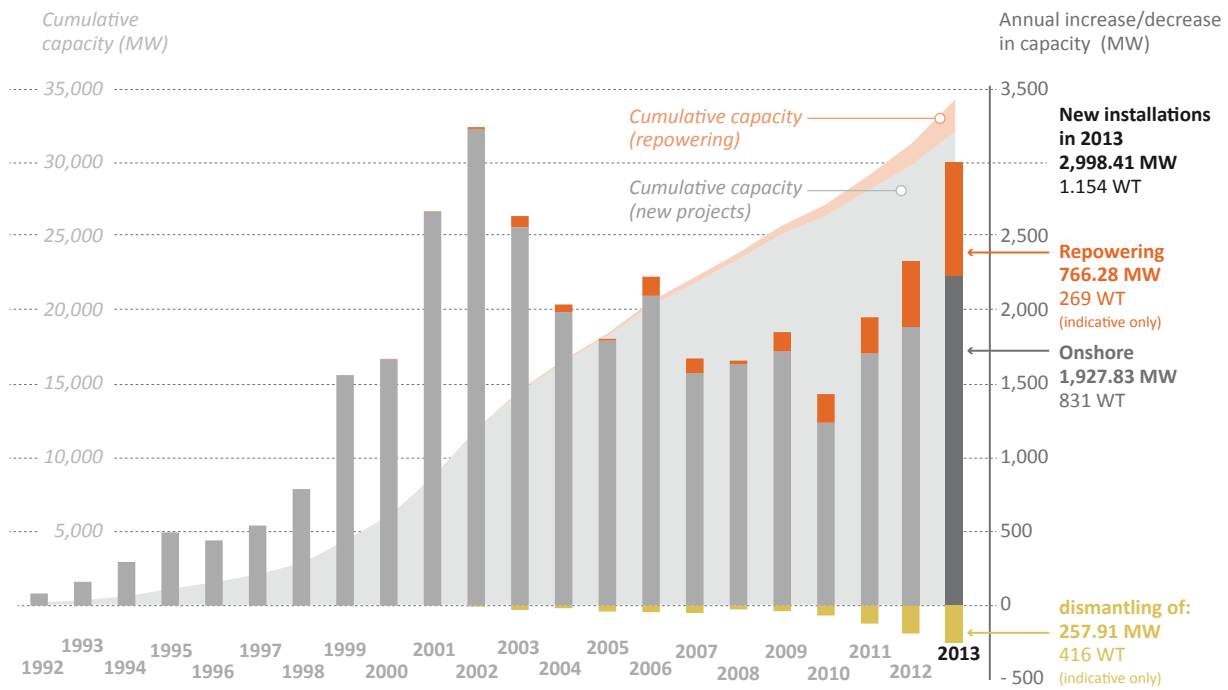
State-by-state comparison: is the South gaining more ground?

It is likely that the many re-powering projects in the most northerly of the federal states, Schleswig-Holstein, were the reason why the state led the field in terms of expansion statistics last year with just under 428 MW, which is 14.2 per cent. However one of the southern federal states became a close second. With 149 new turbines and a total power output of 413

Status of onshore wind energy expansion in 2013

	Status of onshore wind power expansion	Capacity (MW)	Number of turbines
Cumulative 2012	Adjusted cumulative capacity (as of 31 December 2012)	30,989.33	22,907
Development 2013	Gross expansion in 2013	2,998.41	1,154
	- of which repowering (tentative)	766.28	269
	dismantled in 2013 (tentative)	257.91	416
Cumulative 2013	Cumulative capacity (as of 31 December 2013)	33,729.83	23,645

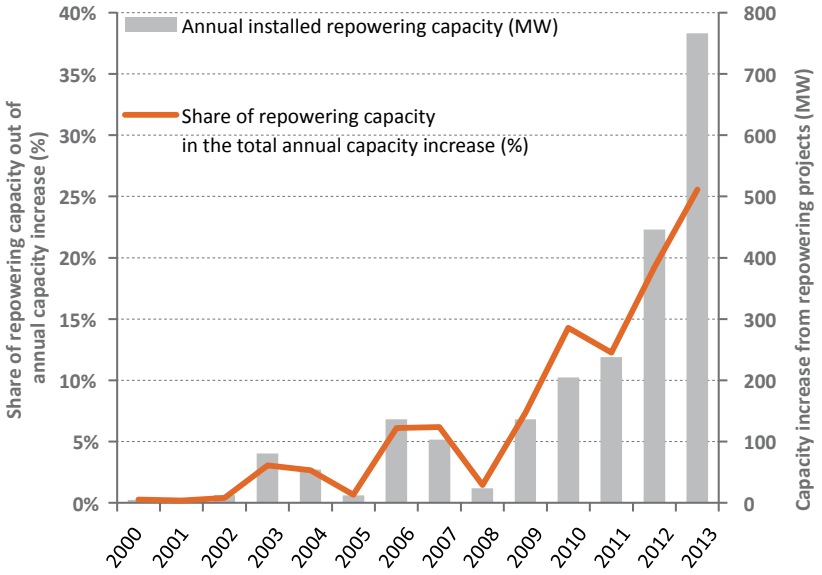
Development of annual installed and cumulative onshore wind capacity (MW) in Germany (as of 31 December 2013)



Source: 1992–2011: DEWI GmbH / from 2012: Deutsche WindGuard GmbH

MW=Megawatt, WT=Wind Turbines

Development of proportionate and absolute installed power from repowering projects



Source: 1992–2011: DEWI GmbH / from 2012: Deutsche WindGuard GmbH

MW=Megawatt

MW, more wind energy capacity was installed in Rhineland-Palatinate than ever before. Mecklenburg-Western Pomerania was in third place, which also succeeded in breaking the 400 MW barrier for added capacity in 2013.

The significant increase in Rhineland-Palatinate was the main reason why the southern federal states were able to increase their cumulative total power output by one per-cent point to 12 per cent. This contribution has increased by about 1 per cent every year since 2008. The expansion of wind energy capacity also made progress in Bavaria, which was able to exceed the additional capacity installed in the previous year by more than 25 per cent for a total of just under 252 MW. Bringing up the rear once again among the German non-city states were Saarland and Baden-Wuerttemberg with 34 and 31 MW respectively. However, the fact that the situation in Baden-Wuerttemberg may be about to change soon can be inferred from the 277 applications received by the regulatory authorities there by 2014. Specific preliminary enquiries have already been made for another 330. According to Pilarsky-Grosch: "Developments in Southern Germany continue to excite interest. On the one hand there is Bavaria, whose new regulations governing distances from other sites could well throttle the hitherto good development there. On the other hand Baden-Wuerttemberg is champing at the bit to continue its expansion of wind energy plant." However it is not yet possible to say whether or not these efforts will be crowned with success given the current debates on EEG reform.

At 46 per cent the largest share of the installed capacity to date is located in the central German states, whereby the proportion of their overall contribution has decreased slightly since 2009. The proportion contributed by the northerly states, by contrast, has remained constant at around 43 per cent over the past five years.

Plant technology: higher, bigger, stronger

It is not only the expansion figures that increased during 2013; the dimensions of the newly installed turbines have also grown. Since 2012 the average rotor blade diameter has grown by 6.5 meters to 95 meters, whilst the average hub height has been raised by 7 meters to 117 meters (2012: 110 meters). The output performance of the rotors has also increased and averaged 2,589 MW in 2013.

Just a bit more than 30 percent of newly installed turbines reached rotor diameters of 100 meters or more and heights in excess of 130 meters, particularly in the inland states such as Rhineland-Palatinate, Bavaria, Hesse and the Saarland.

Wind energy installation in the German federal states (Status 31.12.2013)

		NEWLY INSTALLED CAPACITY IN 2013			AVERAGE TURBINE CONFIGURATION IN 2013		
Rank	State / Region	Installed capacity in 2012 (MW)	Number of wind turbines (WT) installed	Share of total 2012 installations	Average turbine capacity (kW)	Average rotor diameter (m)	Average hub height (m)
1	Schleswig-Holstein	427.95	162	14.3%	2,642	89	85
2	Rhineland-Palatinate	413.40	149	13.8%	2,774	100	134
3	Mecklenburg-Western Pomerania	401.54	135	13.4%	2,974	97	114
4	Lower Saxony	389.84	151	13.0%	2,582	90	110
5	Brandenburg	255.00	106	8.5%	2,406	94	122
6	Bavaria	251.58	98	8.4%	2,567	105	136
7	North Rhine-Westphalia	237.85	108	7.9%	2,202	85	112
8	Saxony-Anhalt	225.95	88	7.5%	2,568	93	122
9	Hesse	184.20	72	6.1%	2,558	106	133
10	Thuringia	105.50	45	3.5%	2,344	97	124
11	Saxony	35.50	15	1.2%	2,367	94	111
12	Saarland	34.10	12	1.1%	2,842	108	136
13	Baden-Wuerttemberg	31.60	11	1.1%	2,873	109	138
14	Hamburg	2.40	1	0.1%	2,400	117	141
15	Bremen	2.00	1	0.1%	2,000	90	105
16	Berlin	0.00	0	0.0%	-	-	-
	Total	2,998.41	1,154	100%	2,598 (*2012:* 2,420)	95 (*2012:* 88.5)	117 (*2012:* 100)

Source: Deutsche WindGuard GmbH

Capacity increase across the North and Baltic Sea

		NORTH SEA		BALTIC SEA	
		Capacity (MW)	Number of turbines	Capacity (MW)	Number of turbines
Increase 2013	Erected OWT with grid connection	240,0	48	0,0	0
	Erected OWT without grid connection	394,6	103	0,0	0
	Foundations without turbines		227		39
Cumulative (31.12.2013)	Erected OWT with grid connection	469,5	94	50,8	22
	Erected OWT without grid connection	394,6	103	0,0	0
	Foundations without turbines		243		39

Source: Deutsche WindGuard GmbH

Offshore: first expansion stage well underway

2013 was a good year for the expansion of offshore wind energy, now that the long awaited construction boom of the initial phase has finally got underway. By the end of the year new installations with a total output of 240 MW had been connected into the grid. Since then the Riffgat wind park became operational in February 2014, which feeds in a further 108 MW. Additional turbines with a combined output of just under 200 MW have already been completed and are just waiting to be integrated into the grid.

As Thorsten Herdan, Managing Director at VDMA Power Systems, reports: "That means that we have already achieved the breakthrough point of the initial expansion phase. By the end of 2013 three offshore wind farms (OWF) had been integrated into the national grid, whilst another has been completed and eight more are currently under construction." He goes on to point out that the high number of 266 anchored foundations and partially completed systems offer proof enough that these projects are now nearing the final completion stage. "We estimate that this will enable us to feed a total of 1500 MW into the grid this year and about another 1000 MW in 2015," Herdan predicts.

Whilst the initial expansion phase is currently well underway, there is not yet much concrete detail to report about the second phase. "The offshore wind industry is awaiting further investment decisions for the second phase of Germany's offshore wind energy expansion", says Norbert Giese, Deputy Chairman of Windenergie-Agentur e.v. (WAB). "For that reason," he continues, "the provisions set out in the Coalition Agreement with regard to offshore wind energy need to be implemented as swiftly as possible."

Large-scale offshore construction: Bard Offshore 1 wind farm.
Photo: Paul-Langrock.de

Erection of a Senvion 3.2M/114 at Beltheim wind farm in the Hunsrück region. Photo: Jan Oelker

Prognosis: uncertain investment climate

The current air of uncertainty within the industry demonstrates the central significance of political framework conditions for the onshore wind energy sector too. Germany's impressive expansion in 2013 was by far the strongest in Europe and defied the massive slump in international markets. Nevertheless the changes and reforms to the EEG announced by the Federal Government are sending out a signal, the ramifications of which can already be felt within the sector. "The current strength of the German market is under threat in light of the uncertainty resulting from the decisions taken by the German Federal Cabinet in Meseberg," Sylvia Pilarsky-Grosch confirms.

And Thorsten Herdan adds that: "Internationally the German wind energy industry remains in a good competitive position and will be able to further consolidate its leading role, even the introduction of an expansion corridor and mandatory direct marketing." But, he goes on to say, a prerequisite for this is a stable market in Germany. And this should not be jeopardised by insufficient provision for the protection of legitimate expectations in the EEG. The restriction of the protection of legitimate expectations to projects due for approval by January 22, 2014, he points out, puts other projects at risk that are planned for 2014 but not yet approved. ■

Outlook

In light of all of the above it is difficult to make any reliable predictions as to the further expansion of onshore wind energy plant in the coming year. Depending upon the results of the EEG saga, BWE and VDMA Power Systems are reckoning with something like 2500 to 3000 MW.

As a cost-effective renewable energy source wind energy power generation already contributes around 8 percent of Germany's power to power production. However in order to prevent slowing this development to a stall it is important not to rein in further expansion artificially. BWE President Sylvia Pilarsky-Grosch is adamant that: "The space and profitability of cost-effective onshore wind energy must not be jeopardised whether through rigid ceilings or looming restrictions or arbitrary regulations with regard to distances between sites."

Goldwind GW 48-750 in the Dabancheng wind area, Xinyang, China. Photo: Jan Oelker

Global wind energy market: low growth – good outlook

The Global Wind Energy Council (GWEC) recorded a slump in global market growth in 2013. Compared to the previous year, 10 GW less capacity was installed. The Chinese remained unperturbed and posted a record year. In contrast, the USA slipped into a deep hole owing to uncertain policy frameworks.

The slump hardly came as a surprise, yet its extent in 2013 in terms of newly installed wind energy capacity in the USA was more dramatic than expected. Only about 1 GW of new capacity was installed in America, which in 2012 had added 13.1 GW in a head-to-head race with China. "This is the deepest hole the USA could fall into," comments Dr. Klaus Rave, President of the Global Wind Energy Council (GWEC). The international association published global figures for last year at the beginning of February 2014.

> "For 2014, we expect the figures to be once again up at the high level of 2012"

New installations: 21 per cent drop

The GWEC recorded global growth in installed capacity of 12.5 per cent for 2013 – in the record year of 2012 this figure was 19 per cent. At the end of 2013 around 318 GW were installed globally. Newly added capacity came to 35.5 GW, approximately 10 GW less than the previous year. The drop in newly built capacity was therefore in the region of 21 per cent. "Uncertain policy frameworks are mainly responsible for the drop in wind energy," explains Klaus Rave.

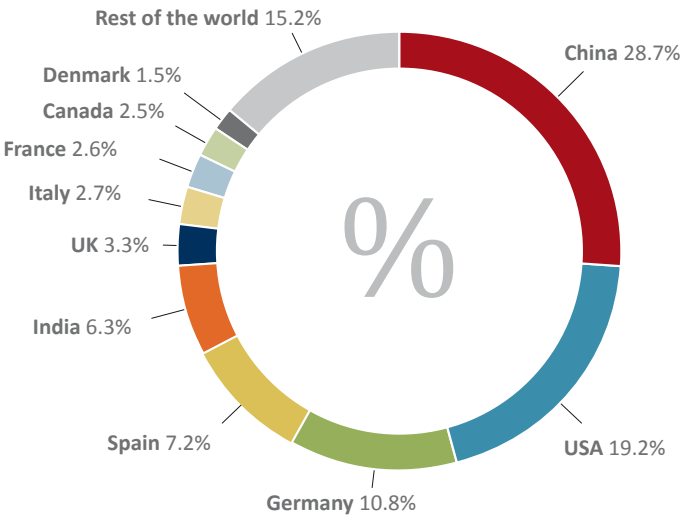
A particularly graphic example of this is the big slump in the USA, as already mentioned. In 2012 there were discussions to continue the tax allowances for 2013, and they were finally adopted after lengthy wrangling. The decision to extend the Production Tax Credit (PTC) only came in January 2013. "That was too late in terms of making plans for 2013 and is behind the catastrophic expansion figures," is how Sylvia Pilarsky-Grosch, President of the German Wind Energy Association (BWE), sums up the situation.

USA: Boom and bust

Since the allowances were finally extended by a year the curve in the USA is now strongly on the way up again. According to GWEC, wind farms currently in construction have a total rated capacity of more than 12 GW. "For 2014, we expect the figures to be once again up at the high level of 2012," predicts Rave. The wind turbine manufacturer, Siemens, for example, is taking advantage of this new boom. The company received an order for over 448 wind turbines from US energy supplier

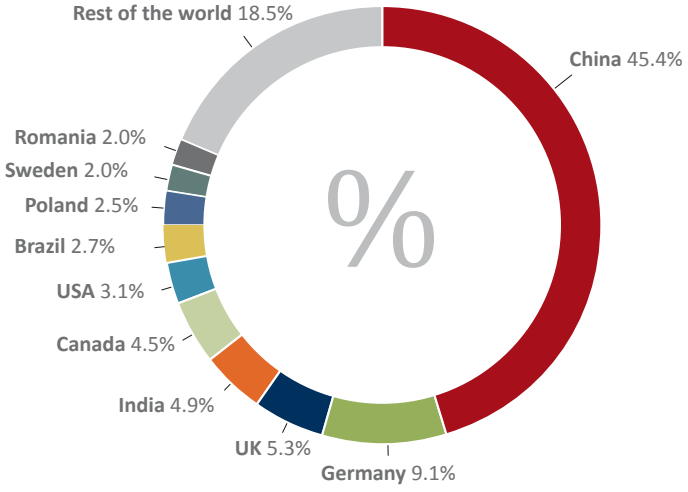
Commissioning of Shiloh II wind farm, California, USA. Photo: Jan Oelker

Top 10 countries for total installed wind capacity (December 2013)



COUNTRY	MW	%
China	91,424	28.7
USA	61,091	19.2
Germany	34,250	10.8
Spain	22,959	7.2
India	20,150	6.3
UK	10,531	3.3
Italy	8,552	2.7
France	8,254	2.6
Canada	7,803	2.5
Denmark	4,772	1.5
Rest of the world	48,352	15.2
Total Top 10	269,785	84.8
Total world	318,137	100.0

Top 10 countries for newly installed wind capacity 2013



COUNTRY	MW	%
China**	16,100	45.4
Germany	3,238	9.1
UK	1,883	5.3
India	1,729	4.9
Canada	1,599	4.5
USA	1,084	3.1
Brazil*	948	2.7
Poland	894	2.5
Sweden	724	2.0
Romania	695	2.0
Rest of the world	6,573	18.5
Total Top 10	28,894	81.5
Total world	35,467	100.0

** Provisional Figure
* Projects fully commissioned, grid connections pending in some cases

Source: GWEC

Wind farm in China. Photo: Gamesa

MidAmerican at the end of 2013. These turbines will be used in five projects in Iowa. According to Siemens, this is the world's largest order for onshore wind energy placed until now.

How long the upturn in the USA will persist is already being questioned again. According to GWEC, there is no guarantee of a permanent continuation of tax allowances, especially as there are new elections in two years. Rave: "We expect heavy fluctuations." The GWEC President speaks of a textbook "boom and bust". According to him, the reason for this is the ongoing dispute between the Senate, House of Representatives and the government in which the fracking euphoria, among other things, has diverted attention away from sustainable energy production. All these ups and downs have been disruptive to manufacturers, particularly in the USA. And foreign business are also having to take steps. German wind turbine manufacturer Nordex reported that it is gradually closing its production sites in the USA. The company gave as a reason the "uncertain situation" regarding the extension to existing allowances for wind energy. Future production of turbines for the US market is expected to take place in Germany and Latin America.

> "An impressive figure. All those who predicted a drop in China because of lower economic growth have been proven wrong"

Record year for China

Quite unlike the USA and apparently completely unaffected by the global drop in expansion figures, China has again posted a record year with 16.1 GW of newly installed capacity (13.2 GW in 2012). A result that the GWEC joyfully comments on. "An impressive figure. All those who predicted a drop in China because of lower economic growth have been proven wrong," states Klaus Rave. The Chinese government has committed itself to wind energy in the long-term, with an official target of 200 GW by 2020.

China has currently installed some 91.4 GW, the country with the highest wind energy capacity. The USA follows with 61.1 GW, then Germany (34.2 GW), Spain (22.9 GW) and India (20.1 GW). The negative developments in the USA mean that Germany moves into second place in terms of annual expansion in 2013 with 3.2 GW (2.4 GW in 2012). Great Britain (1.9 GW), India (1.7 GW) and Canada (1.6 GW) are also ahead of the USA.

Slowdown in Europe too

Overall, the market growth in the EU states slowed down from 12 per cent in 2012 to 10 per cent in 2013. The newly installed capacities fell by 8 per cent on the previous year because of public sector deficits in southern Europe – but also as a result of political disorder. "The wind energy installations in the EU show the negative influence of regulatory and political uncertainty that has washed over Europe. Unstable legal frameworks for wind energy have prevented investment in green growth," explains Justin Wilkes, Deputy CEO of the European Wind Energy Association (EWEA).

Suwalki wind farm (Poland). Photo: RWE Innogy

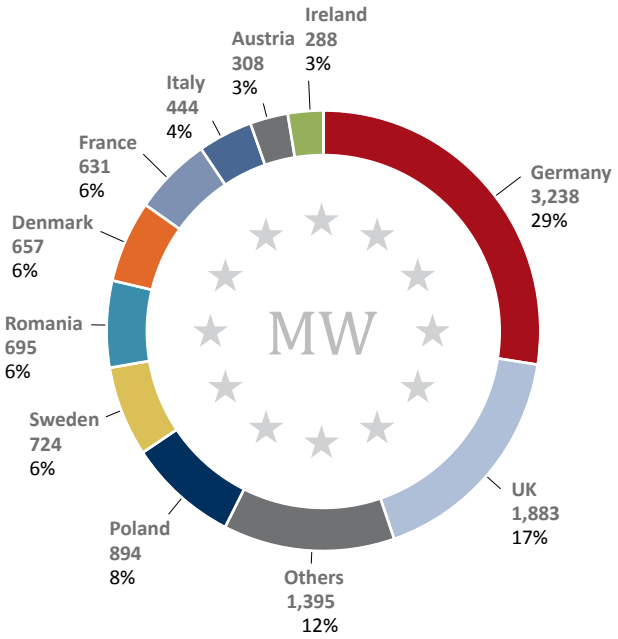
Spain: Extreme uncertainty

Spain presents an extreme example within the EU. The country, which until now was a forerunner in wind power, not only withdrew previous feed-in tariffs but even intervened retroactively in the funding conditions. "This is the biggest blow of 2013," Rave says appalled. "It is absolutely clear that confidence in investing in renewable energies is lacking following a move like this," agrees BWE President Sylvia Pilarsky-Grosch. According to her, Spain is making a big mistake and underestimates the economic potential arising from Spain's close relationships with Latin America, among other things. Just how dramatic the drop was in Spain can be seen by glancing at the figures. Instead of 1.1 GW of installed capacity in 2012, 2013 saw only 175 MW – amounting to a drop of 84 per cent.

Expansion has shrunk significantly in Italy and France too. Installations in these countries fell by 65 and 24 per cent. The EU ranking following Germany and Great Britain is now Poland (894 MW), Sweden (724 MW), Romania (695 MW), Denmark (657 MW), France (631 MW) and Italy (444 MW). A total of 11.1 GW was added across the EU. The EWEA describes the concentration on Germany and Great Britain as "unhealthy"; these two countries accounted for 46 per cent of all new installations in the EU. The last time there was a concentration like this was in 2007, according to the EWEA. Then the three wind energy pioneers were Denmark, Germany and Spain, representing 58 per cent of all new installations.

However, EU countries that until now were not on the radar are now definitely on the wind energy map. These include Poland and Romania as new EU countries, but also Sweden. Casting an eye over all of Europe, the GWEC highlights Turkey with 646 MW of newly installed capacity. "We see enormous potential in Turkey, also because of its importance as a transit country for expansion in the East," explains Rave.

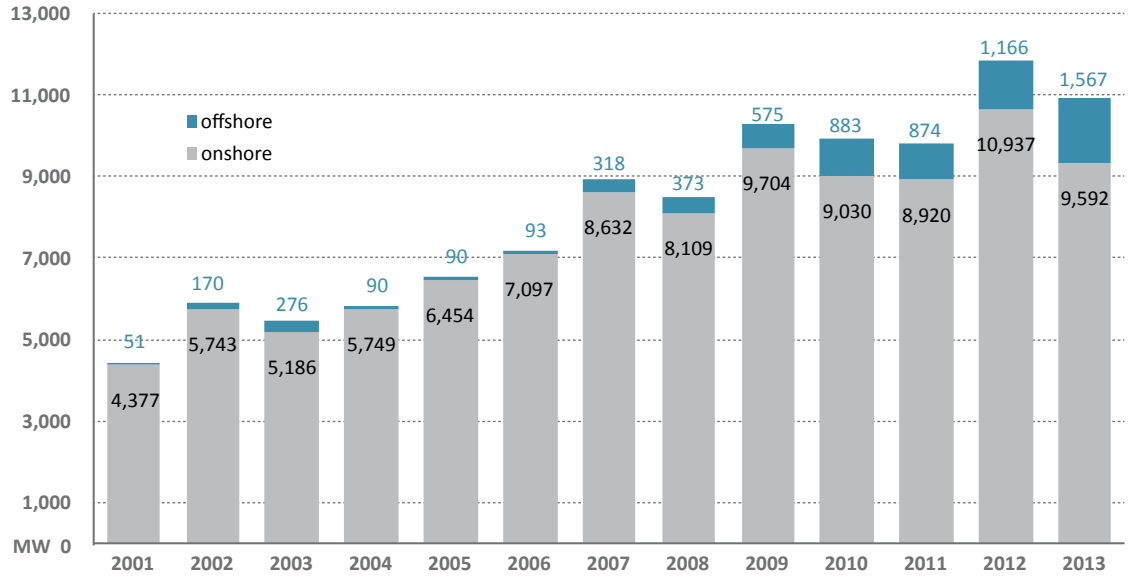
Market shares for new installations in the EU 2013 (MW)



Source: EWEA

Scottish Power's Whitelee wind farm in Scotland, Europe's largest onshore wind farm. Photo: Iberdrola/ Paul Lees

Annual onshore and offshore installation in the EU (MW)



Source: EWEA

EU offshore market: 34 per cent growth

While expansion to the EU onshore market fell by 12 per cent, the offshore market grew by 34 per cent. Between 13 and 18 billion euros were invested in new wind farms out at sea. Offshore facilities accounted for almost 14 per cent of installations across the EU – four percentage points more than in 2012.

"With a total of 1.5 GW of newly installed offshore capacity, this was a record," explains Justin Wilkes of the EWEA. Yet a slowdown in development was already detected during the course of 2013, according to Wilkes. Two thirds of new capacities went onto the grid in the first half of 2013. The EWEA also cites political uncertainty as a reason for the slowdown – particularly in the core markets of Germany and Great Britain. The EWEA makes the assumption that new installations will continue at a high level until 2015 but decline noticeably from 2016. According to the GWEC, the proportion of offshore wind energy worldwide is approximately 2 per cent.

New arrival: Kazakhstan

Internationally, the GWEC reported a newcomer, which the association classified as interesting back last year: Kazakhstan. The construction of a first commercial wind farm was reported – with German involvement. The company FWT Trade GmbH (FWT), which emerged in February 2013 from parts of the insolvent Fuhrländer AG, will install a wind farm with 22 turbines of the 2 MW class and a total rated capacity of 45 MW. The turbines will be erected near Erejmentau, east of the Kazakh capital Astana. FWT received the contract together with the company's Ukrainian subsidiary. The wind farm should be ready to go into operation this year.

The construction of the wind farm is one of the first serious moves to use alternative energies in the former Soviet republic. The turbines will generate 172 million kilowatt-hours of electricity per annum. Even the exhibition centre for Expo 2017 is expected to be supplied with electricity from the turbines. The Expo, which will highlight renewable energies, will herald a green direction and focus for the entire Kazakh economy. By 2020 Kazakhstan wants to install 13 wind farms with a capacity of just under 800 MW. Kazakhstan has an annual economic growth of 9 per cent and its enormous land surface provides ideal conditions for wind energy.

Other newcomer: Africa

Africa steps forward as another hopeful newcomer. Although in 2013 only 90 MW of wind energy capacity was add-

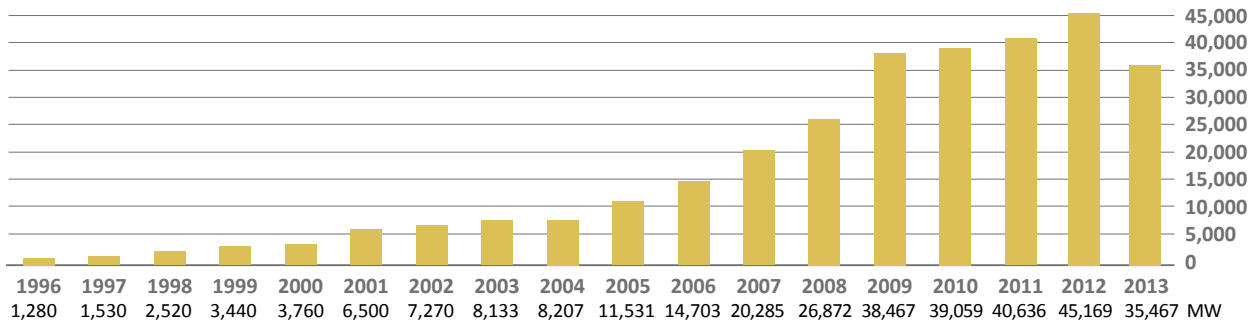
ed in Ethiopia alone, wind energy on the African continent will boom in 2014 according to the GWEC – led by South Africa, Egypt, Morocco, Ethiopia, Kenya and Tanzania.

In Asia, by contrast, Japan made no notable progress in wind energy in 2013. Instead, the first nuclear power stations, which had all been switched off following the Fukushima nuclear disaster, are expected to go back onto the grid soon.

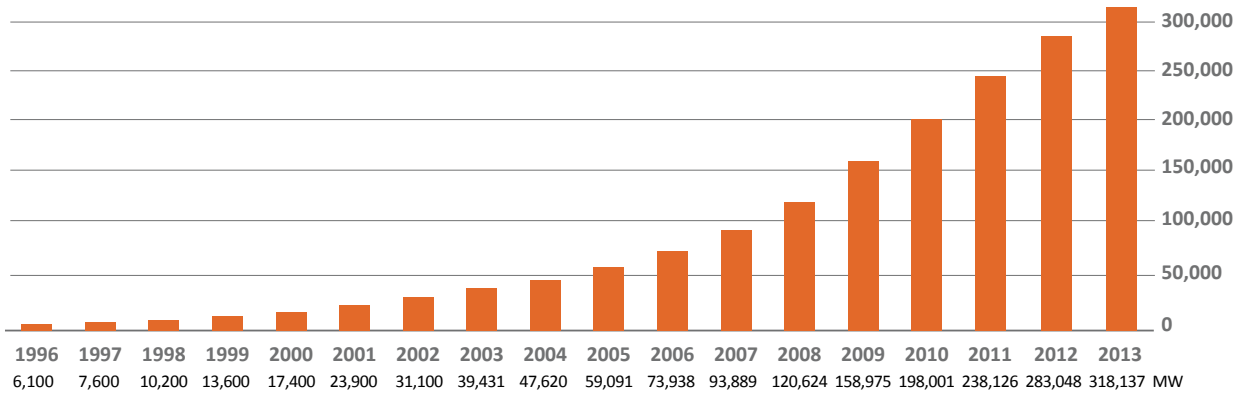
Brazil: Strong upward trend

In contrast, there are pleasing developments in Brazil, which in 2013 reported that drawing on the lessons of Fukushima, the building of planned nuclear power stations will initially stop and instead there will be a greater focus on wind energy. The country already leads Latin America in the ranking with just under 1 GW of expansion and 3.4 GW in total capacity. There is a strong upward trend: according to the GWEC, new projects with a possibly record-breaking 4.7 GW have been kick-started in 2013. Yet there was still some turbulence in this market for foreign manufacturers. In order to support the domestic economy, the country's development bank only awards finance to companies that produce in the country. Manufacturers require relevant certification. And only the Spanish company Acciona and the French turbine manufacturer Alstom have received this certification. Until then, other active manufacturers in 2013 had to look on. Brazil is a traditionally strong rival of Mexico. Here a reform to the energy sector is stimulating further expansion of wind energy. Expansion was just under 600 MW in 2013. ■

Annual global newly installed wind capacity 1996–2013



Total installed wind capacity 1996–2013



Source: GWEC

2014: Return to the targets of 2012

For 2014, the GWEC expects at least a return to the targets of 2012. The big challenge, it says, is to globally stabilise those markets again, which have suffered particularly badly in recent years under uncertain policy frameworks. Considering the developments in the USA and Spain, even BWE President Pilarsky-Grosch is urging for political stability for wind energy in Germany and Europe. This is even more important, she continues, because there is great economic potential based on the increasing global spread of wind energy and a strong domestic market is an important condition for exporting. Conversely, it would be wrong to assume, according to the experts, that the wind energy sector would suffer the same fate as the solar energy sector. "The vertical integration and technological challenge is much higher in wind energy," explains GWEC President Rave. According to him, European expertise and competence are therefore in strong demand for the future.

Photo: Santi Burgos

Technology

Germinon wind farm in the Champagne region, France. Photo: Jan Oelker

The costs at a glance

Onshore wind energy still has the potential to reduce costs per generated kilowatt hour even further. Turbine manufacturers are pursuing innovative strategies with this idea in mind.

In the past few years, not only the capacity of wind energy turbines has grown significantly, but so have the hub heights and size of the rotors. This development also continued in 2013:

Nordex will be releasing N 131/3000 onto the market. This turbine has been designed with a 3 MW rated capacity and a rotor diameter of 131 metres for wind class IEC III sites. It therefore extends the offer of the 3 MW platform with a low-wind turbine. The prototype should be built in the fourth quarter of 2014; series production is due to start in 2015. The turbine is offered with tower heights of 99, 114 and – specially for Germany – 134 metres.

Enercon has extended its E115 model range with a 3 MW turbine, rounding up the platform with a rotor diameter of 115 metres. The E 115/3 MW prototype was built in North Germany at the end of 2013 with a hub height of 135 metres, and, as a wind class IIA machine, is aimed at locations with medium to low wind speeds. Series production is due to start this year.

Global market leader **Vestas** announced in April of last year that they would be introducing three new product variants in the 3 MW class: The 3.3 MW turbine is available as a further development of the V112/3 MW with a rotor diameter of 112, 117 and 126 metres for strong, medium and low wind conditions.

Rostock manufacturer **eno energy** expanded its product range with a wind class IEC II turbine, the ENO 100 / 2.2 MW. The turbine's prototype was built in 2013; at least 10 turbines of this type will go into operation in Germany in 2014.

GE introduced its new 2.5-120 turbine at the end of January of last year. The prototype of the turbine with a rotor diameter of 120 metres was built in Holland at the end of March, with a hub height of 139 metres. The manufacturer refers to the new development as "the most efficient and intelligent" turbine "in the world" – the latter is particularly because of the use of complex forecast algorithms and communication interfaces and the option to equip the turbine with an energy storage facility.

The majority of new turbines are further developments of established concepts which are mostly aimed at locations with medium to low wind speeds. As expected, the hub heights and rotor diameters continue to grow. "This shows," according to Dieter Fries from the BWE operators' advisory board, "that development which has emerged over several years is now further stabilising for larger turbines with lower specific capacity per swept rotor surface. This leads to a better utilisation of the turbines, which in turn puts less of a burden on the grids and positively affects the power production costs, whose reduction is crucial for the future success of wind energy."

"Good locations are becoming rare with time; for this reason investors and operators are interested in sites with lower wind speeds worldwide – in the meantime the suitable turbine technology is still available"

"Stadum-Sprakebuell"-wind farm in Schleswig-Holstein, Germany. Photo: Jan Oelker

Among other things, sales figures for the Nordex N 117/2400 prove that turbines which follow this principle are in demand. According to Felix Nosadal, the Nordex Press Officer, in 2013 48 % of all new orders were for low wind turbines, which have been on the market since the end of 2011. The manufacturer from Hamburg whose production takes place in Rostock, Germany sold 115 of this type of turbine in Germany alone. As a consequence, Nordex also believes that the new N 131/3000 has a similarly high sales potential.

A constantly growing demand for low wind turbines is also being recorded by Senvion (prev. Repower), GE and others: "Good locations are becoming rare with time; for this reason investors and operators are interested in sites with lower wind speeds worldwide – in the meantime the suitable turbine technology is still available," says Fries.

Specific rated capacity continues to decline

The brief study "Entwicklung der Windenergie an Land in Deutschland" (Development of onshore wind energy in Germany) published in June 2013 by the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), on behalf of Agora Energiewende, predicts how future tower heights, rotor surfaces and turbine capacities also grow in relation to each other. It is accepted here that the specific rated capacity will drop even further over the next 20 years for both high and low wind speed turbines, due to increasing rotor diameters and hub heights.

Even better than the models of today, in the future there is the possibility of stepping up the utilisation of turbines with an increasing number of full load hours and therefore producing cheaper wind energy. The current turbines already partly reach and even surpass the average values for 2023. This shows that the sector is headed in the right direction.

Assumptions for the further development of the average parameters of wind turbines

	2013		2023		2033	
	Strong wind	Low wind	Strong wind	Low wind	Strong wind	Low wind
Rated capacity	2.5 MW	2.2 MW	3 MW	3 MW	4.5 MW	4 MW
Rotor diameter	85 m	90 m	100 m	115 m	125 m	140 m
Specific rated capacity	441 W/m²	346 W/m²	382 W/m²	289 W/m²	367 W/m²	260 W/m²
Hub heights	90 m	120 m	110 m	140 m	120 m	150 m
cp_{max}	0.48	0.48	0.5	0.5	0.51	0.51

Source: Fraunhofer IWES, Agora Energiewende: Study *Expansion of renewable energy in Germany at optimum cost*

Results of the sensitivity analysis

VARIANTS	CHANGE		AVERAGE IMPACT ON PPC FOR ALL CLASSES OF SITE	
Main investment costs	– 10%	+ 10%	– 4,8%	+ 4,8%
Additional investment costs	– 10%	+ 10%	– 1,4%	+ 1,4%
Operating expenses	– 10%	+ 10%	– 3,9%	+ 3,9%
Borrowed capital interest rate (BCIR)	3%	5%	– 2,6%	+ 4,1%
Equity capital interest rate	– 10%	+ 10%	– 1,6%	+ 1,6%
Equity capital rate of return (ECRR) (Incentive to develop a windy location)	Removal of incentive 8,75% ECRR at all locations		– 1,7%	

Change of BCIR to 3 or 5 % (output value 3.8 %)

Source: Deutsche Windguard

The price of turbines and power production costs

Another study by the German Windguard, on behalf of the Bundesverbandes WindEnergie and VDMA Power Systems, about the cost situation for onshore wind energy illustrates that the main investment costs of a wind turbine (costs for the turbine, transport and installation) for an assumed operating time of 20 years continues to have the largest influence on the power production costs. This becomes clear when a sensitivity analysis is conducted of the cost pools among themselves: the analysis shows that at this point a reduction in price of 10 % results immediately in the power production costs almost halving.

The study also clearly shows that good results have been achieved already in recent years: compared to 2010, the power production costs for low wind speed locations have reduced on average by a good 11 %. This can essentially be attributed to the development of low wind turbines in recent years, but is also promoted by the current good financing conditions. In addition to the progress made in turbine efficiency, the greatest

The "BSS tower" (= bolted steel shell) from Siemens. Source: Siemens AG

Onshore: current wind turbines (2014)

MODEL	Nominal capacity/ kW	ROTOR Dia,/m	Swept area/ m²	W/ m²
ENERCON				
E 82 - 2,3	2,300	82	5,281	436
E 92 - 2,3	2,350	92	6,648	353
E 101	3,050	101	8,012	374
E 115	2,500	115	10,387	241
E 115	3,000	115	10,387	289
eno energy				
eno 100	2,200	100	7,854	244
eno 114	3,500	114.9	10,369	338
eno 126	3,500	126	12,469	281
GAMESA				
G90 2 MW	2,000	90	6,361	314
G114 2 MW	2,000	114	10,205	196
GE				
GE2,5-103	2,500	103	8,332	300
GE2,5-120	2,500	120	11,310	221
KENERSYS				
K 120-2,3 MW	2,300	120	11,310	203
LEITWIND				
LTW77 1 MW	1,000	77	4,656	215
LTW 2-101	2,000	101	7,992	250
NORDEX				
N100/2500	2,500	100	7,854	318
N117/2400	2,400	117	10,157	236
N131/3000	3,000	131	11,832	254
SENVION *				
RE 3 M-122	3,000	122	11,690	257
RE 3,2M-114	3,200	114	10,207	314
RE 3,4M-104	3,400	104	8,495	400
SIEMENS				
SWT-2,3-93	2,300	93	6,800	338
SWT-3-101	3,000	101	8,012	374
SWT-3-113	3,000	113	10,015	300
VENSYS				
Vensys 82	1,500	82	5,325	282
Vensys 112	2,500	112	9,940	525
VESTAS				
V 90-2 MW	2,000	90	6,361	314
V 100-1,8 MW	1,800	100	7,854	229
V 112-3,3 MW	3,300	112	9,852	335
V 117-3,3 MW	3,300	117	10,751	307
V 126-3,3 MW	3,300	126	12,469	265

*Former Repower

Source: Ingenieurbüro Fries, Stand Januar 2014

Mobile form: Enercon rotor blade factory KTA. Source: Enercon

potential for reducing the costs of onshore wind energy even further lies with manufacturing, transport and installation of the turbines. Manufacturers are investigating the following different concepts for this:

Lower transport costs

An important cost point is the operating time required for transport and assembly. For this reason, some manufacturers have switched, and started to first complete major components such as the tower in small units, and then assemble them on site.

Hybrid towers are already standard from a certain height for manufacturers such as Senvion, Nordes or GE. They solve part of the transport problem by manufacturing the concrete segments on site. They therefore also require a relatively large amount of time for assembly, which must remain reasonable in relation to the lower transport costs. Siemens takes a different approach and uses a bolted steel shell tower: "It's made up of several elements which are assembled directly on site," says Bernd Eilitz from Siemens. "The advantage is that we can transport elements of up to 140 metres of tower height in standard containers to the location." Transporting them in individual

units is an option Siemens also uses for other elements. Eilitz: "With increasing turbine sizes, it could also be possible in the future to transport nacelles in sections."

For larger heights, competitor Enercon uses its semi-finished concrete tower, which is manufactured in the factory and assembled on site. However, the Aurich-based turbine constructor also sells separable rotor blades on the market: Since the blades for the E 126 could each be transported in two units, the E115 series was also equipped with separable rotor blades: "The advantages that transport brings us far outweigh the somewhat greater amount of time spent assembling the turbines on site," reports Felix Rehwald, Press Officer for Enercon.

"The automotive industry with its high degree of standardisation is the model on which we are basing this development"

Progressive industrialisation

The production process in turbine manufacturing is a key cost spiral: "Ultimately," says Rehwald, "as a manufacturer, we must develop an intelligent platform strategy with which we can react to the customer requirements in the most flexible and efficient manner possible." This includes in particular standardising as many components as possible. Rehwald continues: "In this way, project lead times and development times can be shortened at the same time as increasing quality. Of course the manufacturing process must also run as efficiently as possible." The new Enercon rotor blade factory KTA in Aurich, Germany, is an example of an increased degree of automation. Here both time and money are saved by transporting the rotor blades in a mobile form from one processing station to the next.

Siemens is also in pursuit of more efficient processes with the series production in Brande, Denmark, which became an affiliate three years earlier: "The larger the series produced, the greater the potential for reducing costs which can be realised for individual turbines. That is why we began assembly line production of our 2.3 MW turbines four years ago. In this way, we were able to more than half the original assembly time of more than 30 hours," explains Bernd Eilitz. "In the meantime, the majority of our turbines and components come from highly industrialised manufacturing processes. The automotive industry with its high degree of standardisation is the model on which we are basing this development."

A high degree of standardisation is also the goal of Salzburg-based GE. They aim to achieve this by introducing highly modern mass production of rotor hubs and using the "Industrial Internet", among other things. Rostock, Germany has also been relying on mass production since 2011: "Three lines for the main components nacelle, hubs and drive trains, and three further lines for pre-assembly ensure largely standardised processes. Synergies also result from reducing to two platform lines," explains Felix Losada from Nordex.

In total, all manufacturers are working on making their processes leaner and, in doing so, their production more efficient. Against the background of many turbine components continuing to be crafted by hand, we anticipate that there is still some potential for development.

What matters is the overall efficiency of the project. eno wind farm in Plauerhagen. Source: eno energy

More turbines covering less surface area

Whilst the large manufacturers are betting on the enhanced industrialisation of their production processes, this strategy is only partially feasible for smaller and medium-sized manufacturers. "For the last few years now we have been concentrating even more on combining research and development for our projects in-house," explains Stefan Bockholt, Head of Development at eno energy. The company based in Rostock, Germany, has reorganised its R&D activities in the last two years in order to optimise the development of turbines and concepts in close cooperation with suppliers, universities and other research partners.

"We see ourselves less as a simple manufacturer and more as an end-to-end provider who keeps an eye on the costs and efficiency of the entire project." For example, the company has also geared its current turbines to cope with turbulence as well as possible and to cause as little turbulence itself as possible. "In this way, the distances between the individual turbines on a wind farm can be reduced, and the number of turbines per unit of area increased," explains Bockholt.

The majority of manufacturers are acutely aware of topics such as efficient farm layout with optimally designed turbines. The Rostock-based company eno energy, which builds around 30-40 turbines a year, has also developed core expertise for difficult farm structures using this specialisation. And Stefan Bockholt is certain that there will be even stronger demand for that very expertise in the future: "In the end, surface area will be a scarce resource." ■

Well-positioned overall

Clear increases in efficiency in turbine technology, modern transport and assembly concepts, industrialisation of production processes, optimal turbine and farm design, and even the fact that almost all well-known manufacturers have significantly escalated their investment in research and development in the last few years. In this context, a further drop in costs for wind power is to be expected – the sector is already headed in the right direction. Manufacturers also have many opportunities, which are linked to further shortening the innovation cycles in constructing wind turbines and securing technological progress on the international market. There's still plenty of potential.

Smart Blades: Greater performance through intelligent rotor blades

Tomorrow's rotor blades will use their own intelligence to ensure that the wind is used efficiently with every rotation and that load spikes can be avoided. Current research projects provide an insight into the direction the developments are taking.

Larger rotor blades enable a greater energy yield and therefore increased cost-effectiveness per turbine. In addition, using them it is possible to achieve the nominal performance even at low wind speeds, which means that the plant can feed into the grid more reliably and more predictably.

At the same time though, larger blades present new challenges. At radial lengths of up to 85 meters the blades of a single wind energy plant already sweep over a circular area of 22,670 square meters, which is the equivalent of several football fields. Extremely varied wind speeds can occur within this field under gusty wind conditions. In stormy conditions peak differences can be as much as 20 or even 40 meters per second. It is not possible for the rotor blades to balance out such gusts using the current technology. The blades are unable to adapt to the varying wind strengths individually and actively.

Pitch control is not enough

Neither traditional pitch control, which involves adjusting the angle of the blades depending on the wind strength, nor individual pitch control (IPC), which allows for the individual adjustment of each blade, for example in order to balance out varying wind speeds at different heights, are flexible or rapid enough to meet the challenge. As Florian Sayer, Head of the Rotor Blade Department at the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), explains, "pitch control is carried out at the hub end of the blade and is therefore relatively slow. By the time the blades have managed to adjust themselves the gust is no longer coming in at the same position." Therefore, he says, it is not possible to compensate for gusts or even for the tower shadow in this way.

Rotor blades need to make intelligent decisions

This is what the "Smart Blades" project, for which Sayer is responsible at the Fraunhofer IWES, is intended to address. Smart Blades are intelligent rotor blades that are equipped with technologies designed to enable individual blades to adjust themselves in accordance with local wind conditions. The idea is to be able to be capable of influencing the local flow more precisely and faster than has hitherto been the case through the use of clever structural and material configurations, moveable fore flaps or trailing edge flaps. As Sayer explains: "Smart Blades are designed to react within seconds." This enables them to balance out gusts in a targeted manner thereby reducing power output fluctuations. In addition wind power turbines fitted with Smart Blades will not need to be completely turned out of the oncoming wind in the case of powerful gusts.

The "Smart Blades – Development and Construction of Intelligent Rotor Blades" project, which is scheduled to run over 39 months, was inaugurated in January 2013 and has a project volume of 12 million Euros and is sponsored by the German Federal Environment Ministry. In addition to the Fraunhofer IWES the German Aerospace Centre (DLR) is also participating

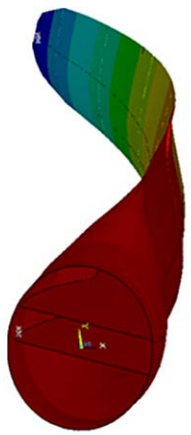
The challenge: non homogeneous wind front meets increasingly larger rotor area. Photo: Paul-Langrock.de

in the project as a coordinator, as well as ForWind, the joint centre for wind energy research of the Universities of Oldenburg, Hanover and Bremen.

Passive and active Smart Blades

Research will be carried out into two fundamental concepts during the "Smart Blade" project. The first of these involves passive Smart Blades, which not only bend but can also twist around their own axes in reaction to aerodynamic load changes. In doing so they change the angle of inflow and automatically counteract load changes. "The laminated construction of the blade is such that it is able to bend and twist under wind load," Sayer explains. He also refers to scythe-shaped blades as another possibility for passive "Smart Blades", which are curved along the rotor surface. In this case too the blade would be deformed and twisted together by the wind.

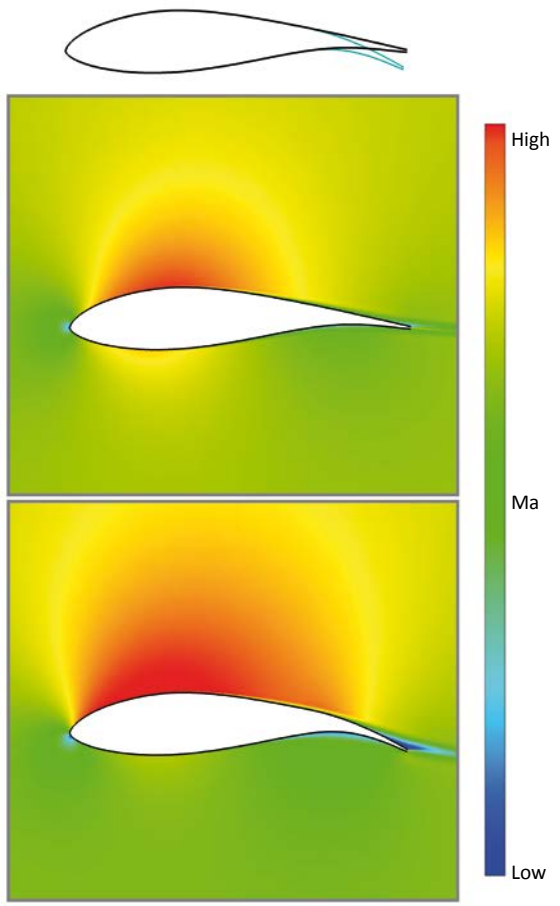
The second concept involves active Smart Blades, which change the angle of inflow by way of actively modifiable components or adjustable flaps mounted either on the leading or trailing edge of the blade. In this case, according to Sayer, "either the front edge or trailing edge of the blade would be deformed in a flap-like manner, but with no loss of geometric integrity." This would require an intelligent sensory and actuating system. The idea is that active blades would be able to pre-empt wind load changes and react in advance.



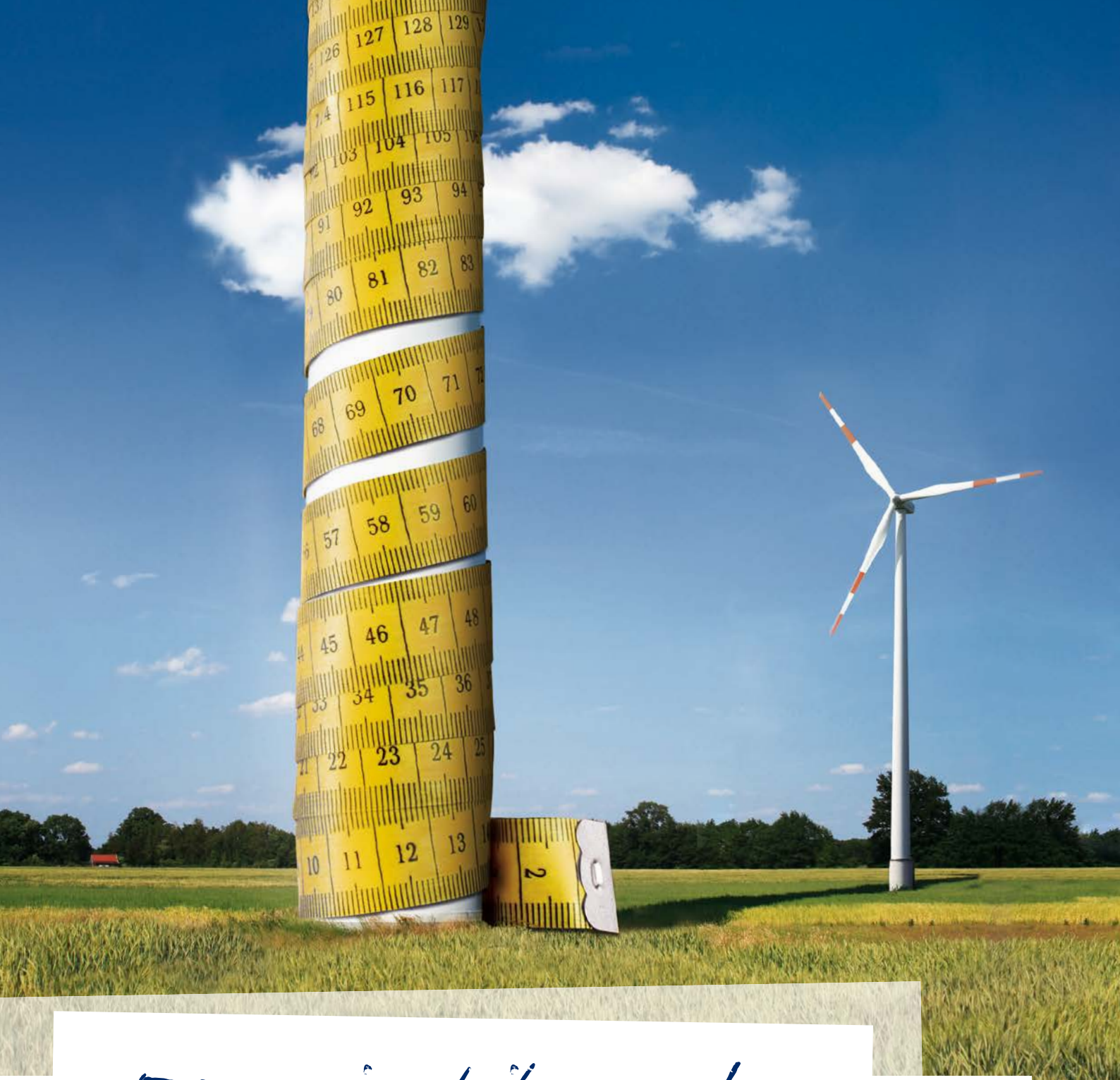
Passive Smart Blades deform in response to aerodynamic load changes..

Aviation meets wind energy

Mechanisms such as moveable trailing edge or front edge blade flaps are already used in the aviation industry. In the case of helicopters, for example, the dynamic uplift is generated by the inflowing air at the rotor blades, whereby flexible front and rear edges on the blades can either increase or decrease the uplift. The same physical laws apply in reverse when an existing flow of air drives a wind power turbine. For this reason the DLR, which is coordinating the "Smart Blades" project, can contribute valuable know-how. In addition the "Smart Blades" project will be overseen by an advisory council made up of industry experts.



Active Smart Blades:
The angle of wind incidence is actively modified
Source: TFD, Leibniz Universität Hannover



Eddy current generators tested

Another venture, whose objective is the development of intelligent solutions to the impact of current flows on rotor blades in new as well as existing plant, involves the US technology group 3M, Smart Blade GmbH and the Technical University of Berlin. The first project involves eddy current generators, which are also well known within the aviation industry. The purpose of these small plastic components, which are only a few centimetres in size, is to prevent the up-drafts and other influences caused by air turbulence. According to initial results, fitting such eddy current generators can increase the energy yield of a wind power turbine by 2 to 5 per cent. However they need to be positioned with millimetre accuracy and need to be individually designed for each rotor blade type. To this end 3M has developed a particularly weather proof plastic as the base material for the generators as well as a special durable glue, with which to permanently affix the eddy current generators to the rotor blades. ■

Before leaving the factory rotor blades are carefully inspected for possible faults and cracks. Photo: Siemens AG

Outlook

Passive Smart Blades almost ready for practical deployment

With regard to the significance of Smart Blade research for the wind power industry, Florian Sayer of the IWES explains that: "passive Smart Blades will be deployed at an earlier, and already being introduced in wind energy plant manufacturing." However, he continues, active Smart Blades will take several more years to perfect. This is because computer-based control mechanisms increase the complexity of the systems and are also more costly and require more maintenance. The biggest challenge will be to ensure that the incorporation of active components within the rotor blades does not make them more fault prone, increase their weight nor make them more maintenance intensive, nor increase the cost of production. The objective of the project is to conduct research into the feasibility, reliability and efficiency of Smart Blades.

Also in focus: automation solutions for rotor manufacture

In addition Sayer is carrying out research at the Fraunhofer IWES into automation solutions, with a view to being able to manufacture the large components of rotor blades in a more cost-efficient and rapid manner and at a higher quality. Until now rotor blades have mostly been manufactured by hand and this is one of the main reasons why they currently account for up to a quarter of the total cost of a wind power turbine. This is why the joint research project "BladeMaker" which involves 15 partner organisations including Siemens, Siemens Industry Software, BASF, Henkel, the University Bremen and Fraunhofer IFAM, and which is coordinated by the Fraunhofer IWES, is focusing on the entire production chain for rotor blades. As Sayer explains: "Blade manufacturers face enormous cost pressures from international competitors, which we want to address through the introduction of automation." The "BladeMaker" project is scheduled to run until the end of September 2017. It is supported by the BMU to the tune of around 8 million Euros. The overall objective of the project is to reduce production costs by 10 per cent.

Photo: Jan Oelker

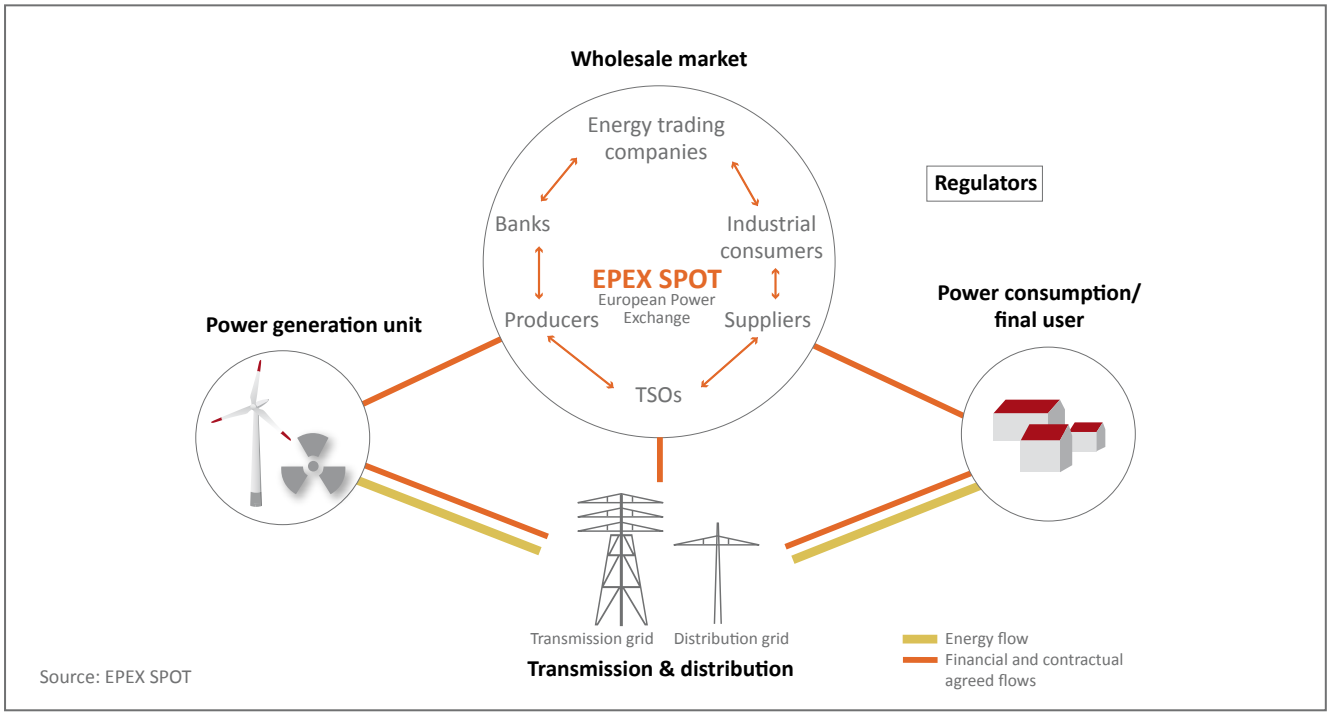
FOCUS

The electricity market

The Emscher art work "The Sorcerer's Apprentice" near Haus Ripshorst. Photo: Frank Vinken | dwb

The power market – how it works, its players and pricing

Knowledge of the power market has now become essential for wind farm operators, who need to understand how it works, who shapes it and how the exchange prices are calculated. Here we provide an overview.



Source: EPEX SPOT

The introduction of the market premium at the start of 2012 led to a positive boom in direct marketing and around 85 % of German wind energy is now directly marketed. The central trading place for this is the EPEX SPOT power exchange in Paris.

Futures market and spot market

Power is essentially traded in different market segments differentiated in particular by their various delivery terms:

Medium- or long-term contracts with lead times of weeks, months or years are traded on the **futures market**. This market serves primarily to cover forecast demand for supply at an early stage and thus creates a predictable and relatively reliable price level at the time of delivery. The futures contracts traded for Germany at the European Energy Exchange (EEX) in Leipzig have by far the largest trade volumes: in 2012, 911 terawatt hours (TWh) of power were traded on the German futures market, generally from conventional power stations with energy production that can be planned for the long term. As a rule, the buyers are companies with a high energy demand for which long-term forecasting is possible.

In contrast to this, power that can be delivered in the short term is traded on the **spot market**. It is sold either in **day-ahead**

Markets, market objectives and marketplaces

Market	FUTURES MARKET >	> DAY-AHEAD MARKET >	> INTRADAY MARKET >	> BALANCING ENERGY MARKET
Response/delivery time	Long- and medium-term (Years/months/weeks)	Short term – day before delivery	Very short term – hours before delivery	Real time – minutes
Objective	Early coverage of forecast demand for supply, hedging of price risk	Equilibrium of generation and consumption		System security
Trading centre	EEX	EPEX SPOT		Transmission grid operator

Source: EPEX SPOT

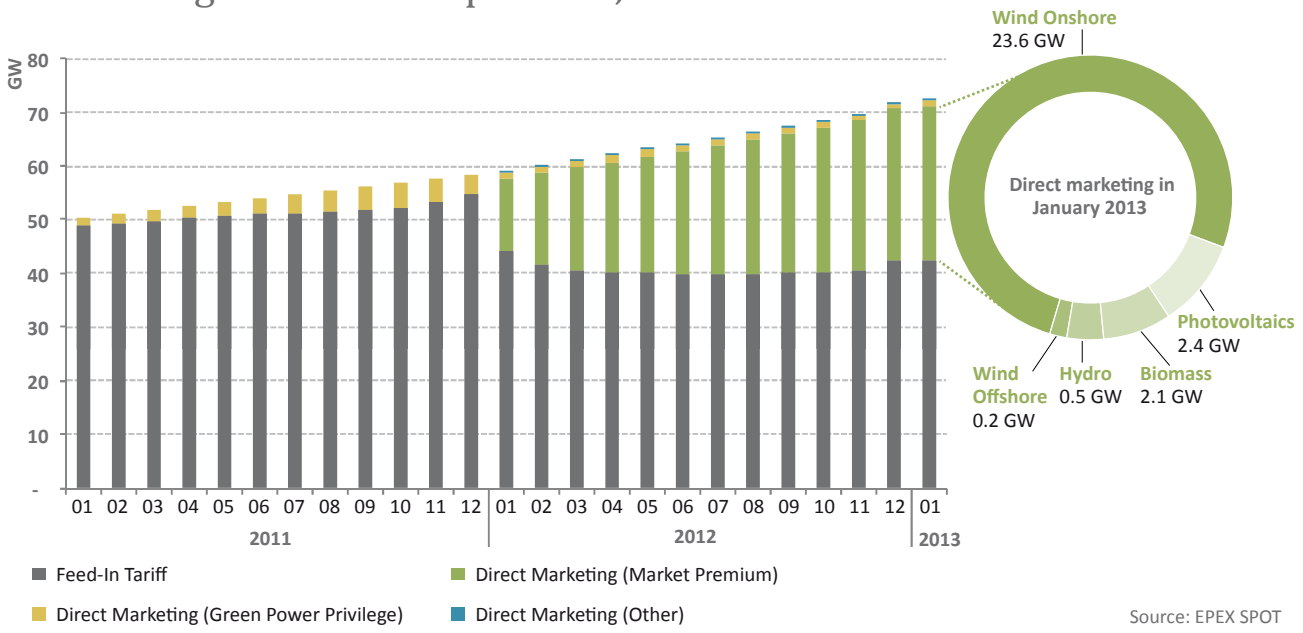
trading, a day before the physical delivery of the power to the buyer by the producer or trader, or in **intraday trading** on the same day with delivery terms of up to 45 minutes before delivery. The spot market for Germany is located at the EPEX SPOT in Paris and is used to establish a short-term equilibrium between power generation and consumption.

With 265 TWh in 2013, the amount of power traded for the German market on the spot market is considerably less than on the futures market – but nevertheless day-ahead and intraday trading plays an important role in the marketing of wind energy. The spot market is the place where renewable energies, with their fluctuating and difficult-to-predict nature, are traded.

The proportion of directly marketed renewables sky-rocketed with the introduction of the market premium in 2012 and has continued to grow steadily ever since. Onshore wind energy plays a key role here, representing over 80 % of all directly marketed renewable power plants.

Balancing power is important for system security, in other words maintaining frequency and voltage in the grid. This topic is presented in more detail in the article on page xx, so we will not go into further detail here.

Marketing renewable capacities , 2011–2012



Source: EPEX SPOT

Who are the players in power trading?

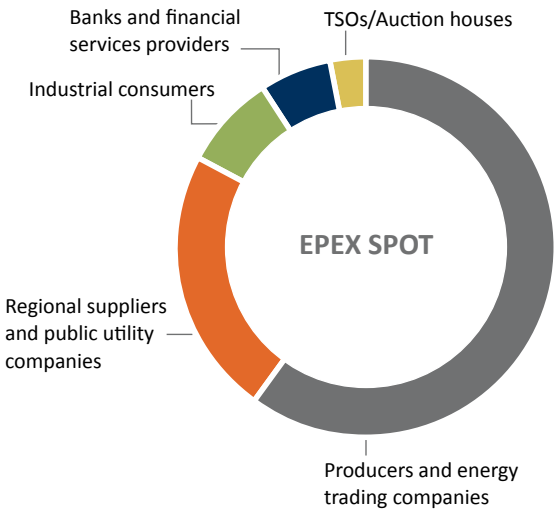
We can answer this question by taking a look at the participants in EPEX SPOT. Around 60 % of exchange members are producers and energy-trading companies, and just under a quarter are regional suppliers and public utility companies. The remaining participants are banks and financial services providers, large energy-consuming companies, and transmission grid operators. The latter operate on the spot markets to balance out their grid losses. In Germany however, they are also responsible for marketing green energy, which is transacted via the fixed feed-in tariffs. This is now playing a smaller role, however.

As well as the German market, EPEX SPOT also runs the markets in Austria, France and Switzerland. Accordingly, participants from these countries are particularly well represented: 37 % of the 212 exchange members (as at January 2014) come from Germany, 12 % from Switzerland, 7 % from France and 6 % from Austria. The remaining trading members come from all over Europe, with the UK and Italy particularly well represented, for instance.

Products and pricing on the spot markets

In day-ahead trading on EPEX SPOT, contracts for individual hours or blocks of several hours can be traded and their prices determined via a daily auction. The market participants submit their bids and offers for the 24 hours of the following

Participants on the EPEX SPOT markets



Source: EPEX SPOT

How does EPEX SPOT take account of the growing proportion of renewable energy?

Dr Wolfram Vogel, Director Public Affairs & Communications at EPEX SPOT: "We have been working on product optimisations for the intraday markets for several years now. A fitting example of this is the introduction of quarter-hour products at the end of 2011 and in which cross-border trade with Switzerland has also been possible since June 2013. At least a third of our market participants, many of them direct marketers, now use these products to balance out their trading portfolios in the short term. Quarter-hour products account for up to 20 % of the German intraday volumes each month, a trend that is clearly increasing.

A further point is the shortening of delivery times, which EPEX SPOT has already successfully reduced from 75 to 45 minutes in the last few years. The possibility of allowing trading even sooner before delivery is currently under discussion with European Commodity Clearing (ECC) and the transmission grid operators concerned.

We are also considering a further extension of intraday trading. Trading of hour products is already possible from 3pm on the previous day and, since the end of 2012, quarter-hour products can be traded from 4pm on the previous day. This has been taken advantage of by our members and around 23 % of all quarter-hour products are traded in the extended trading period. So we are now checking whether the start of trading for such products could be brought forward still further, which would benefit wind power providers in particular."

Trading Floor in Dusseldorf. Photo: Statkraft

day by 12pm (11am for Switzerland) on the previous day. The exchange uses this to determine an (ascending) supply and (descending) demand curve. Where these two curves intersect is the market clearing price (MCP), which represents the determining factor: offers are only accepted if the offered price is less than the MCP, and bids only accepted if the offered price is higher than the MCP. The results of the auction are published shortly after and then represent the current price.

By contrast, in intraday trading, the prices are determined continuously and bilaterally between sellers and buyers. They each make their respective offers and bids in the intraday market trading system and these are executed in real time, as soon as there are two compatible bids and offers.

Market participants on the EPEX SPOT can trade up to 45 minutes before delivery for Germany. It has also been possible to trade in 15-minute contracts since the end of 2011, as well as contracts for hours and blocks of hours. This is important for fluctuating types of energy like wind energy, because it allows hourly fluctuations in production to be balanced out. ■

How do renewable energies influence the power exchange prices?

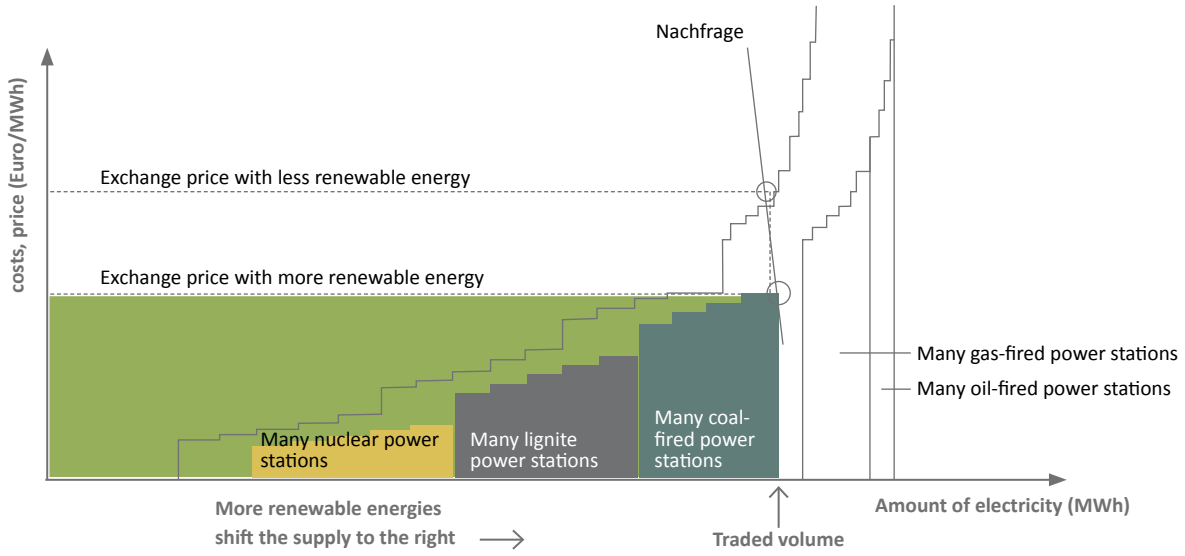
Bucking the current trend for consumer prices generally, the exchange prices for power have declined considerably as the proportion of renewable energy plants have increased. From January to November 2013, the price for base-load power on the spot market fell by an average of 12.2 per cent compared to the previous year from 4.26 cents per kWh to 3.78 cents per kWh. On the futures market, the futures price for power to be delivered in 2014 was listed at less than 3.75 cents per kWh in November 2013, the lowest value since 2007. The following factors, among others, are responsible for this trend:

The merit-order effect: The merit order is the ranking of power plants used based on their marginal costs for power production. Because of their low marginal costs, renewable energies are ranked towards the left of the merit order (= ascending supply curve). They therefore squeeze out conventional production means and have a dampening effect on wholesale prices.

Variation in the pricing structure: The high levels of energy supplied from solar sources in the summer months deflate the peak-load prices around midday. This means that the difference between the base- and peak-load prices has fallen continuously in the last few years.

The advent of negative prices: If renewable sources are supplying high levels of power when demand is weak, this may occasionally result in negative prices on the exchange and affect the income of marketers. But this effect should not be exaggerated – on the German day-ahead market, negative prices occurred on 17 days in 2013 and generally only for isolated hours on these days. Nevertheless, negative prices can also be a useful economic indicator, because they provide the incentive for greater flexibility and increased use of storage capacities. In the long term, this may result in more efficient structuring of the power market taking into account the priority supply from renewable energies.

The influence of renewables on the merit order



Source: Solarenergie Förderverein, Commerzbank Corporates & Markets

Photo: Statkraft

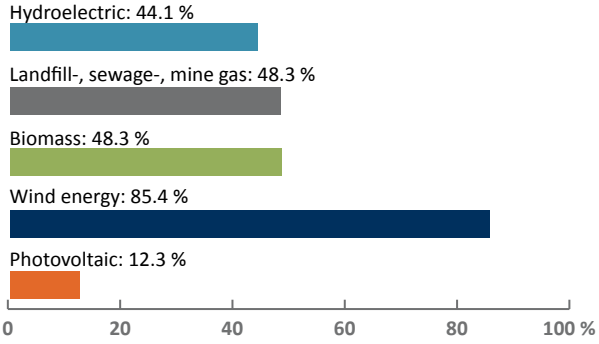
Direct marketing: where is the sector heading?

Due to the market premium within the wind energy sector, direct marketing became established as the dominant route to market in 2013. However changes are expected in 2014.

As Julius Ecke from the consultancy firm 'enervis' explains: "Direct marketing is no longer a novelty". According to the quarterly report for the ongoing evaluation of the direct marketing of electricity from renewable energy sources in November 2013, over 85 per cent of wind energy is already marketed in this way. The percentage is even higher for new plants. "Almost every operator of newly built plants opts for direct marketing," says Ecke, who keeps a keen watch on the market. As early as 2012 the output of wind energy plants using direct marketing doubled from around 12,000 to 24,000 MW. During the course of 2013 it increased again to 27,300 MW (figures from November 2013).

Direct marketing by market premium involves the plant operators forgoing the guaranteed feed-in tariff in favour of selling their electricity on the commodities exchange via a direct seller. They receive a sliding premium as a financial incentive, which balances the difference between the average price achieved via the commodities market and the feed-in tariff, as well as an additional management premium, which the direct sellers and plant operators usually share between them. Overall that exceeds the feed-in-tariff fixed in accordance with the German Renewable Energy Act (EEG), which means that direct marketing is profitable for the plant operators. Over and above this the direct sellers have a financial incentive to market EEG electricity with as little loss of value as possible, i.e., at above average commodity exchange rates. In addition, till now the plant operators have always retained the option of reverting to the fixed EEG tariff at any time, which is a significant prerequisite for a widespread participation in direct marketing.

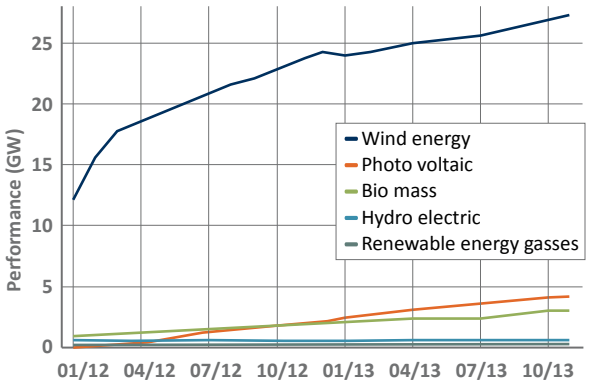
Direct marketing of renewable energy sources; percentage by technology



Source: Ongoing evaluation of the direct marketing of electricity from renewable energy sources by the Institute for Climate Protection, Energy and Mobility (IKEM) at the University of Greifswald, the Fraunhofer IWES, Fraunhofer ISI and the BBH lawyers as at 10/2013.

Photo: Statkraft

Output development in direct marketing by market premium



Source: Source: Ongoing evaluation of the direct marketing of electricity from renewable energy sources by the Institute for Climate Protection, Energy and Mobility (IKEM) at the University of Greifswald, the Fraunhofer IWES, Fraunhofer ISI and the BBH lawyers as at 10/2013 / Transmission System Operators for Electricity 2012/2013.2012/2013

Traded volume increase at the EPEX SPOT

Almost all of the EEG electricity is marketed via the EPEX SPOT's day ahead auction. Day trading of electricity is also increasing, as market participants use so-called intra-day trading to balance out short-term gaps between forecast and actual electricity production. The main reason for the increasing requirement for balancing energy is the higher proportion of renewable energies and/or the differentials between the forecasts and actual electricity production from renewable energy plants. Thus, at around 2 billion kWh, traded volumes in the intra-day market were around 48 percent higher in December 2013 than in the previous year.

The total traded volume of electricity on the EPEX SPOT's intra-day market and on the day-ahead market in December was 31.6 billion kWh. According to the Exchange, that was the highest monthly result since its establishment. One of the reasons for this was the inclement weather in December during which Cyclone Xaver led to the record highs in wind power production. The strong winds over Christmas also contributed to the high traded volumes.

Increasing forecasting quality

"Only in rare cases", says enervis consultant Ecke, "is there any incentive to shut down a power plant, when electricity prices are so depressed that feeding it into the grid needs to be paid for in spite of the market premium." The corresponding risk is borne by the direct seller, who will usually have committed to a fixed fee for the plant operator and also needs to take account of the interests of his portfolio as a whole. According the Ecke, direct marketing has, on the whole, already provided strong incentives for the integration of renewable energies in the electricity market, one of which is forecasting quality.

Janosch Abegg from the direct marketing firm Statkraft Markets is also confident: "the model has already triggered a plethora of innovations within a very short time," he says. He estimates that currently in Germany wind power plant outputting more than 15,000 MW can be controlled remotely and can therefore be utilised in a flexible manner. That, he explains, helps to avoid negative market exchange rates and reduces the costs associated with the EEG. Abegg goes on to say that: "We have access to ever more real time data, which results in increasingly accurate intra-day forecasts." That in turn, he explains, reduces grid usage fees, because the smaller the differences, the smaller the costs for managing and retrieval of reserve power, by means of which the grid operators secure the supply. This optimised form of marketing is implemented via so-called virtual power plants in which various EEG plants are inter-networked and can be centrally controlled (see report on page 64).

This is likely to change in 2014:

Clearly the federal government of Germany is also convinced of the positive effects of direct marketing, and is planning to introduce mandatory direct marketing via market premium for new plants. In the coalition agreement that has been tabled it states: "Mandatory direct marketing will be introduced for new plants with an output of 5 MW and above, on a sliding market premium basis. By 2017 at the latest this will apply to plants of any output capacity. The introduction will be conducted such that the diversity of actors currently existing with the EEG will be retained." In the meantime Energy Minister Sigmund Gabriel has presented his Key Issues Paper, which calls for mandatory direct marketing as of 2015 for plants outputting upwards of 500 MW.

The Coalition is striving for "a rapid and fundamental reform for the German Renewable Energy Act (EEG)." This is to be presented in the summer of 2014 and will create reliable framework conditions within the sphere of energy policy. At the same time older plants will benefit from a retention of acquired rights. According to the coalition agreement, the protection of legitimate expectations with regard to investments that have already been made and are currently in the process of implementation must be guaranteed.

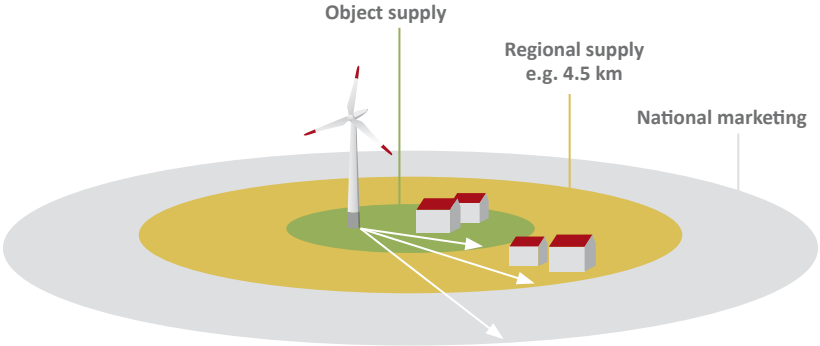
"The investment security of the current optional direct marketing should be retained in the event of a change to mandatory direct marketing."

Criticism of the German Federal Government's plans

As a representative of a major project management firm, Matthias Stark, Head of Electricity Trading at juwi green energy, takes a critical stance on the plan to make direct marketing mandatory. In his opinion it will not result in innovation within the wind energy sector, as already more or less all new plant operators are opting for direct marketing. "Until now," the expert explains, "every plant operator has had the option of reverting to the EEG feed-in-tariff at any time." Following these changes this would no longer be possible. As a result a plant operator would only be able to feed into the grid when it was able to produce a balance group and a schedule for the expected output. De facto this would mean that they would be obliged to collaborate with a direct seller. Should they fail to find one – for example in the case of an interim arrangement – then they would not be able to feed into the grid. This could prove problematic for small power plants in particular.

In addition, he opines, one can expect more difficulties obtaining financing for new plants as the banks would deem the risk to be greater. This can primarily be seen by comparison with the lack of long-term investment security in EEG feed-in-tariffs until now. The risk would also be deemed to be higher due to potential non payments from the direct sellers to the plant operators, as well as the increase in the cost of the services they provide, which is to be expected and which would

National and regional marketing



Object supply

- Consumption prior to public supply grid
- Optimisation vis-·-vis grid consumption through exemption grounds and grid tariff avoidance

Regional supply

- Consumption in spatial context (including via the grid)
- Increased acceptance and regional value add for customers
- Checking the potential for electrical tax exemption

National marketing

- Profit optimisation through direct marketing
- Standard case market premium model

Source: enervis

result from, among other things, potential legislative changes.

Some banks have also confirmed this critical evaluation. Hartmut Kluge, for example, who is responsible for project financing for wind energy parks at the Bremer Landesbank explains that: "The investment security of the current optional direct marketing should be retained in the event of a change to mandatory direct marketing." Otherwise, he says, the financing of a given project could be called into question in its entirety – or at least the resulting increase in capital costs could counteract the desired reduction in electricity production costs. In addition to the further retention of the long-term sliding market premium, investment security could be guaranteed by, among other things, retaining the option to return to the EEG tariff regulations for a limited specified period, as well as by exempting smaller renewable energy plants from the mandatory direct marketing rule.

An oligopoly of the direct sellers?

A study produced by the Energy Brainpool consultancy firm on behalf of the Bundesverband Erneuerbare Energie e.V. (Federal Renewable Energy Association), says the following about bank financing: an absolute prerequisite for achieving parity with the current EEG feed-in-tariff is a binding specification of the new tariff payments for a period of 20 years. Attention is also drawn to the dependence upon direct sellers that would then ensue. As the study points out, this should be viewed all the more critically as there are already indications that the direct sellers are forming an oligopoly. Thus for example, out of 70 companies that market electricity in line with the market premium model, only around 20 also offer marketing services for third-party power plants at the relevant scales. It is even the case that over 50 per cent of electricity volumes directly marketed via the market premium is handled by just 6 direct sellers.

The direct seller Statkraft holds a different view on the changes. From their perspective the main thing is that they will invigorate innovation within the sector. As Janosch Abegg of Statkraft explains: "We assume that innovation in the field of storage solutions will primarily be driven by direct sellers, as they have a high incentive to do so."

Regional marketing of green electricity

The direct seller Clean Energy Sourcing, on the other hand, sees no additional benefits in the mandatory market premium from an energy industry perspective, as almost all newly built plants with an output in excess of a certain level voluntarily embrace the direct marketing model. In general, warns Daniel Hölder, Head of Energy Policy at Clean Energy Sourcing, with regard the exclusive focus on direct marketing via market premium: "Selling electricity via the SPOT market will provide no general guarantee that renewable energies will top the market." He also takes a critical stance on the focus on regulation of wind energy and photovoltaic plants. Our main priority, he maintains, should instead be on increasing the flexibility of conventional power plants and controllable EEG plant (e.g. bio-energy). This is necessary because wind cannot be produced to order.

Another aspect of market premium based market Hölder is critical of is that it will lead to a loss of wind energy from the green electricity community. In this way it will not be possible to supply electricity customers with renewable electricity from Germany. What is therefore required, according to energy market experts, is above all incentives for regional electricity supply from EEG plants, which would contribute both to the acceptance of renewable energies and to lowering grid loads.

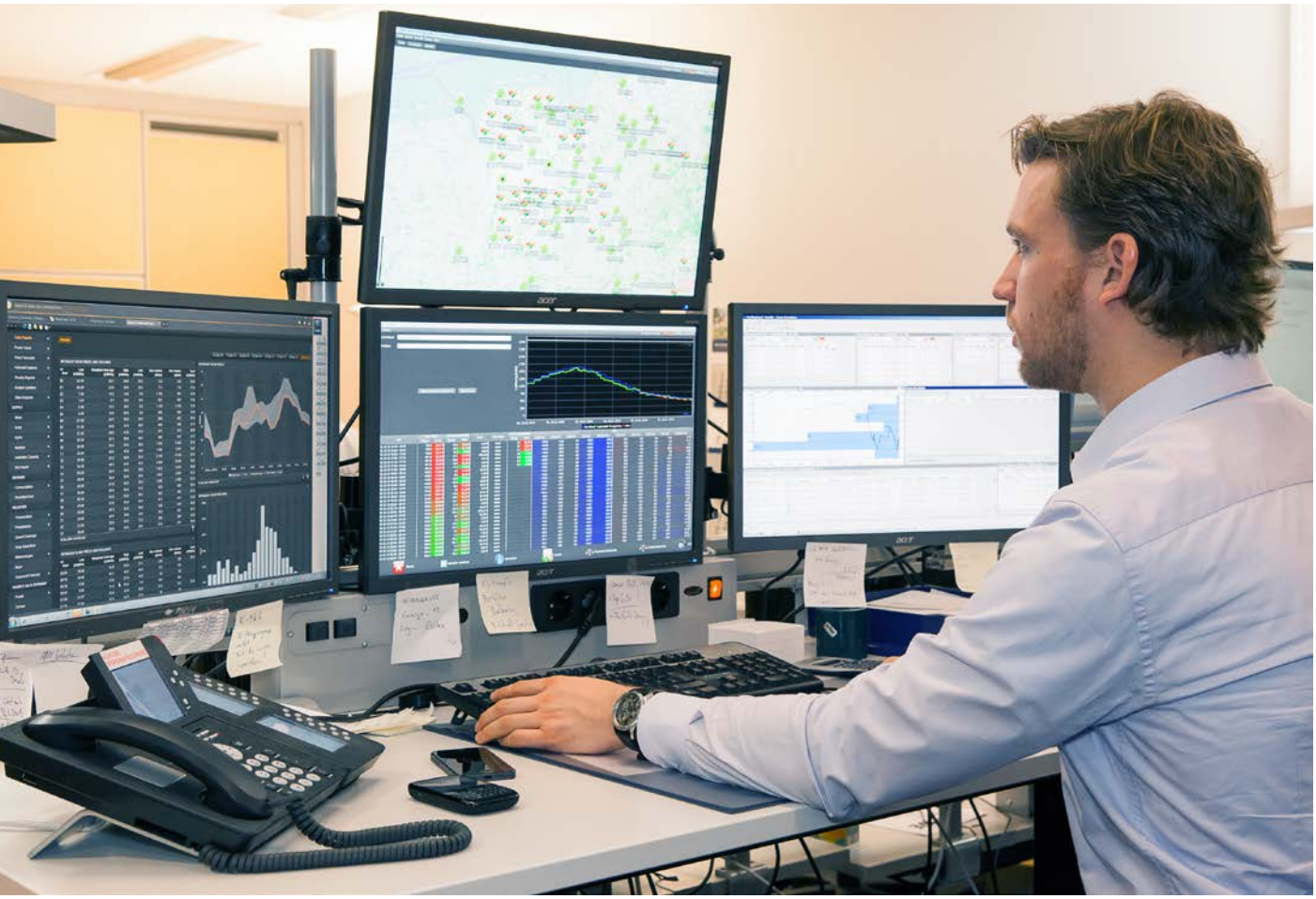
Consumer acceptance

According to Julius Ecke of enervis, wind plant operators are increasingly asking for regional marketing opportunities, in which the electricity feeds are not traded on the commodities exchange, but are instead sold to local industrial consumers or domestic customers. He is convinced that "this will increase the acceptance of wind energy." In this case promotion via the market premium is not always possible, he says, however the scope for savings, for example via electricity tax, should be looked into. In the case of citizen electricity projects, for example in Wörrstadt where the company is located, juwi also foregoes subsidy via market premium in favour of adding value to the region and encouraging user acceptance.

Thus direct marketing by market premium is resulting in significant stimuli in relation to the controllability of EEG plant and also in the further development of virtual power stations. However, on its own, the model is not sufficient to ensure the pre-eminence of and drive forward the integration of renewable energies, and thereby to bring about the success of the energy transition. ■

Virtual power plants – building blocks of the energy transition

With virtual power plants, wind power can be more effectively marketed and provide a significant contribution to grid stability.



Power trading with the virtual power plant (monitors in the centre), EPEX SPOT stock exchange tool (right) and market information (left). Source: EWE Trading

Ever since January 2012, when direct marketing of renewable power got properly under way with the introduction of the market premium, the intelligent linking of several decentralised energy producers, and even consumers to some extent, has become a focus of interest for operators and marketers. Virtual power plants, as well as related concepts including combined cycle power plants, distributed generation and decentralised energy systems, are also key technologies for a successful energy transition because of their potential to provide grid stability and system services.

What are virtual power plants?

A virtual power plant is the interconnection of several decentralised energy generation plants, and switchable loads if necessary, that are centrally controlled and able to provide electrical power based on demand. The sun does not always shine and the wind does not always blow – yet combining lots of small-scale producers can balance out regional differences in wind and sun through the power grid or adjustable biogas plants. If appropriate facilities are integrated, excess power can also be stored or converted into heat.

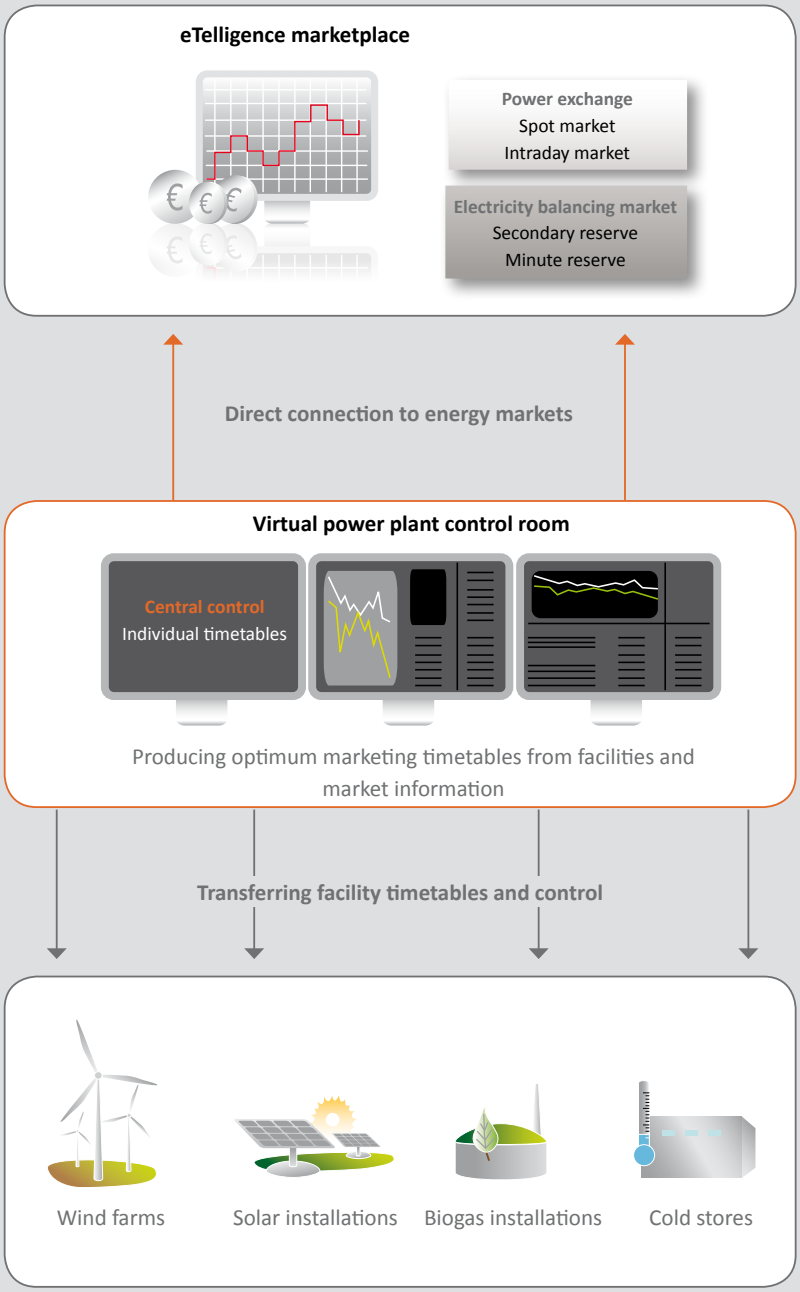
In this way, a network is created that is organised decentrally but towards the outside can act as a larger unit. The higher the number of networked facilities the greater the flexibility and performance capability of the virtual power plants, which can for all intents and purposes be compared with conventional larger-scale power plants. This also allows individual renewable power plants to participate in the energy exchanges, which would otherwise remain closed to them.

Short-term, needs-based power

"The measured generating values of the connected facilities are bundled together in real time and are compared with consumer demand," explains Dr Ul-

How does a virtual power plant work?

The connected facilities are controlled centrally from the control room and marketed through a trading connection.



Source: ©2011 energy & meteo systems GmbH

rich Focken, one of the Managing Directors of energy & meteo systems GmbH in Oldenburg, Germany. "If this demand differs from the amount of electricity produced, the plants can be regulated accordingly and the required amount delivered. The type of plants connected is of secondary importance."

energy & meteo systems entered the market with the first version of its virtual power plant in 2009 and now supports many customers for whom wind energy plays a central role. Customers include direct marketers and large energy suppliers, regional suppliers and local utility companies. Another provider on the market for virtual power plants is Siemens, whose decentralised energy management system DEMS has been in use since 2008. Here too, weather forecasts, power generation projections and the current energy demand are processed to create hourly forecasts and action plans for all connected plants. Some direct marketers of renewable energies also focus on their own developments that follow the same logic.

Central control and marketing unit: the control room

The control room is a central element of virtual power plants and handles two key functions: on the one hand, it manages and monitors the combined plants and on the other it simultaneously markets the energy generated. What is important here is that the connected units can be remotely controlled. Only in this way is it possible to ensure that the power plant pool, which usually consists of a combination of all renewable and some conventional forms of energy, can react promptly.

Optimised marketing of wind power

The role played by virtual power plants for the direct marketing of wind power can be demonstrated with the example of WE2, a subsidiary of EWE Trading GmbH. This company is one of the large direct marketers of renewable energies on the German market and trades in electricity that originates from a large number of wind turbines, among other sources.

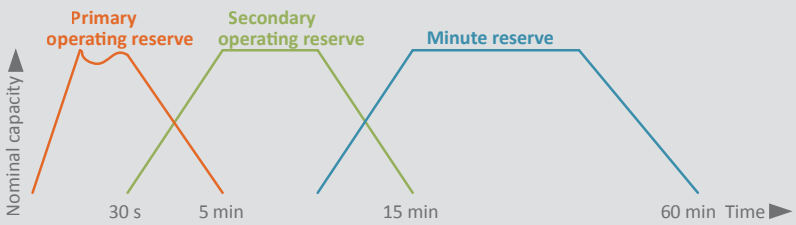
The virtual power plant used for this purpose bundles together all the connected producers and forms an interface where supply and demand are matched to each other. Hendrik Brockmeyer, Power Trader at EWE Trading, explains: "The solar and wind power forecasts provided by our forecasters are updated several times hourly. We use this information in the virtual power plant to derive our trading activities on the intraday market, for example. We also get the optimisation potential from our integrated conventional power plants. The software is linked to the exchange, where we set the trading amounts using drag and drop."

The trading values achieved are then processed again in the virtual power plant. "The trader's task," according to Brockmeyer, "is to decide how much electricity to trade and at what price based on the amount forecast for generation and the demand. The transaction technicalities are handled by the virtual power plant in communication with the exchange." From an energy trader's perspective, this simplifies work enormously: "It amounts to pretty much the same thing whether I'm trading

Operating reserve

Transmission grid operators need both positive and negative operating reserves in order to ensure a balance between generation and consumption of electrical energy within their control areas at any time. This is essential to maintain supply frequency and avoid incidents of grid collapse. Operating energy reserve is divided into three qualities, which differ primarily on the basis of their activation speeds:

The **primary operating reserve**, which is automatically activated in a continual control process as a function of frequency in the second range
The **secondary operating reserve**, which balances out discrepancies within the grid control network and which must be activated within five minutes
The **minute reserve**, which must be generated as reserve capacity within fifteen minutes of being requested.



Temporal progression for operating energy reserve, schematic representation
Source: Fraunhofer IWES

with electricity from one or 1,300 wind turbines," Brockmeyer explains.

Operating reserve

Optimised direct marketing is one core aspect for virtual power plants; another is the possible provision of an operating reserve. For example, half of the networked plants of direct marketer Statkraft are remotely controlled so that production can be curbed in the case of oversupply. "We are therefore creating the infrastructure that will allow us to provide an operating reserve from wind and photovoltaics in the next step," explains Janosch Abegg of Statkraft.

Cologne-based company Next Kraftwerke has already taken a step in this direction. The company is the first direct marketer of renewable energies allowed to trade with an operating energy reserve across all four German control areas with its virtual power plant NextPool. However, this permission still does not include participation of photovoltaic installations and wind turbines, which are also integrated in the virtual power plant.

Taking the long view, an operating energy reserve from wind and sun is vital if the energy transition is to succeed with 100 per cent renewables.

Prequalification – wind and sun excluded

The electricity balancing market is organised by the transmission grid operators directly through the platform www.regelleistung.net. In order to access it, a supplier must pass the prequalification, among other things. While relevant data such as rated capacity, maximum and minimum power or voltage level of the plant/pool are considered, checks are also carried out to ascertain whether the plant meets the reaction-time criteria and whether it fulfils the technical conditions. The provider must also prove 100 % availability of the offered operating energy reserve.

In the case of current tender periods, which are mostly a week on the German market for secondary operating reserves, this represents a significant exclusion criterion in view of the fluctuating properties of wind power. But it doesn't always have to be this way, as proven by the Danish energy market, where wind power is already generating operating energy reserves.

Operating reserve feasible with wind power

The wind and sun are still excluded from the German electricity balancing market. Hope that this situation could change in the future is offered by two research projects supported by the German Federal Ministry for the Environment: "Regenerativkraftwerk Bremen" and "Kombikraftwerk 2". These projects investigate the extent to which system services such as the

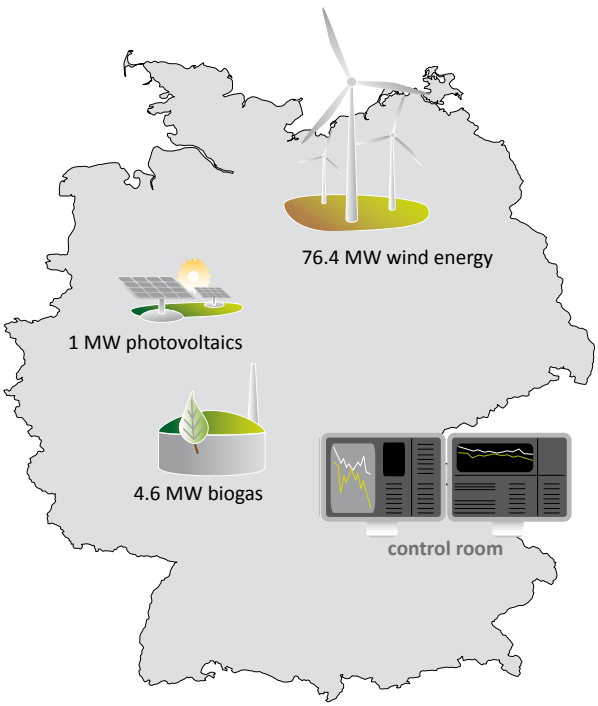
provision of an operating reserve can be assured in a fully renewable energy power supply.

The "Kombikraftwerk 2" project, which is carried out and managed by Fraunhofer IWES with numerous other partners from the renewables sector, is a combination of several wind farms and biogas and photovoltaic installations with a capacity of over 80 MW. "Our continual online capacity measurements and accurate weather forecasting mean that we can closely gauge the expected capacities in the coming minutes and hours. We can also estimate corresponding capacities needed for the provision of operating energy reserves for the power plant timetable," explains Dominik Jost, who is responsible for operating reserve demand at Fraunhofer IWES.

Endurance test under real conditions

In a field test at the end of October 2013 the capacity capability of "Kombikraftwerk 2" was subjected to real conditions. After a specified signal was first initiated for a power request, placing the highest demands on the speed and accuracy of infeed, the plants also had to adapt to a real request signal and provide primary operating energy reserve according to the current frequency situation in the grid. The result proved convincing: "The combined cycle power plant was able to generate the required capacities at any time and react quickly," explains Jost. "It's quite clear that wind and sun can provide operating reserves in conjunction with other renewable energies; electricity supply and grid security are also guaranteed in a 100 per cent renewables scenario." ■

Combined cycle power plant "Kombikraftwerk 2"



Predominantly wind energy in Kombikraftwerk 2
Source: Fraunhofer IWES

Are market adaptations necessary?

The technology for generating operating reserves in the shape of virtual power plants and remotely controllable generating plants is already well advanced; however, the current general conditions are still not adapted to renewable energies: "The lead times, particularly for secondary operating reserves, are currently too long for reliable infeed forecasts. The same applies to product length, which is a week in this case. A drastic cut in lead times and product lengths is essential if wind energy is to participate in this market. There is also a lack of prequalification rules geared to the properties of fluctuating energy sources," according to Jost. "If these general conditions were revised accordingly, the renewable energies could play the role that they are already technically capable of playing in the stable supply of electricity."

It will therefore be crucial to adapt the market design for operating energy reserves if the goal of achieving a full energy supply from wind, sun and other renewables is to be anything other than a distant dream.

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Photo: Paul-Langrock.de

Offshore

Construction in the high seas: Alpha Ventus, Germany's first offshore wind farm in the North Sea. Photo: Paul-Langrock.de

Guarded optimism

The prevailing mood in the offshore sector has significantly brightened over the course of 2013. The reason for this is not least the current number of completed wind farms or wind farms under construction. General conditions also seem to be stabilising, and heading in the right direction – albeit with a few trade-offs.

From the perspective of offshore wind energy, 2013 was a year of mixed fortunes: On the one hand, the installed capacity in the German wind farms significantly increased and a lot was built. The start of construction for a few new projects was also announced in 2013, including the farms Godewind 1 and 2, Butendiek and Amrumbank West. On the other hand, some projects have been shelved and there have been reports of companies facing bankruptcy, such as the Bard group, the developer Windreich and others, while suppliers and component manufacturers downsized – all of which has clouded prospects somewhat.

The capacity of ready-to-operate turbines installed out at sea has almost doubled within a year.

Eight wind farms in construction, four in operation

"As far as the implementation of current and planned projects is concerned, we can be very happy with 2013," reports Andreas Wagner, Managing Director of the German Offshore Wind Energy Foundation. "The capacity of ready-to-operate turbines installed out at sea has almost doubled within a year. We are also seeing what is to date an unsurpassed degree of construction in the North Sea," he adds. "In this respect, we are feeling more optimistic about the future."

Given the numbers, this feeling is justified. At the start of last year, 280 MW was installed in the German North and Baltic Seas meaning that one year later, the capacity of wind energy out at sea has grown to just under 600 MW. With Bard Offshore 1, fully on the grid from September 2013, the largest wind farm to date in the German North Sea started operations, with a capacity of 400 MW. Riffgat 1 wind farm off the island of Borkum is also finished, although it will only start supplying its 108 MW at the start of 2014 due to a delayed grid connection.

More turbines were built in Trianel Windpark Borkum West. Another six wind farms are also being constructed in the North Sea with Amrumbank West, Dan Tysk, Borkum Riffgrund I, Global Tech I, Meerwind Süd/Ost and Nordsee Ost. Over in the Baltic Sea, construction of Baltic 2 began in August 2013. According to EnBW, the first wind turbines should be gradually connected to the grid from this year. "In total," says Wagner, "there should be around 2.4 gigawatt of offshore capacity by the end of 2015."

Grid expansion must accelerate still further

Whereas construction work on the farms is making progress, delays to the grid expansion have not yet been eliminated. For example, although the Riffgat wind farm was built

Short construction time but still waiting for grid connection: Riffgat wind farm.
Source: EWE

within 14 months, it had to be provided with diesel generators for another six months and more because there was no grid connection. "The delays led to additional expenses in the mid double-digit millions," reports Dr Jörg Buddenberg from the operator EWE. Buddenberg, who is also a spokesperson for the AG operators in the Offshore Foundation indicates how important it is "that consent for grid connection is honoured" in this context.

In order to be able to guarantee this in the future, a course was set at the end of 2012 by German legislature – among others, the new regulations concerning the limitation of liability and system changeover for grid expansion. From then on, the latter was to follow a yearly updated offshore grid development plan. The 2013 grid development plan was confirmed in January of this year by the German Federal Network Agency, and should increase planning safety for newly built wind farms.

Buddenberg: "These regulations have made important corrections, which were requested by the sector and are therefore completely in our interests. The procedure that is now being applied with the first grid development plan is also sensible. It gives greater security to investors and planners. However, it requires that the planned projects are also implemented at the planned times."

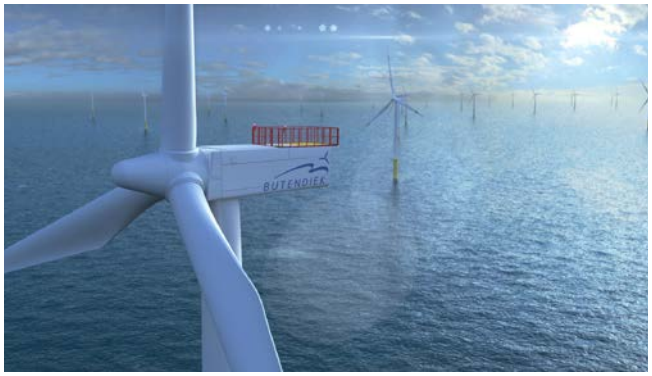
Tennet, the network operator responsible for the North Sea, has been trying to meet these demands. By the end of last year it had awarded contracts of 6.2 gigawatts for offshore cables and grid connections. Given fixed investment consent for 2.9 GW and the farms currently being constructed in practice with just under 2.4 GW, we are already relying on stock, as Tennet Managing Director Lex Hartman reiterated in November 2013.

Uncertainty resolved?

The political signs are also giving cause for confidence. Although the expansion targets for wind energy out at sea were reduced from 10 to 6.5 GW by 2020 thanks to the coalition agreement between the CDU and SPD, it was also announced that the "acceleration model" would be extended until the end of 2019. While the reduction of construction targets corresponds approximately to the assessment of the offshore sector,

the extension of the acceleration model in particular has been unanimously welcomed: "In our view, this extension is a useful political decision which enables further expansion," explains Christians Schnibbe, Press Officer for wpd AG. "What we also need is sufficient time to set up projects."

wpd AG had some good news to report in its offshore branch over the last year. Financing has been in place since March 2013 for the former community wind farm Butendiek, construction is due to start this year, and the wind farm should be supplying electricity from 2015. Another wind farm was secured in the North Sea with Nordergründe, and commissioning is planned by the end of 2016. In January of this year, the Bremen-based company could acquire yet another investment partner for Butendiek. "This shows that investors' uncertainty has recovered somewhat recently," reports Schnibbe. "We are currently working with a whole range of national and international investors who want to engage in the German offshore market."



Due to be connected in 2015: Butendiek wind farm (photo montage). Source: wpd AG

The decision by Dong Energy in November 2013 to build the Godewind 1 and 2 wind farms is also indicative of improvements to the investment climate. Construction of the

Expansion status in the North and Baltic Seas

Offshore windfarm	Owner approval	Capacity	Start of construction	Commissioned
IN OPERATION				
alpha ventus	Stiftung OFFSHORE-WINDENERGIE	60 MW	08/2007	04/2010
EnBW Windpark Baltic 1	EnBW Erneuerbare Energien GmbH	48 MW	07/2009	04/2011
BARD Offshore 1	BARD Holding GmbH	400 MW	03/2010	09/2013
Riffgat	Offshore-Windpark Riffgat GmbH & Co. KG	108 MW	06/2012	Q1/2014
UNDER CONSTRUCTION				
Trianel Windpark Borkum	Trianel Windpark Borkum GmbH & Co. KG	200 MW*	09/2011	2014
Meerwind Süd/Ost	WindMW GmbH	288 MW	09/2012	2014
Global Tech 1	Global Tech 1 Offshore Wind GmbH	400 MW	09/2012	2014
Nordsee Ost	RWE Innogy GmbH	295 MW	12/2012	2015
Dan Tysk	Vattenfall Europe Windkraft GmbH	288 MW	02/2013	2014
Borkum Riffgrund 1	Borkum Riffgrund 1 Windpark A/S GmbH & Co. oHG	277 MW	08/2013	2015
EnBW Windpark Baltic 2	EnBW Baltic 2 GmbH	288 MW	08/2013	2014
Amrumbank West	E.ON Kraftwerke GmbH	288 MW	01/2014	2015
APPROVAL WITH DECISION TO INVEST				
Butendiek	OWP Butendiek GmbH & Co. KG	288 MW	2014	2015
Gode Wind 1	Gode Wind 1 GmbH	330 MW	2015	2016
Gode Wind 2	Gode Wind 2 GmbH	252 MW	2015	2016

First expansion phase

Total: 3,810 MW
Further approved projects: 5,887 MW

Source: Stiftung OFFSHORE-WINDENERGIE, February 2014


NORTH SEA
568 MW
870 MW
2,036 MW
3,474 MW
Denmark
Dan Tysk
288 MW
Butendiek
288 MW
Amrumbank West
288 MW
Nordsee Ost
295 MW
Meerwind Süd/Ost
288 MW
Global Tech 1
400 MW
BARD Offshore 1
400 MW
alpha ventus
60 MW
Trianel Windpark Borkum
200 MW
Borkum Riffgrund 1
277 MW
Riffgat
108 MW
Gode Wind 2
252 MW
Gode Wind 1
330 MW
Heligoland
Flensburg
Schleswig
Büsum
Brunsbüttel
Cuxhaven
Bremerhaven
Stade
Nordenham
Bremen
Wilhelmshaven
Emden
Norddeich
EEZ
12 sea mile border
Netherlands
German territory and EEZ
Construction zone offshore wind energy
12 sea mile border/EEZ
In operation
Under construction
Approval with decision to invest
(Start of construction 2014/2015)
Port service
Port components
Port base


BALTIC SEA
48 MW
288 MW
336 MW
EnBW Windpark
Baltic 2
288 MW
EnBW Windpark
Baltic 1
48,3 MW
Sassnitz
Barhöft
EEZ
12 sea mile border
Kiel
Stralsund
Rostock
Greifswald
Lübeck
Wismar
Hamburg
Poland
Germany
STIFTUNG OFFSHORE WINDENERGIE
© Stiftung OFFSHORE-WINDENERGIE
February 2014
Offshore wind energy
In operation | Under construction | Approval with decision to invest
616 MW
870 MW
2.324 MW
15 Wind farms
885 Turbines
3.810 MW Total capacity

Erecting wind turbines at Gunfleet Sands III wind farm. Photo: Paul-Langrock.de

Offshore: current wind turbines (2014)

MODEL	ROTOR			
	Nominal capacity/kW	Dia,/m	Swept area/ m²	W/m²
SWT 3,6 - 120	3,600	120	11,310	318
SWT 6 -154	6,000	154	18,626	322
Repower 6M	6,150	126	12,469	493
Repower 6M	6,150	152	18,146	339
Alstom 6 MW	6,000	150	17,671	340
Areva 5 MW	5,000	116	10,568	473
Areva 5 MW	5,000	135	14,314	349
Bard 5 MW	5,000	122	11,690	428
PROTOTYPES IN OPERATION OR PREPARATION				
Samsung 7 MW	7,000	171	22,966	305
Vestas V 164	8,000	164	21,124	379

The series-produced turbines now reaching the market have a rotor diameter of ca. 150 m, which is an increase in the swept rotor area of about 50 per cent compared to existing turbines. This leads to considerably larger annual yields and with this lower production costs since the costs of foundations are only slowly increasing. Using monopiles up to 10 m in diameter can also save costs compared to tripod foundations. Source: Ingenieurbüro Fries, January 2014. Source: Ingenieurbüro Fries, Stand Januar 2014

two projects totalling 582 GW is due to commence in the first half of 2015, with commissioning planned for 2016.

What does the future hold beyond 2020?

The regulations concerning grid expansion that have already been implemented and the political signs may have achieved their intended result. Jan Rispens from the Renewable Energy Hamburg cluster estimates that, in addition to projects currently being constructed, another four gigawatts could be installed by 2020 – "provided the announcements from the coalition contract are quickly converted into credible laws and regulations. It all comes down to this now."

We must also not lose sight of what will happen beyond 2020: "For projects which are currently still stuck in the first planning stage, the acceleration model extended until the end of the decade could still fall short." In comparison to previous years, further expansion targets for 2030 could then be "heavily reduced, which would probably also affect investments in ports, ships and other infrastructure." In this respect, we could act on the assumption of sensible general conditions. "However," says Rispens, "I think there will still be a need for action in the future. Especially as there is currently not much sign of a second wave of expansion following on from existing wind farms."

Potential for reducing costs

With power production costs of 12.8 to 14.2 euro cents/kWh, offshore wind energy is undeniably not yet one of the lower-priced renewable energies. There is, however, significant potential for the reducing costs according to a joint study conducted in August 2013 by Prognos AG and the Fichtner Group: calculated over a service life of 20 years, the costs per kilowatt hour in an assumed off-

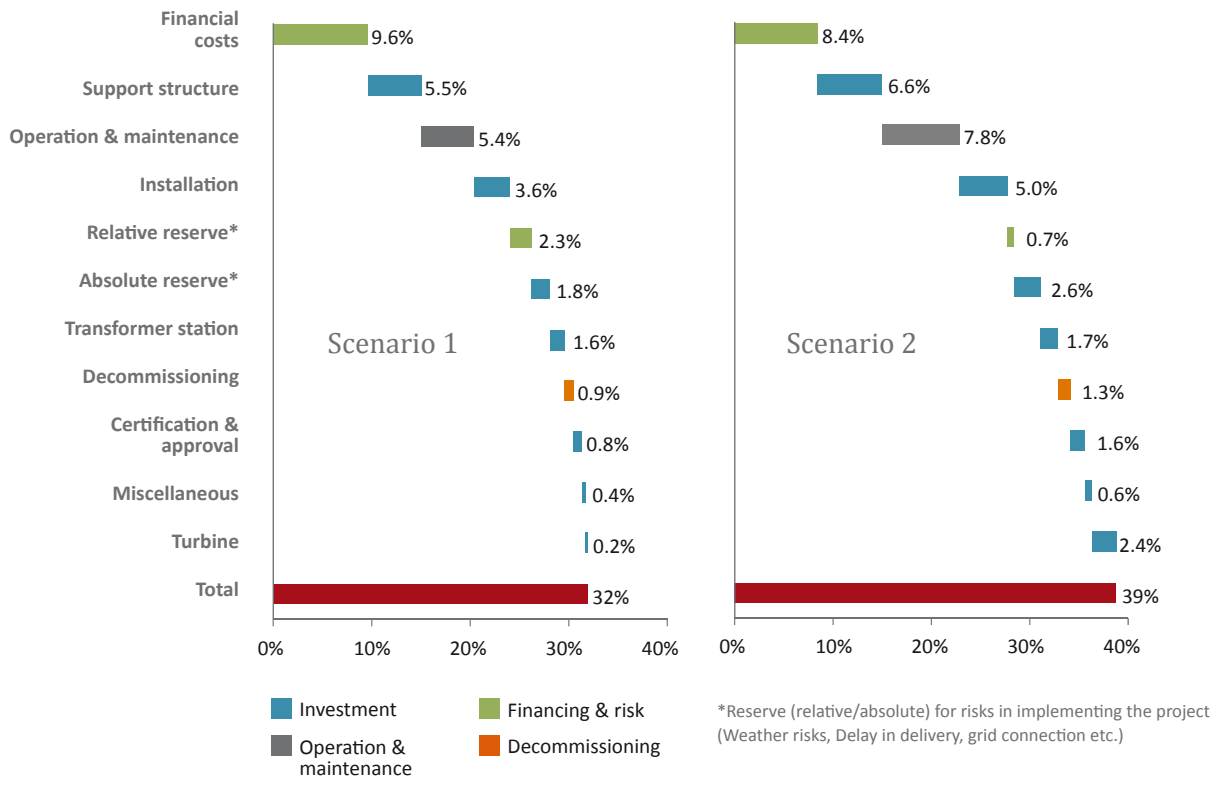
shore expansion to 9 GW could fall by 32 % in 2023, or even by 39 % in a best-case scenario (expansion to 14 GW by 2023). The latter is the equivalent of 8-10 euro cents/kWh at today's onshore prices.

A large proportion of this potential involves reducing the investment costs for purchasing, assembling and installing turbines by 14 or 21 %. Considerable savings are also expected from reducing financial expenses and the ever lower project risks. In third place, there is a 5 or 8 % decrease in operating and maintenance costs. Increased efficiency in the construction of turbines and components, logistics and grid connection are also expected. Last but not least, the development of turbine technology is an important factor, for example, more efficient turbines with larger rotors and higher towers.

"This study is realistic, since in addition to technical development it particularly takes account of learning curves, which can be achieved with the farms that are already built or being built," says Andreas Wagner from the Offshore Foundation. However, there is also the underlying assumption that at least 9 gigawatts will be implemented by 2023. "And this is in fact necessary," continues Wagner. "Because this is the only way that we can gain sufficient experience which will spur us on to cost-cutting innovations. For this, the industry also needs planning certainty in the long term."

Reliable general conditions continue to be a key topic, because the greater the uncertainty, the greater the danger of more investment backlogs, with subsequent effects on the offshore sector, which is predominantly medium-sized. If the German government stays true to their word and follows through with their announcements in the coalition contract, then the outlook for German offshore wind energy in the near future is optimistic. ■

Potential for reducing costs in an example offshore wind farm



Source: Prognos/Fichtner

Photo: Tim Riediger / nordpool

Service

Service technician for the inspection of wind turbines. Photo: Ulrich Mertens

Continued growth in the service market

The service market is growing continuously and the sector is confident about the immediate future. However it is not yet possible to discern any clear tendency as to the future development of the market.

The service industry is characterised by a high level of continuity in comparison with the rather more unstable business in which wind turbine manufacturers operate. This is also evident in the number of people employed within the sector, which has increased steadily this year as it did last year. Around one in three of the companies surveyed in the previous year has, according to their own statements, again increased its staff in 2013.

The majority of the new jobs were created within the independent service companies. The market leaders Availon and Deutsche Windtechnik made the greatest increases in this respect. The latter increased its core workforce from 50 to 330 and, in addition, succeeded in closing its 1500th wind energy plant maintenance contract at the start of 2014. But even medium sized and small providers such as seebawind, c.p. max, Rotortechnik, Seilpartner Windkraft, Rotorcontrol and Aeroconcept have grown. The increased employee figures in the service divisions of manufacturers such as Senvion (formerly Repower) and Siemens also demonstrate the fact that the service business is booming.

Market developments

Among other developments two corporate takeovers were announced last year. L&L Rotorservice's name change to BayWa r.e. Rotor Service GmbH was announced in January, after the company had been taken over by BayWa r.e. renewable energy GmbH (BayWa r.e.) in December of the previous year. Matthias Taft, Managing Director of BayWa r.e. explained that, "this company, which specialises in the maintenance and optimisation of rotor blades is an ideal addition to the professional management of wind farms that we provide to a broad customer base. We'll also continue to expand our service arm as we are convinced of the long-term growth prospects for this market."

Windservice NF GmbH from Rantrum near Husum has also had a new proprietor in DMP Mølleservice since February 2013. This is part of the Danish service provider's strategy to "expand into attractive markets outside of the Nordic regions", as Carlos Christensen, Managing Director of DMP Mølleservice, emphasised at the time of the takeover. Given the fact that the expansion figures in Germany reached an all-time high in 2013, this strategy is certainly understandable.

Gaps in the wake of Fuhrländer bankruptcy

In addition FWT Trade GmbH was founded in the past year and is a company that will, among other things, continue to operate part of Fuhrländer's service business. "The company was originally founded in January 2013 in order to ensure the availability of spare parts for Fuhrländer plants", reports Henning Zint, an in-house lawyer, whose responsibilities, among other things, include marketing for the new company. "We concluded our first service contracts in March," he adds, "and now we employ 55 members of staff, who support 250 power plants in Germany, Poland and the Ukraine." In the meantime the service business has been outsourced to the independent sister company FWT Service GmbH, which plans to expand its maintenance services provision in future to cover plants from other manufacturers. According to Zint initial expressions of interest have already been received.

The fact that the bankruptcy of the Westerwald-based manufacturer has left gaps in the service sector can also be seen in developments at seebawind GmbH, who have approximately doubled the number of employees and turbines under their management in both of the preceding years. "Naturally the demand for good service among ex-Fuhrländer customers has grown abruptly", says Holger Hämel of seebawind. "There is no doubt that this has had a significant impact on service providers with the relevant experience."

Open for collaboration

This development was also one of the reasons why seebawind founded "windnetwork 360°" in 2012 in collaboration with four partner companies – a consortium of service providers with offices throughout Germany, which specialise in Fuhrländer-, Nordex- and Repower plant. "With the foundation of windnetwork 360° two years ago", says Hämel, "we have succeeded in combining the performance strength of a major corporation, e.g., in relation to spares procurement or major repairs, with the flexibility and customer focus of a small company".

Spares pool. Source: seebawind GmbH

Very few independent service providers are able to unite all relevant skills under one roof. That is why collaborative agreements with partners who offer specialist know-how, e.g., in relation to rotor blades, are considered business as usual. As Matthias Taft says: "A significant proportion of our customers are other service providers who draw upon our specialist know-how."

Next to specialist know-how and quality, reaction time is a decisive factor within the service industry, for the longer a plant is shut down the higher the losses for the operator. Another company that implements a collaborative model in order to ensure high plant availability is juwi: "Our local wind farm managers are subcontractors based close to the managed plants, who undertake smaller tasks based on their various qualifications," says Jens Weise, Director of Marketing, Sales and Investor Relations at juwi Operations & Maintenance GmbH. "That goes for everything from the electrician employed to carry out manual resets at the turbine to the grounds manager responsible for maintaining the lawns and greenery as well as for providing winter road services. Our objective is to be able to react to plant faults as rapidly as possible whilst also reducing travel costs. In addition, more of the added value is retained within the region." His company has also entered into collaboration agreements with manufacturers such as GE and Kenersys as well as other independent service providers. "We regard collaboration agreements with manufacturers and service partners as an important approach to ensure our market competitiveness," says Weise.

Opportunities for smaller providers

The fact that competition is getting tougher in spite of steady growth can be seen, among other things, in the efforts of manufacturers to induce their customers to sign up to comprehensive service contracts of as long a duration as possible.

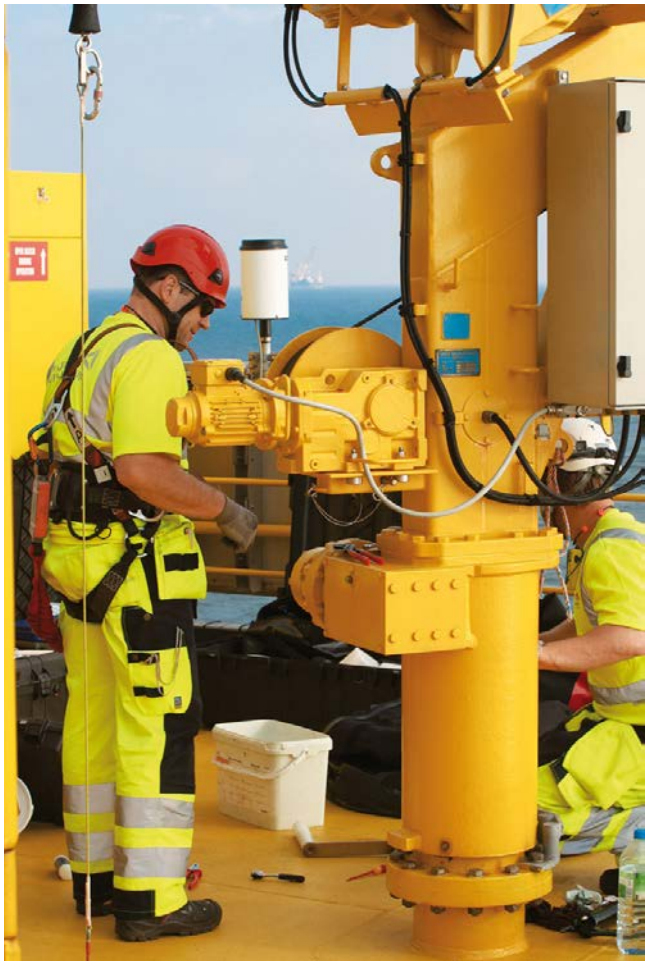
Inspection up in the nacelle. Photo: Jan Oelker

Several independent service providers are also offering comprehensive service contracts. In addition to market leaders Availon and Deutsche Windtechnik this includes companies like juwi, BayWa r.e., seebawind, baju energy and Enertrag. Currently Availon and Deutsche Windtechnik combined have comprehensive service contracts for almost 900 power plants. This shows there are also opportunities for independents even in this area.

"In the final analysis it is down to the best service package", says Gerald Riedel of GETProject GmbH and spokesman for the BWE's Operational Managers Advisory Board. "Comprehensive, worry-free packages are of course attractive, e.g., for newly commissioned plants, especially with regard to financing. But in addition to the manufacturers, only the major independent service providers can offer such comprehensive, worry-free packages, as such contracts always entail an element of risk for the service provider." Riedel's company operates 85 wind energy systems in 12 wind farms and carries out its service operations in collaboration with both manufacturers and independent service providers. "The smaller companies," he explains, "have other benefits compared to the manufacturers, two of which relate to customer support and response time."

This is evident in the case of companies like EEG Service und Technik. This regional service provider supports 33 wind energy plants with 8 members of staff, all of which are practically next door. "All of our technicians live within a maximum of half an hour by car from the wind farms," says Holger Hämel, who in addition to his work at seebawind is also the managing director of this Melle-based service provider. "Apart from that our customers also know their contact people personally and get in touch with them directly whenever issues arise. And our employees are fully conversant with the turbines they help to maintain and therefore usually know very quickly what action needs to be taken." In this regard, he goes on to say, the concept of being a purely local provider works really well.

In Riedel's opinion, the long-term maintenance of older turbines in particular, could develop into a market with real future potential for smaller service providers. "Given the political debate surrounding wind energy the question of ongoing operations after 20 years is becoming increasingly interesting. In that



Limited but steady market potential: Offshore service
Source: Deutsche Windtechnik AG

case the wind turbines would not only need to be maintained and serviced, they would also have to be upgraded." That could result in good opportunities for companies that specialise in these older machines and who provide local maintenance services. According to Riedel: "Of course the same goes for companies that specialise in the refurbishment of components for older plants that are no longer produced."

Offshore service picking up speed

One topic that has, as expected, become more important, is service provision for offshore wind energy plants. Around 30 per cent of the providers represented in the service overview are already active in this field. These include specialists for rotor blades, oil service or transmission units, but also companies offering comprehensive service portfolios such as Deutsche Windtechnik, which concentrated all of its offshore activities in a dedicated company in summer 2013. As Matthias Brandt, Chairman of Deutsche Windtechnik AG and Managing Director of the new business unit explains: "We had been noticing an increase in the number of enquiries and orders in the offshore service sector and are working on the assumption that offshore wind energy will offer a limited, but steady market potential. So setting up a dedicated subsidiary was a logical step that we had been planning for quite a while."

Whilst it is true that offshore wind turbines are often covered by comprehensive service contracts provided by the manufacturers, these do not cover the plethora of components and auxiliary systems such as transformer substations, corrosion protection, or crane, communications and security technologies. "This is precisely where the challenge arises for independent service providers to take an efficient approach to these auxiliary tasks and to offer attractive service packages," says Brandt. For this is the only way to ensure that the high freight charges and transport costs can be kept in a reasonable ratio to the actual operational task. "That's why', Brand continues, "service providers with a comprehensive services portfolio will have a good hand in the offshore market. Even and especially in the face of the expected consolidation of the offshore service market."

Outlook: No clear trend

"All in all", says Gerald Riedel, "the service sector can regard 2013 as having been a successful year." However there is currently no clearly emerging trend to indicate the direction in which the industry will develop. "On the one hand the service divisions of some of the manufacturers and larger service providers are growing. The number of comprehensive service agreements is also increasing. But on the other hand the demand is still high for specialist knowledge relating to rotors and other specific components – and that's how it will remain. In addition, the urgent requirement for smaller, regional providers will continue in future. "The market," concludes Riedel, "is big enough for there to be plenty to do for all kinds of service companies – providing that they produce quality work."


psm

Overview of service suppliers

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
ABO Wind AG www.abo-wind.de	Germany: 230 Abroad: 95	Engineers: 11 Technicians: 11	Germany, France, the United Kingdom, Ireland, Bulgaria	Only onshore	Central remote monitoring and operation management in Heidesheim, local operation management in the UK, Ireland, France and Bulgaria. International distribution of products (services, upgrades and optimisations) and technical support centralised in Germany. In the case of operational disruptions, external maintenance and service companies are commissioned (under ABO Wind control).	DeWind: D60, D62 Enercon: E53, E82, E2; GE: 1,5sl, 1,5s Nordex: S77, N54, N60, N80, N90, N100, N117 Repower: MD77, MM92;3.X SeeBa/Nx N43 Siemens AN Bonus; Vestas: NM1000, V80, V82, V90
AEROCONCEPT Ingenieurgesellschaft für Luftfahrttechnik und Faserverbundtechnologie mbH www.aeroconcept.de	Approx. 200 turbines/year for individual orders across Europe.	Engineers: 7 Composite technicians: 22	Europe, Turkey Worldwide on request (e.g. USA).	Onshore and offshore	Central procurement, engineering support and team resources planning. Temporary, order-based support centres for the teams.	Maintenance and servicing of all current rotor blade series.
Availon GmbH www.availon.eu	Germany: 880 Abroad: 490	Engineers: 20 Technicians: 160	Worldwide with a focus on Germany, Austria, Italy, Spain, Poland, other European countries and the USA.	Onshore	Central remote monitoring, data analysis and technical consulting with our own engineers, majority of service engineers decentralised, central spare parts warehouses with supply of all materials necessary for maintenance and repair, including major components. Decentralised spare parts warehouses with the most important spare parts.	Vestas: V52, V66 VCS, V80, V90 2.0 MW; Gamesa: G5x, G8x, G9x; Tacke: TW600, 600e; GE: 1.5 (with Tacke and Enron); Nordex: N60/62, N80/90, S70/77 (incl. MD 70/77), FL MD 1500 kW; DeWind: D6 (1/1.25) MW, D8.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
No	Standard packages for technical and commercial management (e.g. two inspections of wind turbines and transformer stations per year; maintenance works resulting from the inspections are commissioned). Contracts depending on requirements individually negotiable, price agreement for extra services.	Payment depending on the annual revenue from the sale of electricity, or fixed prices, depending on the type and age of turbine.	Generally three years, can also be arranged individually	Technical and commercial management, inspection and technical condition testing, remote monitoring, upgrades, optimisations, maintenance of transformer and transfer stations, cable sheath and BGV-A3-inspections, testing safety devices.	No	In the case of operational disruptions, companies are contracted to rectify faults within 6 hours of their being detected. Service companies' response times are checked. Any cases of non-compliance are reported to the operator/ owner.	Further development of service products
No	Individual offers, framework contracts with fixed conditions.	Individual offers based on the services required, fixed prices are possible.	Individual	Full maintenance from inspection to complex structural repairs to rotor blades, both on mounted rotors and in our workshop. Vibration analysis and optimisation of the rotor. Noise optimisation for rotor. Development of maintenance concepts and repair methods. Implementation of development projects in the rotor blade area (turn key). Asset management consulting for rotor blades. Development of rope-based access technologies based on our patented AEROCLIMB operating platforms.	No	Depending on availability and region.	Further development of service concepts, adaptation of our patented AEROCLIMB operating platform technology for additional turbine types and size classes, development of consulting. Optimisation of inspection technologies with robotics.
Yes	Modular service package individually tailored to the customer, four contract types building on each other, with modular provision of services. Basic is maintenance in 6-monthly intervals. Depending on the contract type, also other maintenance and optimisation modules up to extensive complete service and maintenance contract including guarantee of technical availability and major components.	Project-related fixed prices according to the type of wind turbine and contract, for full maintenance contract also in cents per kWh.	Can be negotiated flexibly. Terms between two and 15 years. Full maintenance contract - five to 15 years.	Around-the-clock remote monitoring, error analysis and troubleshooting, preventive and status-oriented maintenance and servicing for SF6 and transformer device, spare part management including main components and expendable parts, technical consultancy, development and implementation of upgrades/ optimisations, rotor blade service, drive train analysis by video endoscopy and offline vibration analysis, testing safety technology (BGVA3 among others), non-destructive materials testing, steel and concrete, damage management.	Yes. Generally 97 % availability with bonus-penalty system. 12-24 month replacement warranty for major components.	Yes, remote monitoring immediately, within a maximum of 60 minutes, error rectification on site within 24 hours following error notification, faster response times by arrangement.	Creating new additional optimisation modules, expanding regional teams and warehouses, expanding our portfolio of turbine types.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
baju energy GmbH **www.bajuenergy.de**	250 wind turbines worldwide.	Technicians: 25 Engineers: 2	Worldwide with focus on Germany.	Onshore	Central procurement, engineering support and team resources planning/Temporary, order-based support centres for the teams.	All wind turbine types from Repower, Vensys, Siemens, Nordex, Fuhrländer, Powerwind.
BayWa r.e. Betriebsführung GmbH	Wind 510 MW, photovoltaics 350 MWp	32	DE, UK, ES, IT, FR, GR, PL	Onshore	Own on-site service, central, also local.	All conventional wind turbine manufacturers and inverters in PV.
BayWa r.e. Rotor Service GmbH **www.baywa-re.com**	Germany: approx. 1,800 Abroad: approx. 250	Engineers: 3 Technicians: 60	Europe-wide	Onshore	Spare parts, materials and components from selected distributors and from the manufacturer available at short notice.	Rotor blades of all types available on the market and GRP components.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
YES	Framework contracts, individual offers from basic service to full maintenance contract, with reports, expert checks and rotor blades covered separately.	Individual, depending on the project, service and scope.	Individual on request.	Manufacturer-independent service, maintenance and repairs - Rotor blade servicing, maintenance and repairs with rope access and platform technology - Expert checks on equipment subject to inspection - Maintenance, servicing, calibration of hydraulics and electric screw technology - Maintenance, repairs and installation of service lifts - Turbine construction and completion of commissioning - On-call and fault-clearing service Carrying out: - Technical maintenance training (TMT) - Safety applications (SaAp) - Technical orders (TO) - Technical training (TT) - Training for foreign companies - Rope-assisted work (certified by Fisat) - Servicing of safety equipment (Skylotec specialist dealer)	–	Depends on location, project and service	Creation of a technical management business unit, development of service activities and site expansion.
No (only checks)	Technical management/TCMA	By agreement	By agreement	Technical management for wind power and photovoltaics.	No	We guarantee immediate response thanks to our three-shift coordination centre.	Expansion of business operations to other European and non-European countries, in both wind power and photovoltaics field.
Yes, rotor blades.	Individual arrangements in separate contracts.	Calculation determined by the individual scope of service provision in each case.	Individual. Majority of contracts run for two to six years.	All services are certified according to DIN ISO 9001 and GL from 2013. Rotor blade inspection (periodic inspections/condition-oriented maintenance), maintenance, care, optimisation, GRP repairs on site/in the factory, coating. Tower and nacelle: cleaning works, maintenance, safety check. Marketing: storage of components, complete disassembly of wind turbines, disposal of rotor blades. Heavy transport logistics. Training in our own academy. Research and development (capacity increase through e-ro, anti-ice system).	Rotor blade set replacements available for a range of wind turbine types.	Within 24 hours in emergency situations.	Marketing of e-ro dynamic, development of e-ro arctic, HSE certification.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Rexroth Bosch Group Bosch Rexroth AG www.boschrexroth.de	-	Technicians: 20 (EU) Engineers: approx 20 (DE)	Worldwide	Onshore/ Offshore	International distribution of spare parts, new parts, field service and replacement gearboxes.	E.N.O. Energy (E.N.O. 82) Gamesa (G47, G52, G58, G80, G87, G90, G94, G97) Nordex (N80, N90) Alstom, Ecotecnica (ECO 70/80) GE Energy (GE 1.5, GE 2.X) Repower (MM82/92) Enercon (E30, E40, E58, E66, E112) Kenersys (K100) Vestas (V47, V52, V66, V80, V90, V112, V164).
BRAUER Maschinentechnik AG BRAUER Maschinentechnik AG www.brauer-get-riebe.de		50 employees incl. engineers and technicians	Europe-wide	Yes	Independent procurement of spare parts and comprehen-sive supply.	Gear maintenance for all turbine types and sizes.
C&D ÖLSERVICE C&D Ölservice GmbH www.oelser-vice-gmbh.de	Germany: approx. 1700 Abroad: approx. 650	Technicians: 16 Engineers: 1	Germany and all EU countries	Onshore/ Offshore	Central organisation in Old-enswort.	Oil changes of all geared wind turbine types; oil changes of pitch hydraulics and yaw and pitch gear motors with hub height of up to 145 metres.
cp.max cp.max Rotortechnik GmbH & Co. KG www.cpmax.com	Germany: approx. 450 Abroad: approx. 150	Engineers: 11 Technicians: 35	Worldwide	Onshore and off-shore rotor blades	Central	All manufactur-ers and types of turbine.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Yes	We provide service packages individually tailored to our customers' needs.	On request	On request	Spare parts (replacement gearbox), new parts, field service (inspections, maintenance, gear adjustment), training, condition monitoring.	-	Quick response times.	Standardised service contracts, up-tower gear replacement, expansion of field-service network, ongoing upgrades to the field-service portfolio.
Available on 100 replacement gearboxes.	Needs-based individual offers.	Depending on the project	Individual according to customer wishes	Maintenance and optimisation of gearboxes	-	Replacement gearboxes immediately available (with reservations), best possible delivery times.	
	Offer of fixed, flat rates.	Flat rates including oil, filter, travel, disposal of used oil and service.	Without. But also certain two to three-year framework contracts with wind turbine manufacturers, who also normally carry out repairs.	Oil changes of all geared wind turbine types; oil changes of pitch hydraulics and yaw and pitch gear motors with hub height of up to 145 metres.	N/A	Normal response time of four to eight weeks, within a few days in the event of damage.	Planning a service company abroad.
	Framework contracts with fixed hourly rates. Individual proposals on request.	On a time and material basis, hourly rate for repair teams, rotor blade reports are the basis of the calculation. Fixed prices if the customer so wishes.	Individual basis - from twelve to 120 months.	Onshore and offshore rotor blades: inspection, maintenance, care, optimisation, GRP repairs on site / in the factory, coating. Tower and nacelles: cleaning works, maintenance, safety check. Provision of training courses, research and development.	No	Within one or two days in the event of turbine downtime caused by damaged rotor blades.	New concept for blade repairs in our warehouse (until now works have been carried out directly on the turbines using rope access technology and/or work platforms.) Long-term: offshore, more foreign projects.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
DEUTSCHE WINDTECHNIK Deutsche Windtechnik AG www.deutsche-windtechnik.de	January 2014: Fixed maintenance contracts for over 1,500 wind turbines, including full maintenance for over 400 turbines; 53 substations under contract; alongside rotor blades, repairs, assessment, safety checks and much more for around a further 1,500 turbines.	330 employees in total, including technicians and engineers.	Primarily Germany, neighbouring countries; spare parts traded worldwide.	Onshore and offshore	Extensive, decentralised service network with 38 locations in Germany with headquarters and several branches and service support centres, from which operations can take place across Europe.	Focus on maintenance and servicing of all Vestas®, NEG Micon®, SIEMENS® and AN BONUS® wind turbines. Rotor blade and oil service, assessments, inspections, safety technology, consulting and services regarding the foundations, tower, substations, control, as well as repowering for all turbine types.
HANSEN Dirk Hansen Elektro- und Windtechnik GmbH www.hansen-wind-technik.de	Approx. 180 wind turbines worldwide	21 technicians and engineers.	Germany and Europe	Onshore	Network with manufacturers for major component servicing, own major components in stock.	Vestas V27 – V66, Tacke / GE TW 60 – 1.5 MW; DeWind: D4/D6; Nordex: N54; Südwind: MD series.
EEGST EEG SERVICE & TECHNIK GMBH EEG Service & Technik GmbH www.eegst.de	Germany: 46	Engineers: 2 Technicians: 4	Schleswig-Holstein	Exclusively onshore	Completely through purchasing groups with our customers.	Südwind: S70/77 or wind turbines constructed in the same way by Fuhrländer, Repower; NORDEX: N80/90; Repower: MD and MM models.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Yes	Individual, tailored, modular service offer from basic service to a complete maintenance contract, which also comprises repairs to external damages, including major components. All services can be freely combined. If required, separate contracts for reports, safety checks, rotor blades, etc.	Optionally flat-rate, according to hourly rate or also service-related.	Freely definable, greatest possible individuality.	Full service package for the technical repairs on wind turbines from a single source: servicing, maintenance, optimisation, control, power electronics, including repairs, analysis and optimisation, rotor blade service, tower and foundations (testing, refurbishment, corrosion protection, cleaning and sealing), oil service, substations (maintenance, around-the-clock monitoring), safety technology, onshore and offshore expert reports (UVV, TÜV), repowering: acquisition, disassembly, logistics, consultancy, planning, mediation, reconditioning, storage.	Full maintenance contract: guaranteed up to 97 % technical availability. Guarantees for all services, warranty extension possible on an individual basis.	Generally via remote data transmission, response times under 60 minutes. Faults rectified within 24 hours.	Further expanding the service network and staff numbers; recruiting staff in all areas: service, control, rotor blades, substations and safety. New developments for wind turbine optimisation (retrofits). Increasing training and qualification (including on the job training), further offshore activities and international orders.
Yes	Maintenance contracts / maintenance according to manufacturers' guidelines.	Fixed maintenance amounts depending on the type of the turbine, on request turbine check according to wind turbine type and time and effort.	2 years, modular design.	Service, repairs, maintenance: major component replacement, from gearboxes through to generators to rotor blades. Around-the-clock remote monitoring. Repairs to control electronics (Mita, DanControl, Sentic, CT Module); reassembly and disassembly, repowering and replacement of Major components in global use; provision of qualified expert reports.	Up to two years for major components, insurance for an expansion also possible.	Fault clearance within a maximum of 24 hours.	Extending control systems for frequency converters and power electronics as well as the network for major components in order to be able to respond more quickly in future. Long-term: expanding service activities in Germany with new sites. Planning service operations and technical training in the Central America region.
Yes, together with partner companies.	Service contracts only as full service package including repairs, remote monitoring, fault clearing at a flat rate. Delimitation in case of special repairs such as replacement of gearboxes, or repairs to the generator, for which the services of special firms must be employed.	Fixed prices, details on request.	Individual	Full service with spare parts and major components (purchase via purchasing groups). Remote monitoring; alongside special tasks such as replacing major components. Works on rotor blades, gearboxes and other major components in cooperation with specialists.	Not generally, but can be individually arranged.	Yes, to be agreed individually depending on the location.	Future plans depend on potential new customers. In the long term, the market will demand more full-service options.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
ENERCON GmbH www.enercon.de	Approx. 21,500 ENERCON wind turbines worldwide.		ENERCON sales area		Worldwide, decentralised service network with headquarters and several branches and service stations, additional central warehouse in Gotha.	All ENERCON turbine types
ENERTRAG Service www.enertrag.com	Germany: approx. 750 Abroad: approx. 250	80 service engineers, 25 employees in sales administration.	Across Germany, Benelux, France, Austria, Poland, the rest of Europe on request.	Onshore	Decentralised service support centres in 22 locations, Lotte and Lübeck regional centres, central spare parts warehouse, "just in time" deliveries to decentralised locations, major components in the central warehouse or from suppliers.	DeWind: D4, D6-1000, D6-1250, D8; Tacke/GE bis 2.5MW; NEG-Micon up to NM64 Repower: MD70/77 Fuhrländer: FL70/77, FL2.5 EV2500 Nordex: N70/77 Südwind: S70/77 All types of Kenersys
eno energy systems GmbH www.eno-energy.com	>50	12	Germany-wide/Europe-wide	Onshore	Stocking of spare parts and distribution through central warehouse. Maintenance material through goods on consignment.	eno 82, eno 92, eno 100, eno 114, eno 126.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
	Full maintenance contracts ("EPK", Enercon Partner concept) and maintenance contracts	Variable pricing according to the energy yield with a minimum fee.	Variable contract periods of up to 15 years with an option of a follow-up contract providing cover up to the 20th year of operation and service concepts from the 20th year of operation.	Quarterly maintenance operations, 24/7 remote monitoring via ENERCON SCADA including remote reset and automatic applications planning, technical support; Planned and corrective maintenance including provision of qualified workers, all spare parts, main components and consumables including their procurement, transportation, servicing and professional waste disposal of dismantled materials. Provision of the required tools and equipment including cranes, supervision and execution of all activities necessary for fulfilment of the contract in the wind farm; documentation of service activities, software updates of wind turbine control and SCADA system, telephone customer support, availability guarantee over the whole duration of the full maintenance contract as well as online reporting.	In the case of full maintenance contracts for the whole contractual period.		
Preventive drive concept. Maintenance (monitoring) through to repairs, replacement of bearings on wind turbines.	The service contracts are on a modular basis and can be individually arranged as required. Full maintenance contracts offered since 2012.	Depending on the scope of services, location of the turbines and duration of contract.	According to individual agreement.	24/7 remote data monitoring, maintenance and inspection according to manufacturers' guidelines, servicing, technical support, spare part management with online sales, maintenance of converters and transformer stations, drive train analysis by video endoscopy and vibration measurement, oil change service, expert testing, rotor blade service (inspections/repairs), replacement of major components, retrofit measures.	Availability guarantee is offered for wind farms.	Failure analysis and immediate repair where appropriate within 6 hours between 6 am and 6 pm on working days and within 12 hours at other times. For fault messages that arrive by 12 noon, action will be taken on the same day. For fault messages that arrive after 12 noon, action will be taken by 10 am at the latest the next day.	Operational and administrative processes will be continually optimised to improve the quality of service. Service operations will be given technical support with a view to increasing efficiency. Fixed employee qualification programme. Setting up an online spare parts shop.
Depends on contract	Complete Care/Advanced Care	By agreement	5 to 20 years		97%	3 hours	

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
FWT Trade GmbH www.fwt-trade.de	210	55	Mechanical engineering for new turbines, service and maintenance, remote monitoring, vibration monitoring, major component replacement, dismantling of turbines, trade with major components and spare parts, engineering.	Only onshore	Production, service and monitoring headquarters in Waigandshain in Westerwald. Engineering and development is also located in Waigandshain. There are also several service support centres and off-premises warehouses to ensure proper supply of materials to customers from trade division and service.	FL30/100/250 PWE 650, FL800, FL1000, FL1250, FL2500 FWT2000,F-WT2500, FWT3000 MD70/77 PWE 1500 EV2000
GE imagination at work GE Wind Energy www.ge.com	Germany: approx. 1,000 Europe: approx. 3,000	Engineers: approx. 150 Technicians: approx. 150	In 30 countries worldwide.		Decentralised locations worldwide. Germany: eight service locations and several support points, from which technicians can reach 95 % of all turbines in less than an hour. Service vehicles are equipped with commonly required spare parts. Central spare parts warehouse for “just-in-time” deliveries to decentralised locations (from routine maintenance kits through smaller spare parts up to major components).	All of the turbine models previously supplied by Tacke, Enron and GE Wind.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Yes	Standard maintenance contract Extended maintenance contract Full maintenance contract Support contracts Framework supply contracts Standard service contracts Standard service agreements	Varies, depending on the customer's wishes: Billing according to actual expenditure Fixed price Depending on income Firmly agreed supplement table (only in combination with the corresponding framework contract)	Individually, depending on the selected contract model, we offer periods from 1 to 13 years.	7/24 remote monitoring, vibration monitoring, performance optimisation, sonic surveys, machine maintenance, converter maintenance, blade maintenance, component replacements, repairs, individual solutions for turbine communication/farm communication, supervision. Design of various data interfaces according to customer wish. Procurement of spare parts and components.	Yes Ø 97 % depending on contract design	Yes, 2 h per remote monitoring. Depending on region & contract, between 30 min and 24-hour service on-site, if necessary.	Acceptance of other third-party products in service and maintenance. Researching additional concepts for optimising turbines. Widening new turbine business. Expanding the trade division.
Yes	Customers can book modules for service and operation. From straightforward technical consulting to full maintenance contract (also operation, remote monitoring and planned maintenance, servicing, performance reports, fault clearance).	Prices determined by scope of services and the project-specific costs.	Individual: majority of contracts run for five to 15 years.	Around-the-clock remote monitoring and troubleshooting, maintenance, servicing and small repairs, manual restarts, maintenance of frequency converter, transformer and special turbine equipment, supply of replacement parts, condition monitoring systems including data analysis and evaluation, manual power train analysis, retrofitting to maintain and increase availability, retrofitting to fulfil grid connection conditions, guarantee of availability, repairs, major component repair and replacement, blade maintenance. Performance-enhancing software and hardware upgrades.	Yes, provided a certain level of maintenance was also commissioned from GE Wind. As a basic value, 97 % availability applies. Also possibility of an availability guarantee based on time and energy for specific projects.	Yes. Details can be negotiated.	Continual improvement of the customer's energy yield by technical software and hardware upgrades (e.g. reduction of noise emissions, optimisation of pitch regulation). Continual reduction of operating costs of the turbine over the turbine's service life, e.g. by repairs in the nacelle (uptower), consistent fault evaluation as a basis for proactive maintenance (pulsepoint), regular upgrades of control software, etc.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
juwi juwi Operations & Maintenance GmbH www.juwi.de	Turbines covered by technical and/ or commercial management contracts and/or service contracts: 401	29 employees within the Wind Service section (from mechatronics engineers to engineering graduates); number of employees in total: approx. 170 (across all sites, technologies and roles).	Germany	Onshore	Service support centre at company headquarters in Wörrstadt and decentralised service network in collaboration with qualified service partners; provision of spare parts from own warehouse at the company headquarters and through framework contracts with manufacturers.	Turbines covered by technical and/or commercial management contracts and/or service contracts from the following manufacturers: Vestas, Kenersys, GE, Fuhrländer, NEG Micon, Nordex, RePower, DeWind, Enercon.
LTB-Hochsauerland GmbH LTB Hochsauerland GmbH www.ltb-hochsauerland.de	Germany: approx. 1000 Abroad: approx. 200	Approx. 40	Across Germany and Europe	Onshore	Preferably from the manufacturer and in free trade.	All wind turbine types >> Rotor blades and other fibre-composite components of all types.
MMM-Windtechnik GmbH MMM-Windtechnik GmbH www.mmm-windtechnik.de	Germany: 27 under contract.	Technicians: 1	Germany, to some extent also the Czech Republic, and as a subcontractor in Turkey and Azerbaijan.	Onshore	Remote data monitoring and analysis, as well as rectification remotely or on site.	Vestas: V29 to V90 Micon: 15000/600 kW Nordex: N27
N.T.E.S. WINDKRAFTSERVICE N.T.E.S. GmbH www.ntes-service.de	Germany: 260	Technicians: 20	Germany	Onshore	Central remote monitoring and operation control in Bremervörde. Service station in Hohenhameln. Central procurement of spare parts.	Bonus/Siemens 150 KW - 2.3 MW.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
juwi offers the replacement of major components, as well as individual components. We also offer services for dismantling, transporting and reassembling (repowering).	For wind turbines, juwi offers the following types of contracts: technical management contract, commercial management contract, maintenance contract or a combination of the aforementioned service modules; we also offer contracts with individual scope of services on request.	Gen. basic remuneration and performance-related bonus payment, in relation to the energy availability of the wind farm supervised.	Individual	Maintenance (inspection, maintenance, repairs & improvements), rotor system technology, repowering, ground maintenance and technical and commercial management for wind, photovoltaic and bioenergy plants.	-	Short on-site response times in the event of breakdown.	Real-time data transfer, strengthened use of condition monitoring and ice detection and prevention systems.
	Individual support depending on the damage, creation of repair concepts, on request accompanied by a certifier (e.g. Germanischer Lloyd).	Individual on request.	On request and dependent on the task.	Rotor blade servicing using vacuum and infusion laminate technology for all types of damage ratings and general fibre composite technology. Access technology: self-drive work platforms, 2,200 m² workshop, mobile workshop for major on site repairs.	On request on an individual basis, depending on the range of functions.	From 24 hours after enquiry depending on the damage, individual basis.	Expanding capacities for platform operations, increasing capacities for European operations.
Gearbox replacement (main and turning gearboxes), generator replacement.	We offer our customers specially tailored contracts, as well as full maintenance contracts.	Fixed prices depending on the contract, and pricing depending on the cost of services in the case of breakdown and repair.	One to five years.	Maintenance and repairs, oil changes, crane testing, checks of the arrester system, switching authorisation up to 30 kV.	Rectification of faults on weekdays, weekends and public holidays.	Via remote monitoring or within 24 hours on site	Extension of the service offering as a subcontractor, new models and adaptation in the field of internal communication.
	Contracts for maintenance operations individually on a time and material basis or flat-rate. Contracts for repairs and fault clearance on a time and material basis.	Price depends on wind turbine and contract type.	1 year or according to customer wishes.	Maintenance operations and repairs, major component replacement, remote monitoring, tech. inspections, system dismantling.	No	Response time of 1 hour by remote monitoring and fault detection per SMS, error rectification within 24 hours or individually by agreement.	Development of more cost-efficient repair processes. Expanding the service network. Adding new staff members and sites, further developments for wind turbine optimisation, extending the customer network.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Nordex SE www.nordex-online.com	Worldwide over 5,000 turbines, of which approx. 1,750 are in Germany.	Approx. 140 technicians and engineers in service in Germany.	Throughout Germany and worldwide in the regions of Europe, North and South America, Middle East, Africa and Asia/ Pacific.	Nordex concentrates exclusively on onshore business, and offers all services described here.	24/7 remote monitoring and technical support are operated in the Hamburg headquarters and in Rostock. The logistics centre for spare parts in Rostock supplies some 150 service points worldwide, all of which are located in the immediate vicinity of Nordex wind farms and 33 of which are in Germany.	The whole Nordex product portfolio (N27-N100/N117) and the former Südwind portfolio (S46-S77).
psm GmbH & Co. KG www.psm-service.com	400 with technical service, in total 220 with maintenance contract.	50	Across Europe, with a focus on Germany, France, Italy and Portugal.	Onshore	Major components are stored in the central warehouse in Erkelenz. There are various regional warehouses for standard components. Small components are in stock in service vehicles. Major components are also stored.	Fuhrländer, Repower, Nordex, (MD series); DeWind; NEG Micon; WindWorld.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
In the Premium contract, the replacement of major components is included. For all other contract models, replacement can be on the basis of individual commissions.	Four contract models with different terms and contents: Basic: regular maintenance work and 24/7 remote monitoring Extended: additional availability guarantee and regular reporting Premium: also covers all costs for maintenance, repairs and delivery of spare parts Premium Light: combines the preferences of the Premium contract with co-payments for selected components and repairs allowing operators to organise their risk coverage even more affordably and adapt it even more to individual needs. These contract packages can be extended by optional services (e.g. condition monitoring systems, inspection of safety equipment and much more).	Prices on request. In addition to the turbine class and contract model, many factors are taken into account. This includes the term of the contract, the turbine location (distance from service points, local wind conditions such as wind speeds and turbulences, expected annual output in kWh) and the amount of guaranteed availability.	The contract terms vary depending on the contract model: The Basic contract has a minimum term of three years, the Extended contract has a term of five to ten years and the Premium/ Premium Light contract has a term of fifteen years. Conditions that are specific to the project and country can vary.	Nordex offers all services from a basic solution to a comprehensive care-free package. In a modular way and depending on the contract model, this includes 24-hour remote monitoring, incl. accessibility and error diagnostics, availability guarantee, repairs up to the replacement of major components, spare parts provision, CMS, rotor blade service, modernisation and upgrades.	Yes, in Extended, Premium Light and Premium contracts.	Response times and spare part availability are covered indirectly by means of the availability guarantee in the Premium, Premium Light and Extended contracts.	Increase in the number of technicians by 10 % corresponding to the growth in turbines sold. The service point network in the south and south-east will be extended. Intensive training of all employees on Delta turbines, in order to be equipped for the stronger wind sector and to guarantee high availabilities.
Yes	Every service can be individually agreed or arranged as a package.	Maintenance costs on an individual basis depending on the type and location of the turbine. The bases for calculation in each case are the maintenance agreements. Special services (e.g. gearbox videoscopy, converter service) are offered at a flat rate or as a framework agreement.	Flexible; individual maintenance operations can also be commissioned.	Maintenance & service, technical management, commercial management, repowering (turbine assembly/ disassembly) large component replacement, full service for frequency converter, gearbox videoscopy, special service for transformer service, consulting.	By individual arrangement. In principle, guarantees apply to all components under statutory law. Extensions possible.	Response to the fault within 12 hours. A service team is guaranteed to be on site within 24 hours.	Greater focus on the individual components of our wide range of services, e.g. our electrical expertise.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Renertec GmbH www.renertec-gmbh.com	100 turbines, approx. 150 MW total installed capacity.	4	Germany		Full maintenance contracts with turbine manufacturers, coordination of maintenance teams.	Enercon, Vestas, GE, Fuhrländer
Senvion SE www.senvion.com/de	Germany: 1707 wind turbines (onshore) Abroad: 186 wind turbines	"Operations" division (maintenance and repairs): 175 technicians and 13 foremen.	In the field of repowering services, CE	Onshore	17 service support centres with material store in Germany. 4 support centres with warehouse in Poland, and 2 in Austria. Also 85 service vehicles with material, which are supplied with spare parts from the service warehouses as required. Rapid service is guaranteed with the recently implemented warehouse management system (SAP-controlled, project-specific spare parts lists).	REpower: all wind turbines in the current portfolio and old turbines of the HSW and MD series (provided that current safety requirements are met); additional contracts for similar wind turbines from other manufacturers.
REWITEC GmbH www.rewitec.com	Germany: approx. 200 Abroad: approx. 50	Technicians: 1 Engineers: 2	Worldwide	Predominantly onshore	Service operations for REWITEC application and surface analysis organised centrally from the company headquarters in Lahnau (situated in the centre of Germany).	All gearboxes and bearings from all manufacturers.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
	Technical management	./.	~ 20 years.	Planning of turn-key wind farms, financing, operation (technical/ commercial management).	Min. 97 %	./.	Planned construction and commissioning of 27 wind turbines at 3 MW, total 81 MW.
Major components are replaced in-house by an independent, specialised service unit.	Standard maintenance contract: contract on a modular basis with individual services; complete maintenance contract (Integrated Service Package - ISP): all services including major components. In each case, ISP is adapted to the requirements of the project, customer or location, and is designed for newly built wind farms. Individual service solutions for non-ISP wind farms. There are also separate service conditions for offshore wind farms, which are tailored to offshore requirements.	Standard maintenance contract: Fixed prices depending on the wind turbine type and scope of service. ISP: conditions depend on the project. Prices are calculated in performance-related, annual, fixed remuneration.	Full maintenance contract: up to 15 years, can be renewed for five years. Standard maintenance: from five years upwards, can be renewed annually.	Range of services includes standard maintenance and a wide variety of individual service packages, in which all turbine-related services from remote monitoring to special inspections are offered. See also "Contracts offered". At least one year's guarantee for services.	ISP guarantees fixed turbine availability for the contract period. Compensation for failure to achieve the guaranteed availability corresponds to the actual income lost from the supply.	Not by default. A special remote monitoring service is offered for power reductions organised by the customer.	New challenges due to a growing service structure, differentiated customer structure and new projects. For customers who do not wish to extend their contracts when they expire, REpower offers individual contract models that include technical support services. REpower will offer a production guarantee as a new product.
No	Service and financing contracts over 1-5 years.	Prices depend on the wind turbine capacity or quantities of lubricant used. The coating for a 1.5 MW gearbox costs 6,000 euros. Coating lubricant costs 400 euro/kg.	Financing: two years Service contracts: five years	Protective coating for gearboxes; special lubricant for gear teeth and bearings; surface analyses of gear teeth.	No	No	Delivery to OEMs and service companies, further product optimisation, patenting.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Rotor Control GmbH www.rotor-control.de	Repairs and assessments for approx. 400 turbines.	15 employees, of which 11 technicians.	Across Germany and neighbouring countries, assessment using rope access technology, EU, USA and Canada.	Exclusively onshore	Central	All manufacturers and types of turbine.
RoSch Industrieservice GmbH www.rosch-industrieservice.de		Approx. 30 service engineers.	Worldwide with a focus on Europe	Onshore and offshore		All manufacturers and types.
seebaWIND Service GmbH www.seebawind.de	Approx. 500 wind turbines in Germany and abroad.	55 employees in total, including technicians and engineers.	Germany, Poland, France, Benelux	Onshore	Decentralised service structure with 10 service support centres and several regional centres. Founding member of Windnetwork 360° (the expertise network for manufacturer-independent service) with more than 20 service support centres. Central warehouse in Osnabrück and other smaller warehouses at the regional centres and support centres. Management of several spare parts pools (wind turbine-specific) owned by the operator and contact partner for participation in these spare parts pools.	Specialises in Nordex N60/62, S 70/77, N 80/90/100/117, Fuhrländer FL MD 70/77, FL 2500, REpower MD 70/77, MM 70/82/92 Südwind S 70/77.
Seilpartner Windkraft GmbH www.seilpartner.com	Approx. 750 in Germany and 600 abroad.	2 engineers 25 technicians	Worldwide	Onshore and offshore: maintenance concepts for foundation structures, repair work for rotor blades and towers.	Central work coordination from Berlin headquarters. Spare parts procured directly from manufacturer or supplier.	Rotor blades, fibre-reinforced components and turbine towers by all manufacturers.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
No	Framework contracts at a fixed price, individual proposals on request.	At cost on an hourly basis for repairs following rotor blade reports, assessment using rope access technology at a fixed price, if the customer wishes.	Can be negotiated flexibly.	Rotor blade repairs and servicing with our own rope work platforms, condition check using rope access technology.	No	Yes, depending on the individual location.	Test phase of a newly developed multi-functional service lift, which can also be used for wind turbines which cannot be stopped vertically, or facilitates access to the hub, and has a shelf up to 14 metres wide for large wind turbines. It is also suitable for use on offshore turbines due to its compactness.
Yes	Individual offers and framework contracts with fixed conditions.	Fixed prices and individual offers based on the services required.	Individual	Service and maintenance work, mechanical and electrical assembly of subcomponents, repairs of dynamic loading components, special developments and solutions, inspections, expert opinion reports.	No	Depending on region and availability.	Expansion and development of offshore services.
Yes, with appropriate special tool for all the wind turbine types we specialise in. We have major components in the warehouse for these wind turbine types.	Designed modularly with a range of options from basic provision through partial maintenance to full maintenance incl. major components. Each package can of course be customised.	The prices vary according to the project and the services agreed.	Individual	360° service: 24/7 remote monitoring, service, maintenance and repairs, replacement of major components, engineering, optimisation and upgrades, dismantling and commissioning, rotor blade service, tower service, gearbox video endoscopies, expert testing, technical management, participation in purchasing pools (spare parts pools).	Yes, we guarantee availability of 97% depending on the service package.	Yes, 1 h for remote monitoring and 24 h for on-site service in each service package.	Expanding foreign business, extending the offer for optimisations and upgrades, starting programme to increase efficiency and individual adaptations on site. Introducing smart and transparent software for automatic, crosswise analysis of data (linking of data from SCADA, CMS, service and weather stations) for early detection of performance problems and electrical and mechanical faults, with web access for our customers.
	Flexible according to the type of activity and how it will be performed. Individual, block, flat-rate and maintenance packages available.	Fixed prices for inspection and repair works. Flexible pricing for maintenance contracts.	Individual arrangement. 6-year maintenance contracts depending on location and number of wind turbines.	Rotor blade and tower status testing, rotor blade repairs, fibre-reinforced repairs, corrosion protection work, torque testing and assembly using rope access and positioning technology and work platforms possible. Onshore and offshore services.	24 months for fibre-reinforced repair and corrosion protection works.	Depends on urgency.	Forming cooperation communities as a full service option.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Service4Wind GmbH & Co. KG www.service4wind.de	60	8	Germany	Onshore	Service network across Germany, decentralised fully-equipped spare part storage.	Nordex N43 to N100 Fuhrländer FL 77; FL 2500, Dewind D 4 and D 6.
Siemens Wind Power www.siemens.com	Approx. 16 GW under guarantee and in service worldwide.	Around 2,700 service employees worldwide.	4 regions, 20 countries worldwide.	Service programmes for onshore and offshore wind farms.	4 regional service subsidiaries and training centre (UK, DK, DE, US), spare parts warehouse for Europe in Tinglev (DK), storage area of 35,000 m² and local and regional warehouses	All Siemens wind turbines.
SKF GmbH www.skf.com	Based on orders for individual turbines.	Service technicians: 6 Engineers: 35 (in Germany)	Worldwide on request, focus on Germany, Denmark, Spain, the UK, USA, China and India.	Yes	Spare parts worldwide, central service sites in selected countries. Available worldwide on request.	Offers for all conventional wind turbines. Scope of offer varies depending on the turbine type. Details on request.
Speedwind GmbH www.speedwind.de	Germany: 52	Technicians: 6	Regions across Germany	From 2014, offshore oil change	Spare parts from suppliers (manufacturers of the parts) and the wind turbine manufacturers if necessary. Major components are subcontracted.	Nordex: N27 to N 62 Südwind: S70/77 NEG Micon: NM1000 Siemens, ANBonus: AN 1300, SWT2000 Vestas: V47,V80/90; Windworld WW 750 Technical monitoring E82.
UTW Dienstleistungs GmbH www.utw-gmbh.de	Approx. 550	30	Europe	Onshore	Not specified	GE, Nordex, Gamesa, Vestas, amongst others.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Gearbox, generators	Basic to full service contracts including 24/7 remote monitoring all year round.	Fixed maintenance fees, fixed prices also possible for repairs.	1 year or on an individual basis.	Full service with decentralised structure, close to wind farm, gear replacement, generator repairs, etc.	Possible according to individual agreement.	Via remote monitoring, immediate initiation of measures within 8 hours, on-site operations within 24 hours.	Service contracts with Pfleiderer, vibration analysis, rotor imbalance analysis
Included in the scope of contracts with a guarantee, or offered separately.	Service programmes: SWPS-100B (Basic), SWPS-200A (Availability), SWPS-300W (Warranty), SWPS-420O (Offshore Availability), SWPS-430O (Offshore Warranty) Additional service products that can be flexibly chosen: remote diagnostics, training, modifications and upgrades, extended warranty, turn-key, etc.	Specific to the project and dependent on scope of service.	Onshore up to 20 years Offshore up to 15 years	Maintenance and repair, technical support, 24/7 remote monitoring, TCM, SCADA, remote diagnostics, availability guarantee, spare parts concept, guarantee of spare parts, replacement of major components, offshore service, offshore logistics concepts, product and safety training, optimisation and upgrades, rotor blade service, turn-key service.	Included in all service programmes, except SWPS-100B Basic	For standard maintenance work, start of work within 24 hours, response times for main components depend on contract type and individual agreement.	Extending remote monitoring and remote diagnostics expertise, completing the first boats specially developed for offshore use, continued rollout and expansion of the Siemens customer portal.
No	Spare parts management with guaranteed availabilities, service provision can also be contractually regulated.	Prices determined by scope of services and the project-specific costs.	Individual	Spare parts management, condition monitoring systems incl. online condition monitoring (also vibration analysis on site), small repairs to wind turbines, repairs of individual major components.	No	Yes, for online monitoring of condition monitoring systems.	Extending spare parts management and building up strategic stock in order to guarantee fast availabilities on the market, upgrades for different products, optimised solutions for replacing main bearings.
	Individual contracts after consultation with the customer, Basic, Basic + and All-in contracts.	Prices calculated according to time, material and distance (on an individual basis depending on the type of turbine).	Individual	Service, repairs, oil change, around-the-clock remote monitoring (24-hour remote data monitoring), technical acceptance (ladders, cranes, delivery of transformer stations, fire extinguishers etc.) inspection of wind turbines; blade maintenance and replacement of major components in cooperation with partner companies!	By arrangement.	12 to 24 hours.	Offshore oil change.
No	- Expert checks of all safety-relevant elements of a wind turbine - BGV-A3 inspection	Not specified	According to customer wishes (generally 6 years).	1. Expert checks of all safety-relevant elements of a wind turbine: ladder/arrester system, rope winch/crane, service lift, PPE etc. 2. Fault rectification according to the expert check 3. BGV A3 wind turbine testing 4. Cleaning e.g. after oil damage 5. Rectifying corrosion damage 6. Flange renovations 7. Transformer station maintenance and much more.	Not specified	Not specified	

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Range of onshore/ offshore services	Service network and procurement of spare parts	Types of turbine
Windigo GmbH www.windigo.de	Approx. 400 wind turbines	35 technicians and engineers.	Worldwide	Onshore & offshore	5 service stations: Berlin, Hamburg, Dortmund, Erfurt, Neunkirchen.	All wind turbines and all blade types; specialist for LM blades.
ZF Friedrichshafen AG, ZF Services www.zf.com	Not relevant (approx. 25,000 own main gear-boxes supplied)	25/35 (EU)	Global	Onshore/ Offshore	Local service subsidiaries in all wind energy markets (D, E, UK, I, BEL, CHI, USA, IND), global sales network.	Various (focus: Vestas/NEG in all platforms and GE 1.5 MW), others on request.
ZOPF Energieanlagen GmbH www.zopf-gmbh.de	Not specified	Technicians: 5 Engineers: 5	Across Ger-many		Central stock, supply of spare parts primarily in a circular ex-change process, components for maintenance, control and electronics in the workshop.	GE, Nordex, Re-power, Fuhrländer, Tacke, Dewind, Südwind.

Replacement of major components	Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
No	Rotor blade check and maintenance; inspection modules which cover all externally required tests (periodic inspections, condition-oriented maintenance, safety).	Fixed prices for inspections; repairs, generally on a time and material basis; the required works can be prioritised according to the budget.	Individual; offers on request.	Service for rotor blades, tower and ladder: assessments, inspection, maintenance and repair (onshore & offshore); Certification: GL, ISO 9001, SCC**; Development of manufacturers' projects; Rotor blade training and seminars; Platforms and rope-access technology; German/English documentation.	No	1-2 days as a rule in the case of turbine downtime caused by the rotor blade or impending shutdown; depends on the damage and location.	Rotor blade training for wind energy service technicians, training on the job on wind turbines.
	Individual solutions.	On request		Multi-brand main gearbox and main bearing repairs, yaw gearbox repairs, field repairs and inspections of main gearboxes, spare parts, new and replacement gearboxes (main gearbox).	Agreement possible.	Generally less than 48 h.	Continuous innovation of the portfolio, aimed at the market requirements.
	No contract necessary.	Maintenance prices are significantly less than the contract price from the manufacturer.		Spare parts and repair service for SEG converter 310-311-313 Racs (Semikron), Alstom phase modules for MD2000 converter.	12-month warranty for repaired parts.	Delivery within 24 hours Direct delivery possible on the same day.	Continually expanding the spare parts pool.

Service technician inspecting a wind turbine. Photo: Ulrich Mertens

The customer the king

Turbine manufacturers are regaining lost ground in the service business. In the latest BWE service survey they confirmed last year's good performance for repairs and maintenance. The run on independent servicing has stopped for the time being.

BY SASCHA RENTZING

Things have not been running very smoothly for wind energy company Enertrag: engineers have been lured away by the competition, the quality of maintenance and repairs has diminished and operators have been dissatisfied. The upshot: in the latest service survey by the German Wind Energy Association (BWE), Enertrag does not score higher than 2.29, after 1.85 in 2012. "Our work has been poor in places," explains service manager Johannes Heidkamp self-critically. The BWE survey is highly valued in the sector. It is the largest independent assessment of maintenance firms in Germany and is therefore regarded as an important reference point for businesses.

But Enertrag's low rating is not only down to internal reasons; the euphoria over independent servicing has largely subsided. The independent providers in previous years were immensely popular because the operators were in part very dissatisfied with the services of the manufacturers. This trend has now stopped, which is demonstrated in the BWE survey in the weak return in the category of independently maintained turbines. After 1,466 turbines were assessed in 2012, in 2013 this dropped to 760. In contrast, there appears to no longer be a movement away from manufacturers, whose number of assessed turbines even rose slightly from 3,214 to 3,357.

This development can also be explained by the fact that the manufacturers are now getting to grips with servicing more so than before. Although their new installation business is booming, they have held on to their good level of previous years in terms of maintenance and repairs. In the current BWE service survey, the six turbine manufacturers assessed score an average of 2.7, as they did in 2011 and 2012.

This generally steady performance was not necessarily to be expected. During previous booms, turbine manufacturers often neglected their customer service. This is clearly no longer the case; service has become a mainstay. "It's through service that the manufacturer can document the quality of their product," says BWE expert Carlo Reeker.

There's something else making the situation more difficult for independent service providers as well: the operator structure is changing, in some measure to their disadvantage. Instead of private individuals and cooperatives, increasing numbers of major providers like municipal utilities companies are now investing in wind energy. And these investors, according to Angelo Bargel, spokesman of the BWE forum for independent servicing firms, tend to enter into long-term full maintenance contracts with the manufacturers since they offer more security to the financing banks and can better secure their investment. This leaves little breathing space for independent firms. Although in the past operators often opted for independent servicing at the end of the warranty period, in future they will increasingly not be able to switch until the end of a ten-year full maintenance at least.

Manufacturer

		Enercon	GE Energy	Nordex	Repower	Siemens	Vestas	Ø
Overall score	**100 %**	**1.94** (1.96)	**2.49** (2.64)	**2.87** (2.70)	**3.00** (2.75)	**2.86** (3.14)	**3.24** (3.04)**	**2.73**
Underlying data, questionnaires		404 (392)	48 (46)	33 (39)	46 (39)	25 (35)	133 (147)	114.83
Number of turbines		1886 (1809)	290 (280)	100 (189)	299 (139)	108 (152)	674 (645)	559.50
Willingness to switch in per cent		1.24 (0.79)	4.26 (8.89)	18.18 (21.05)	13.04 (20.51)	24.00 (40.00)	23.85 (17.36)	14.10
Maintenance	33.3 %	2.09 (2.09)	2.27 (2.31)	2.80 (2.57)	2.94 (2.75)	2.55 (2.86)*	3.00 (2.92)	2.61
Arrangement and keeping of maintenance appointments		1.91 (1.92)	1.96 (1.98)	2.61 (2.37)	2.82 (2.69)	2.32 (2.54)	2.98 (2.96)	2.43
Quality of the work		1.69 (1.62)*	2.04 (2.07)	2.66 (2.49)	2.40 (2.13)*	2.40 (2.43)	2.51 (2.45)	2.28
Feedback on maintenance (reports, logs)		2.24 (2.34)	2.06 (2.33)*	2.79 (2.56)	3.49 (3.33)	2.28 (2.89)**	3.26 (3.07)	2.69
Satisfaction as regards value for money		2.52 (2.49)	2.94 (2.89)	3.16 (2.84)	3.07 (2.87)	3.20 (3.60)*	3.24 (3.19)	3.02
Unscheduled repairs	33.3 %	1.93 (1.94)	2.17 (2.38)*	2.76 (2.54)	3.11 (2.92)	2.74 (2.93)	3.00 (2.76)**	2.62
Service team availability		1.69 (1.66)	1.83 (1.85)	2.55 (2.05)**	3.41 (3.42)	2.20 (2.46)	2.52 (2.47)	2.37
Speed of repairs - to essential parts		1.65 (1.64)	1.98 (2.28)**	2.61 (2.44)	2.98 (2.72)	2.52 (2.85)	2.65 (2.65)	2.40
- to all other parts		1.81 (1.87)	2.38 (2.80)**	2.94 (2.74)	3.17 (2.79)*	3.00 (3.29)	3.43 (3.01)***	2.79
Quality of the repairs		1.71 (1.57)***	2.10 (2.22)	2.48 (2.41)	2.42 (2.21)	2.44 (2.32)	2.44 (2.38)	2.27
Feedback on repairs (reports, logs)		2.25 (2.42)**	1.92 (2.37)***	2.85 (2.64)	3.52 (3.44)	2.76 (3.00)	3.39 (2.85)***	2.78
Satisfaction as regards value for money		2.50 (2.49)	2.79 (2.75)	3.16 (2.89)	3.17 (2.90)	3.52 (3.73)	3.59 (3.17)***	3.12
Additional services	33.3 %	1.81 (1.85)	3.03 (3.11)	3.06 (3.12)	2.97 (2.60)*	3.31 (3.55)	3.72 (3.30)***	2.98
Complementary improvements (Updates etc.)		1.65 (1.72)	3.09 (3.10)	3.12 (3.22)	2.67 (2.59)	3.38 (3.62)	3.41 (3.18)*	2.89
Willingness to make gestures of goodwill		1.98 (2.00)	2.98 (3.14)	3.00 (3.00)	3.21 (2.66)**	3.22 (3.56)	4.07 (3.42)***	3.08

2013 values in brackets. Significant changes are marked with *.
Level of significance: 1% ***, 5% **, 10% *

Forerunner of full maintenance for turbines is the Aurich-based firm **Enercon**. With its Enercon Partner Concept, it paved the way years ago for a comprehensive no-hassle package in wind energy. According to details from Ulf Winkler, spokesman of the BWE forum for Enercon operators, operators have to pay around 13 per cent of their revenue for the package, and in return Enercon ensures above-average availability for the turbines. Bottlenecks for replacement parts are also an exception for Enercon, which manufactures almost all components itself. "This comprehensive no-hassle package provides operators with a high degree of service security," declares Winkler.

The success of the comprehensive no-hassle package is another reason why Enercon remains the clear number 1 in manufacturer servicing. The company meanwhile scores 1.94 (1.96 for the previous year). "This indicates a high level of customer satisfaction and is a clear indication of high quality and reliability," says service manager Volker Kendziorra. Enercon has particularly improved in the feedback on the work undertaken. "The measures that Enercon Service has consistently implemented in order to optimise customer information and transparency of its services are paying off here," explains Kendziorra. An example would be the introduction of the Service Info Portal (SIP), which enables operators to bring part of the remote monitoring of their turbines onto their own computer.

"We took the results of the last surveys very seriously and have focused on tackling the critical points"

Winkler, too, praises the latest version of SIP as a "genuine tool for operational management". But the Enercon expert also sees weaknesses in the market leader's service. The company Umweltplan, for which the engineer works, operates Enercon turbines in eastern Germany and Poland. "The service quality varies greatly here." Winkler believes that better training, above all, is necessary for new employees. This demand does not appear unjustified, because in terms of the quality of unscheduled servicing Enercon slips from a 1.57 to a 1.71.

GE Wind Energy occupies second place in the latest BWE survey. The company has improved from a 2.64 to a 2.49. "We took the results of the last surveys very seriously and have focused on tackling the critical points," explains service manager Uli Schulze Südhoff. The company has got better, particularly in terms of the speed of its reconditioning and feedback – on both points GE scores a 1 before the decimal place. In terms

Independent companies

		Availon	DWTS	Enertrag	NTES	PSM	Wind Max	Ø
Overall score	**100 %**	**2.60** (2.52)	**2.01** (2.07)	**2.29** (1.85)**	**1.43** (1.37)	**1.60** (1.87)***	**1.53** (1.59)	**1.91**
Underlying data, questionnaires		22 (32)	74 (63)	21 (39)	16 (12)	30 (30)	13 (17)	29.33
Number of turbines		126 (313)	335 (280)	106 (659)	36 (23)	118 (159)	39 (32)	126.67
Willingness to switch in per cent		22.73 (22.58)	0.00 (1.61)	9.52 (5.56)	0.00 (0.00)	3.33 (3.33)	0.00 (0.00)	5.93
Maintenance	33.3 %	2.33 (2.50)	1.84 (1.91)	2.16 (1.76)**	1.36 (1.35)	1.66 (1.78)	1.56 (1.44)	1.82
Arrangement and keeping of maintenance appointments		2.68 (2.31)	1.79 (2.05)*	2.05 (1.71)*	1.81 (1.67)	1.73 (1.93)**	1.54 (1.35)	1.93
Quality of the work		2.18 (2.47)	1.77 (1.71)	2.30 (1.67)***	1.31 (1.33)	1.75 (1.97)*	1.46 (1.29)	1.79
Feedback on maintenance (reports, logs)		2.18 (2.44)	1.69 (1.74)	2.20 (1.79)*	1.19 (1.25)	1.10 (1.30)	1.69 (1.59)	1.68
Satisfaction as regards value for money		2.24 (2.78)***	2.04 (2.14)	2.10 (1.87)	1.12 (1.17)	2.03 (1.93)	1.54 (1.53)	1.84
Unscheduled repairs	33.3 %	2.30 (2.28)	1.83 (1.81)	2.04 (1.78)	1.31 (1.38)	1.63 (1.76)*	1.50 (1.52)	1.77
Service team availability		1.86 (1.88)	1.53 (1.63)	1.68 (1.49)	1.19 (1.42)	1.27 (1.53)*	1.46 (1.18)*	1.50
Speed of repairs - to essential parts		2.55 (2.26)	1.69 (1.66)	2.21 (1.89)	1.25 (1.00)	1.60 (1.73)	1.50 (1.47)	1.80
- to all other parts		2.64 (2.44)	2.15 (1.87)**	2.00 (1.97)	2.00 (1.45)**	1.87 (1.93)	1.67 (1.71)	2.06
Quality of the repairs		2.36 (2.28)	1.77 (1.73)	2.25 (1.63)***	1.25 (1.27)	1.87 (2.07)**	1.17 (1.35)	1.78
Feedback on repairs (reports, logs)		2.00 (2.22)	1.74 (1.87)	2.05 (1.66)*	1.12 (1.50)**	1.17 (1.37)	1.67 (1.69)	1.62
Satisfaction as regards value for money		2.38 (2.59)	2.07 (2.13)	2.05 (1.97)	1.06 (1.17)	2.00 (1.93)	1.33 (1.76)**	1.81
Additional services	33.3 %	3.16 (2.77)*	2.24 (2.37)	2.63 (2.07)*	1.62 (1.38)**	1.52 (2.07)***	1.62 (1.78)	2.13
Complementary improvements (Updates etc.)		3.35 (2.90)*	2.32 (2.42)	3.05 (2.17)**	2.06 (1.55)**	1.90 (2.24)*	1.64 (1.81)	2.39
Willingness to make gestures of goodwill		3.00 (2.53)**	2.18 (2.38)*	2.00 (1.97)	1.19 (1.17)	1.13 (1.93)***	1.67 (1.71)	1.86

2013 values in brackets. Significant changes are marked with *.
Level of significance: 1% ***, 5% **, 10% *

of exceptional service, however, GE made no progress with a 3.03, although the company has invested heavily in innovations according to Schulze Südhoff.

In 2013 GE presented its new Powerup product, a type of basic upgrade. Specialists in the company analyse an existing wind farm, and determine which improvements to software and hardware would be required to improve capacity and how much additional electricity the customers could therefore generate. GE then also undertakes the adjustments free of charge. Payment is only needed when efficiency really increases and profits rise. Through a combination of software and hardware solutions GE achieves a surplus of up to 4 per cent. That the company achieved only a "satisfactory" for exceptional service means that Schulze Südhoff wants to use the opportunity to communicate innovations even better in the future. "We need to approach customers more pro-actively."

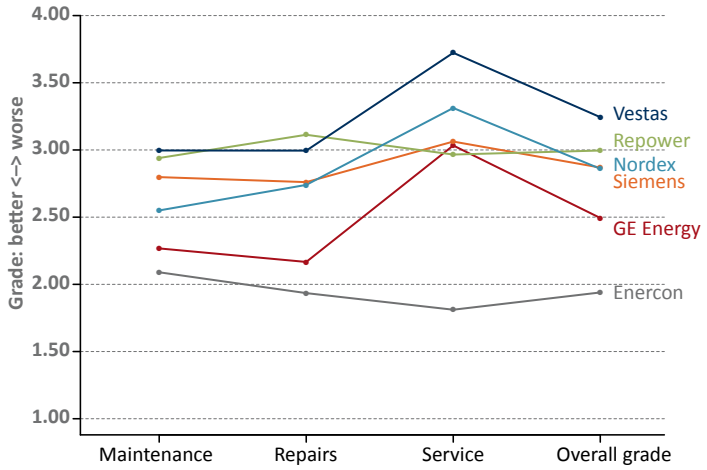
Competition against GE today comes mostly from **Siemens**, which climbs from last to third place with a 2.86 in the manufacturer ranking. For Karsten Skov, service manager for Germany, this development is only logical. "We set up a new service structure in 2013 based on three pillars: a better supply of replacement parts, greater flexibility and closer customer relations." He goes on to explain that operators now have direct contact partners, unlike before. "We have created clear responsibilities," says Skov. According to him, the service is now better organised too. For example, there is now a clear division between maintenance and fault clearance teams. "If scheduled maintenance is due, the fitters can now only be called in extreme emergencies and following agreement for fault clearances – making service more reliable." The operators appreciate the measures taken: Siemens has increased significantly for regular maintenance work from a 2.86 to a 2.55.

The Hamburg-based turbine manufacturer **Nordex** meanwhile slips into fourth place in the BWE survey. Although Nordex does not get beyond a 2.87 compared to last year's 2.7, this is not seen as a shortcoming by Jörg Hempel, manager for Germany. "We are not really unhappy because we have confirmed our good previous year's result." Despite the fact that, according to service manager Volker Bartolles, last year saw a significant proportion of recently employed and trained service technicians immediately engaged in installing and commissioning new turbines. Business is booming at Nordex. In 2013 the company increased its sales by about 165 per cent. For the first time since 2010 it once again posted a surplus of 1.3 million euros last year.

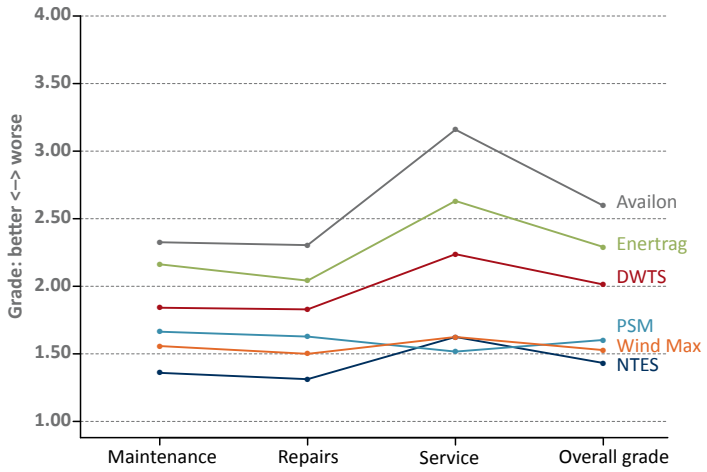
In an otherwise good level of manufacturer servicing, Senvion and Vestas were the disappointing exceptions. The reasons

Manufacturer grades in 2013 service survey

MANUFACTURER



INDEPENDENT COMPANIES



for **Senvion** scoring a relatively weak 3.0 are apparent. The company has re-organised and responsibilities have been redistributed. At the same time, Kai Froböse, managing director of Senvion GmbH, which is responsible for the German market, reported record growth for 2013: "We have newly erected 164 turbines in Germany in 2013. There are significantly more turbines to service than in the previous year."

Vestas, too, has to take some sharp criticism from its operators. With a 3.24, the Danish company is bottom of the service ranking. Above all, its willingness to show goodwill is lacking – it slips from a 3.42 to a 4.07. However, BWE forum spokesman Siggi Schülter warns against criticising Vestas' service on principle. "Only the administrative side was punished, the fitters on site continue to do good work." In fact, the technicians save Vestas from an even more mediocre score. The company scores a 2.51 and 2.44 for the quality of its maintenance and repairs respectively.

Whether the independent providers can capitalise on the deficits of the manufacturers as in the past is questionable. Almost all of Vestas' new turbines are only offered in combination with full maintenance contracts – making things difficult for independent turbine services, according to Schülter. Vestas has

also revised its service prices down. "For many operators, switching to independent service providers does not seem worthwhile." Enertrag service manager Heidkamp also believes the independent service market is facing major challenges. "Previously, manufacturers did not even accept service orders for less than ten turbines – now they're piling on the resources for free servicing and are trying to get the best prices, particularly for large components."

Has this independent servicing model had its day? BWE experts believe that independent providers are indispensable. "Who will look after special and frequently older turbines? Who will take over the turbines that are not repowered? Independent providers are made for these tasks, they have an enormous amount of knowledge," says BWE forum spokesman Bargel. The consistently good average score of 1.9 achieved by the independents confirms his assessment. PSM in Erkelenz even improved from a 1.87 to a 1.60, with its technical innovative strength particularly praised. "We offer our customers a range of options to increase the revenue of their turbines. These include hydraulic upgrades, upgrades for yaw brakes or retrofitting pitch systems," explains PSM spokeswoman Annekatrin Dretzke

There's another option open to businesses to position themselves in the market. They could also offer full maintenance concepts and try to throw down the gauntlet to manufacturers in the servicing of new facilities. Availon and Deutsche Windtechnik are already making a start. At the beginning of the year they both entered into comprehensive no-hassle packages with Swiss energy providers for several wind farms. Will other service providers follow suit? How good will they be at full maintenance? Exciting times are in store.

Maintenance work at Nauen wind farm. Photo: Jan Oelker

Global Service Protocol (GSP) introduces transparency to the maintenance of wind energy plants

The GSP Guideline has been available from the Fördergesellschaft Windenergie e.V (Society for the Promotion of Wind Energy - hereinafter FGW) since 01.01.2014. The Global Service Protocol provides a common data format for the exchange of maintenance data. This enables plant operators, service providers and industry experts to use an open industry standard for their electronic communications.

Until now exchanging maintenance data and inputting the data into one's own IT system has often been highly time-consuming and expensive in terms of development and file conversion. The GSP helps meet the requirement for greater efficiency and transparency in relation to the transfer of maintenance data.

Firstly it creates unambiguous structures and designations for the information exchanged, whereby industry standards for plant identification (RDS-PP©) and condition appraisal (Condition-Event-Causes-Key for Production Units - CECK) have been incorporated. Secondly the GSP standard provides an XML-based data format, which can be used on any platform and can be augmented as required by individual parties.

Users of the GSP standard will benefit from the ability to automate the exchange of maintenance data. Thus the cornerstone has been laid for more transparency and meta analyses, e.g., within the WInD-Pool Database for Reliability Data. Maintenance service providers, expert assessors and manufacturers can now augment their service portfolios with a customised transfer of the agreed maintenance data in GSP compliant format. As a value-add, that will provide customers with the basic data required for a life cycle record for the supported plant.

The GSP is based on the experience and requirements of operations managers, industry experts and service providers as well as universities and research institutes, and is aimed at both the onshore and offshore sectors. It was developed over several years by the FGW Global Service Protocol Work Group (GSP WG), in collaboration with others. For example the project group of the EVW2 research project "Increasing the Reliability of Wind Energy Plant" was closely involved in the activities of the GSP WG.

The GSP WG plans to continue development on the GSP standard and therefore remains open to all industry stakeholders. This will ensure that experience and new ideas will also be reflected in future revisions of the GSP.

The text of the guideline is available for free download at the FGW e.V. webpage, where both the protocol documentation (Annex A) and the associated XML scheme can also be obtained for a fee.

CONTACT:
www.wind-fgw.de
Link to free download:
www.wind-fgw.de/pdf/TR7_D3_Rev0.pdf
Head of GSP WG: Sebastian Pfaffel, Fraunhofer IWES
EVW II Project and WInD-pool database (web page):
www.evw-wind.de

Photo: Tim Riediger / nordpool

Überblick

Technical Committee (TC)	Technical Directive (TR)		Publication	IEC - Mirror Committee
TC for Noise	TR1 Rev.18	Determining Noise Emission Values	01.02.2008	61400-11
TC for Performance Curve	TR2 Rev.16	Determining Performance Curves and Standardised Energy Yields	28.01.2010	61400-12-1
				61400-12-2
				61400-12-3
	TR5 Rev.5	Determining and Applying the Reference Yield	30.01.2013	
TC for Electrical Characteristics	TR3 Rev.23	Determining the Electrical Characteristics of Production Units within Medium, High and Ultra-High Voltage Grids	5/1/2013	61400-21
	TR4 Rev.6	Modelling and Validation Requirements for Simulation Models of the Electrical Characteristics of Production Units and Plant	5/1/2013	61400-27-1
				61400-27-2
	TR8 Rev.6	Certifying the Electrical Characteristics of Production Units and Plant within Medium, High and Ultra-High Voltage Grids	5/1/2013	-
TC for Wind Potential	TR6 Rev.8	Determining Wind Potential and Energy Yields	5/19/2011	-
TC for Preventative Maintenance	TR7 Rubric A Rev.1	Operation and Maintenance of Renewable Energy Power Plant	10/15/2010	61400-26-1
	TR7 Rubric B3 Rev.0	Subject-specific application exposition on the inspection and foundation of support structures in wind energy plant.	1/1/2014	-
	TR7 Rubric D2 Rev.1	Condition-Event-Causes-Key for Production Units (CECK)	10/1/2013	-
	TR2 Rubric D3 Rev.0	Global Service Protocol	1/1/2014	61400-25 series
FA Elektromagnetische Verträglichkeit	TR9 Draft Rev. 0	Test Procedure for Documented Evidence of Conformity in Compliance with Cispr 11 and IEC 61000-4	2. Quartal 2014	IEC Cispr 11

TC for Noise

Technical Directive (TR):
TR1 Rev.18
Determining Noise Emission Values

Publication: 01.02.2008

IEC - Mirror Committee: 61400-11

Contents:
TR1 specifies the procedure for the sonic assessment of wind energy plants (WEP). It includes the measurement and evaluation methodologies for determining the immission-relevant sound power level, as well as analytical procedures for determining the tonality and impulse characteristics of the emitted sound.

Changes in the current revisions.
Next steps:
Will require modification as soon as the authorities mandate measurements in compliance with 61400-11 Edition 3.
Inter-laboratory tests should be carried out either this year or next year.

TC for Performance Curve

Technical Directive (TR):
TR2 Rev. 16
Determining Performance Curves and Standardised Energy Yields

Publication: 28.01.2010

IEC - Mirror Committee: 61400-12-1, 61400-12-2, 61400-12-3

Contents:
TR2 describes the measuring methods for determining the performance curve of WEP.
As a matter of principle the measured values are evaluated in compliance with IEC 61400-12-1. Additional specifications over and above these standards are provided for the purposes of minimising measurement uncertainties as well as increasing the repeatability of the measurement results.
The performance curve is the decisive statistic for calculating the annual yield, which often forms the basis of purchasing decisions and funding approvals. Hence the requirement for particularly accurate and reliable measurements.
This guideline was developed in collaboration with measurement institutes, wind turbine manufacturers and other engineering firms under the auspices of the responsible work group.

Changes in the current revisions.
Next steps:
No new revision is planned for the current year..

Technical Directive (TR):
TR5 Rev. 5
Determining and Applying the Reference Yield

Publication: 30.01.2013

IEC - Mirror Committee: 61400-12-1, 61400-12-2, 61400-12-3

Contents:
TR5 specifies the application rules for the performance curve, which should be used to calculate the reference yield in compliance with the German Renewable Energy Act. The calculation of the extended period of the increased initial tariff and the implementation of the reference yield procedure on the basis of the German Renewable Energy Act are defined in TR5.

Changes in the current revisions.
Next steps:
The revision published in January 2013 includes a procedure for WEP for which there is no reference yield based on a measured performance curve once the due date is reached (5 years after initial commissioning), and for which is has not yet been possible to calculate a reference yield in compliance with TR5.

No new revision is planned this year unless the TR5 needs to be modified to take account of modified political directives.

TC for Electrical Characteristics

Technical Directive (TR):
TR3 Rev.23
Determining the Electrical Characteristics of Production Units within Medium, High and Ultra-High Voltage Grids

Publication: 01.05.2013

IEC - Mirror Committee: 61400-21

Contents:
TR3 comprises test procedures and minimum requirements for carrying out electrical measurements and tests for production units and production plant, whose network connection point is within the general supply grid at the medium, high and ultra-high voltage levels.
It specifies a set of measurement and testing rules, and stipulates the parameter requirements for grid compatibility, controllability within the grid and voltage drops.
TR3 provides the measurement results and parameters for two more technical guidelines: "Modelling and Validation Requirements for Simulation Models of the Electrical Characteristics of Production Units and Plant" (TR4) and "Certifying the Electrical Characteristics of Production Units and Plant within Medium, High and Ultra-High Voltage Grids" (TR8).

Changes in the current revisions. Next steps:
Rev. 23 includes the following changes and/or additions vis-à-vis Rev. 22:
- Performance restriction operation by grid operator
- 10 % stage to be used instead of 15%
- Actions during supply grid faults:
- New: defined idle power (under and over excited) prior to the voltage drop for two tests
- New Annex D
- New: Test procedure for combustion engines in Annex H
- Fundamental revision of test procedures for production plant controllers
- Introduction of a separately available sample report
- Minimum requirements for a complete test report and example of a completed test report with predefined illustrations and tables

Technical Directive (TR):
TR4 Rev.6
Modelling and Validation Requirements for Simulation Models of the Electrical Characteristics of Production Units and Plant

Publication: 01.05.2013

IEC - Mirror Committee: 61400-27-1, 61400-27-2

Contents:
TR4 describes modelling and validation requirements for simulation models of the electrical characteristics of production units and production plant that have been surveyed in accordance with Society for the Promotion of Wind Energy (Fördergesellschaft Windenergie e.V - hereinafter FGW) TR3 "Determining the Electrical Characteristics of Production Units within Medium, High and Ultra-High Voltage Grids" and FGW TR8 "Certifying the Electrical Characteristics of Production Units and Plant within Medium, High and Ultra-High Voltage Grids", and should be certified in accordance with the grid connection rules as per the German Energy and Water Industry (BEDW) Guideline "Production Plant in the Medium Voltage Grid - Guideline for the Connection and Parallel Operation of Production Plant in the Medium Voltage Grids", including the latest addendum, and TC 2007.

Changes in the current revisions. Next steps:
Changes to Rev.6:
Definition of fault inception and fault resolution as well as transient/stationary zone
- Limited expansion of the model scope and the dynamic nominal values Draft TR4 Rev. 7, if necessary also as addendum to TR4 Rev.6:
- Results of the Combustion Engine Work Group for a modelling procedure for combustion engines to be included.

Technical Directive (TR):
TR8 Rev. 6
Certifying the Electrical Characteristics of Production Units and Plant within Medium, High and Ultra-High Voltage Grids

Publication: 01.05.2013

IEC - Mirror Committee: –

Contents:
TR8 is regarded as a common working basis for the certification of the electrical characteristics of production units and plant. A unified implementation guideline for the certification process is intended to enable a better application of the regulations published by the grid operators, in particular the BEDW's Guideline "Production Plant in the Medium Voltage Grid - Guideline for the Connection and Parallel Operation of Production Plant in the Medium Voltage Grids". The current implementation guideline for the certification process also unifies their areas of application: the determination of measurement results, the validation of production unit models, the simulation of plant performance as well as their formal processing. In addition the guideline is intended as a common basis for the documented evidence of the electrical characteristics for the connection of wind energy plant to medium, high and ultra-high voltage grids as required in the ordinance on system performances by WEP (System Services Regulation – SDLWindV)

Changes in the current revisions. Next steps:
Significant changes to FGW TR8 Rev.6:

- Verification method: BDEW 4 addendum incorporated for production units and plant
- Certification procedure for combustion engines tentatively included in Annex H
- Prototype regulation in plant certification
- Position of machine transformer taps via Uc in case of absence of further stipulations
- Durable restriction of the maximum active power in favour of the reactive power
- Validity period of a certificate in the case of several construction phases: Plant certificate max. up to 12 months after initial commissioning of the first production unit within the production plant
- Requirements for the level of accuracy of the required idle power settings at the grid connection point
- Incorporation of the combustion engine production unit certification process

TR8 Rev.7 is currently at the draft stage. Among other things, the following are being developed:

- Due consideration of the changed requirements from E VDE-AR-N 4120 (high voltage technical connection conditions, draft version)
- Mandatory certification procedure for combustion engines
- Plant certification in mixed energy type parks and in local (site) grids
- Modification of the declaration of conformity
- Independent power supply check
- Modified in line with the safety inspection records
- Due consideration given to fault conditions in connection with dynamic grid support
- Development of a certification process for storage devices in low and medium voltage grids
- Further development of the production plant controller certification procedure

TC for Wind Potential

Technical Directive (TR):
TR6 Rev. 8
Determining Wind Potential
and Energy Yields

Publication: 19.05.2011

IEC - Mirror Committee: –

Contents:
The current guideline specifies a procedure for determining the wind potential and energy yields at WEP locations.
A report must be produced on the determination of the wind potential and energy yield, the essential results of which are to be determined on the basis of the procedure set out in this guideline.

Changes in the current revisions.
Next steps:
TR6 is currently being revised as Rev.9.

- Restructuring of TR6
- Inclusion of expanded requirements
- Expansion of LIDAR measurement procedure

TC for Preventative Maintenance

Technical Directive (TR):
TR7 Rubric A Rev.1
Operation and Maintenance of
Renewable Energy Power Plant

Publication: 15.10.2010

IEC - Mirror Committee: 61400-26-1

Contents:
The purpose of TR7 is to define terminology, necessary processes and documentation in the field of maintenance of regenerative production units, including the associated infrastructure, as well as standardised communication points for the exchange of maintenance-relevant information.

Changes in the current revisions.
Next steps:
TR7 Rubric A Rev.2 is currently being prepared, however it is highly unlikely to be published in 2014.
An English translation is currently being prepared.

Technical Directive (TR):
TR7 Rubric B3 Rev.0
Subject-specific application exposition on the inspection and foundation of support structures in wind energy plant.

Publication: 01.01.2014

IEC - Mirror Committee: –

Contents:
The application scope The Guideline for Onshore Production Units, Part 7, Rubric A shall apply. This TR primarily treats the foundation structures. Later versions will include the construction site and foundations as well as the support towers.

Changes in the current revisions.
Next steps:
Initially TR7 Rubric B3 should be used for the preparation of expert opinion reports and experience with the new processes should be acquired.

Technical Directive (TR):
TR7 Rubric D2 Rev. 1
Condition-Event-Causes-Key for Production Units (CECK)

Publication: 01.10.2013

IEC - Mirror Committee: –

Contents:
Provisions are made for the Condition-Event-Causes-Key (CECK) to reduce the plethora of available information to a more manageable volume as well as to structure it and increase it specificity in order to achieve a detailed itemisation for analyses. The specifications are labelled within this guideline as they are valid for the application of CECK and do not purport to represent a generally applicable standard.
The terminological definitions are set out in the corresponding specifications for the direct transfer of the information units for technical processing in databases.

Changes in the current revisions.
Next steps:
An English translation of Rubric D2 is currently being prepared.

Technical Directive (TR):
TR2 Rubric D3 Rev. 0
Global Service Protocol

Publication: 01.01.2014

IEC - Mirror Committee: 61400-25-series

Contents: The purpose of the Global Service Protocol (GSP) is to provide a common format for electronic data and documentation, which will facilitate communications between the various parties involved in the maintenance of renewable energy plants.
The definition of a common format and unambiguous identifiers will ensure the compatibility of data produced by the various parties involved, which will enable the exchange of maintenance-relevant data, which will in turn provide the basis for a comprehensive documentary record (life cycle record) of all maintenance works.
As soon as the IT systems of the individual actors support the exchange of data in the GSP document format then it will immediately be possible to exchange data with all other systems that support the GSP format with no further ado. Hence there is no longer any requirement for time-consuming file conversions or manual management of maintenance data.
In terms of defining the protocol content the GSP will be based on FGW Guideline TR7 Rubric A as well as other standards and guidelines. In addition to the predefined protocol contents the various actors can also define and exchange additional information among themselves by way of the user-specific data fields provided.

Changes in the current revisions.
Next steps: An English translation of Rubric D2 is currently being prepared.

TC for Electromagnetic Compatibility (EMC)

Technical Directive (TR):
TR9 Draft Rev. 0
Test Procedure for Documented Evidence of Conformity in Compliance with Cispr 11 and IEC 61000-4

Publication: Quarter 2, 2014

IEC - Mirror Committee: IEC Cispr 11

Contents:
Interpretation and specification of the [IEC/CISPR 11] as well as EN 55011 for the determination of high-frequency emissions of electrical fields from regenerative energy production units.

Changes in the current revisions.
Next steps:
TR9 will only be applicable in conjunction with IEC/Cispr11, and, as a first step, is intended to reduce conformity uncertainty by specifying unambiguous and generally recognised mensuration guidelines for production units.
The "worst operating condition" of a given production unit will be determined through measurement, simulation, and calculation, in order to placee the appraisal and therefore the operational safety of the production on as legally sound a basis as possible.
The TC for EMC intends to carry out a broad-based investigation into series variation in relation to the EMC emissions from different production units. This will enable a type approval, which, according to the [IEC/CISPR 11] is absolutely not possible for "measurements taken at the installation and operational location".

WIND ENERGY LAW

Changes in wind energy law in 2013

LAWYER AND NOTARY FRANZ-JOSEF TIGGES,
CHAIRMAN OF THE LEGAL COMMITTEE

Legislative changes

Looking ahead to the comprehensive amendment to the German Renewable Energy Sources Act (EEG) due in 2014, there were no notable amendments to the EEG in 2013 of particular interest to the wind sector. Beyond the mostly negative broad outline of the future EEG amendment, which also impacts the wind sector and will need to be discussed elsewhere, the current draft bill (in any case) contains one fairly important clarification from a practical perspective which can definitely be assessed positively. On 09/07/2012 the Kammergericht in Berlin (Higher Regional Court of Berlin) decided with regard to section 6 (1) of the EEG 2009 that, contrary to rather widespread practice, it is not sufficient to make bundled provisions for the remote control of feed-in capacity and measuring equipment for a wind farm. According to the judgement, these provisions should apply to each individual wind turbine. The further appeal on points of law submitted to the Federal Court of Justice was surprisingly rejected at the end of 2013 – no justification was given. This ruling, which often even contradicts the network operators' own specifications, is expected to be corrected by the future EEG amendment, retroactively from 2009.

In terms of administrative provisions, German legislators have been busy in the field of planning security in 2013. While section 15 (3) of the Federal Building Code (BauGB) previously gave local authorities the option to suspend wind energy projects for a year at the longest if they had decided to designate wind power concentration zones, they have now been granted the option to extend this term by a further year, where "special circumstances" demand it, in legislation dated 11/06/2013 relating to section 15 (3) p 4 of the BauGB. It is clear that this distinction will be difficult to make in individual cases, and it is already conceivable that this new provision will be a source of many legal disputes.

Case law
RENEWABLE ENERGIES ACT (EEG)

In several decisions, the constitutionality of the physical transfer of electricity subsidised in accordance with the Renewable Energy Resources Act (sections 35 – 37 of the EEG) was put to the test. In their respective judgements (22/03/2013 – 1 HK O 1113/12 –, in the 2013 ZNER (journal), p 185, 20/02/2013 – 38 O 55/12 KfH –, in the 2013 ZNER, p 417, and 14/05/2013 – 19U 180/12 –, in the 2013 ZNER, p 521), the Regional Courts of Chemnitz and Stuttgart and the Higher Regional Court of Hamm confirmed that the obligation of electricity companies to pay the levy in accordance with section 37 (2) of the EEG is not in breach of the financial constitution regulated in art. 110 of the Basic Law (GG), because the EEG levy is not subject to Parliament's right to approve the budget. It is already deemed not to be a public levy because it generates no tax revenue for the public purse.

There was good news too from the Federal Court of Justice (decision of 26/02/13 – EnVR 10/12 –, in the 2013 ZNER, p 265) in relation to its clarification of section 7 (1) of the EEG 2009, which had been anticipated, that the turbine operator is entitled to personally undertake measurements of the volume of electricity supplied.

Anyone who thought that discussions about the right grid connection point within the same grid had come to an end following the decision of the Federal Court of Justice of 10/10/2012, will be disappointed by interim developments: With the prevailing high court ruling, the Regional Court of Kiel is adhering firmly to the judgement of 25/01/2013 – 6 O 258/10 –, in the 2013 ZNER, p 291, that section 5 (1) p 1 of the EEG 2009 only makes an exception to the network operator's obligation to connect to the geographically closest connection point if another grid provides a connection point that is technically and commercially more advantageous. Contrary to the ruling of the Federal Court of Justice and the recommendation of the clearing house, it cannot be assumed on the basis of the clear wording of this provision that this overall economic consideration would also be applied in the case of another potential connection point within the same grid. This insubordination of a court of law against the highest German civil court is enough to make us sit up and take notice. Even more remarkable is the justification – the Regional Court of Kiel criticises no less than the Federal Court of Justice for unconstitutionally overstepping the limits of possible interpretation of the law. Pretty much as expected, the Higher Court of Schleswig reversed the judgement of the Regional Court with its decision of 05/11/2013 – 9 U 21/13 –, in the 2014 ZNER, p 102, but ducked out of giving a clear opinion regarding criticism of the Federal Court of Justice. The arguments of the regional court were perfectly reasonable, yet were ultimately irrelevant because if the network provider followed the Federal Court of Justice, even unknowingly, it could not be accused of culpable behaviour – with the result that, in the absence of culpability, no claim could be made for coveted compensation (based on connection to the wrong grid connection point). Meanwhile, in an act of "double" disobedience as it were (the Regional Court of Flensburg is subordinate to the Higher Court of Schleswig in the appeal stages), the Regional Court of Flensburg declared that it strongly disagreed (decision of 27/02/2014 – 4 O 248/12 –, in the 2014 ZNER, p 110). The decision by the Federal Court of Justice was deemed to be erroneous, and the "fault solution" which was also favoured by the Higher Court of Schleswig dismissed. The defending network operator was said to have acted in the knowledge that his legal position was unclear, and therefore at his own risk. Conclusion: The Higher Court of Schleswig and the Federal Court of Justice will have to rule again, and every indication suggests that the matter of (final) clarification will be brought to the Federal Constitutional Court.

Access roads and cabling

Wind turbine operators might finally have the long-awaited certificate of immission control approval within their hands, but it's not unusual for considerable delays to be caused by local communities who oppose use of local roads for either cabling or access. In this situation the Regional Court of Cologne (decision of 06/08/2013 – 5 O 221/13 –, in the 2013 ZNER, p 530) has ascertained that the owner of a farm track (specifically the local authority) has no exclusion right concerning an electric cable routed 4 metres below the track. Owners of a piece of land cannot prohibit actions that take place at such a height above or such a depth below their land that they have no interest in excluding the action.

As a last consequence, the required easement for securing cabling can also be brought against the will of the owner, by way of expropriation in accordance with section 45 (1) no. 2 of the German Energy Law (EnWG) (Higher Court of Jena, judgement of 05/11/2013 – BI U 299/12 –, in the 2014 ZNER, p 97). In principle, expropriation is therefore conceivable for the benefit of securing access. According to the judgement of the Higher Court of Jena, there should regularly be solutions that are less burdensome on owners and equally satisfactory and therefore preferable for reasons of proportionality for the wind turbine operators, e.g. by proposing an acceptable offer of infrastructure provision.

Planning law
Hard and soft taboo zones

In its judgement of 13/12/2012 (– 4 CN 1.11 –, in the 2013 ZNER, p 209), the Federal Administrative Court had already confirmed that differentiating between so-called "hard" and "soft" taboo zones is vital in designating wind power concentration zones. It stated that the planning authority would have to be consciously aware of this difference to avoid an error in the process of assessment, and above all document this difference in the planning documentation. The topicality of this case law is underlined by a series of follow-up decisions (Federal Administrative Court, judgement of 11/04/2013 – 4 CN 2.12 –, in the 2013 ZNER, p 429 and, for example, the Administrative Court of Koblenz, judgement of 16/05/2013 – 1 C 11003/12.OVG –, in the 2013 ZNER, p 435 and the Administrative Court of Münster, judgement of 01/07/2013 – 2 D 46/12.NE –, in the 2013 ZNER, p 443). Practice shows that a large number of plans for wind power concentration zones – both on a regional and local authority urban land-use planning level – have not even made a distinction such as this, or that the decision has been made using incorrect criteria. For example, the Administrative Court of Münster therefore decided that minimum distances around settlement areas defined by immission control legislation, fixed safety distances around Natura 2000 areas or bird reserves, or minimum distances for species in accordance with the recommendations of the Working Group of German State Bird Conservancies did not in principal represent hard taboo criteria, but are amenable to consideration in accordance with planning law.

Although these standards have been set by the courts in retrospect, in substance they still represent nothing more than an interpretation of the prevailing legal status, which has remained unchanged since 1997. It is apparent that a great number of old plans do not satisfy these requirements and are therefore actually in breach of the law in substance. The extent to which they can still be attacked today ultimately depends exclusively on the question to be answered in the individual case, as to whether they can be effectively protected through what are known as planning safeguards in the BauBG.

As the Federal Administrative Court already decided some time ago, in addition to reviews of incidental issues based on administrative law, wind concentration plans are subject to so-called legitimacy reviews too, i.e. they can also be directly attacked with the aim of declaring erroneous planning as a whole as invalid. With its judgement of 31/01/2013 – 4 CN 1.12 –, in the 2013 ZNER, p 306, the court meanwhile makes it clear that this capacity for legitimacy reviews refers only to the exclusionary effect intended by the planner, in other words the negative aspect of planning, and that no wind energy use ought to be possible outside the designated suitable areas. The presentation of the positive areas, meanwhile, is likewise an unsuitable subject for a legitimacy review, as is the presentation of height restrictions of wind turbines. Stipulations such as these could only be fought for incidental issues, namely in the procedure for implementing concrete approval.

White spots

If the examination reveals that a specific priority area ought not to have been designated as such because of drastic errors of assessment, according to the opinion of the Administrative Court of Lüneburg (judgement from 17/10/2013 – 12 KN 277/11 –, in the 2013 ZNER, p 640) this does not mean that this area is to be subsequently assigned to the wind energy exclusion areas. Instead, indifferent "white" planning spots occur.

Planning safeguards

As mentioned earlier, it is entirely possible, on the basis of the regulations relating to planning safeguards in the BauBG, cf. sections 214 et seq. of the BauBG, that urban land-use plans remain effective on the outside although they contain faulty (assessment-wise) content. With a view to the prevailing regulation of section 215 (1) no. 2 of the BauBG that applied to old plans up until 19/07/2004, this is problematic, since according to the wording of the standard even a serious defect in the assessment result becomes inconsequential after the seven-year term cited therein has elapsed without an objection being raised. With its judgement of 11/11/2013 – 12 LC 257/12 –, the Administrative Court of Lüneburg enforces this in principle, but states that acceptance of a serious defect within this meaning is only justified if the plan itself is defective in such a way that it cannot be worth protecting confidence in the validity of a legal standard. According to the judgement, the defect in the assessment result must strongly suggest itself to a judicious observer.

Community wind farm

The acceptance of wind energy use depends crucially on opportunities for (financial) participation by citizens in wind energy projects. Community wind farms such as these, however, are a problem to implement by means of urban land-use planning. Stipulating a wind energy development plan with the aim of putting in place substantial co-determination by the municipality in the future operating company of a “community wind farm” is in any case not permitted according to the judgement of the Administrative Court of Schleswig of 04/04/2013 – 1 LB 7/12.

Nature conservation

The law on nature conservation and the protection of species continues to be one of the "main arenas" that a wind turbine operator has to struggle through when implementing a wind energy project. Whether wind turbines harm a specific species, mostly birds or bats, is already the subject of lively disputes among experts regarding nature conservation. From a legal perspective, the Federal Administrative Court believes that a "nature conservation assessment prerogative" must be granted to official nature conservancies (Federal Administrative Court, judgement of 27/06/2013 – 4 C 1.12 –, in the 2013 ZNER, p 532, and judgement of 21/11/2013 – 7 C 40.11 – with note from Brandt, in the 1/2014 ZNER). A prerogative such as this ought to influence site surveys and risk assessments, in the respect that no generally acknowledged status in terms of specialist knowledge has been developed regarding ecological issues (differentiating Administrative Court of Magdeburg, judgement of 16/05/2013 – 2 L 106/10 –, in the 2013 ZNER, p 328). Whether or not the courts still completely fulfil their constitutional task of independently administering justice, is hotly disputed, and one may venture to say that this will lead to an appeal to the Federal Constitutional Court. The mistrust on the part of the competent authorities when it comes to the correct application of nature conservancy law is unfortunately, from the undersigned's perspective, all too often justified. Admittedly, once approval has been granted, this case law does provide better protection from attacks on the part of voluntary nature conservation organisations.

Noise control

In immission control approvals, the stipulation of sound power values for the approved wind turbines is often accompanied by the setting of a corresponding immission value. This is not permitted. Immission values are inappropriate as control values, according to the pithy judgement of the Federal Administrative Court of 21/02/2013 – 7 C 22.11 –, in the 2013 ZNER, p 313. According to this judgement, only emission values and not immission values provide reliable conclusions for deficiencies in turbine operation. A firm relationship between immission values and turbine behaviour is deemed to be lacking solely because the strength of an emission source is only one factor among many which determine the immission load of a protected object.

Radar, aviation safety

The supposed disturbance to radar facilities for aviation safety or air defence is and remains a long-running issue. After the Administrative Court in Hanover with its decision of 21/12/2010 – 12 B 3465/10 –, in the 2011 ZNER, p 90, made a welcome start for wind turbine operators in the problem area of interference to radar facilities for air defence, the Administrative Court of Aachen with its judgement of 24/07/2013 – 6 K 248/09 –, in the 2013 ZNER, p 544, ruled for the field of radar facilities for (military) aviation safety that drastic disturbances within the meaning of section 18a (1) p 1 of the Air Traffic Act (LuftVG) are only present if damage can be expected to occur, not only hypothetically, but with sufficient likelihood within the foreseeable future. Even future developments are to be included in such a prognosis. According to the judgement, whether interference to radar coverage caused by wind turbines leads to intolerable disruption must be legally tested in its entirety. To this extent, there is no discretion for the specialist authorities (in this case the Federal Armed Forces).

DATA SHEETS

Technical Data explained

What's what and what's where in this overview?

What do the individual categories mean? The following glossary answers these questions – and is recommended in particular to those who are dealing with data sheets on wind turbines for the first time.

ANKE GRUNWALD, JAN LIERSCH AND PROF. DR. JOCHEN TWELE

All technical data on the wind turbine models listed in the table of contents can be found in the data sheets. For the large turbines technical details are provided, together with extracts from the test reports for measuring the turbine's power curve, noise and electrical properties.
It should be noted that all the information published here has been compiled and released by the manufacturers. The publisher cannot guarantee the accuracy of the information. For specific planning and economic viability calculations the complete set of documents should always be requested directly from the manufacturers.

Below is a brief explanation of the features and measurement results presented in the data sheets.

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Senvion SE
Hamburg, Germany

POWER			
Rated power	3,200 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	114.0 m	Swept area	10.207 m²
Number of blades	3	Rotor speed	approx. 12.6 rpm
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:99.5
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	640–1,200 rpm	- Grid frequency	50 Hz
- Voltage	950 V (stator)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	**SOUND POWER LEVEL**	**ELECTRICAL CHARACTERISTICS**
on request	on request	on request

TOWER/HUB HEIGHT	**93 m**	**123 m**	**143 m**	
Type / Shape	steel tubular,conical	concrete tower, hybrid tower concrete-steel, conical	concrete tower, hybrid tower concrete-steel, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	approx. 15.0 t	approx. 15.0 t	approx. 15.0 t	
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 68.0 t	approx. 68.0 t	approx. 68.0 t	
Nacelle (without rotor & hub)	approx. 104.0 t	approx. 104.0 t	approx. 104.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt WZ3	IEC IIa/DIBt WZ3	IEC IIIa/DIBt WZ3	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	

REFERENCES 31/12/2012	Installed turbines worldwide: First installation in: 40.878
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) permanent yaw lubrication system, divers country-specific grid connection solutions, e.g. EEG-package for Germany
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control ("fail-safe" design). Divers options and service packages on request. Tower heights are effective hub heights. Hub heigth can be modified by changing the foundation.

Photo: Nordex

1 Power

One of the most important characteristic variables of a wind turbine is the **rated power** which is reached at a given **rated wind speed**. This statistic is used to grade the turbines in the market overview. If two values are given for rated power, this is normally because it is a stall-controlled wind turbine with two fixed operating speeds and a two-speed generator. The generator operates at its low speed level when wind speeds are low (below the rated wind speed), and at its high speed level during high wind speeds. The operating range of the wind turbine lies between the **cut-in wind speed**, at which the turbine begins to feed power into the grid, and the **cut-out wind speed**, at which the turbine turns off for safety reasons and stops feeding power into the grid.
Indication of a range at the cut-out speed means that the wind turbine is not suddenly disconnected in case of a storm but that feed-in can be positively regulated; this also serves to support the electricity grid. The correlation between wind speed and power output is provided by the power curve.

2 Rotor

The **rotor diameter** can be used to describe the circle area that is swept by the rotor. This is a key parameter for the aerodynamic conversion of wind energy into mechanical energy. As a basic rule, doubling the rotor diameter quadruples the turbine's power output. This means that rotor power is directly proportional to the **swept area**.
Larger turbines are very similar with respect to the **number of rotor blades**. Three is by far the most common. Some smaller turbines have two-blade systems, but there are others featuring four or more. **Rotor speed** is either fixed or variable and gives an indication of the generator and control concept used. If one or several fixed rotor speeds are given (normally two), these are stall-controlled wind turbines with grid-controlled (multi-speed) asynchronous generators. If a speed range is given, the turbines are pitch-controlled and likely to come with synchronous or double feed induction asynchronous generators. Turbines with very low speed ranges are referred to as low-speed turbines.
The maximum tip speed can be calculated from the maximum rotor speed and the diameter. Tip speed crucially influences rotor noise. The higher the tip speed, the greater the aerodynamic losses and therefore noise emission.
The **type number of the rotor blades** can sometimes contain information on the profiles used. In most cases it simply indicates the **manufacturer** and the respective blade length.
If several blade models are given, it means that these turbines are available with different blades. The **material** of the rotor blades is also given: Glass reinforced plastics with epoxy resin (GRE) are common, but the more expensive carbon fibre reinforced plastic (CRP) is also used.
The aerodynamic performance of the rotor blades is critical for the overall efficiency of the wind turbine. Overall efficiency is denoted by the performance coefficient CP, which is indicated in the power curve for the wind speeds measured.

3 Nacelle

The **nacelle** incorporates the entire machine unit of the turbine. It is mounted on the tower so that it can rotate and therefore allow for yaw control. **Nacelle design** describes the concept chosen by the manufacturer for positioning the components of the drive train (rotor shaft with bearings, gearbox and generator) on the motor support. So-called „separated design“ indicates that all components are arranged separately. „Partially integrated“ or „integrated“ design means that several functions are combined in one component, for example the second bearing on the rotor shaft. The **gearbox** adjusts the rotor speed to the generator speed. This normally requires several stages, which are often achieved by spur wheel and/or planetary gears. If a specially developed high pole count ring generator with a large diameter is used, the gearbox may not be needed. **Generators** may be simple, robust multi-speed asynchronous generators which generally have fixed speeds and are connected directly to the electricity grid. They may also be generator systems which are operated at variable speeds. In case of variable speeds, both synchronous generators with full converters and double-feed asynchronous generators with semi-converters are used.
If **grid connection** is via converter, generator frequency is decoupled from the set grid frequency by a direct current intermediate circuit. Variable generator frequency enables variable rotor speed, which reduces loads on the rotor blades and the drive train. Another advantage of this type of grid connection is its better grid compatibility. In order to meet the rising standards of some grid operators, manufacturers also offer turbines with asynchronous generators with full converters.
In smaller wind turbines a synchronous generator is often used. Energy is fed into a battery via a rectifier / charge controller.

4 Control and protection system

Most rotors operate according to the lift principle, which means a blade profile facing the oncoming airflow and with

adjacent air flow in normal operation. Two basic principles are used for **power limitation**: power limitation via air flow separation on the rotor blade (stall effect) and movement of the rotor blade along its horizontal axis (pitch control).
In larger wind turbines some manufacturers also use so-called active stall control, where the stall effect is brought about by actively turning the rotor blade along its horizontal axis. Stall-controlled rotors are generally operated at two fixed speeds. Pitch-controlled rotors often work at variable speeds.
Certification guidelines for wind turbines stipulate two independent **brake systems**. One is normally an aerodynamic brake, such as blade-tip brakes activated by centrifugal force on stall-controlled wind turbines, or the active turning of the entire rotor blade on pitch-controlled wind turbines. If the rotor blades can be operated individually (so-called individual blade pitch), each blade counts as its own braking system, thereby securing the rotor. The other braking system is often a mechanical one, for example a disc brake.
Yaw control is ensured via several electric or hydraulic drive motors on the tower head. A wind vane mounted on the nacelle acts as a signal transmitter. In very small wind turbines yaw control can also be passive, for example using a large wind vane. The wind turbine is an automatic operating system. A monitoring system is attached to the operating control system for remote monitoring and remote control where necessary. This flags up operating faults and can also be used to call up operating data and parameters.
SCADA stands for Supervisory Control and Data Acquisition. There is considerable variation in the range of functions available with the SCADA systems on offer, both in terms of monitoring and control and the collection, storage and analysis of operating data.

5 Measurement results for power curve, sound power level and electrical characteristics

Where the manufacturer has submitted a measured **power curve** for a given turbine, the section „measurement results“ will contain a one-page summary of important test results obtained by accredited testing laboratories. Where available data are also provided on the **sound power level** and the measured **electrical characteristics**.

6 Tower

The growing power of wind turbines places increasing demands on **towers**, too. Higher **hub heights** are achieved by using increasingly higher towers. In case of large wind turbines, several metres may be between the construction height of towers (free-standing structures) and masts (supported structures) and the respective hub height. Only hub height is listed in the market overview since this is the relevant parameter for calculating energy yields. Selecting the appropriate hub height primarily depends on the wind conditions of the site and, more specifically, on the roughness of the terrain). Relevant information on this is provided in the wind analysis reports. In most cases greater hub heights are economically advantageous at inland locations with high roughness and corresponding turbulences.

The basic construction **types** for small wind turbines are supported tubular masts and tubular steel or reinforced concrete towers for large turbines. Lattice towers are also chosen for very large hub heights since they are lighter than tubular towers and can be transported more easily in segments. Although concrete towers are comparatively heavy and more expensive, they do keep down noise emission on account of their damping properties. Since the bottom segments of tubular towers have larger diameters, this can pose considerable logistical challenges when it comes to inland transport. Possible solutions include towers made from in-situ concrete or prefabricated sections, lattice towers or so-called hybrid towers where only the bottom sections are made of concrete and the upper sections of steel, for example.

7 Weight

Apart from the total weight of a turbine the weight of individual components is also important, in particular for transport and installation.

8 Type approval

Type approval is required to apply for building permission for a wind turbine. If this does not exist individual approval of comparable validity may need to be carried out.
Guidelines on how to carry out type approval can be obtained from the International Electric Committee (IEC) and the Deutsches Institut für Bautechnik (DIBt). In accordance with IEC 61400-1 there are four turbine classes (I to IV) for different environmental conditions with various turbulence intensities (a to c). The DIBt guidelines class installation sites according to three different wind zones (1 to 3).
The **survival wind speed** provides planners with an estimate of whether the turbine is suitable for the intended site. The month and year of testing may be significant in terms of which edition of the respective guidelines were used.

9 Reference energy yield

Reference energy yields are annual energy yields (kWh/a) calculated for the so-called reference site specified in the German Renewable Energy Sources Act (EEG). The reference site is characterised as follows: Average annual wind speed v = 5.5 metres per second (m/s) at 30 m above ground, frequency distribution of wind speed according to a Rayleigh distribution, i.e. a Weibull function with a form factor of k = 2 and a roughness length of z_0 = 0.1 m.
As a general rule the values given are the certified reference yields according to the guidelines of the German Association for the Promotion of Wind Energy (FGW). How to calculate these is shown in the FGW's Technical Guidelines 5 Rev. 02. Reference yield according to the FGW is defined as a five-year yield. In this market overview the five-year yields have been broken down into one-year yields.
A footnote indicates cases where the values presented are not certified reference yields but data provided by the manufacturer. These values provide for orientation only and cannot be used to calculate potential remuneration to be obtained from the German EEG. They should also not be used to determine economic viabilities. Binding reference yields are listed on the FGW homepage on www.wind-fgw.de.
Further information on reference yields and the resulting calculation of feed-in conditions is provided on the homepage of the German Wind Energy Association (www.wind-energie.de).

10 References

The number of turbines erected since this type was first installed gives some indication of the experience that has been gained with this turbine so far.

11 Special features and miscellaneous

Many turbines have other characteristics and special features which are listed in this section. These may include special lightning protection systems, ice sensors or condition monitoring systems (CMS).

E-48

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	800 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	48.0 m	Swept area	1.810 m²
Number of blades	3	Rotor speed	16–31 (variable) rpm
Type	E-48		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	16–31 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	4 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	50 m	55 m	60 m	76 m
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	steel tubular, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 1,878 First installation in: 2004			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

E-53

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	800 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	52.9 m	Swept area	2.198 m²
Number of blades	3	Rotor speed	11–29.5 (variable) rpm
Type	E-53		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	11–29.5 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	4 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	60 m	73 m		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation		
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 1,240 First installation in: 2006			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

E-44

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	900 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	44.0 m	Swept area	1.521 m²
Number of blades	3	Rotor speed	12–34 (variable) rpm
Type	E-44		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	12–34 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	4 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	45 m	55 m		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation		
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 563 First installation in: 2007			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

VENSYS 77

VENSYS Energy AG
Germany

POWER			
Rated power	1,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	76.84 m	Swept area	4.637 m^2
Number of blades	3	Rotor speed	9–17.3 rpm
Type	LM 37.3P		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	9–17.3 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	VENSYS Energy AG

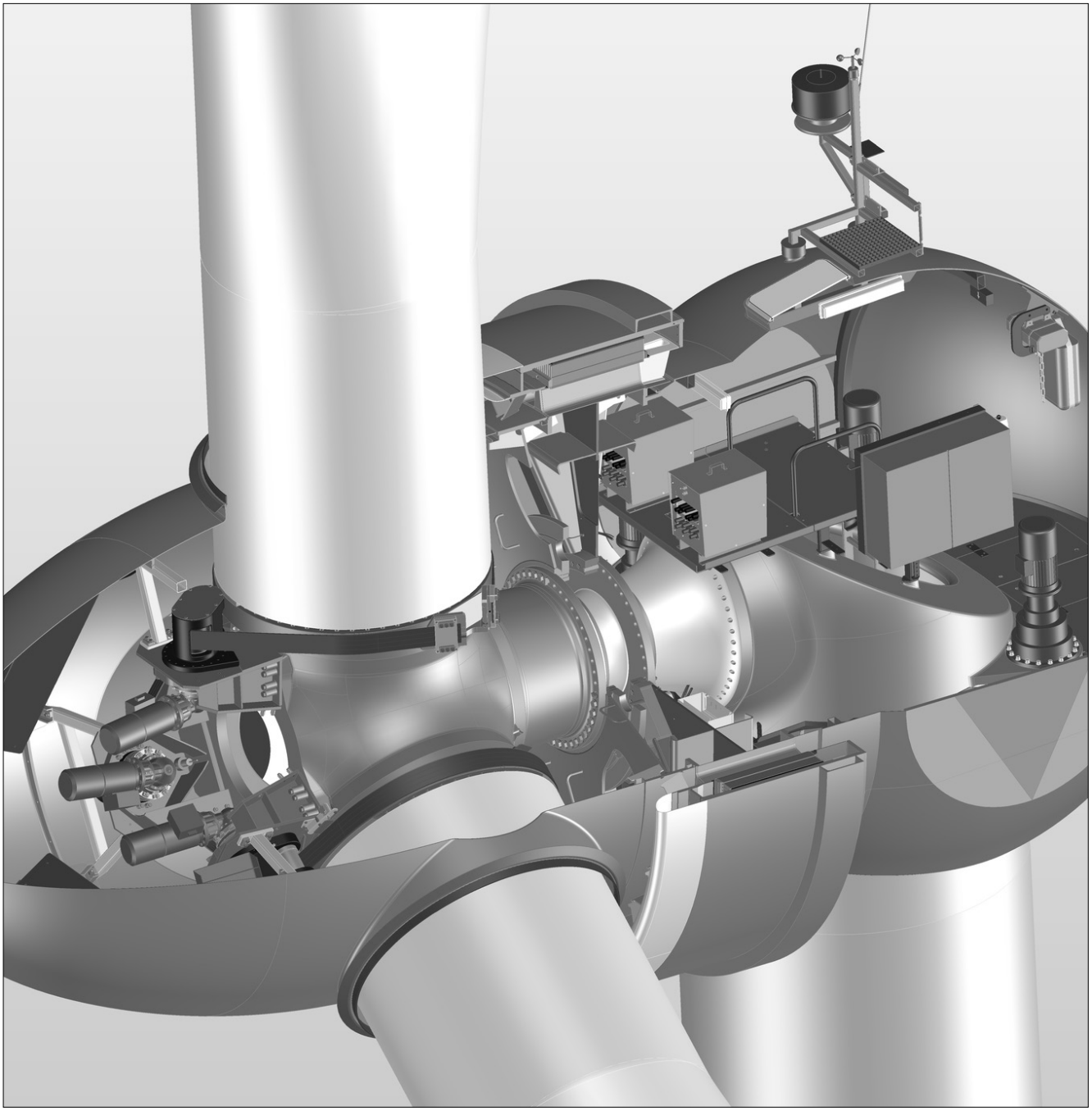
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor
Main break	individual blade pitch control
Second brake system	individual blade pitch control
Yaw control system	3 electric gear motor(s)
Manufacturer of control system	VENSYS Energy AG
SCADA-System	VENSYS SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	62 m	85 m	100 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt 3	IEC IIa/DIBt 3	IEC IIIa/DIBt 2	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	3,904,000 manufacturer information	4,293,000 manufacturer information	4,485,000 manufacturer information	
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	
REFERENCES 31/12/2012	Installed turbines worldwide: 1,019 First installation in: 01.05.07			
SPECIAL FEATURES	optional Eissensor			
MISCELLANEOUS				

VENSYS 77

Cross Section



VENSYS

VENSYS 82

VENSYS Energy AG
Germany

POWER			
Rated power	1,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.5 m/s	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	82.34 m	Swept area	5.325 m²
Number of blades	3	Rotor speed	9–17.3 rpm
Type	LM 40.3		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	9–17.3 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	VENSYS Energy AG

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor
Main break	individual blade pitch control
Second brake system	individual blade pitch control
Yaw control system	3 electric gear motor(s)
Manufacturer of control system	VENSYS Energy AG
SCADA-System	VENSYS SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	100 m			
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/DIBt 2	IEC IIIaDIBt 2		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	4,713,000 manufacturer information	4,840,000 manufacturer information		
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide: 218 First installation in: 2008			
SPECIAL FEATURES	optional Eissensor			
MISCELLANEOUS				

GE 1.6-100

GE Energy
Germany

POWER			
Rated power	1,600 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	11.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.854 m²
Number of blades	3	Rotor speed	9.75–16.2 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:111.5 (50Hz) 1:89 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	rpm	- Grid frequency	60 Hz
- Voltage	690 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM				
Power limitation	pitch			
Speed control	variable via microprocessor, active blade pitch control			
Main break	individual blade pitch control			
Second brake system	disk brake			
Yaw control system	4 electric gear motor(s)			
Manufacturer of control system				
SCADA-System				
POWER CURVE		**SOUND POWER LEVEL**		**ELECTRICAL CHARACTERISTICS**
view in measurement results		view in measurement results		view in measurement results
TOWER/HUB HEIGHT	**80 m**	**96 m**		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	65.0 t	65.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIb	IEC IIIb		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	manufacturer information	manufacturer information		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance		
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) WindRIDE-THRU« Anlagenbetriebssystem			
MISCELLANEOUS	- WindControl« Leistungsregelsystem–WindFREE« Reactive Power Blindleistungssystem–WindSCADA System–WindINERTIA Control			

GE 1.6-82.5

GE Energy
Germany

POWER			
Rated power	1,600 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	11.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	82.5 m	Swept area	5.346 m²
Number of blades	3	Rotor speed	17 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:107 (50Hz) 1:86 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
view in measurement results	view in measurement results	view in measurement results

TOWER/HUB HEIGHT	65 m	80 m		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	57.0 t	57.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	manufacturer information	manufacturer information		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance		
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) WindRIDE-THRU« Anlagenbetriebssystem			
MISCELLANEOUS	- WindControl« Leistungsregelsystem–WindFREE« Reactive Power Blindleistungssystem–WindSCADA System–WindINERTIA Control			

Senvion MM100

Senvion SE
Hamburg, Germany

POWER			
Rated power	1,800/2,000 kW (50/60 Hz)	Cut-in wind speed	3.0 m/s
Rated wind speed	10.5/11.0 m/s (50/60 Hz)	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.854 m²
Number of blades	3	Rotor speed	7.8–13.9 rpm
Type	diverse		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:103.7 (60Hz) 1:129.6 (50Hz)
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	720–1,440 rpm (60 Hz), 900–1,800 rpm (50 Hz)	- Grid frequency	50 / 60 Hz
- Voltage	575 V (60 Hz), 690 V (50 Hz)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	80 m (Offshore)	100 m (Onshore)		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	8.5 t			
Hub (incl. installed equipment)	17.5 t			
Rotor (incl. hub)	43.0 t			
Nacelle (without rotor & hub)	72.5 t	t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/up to			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years			
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse Options and service packages on request.			

E-82 E2

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	2,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	82.0 m	Swept area	5.281 m²
Number of blades	3	Rotor speed	6–18 (variable) rpm
Type	E-82 E2		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	6–18 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	78 m	85 m	98	108 m
Type / Shape	steel tubular, conical	steel tubularalternative: concrete tower, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	on request	on request	on request	on request
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 3.150 First installation in: 2005			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

eno 82

eno energy systems GmbH
Rostock, Germany

POWER			
Rated power	2,050 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	82.4 m	Swept area	5.333 m²
Number of blades	3	Rotor speed	7–17.9 rpm
Type	LM 40.0 P		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber		
NACELLE			
Design	semi-integrated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:96
- Manufacturer	Bosch Rexroth		
Generator / Type	synchronous		
- Number	1	- Grid connection	
- Speed	650–1,700 rpm	- Grid frequency	50 Hz
- Voltage	600 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	3 electric gear motor(s)
Manufacturer of control system	Bosch Rexroth
SCADA-System	eno energy

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	59 m	80 m	101 m	108 m
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	steel tubular, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade	6.3 t	6.3 t	6.3 t	6.3 t
Hub (incl. installed equipment)	18.5 t	18.5 t	18.5 t	18.5 t
Rotor (incl. hub)	37.4 t	37.4 t	37.4 t	37.4 t
Nacelle (without rotor & hub)	60.0 t	60.0 t	60.0 t	
Tower	62.3 t	124.3 t	254.7 t	213.0 t
Total weight	159.7 t	221.7 t	352.1 t	310.4 t
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC IIIa	DIBt 3/IEC IIa	DIBt 2/IEC IIIa	DIBt 2/IEC IIIa
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer
WARRANTY	2 years	2 years	2 years	2 years
REFERENCES 31/12/2012	Installed turbines worldwide: 30 First installation in: 01.03.08			
SPECIAL FEATURES	lightning protection system, ice sensor Condition Monitoring System as standard, shadow cast module, options on request			
MISCELLANEOUS				

Senvion MM82

Senvion SE
Hamburg, Germany

POWER			
Rated power	2,050 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	14.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	82.0 m	Swept area	5.281 m²
Number of blades	3	Rotor speed	8.5–17.1 rpm
Type	diverse		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:105.5 (50Hz) 1:83.3 (60Hz)
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	900–1,800 rpm (50 Hz) / 720–1,440 rpm (60 Hz)	- Grid frequency	50 / 60 Hz
- Voltage	690 V (50 Hz) / 575 V (60 Hz)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	59 m (Onshore)	69 m (Onshore)	80 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	6.4 t	6.4 t	6.4 t	
Hub (incl. installed equipment)	17.5	17.5	17.5 t	
Rotor (incl. hub)	36.0 t	36.0 t	36.0 t	
Nacelle (without rotor & hub)	69.0 t	69.0 t	69.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt 3	IEC Ia	IEC Ia/DIBt 3	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	4,611,421 manufacturer information		5,121,056 manufacturer information	
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	

REFERENCES 31/12/2012	Installed turbines worldwide: 1,883 First installation in: 01.05.03
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Optional: Cold Climate Version (CCV) and Hot Climate Option (HCO); Diverse country-specific grid connection solutions, e.g. EEG-package for Germany; Sound reduced operation modes
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse options and service packages on request.

eno 100

eno energy systems GmbH
Rostock, Germany

POWER			
Rated power	2,200 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.5 m	Swept area	7.933 m²
Number of blades	3	Rotor speed	5–14.2 rpm
Type	LM		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber		
NACELLE			
Design	semi-integrated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	4	- Ratio	1:111
- Manufacturer	Bosch Rexroth		
Generator / Type	synchronous		
- Number	1	- Grid connection	
- Speed	650–1650 rpm	- Grid frequency	50 Hz
- Voltage	600 V	- Manufacturer	

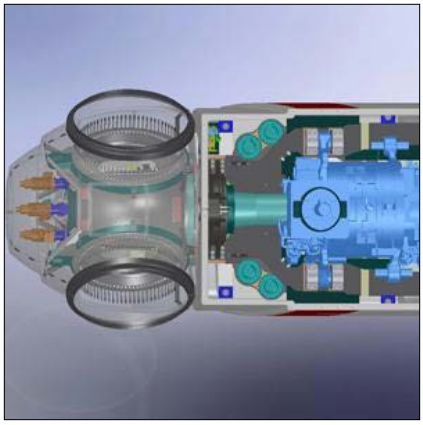
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bosch Rexroth
SCADA-System	eno energy

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	99 m			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade	8.7 t			
Hub (incl. installed equipment)	18.6 t			
Rotor (incl. hub)	43.0 t			
Nacelle (without rotor & hub)	67.0 t			
Tower	193.1			
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC IIIa			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer			
WARRANTY	2 years			
REFERENCES 31/12/2012	Installed turbines worldwide: 1 First installation in: 01.08.13			
SPECIAL FEATURES	lightning protection system, ice sensor Condition Monitoring System as standard, shadow cast module, options on request			
MISCELLANEOUS				

eno 92

eno energy systems GmbH
Rostock, Germany



POWER			
Rated power	2,200 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	92.8 m	Swept area	6.764 m²
Number of blades	3	Rotor speed	6–14.8 rpm
Type	LM 45.3 P		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber		
NACELLE			
Design	semi-integrated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	4	- Ratio	1:111
- Manufacturer	Bosch Rexroth		
Generator / Type	synchronous		
- Number	1	- Grid connection	
- Speed	650–1,650 rpm	- Grid frequency	50 Hz
- Voltage	600 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bosch Rexroth
SCADA-System	eno energy

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	103 m	123 m		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	8.1 t	8.1 t		
Hub (incl. installed equipment)	18.6 t	18.6 t		
Rotor (incl. hub)	43.0 t	43.0 t		
Nacelle (without rotor & hub)	67.0 t	67.0 t		
Tower	222.8 t	311.0 t		
Total weight	332.8 t	406.0 t		
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC IIIa	DIBt 2IEC IIIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide: 26 First installation in: 01.06.10			
SPECIAL FEATURES	lightning protection system, ice sensor Condition Monitoring System as standard, shadow cast module, options on request			
MISCELLANEOUS				

E-70

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	2,300 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	71.0 m	Swept area	3.959 m²
Number of blades	3	Rotor speed	6–21.5 (variable) rpm
Type	E-70		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	6–21.5 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	64 m	85 m	98 m	113 m
Type / Shape	steel tubular, conical	steel tubular, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 4.360 First installation in: 2003			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

AV 1010–2.3 MW

AVANTIS
Hamburg, Germany

POWER			
Rated power	2,300 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.2 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.6 m	Swept area	7.949 m²
Number of blades	3	Rotor speed	14 rpm
Type	AVANTIS		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	AVANTIS		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, permanent magnet Permanent magnets, synchronous		
- Number	1	- Grid connection	
- Speed	14 rpm	- Grid frequency	50 / 60 Hz, Converter (AC-DC-AC)
- Voltage	690 V	- Manufacturer	GDS

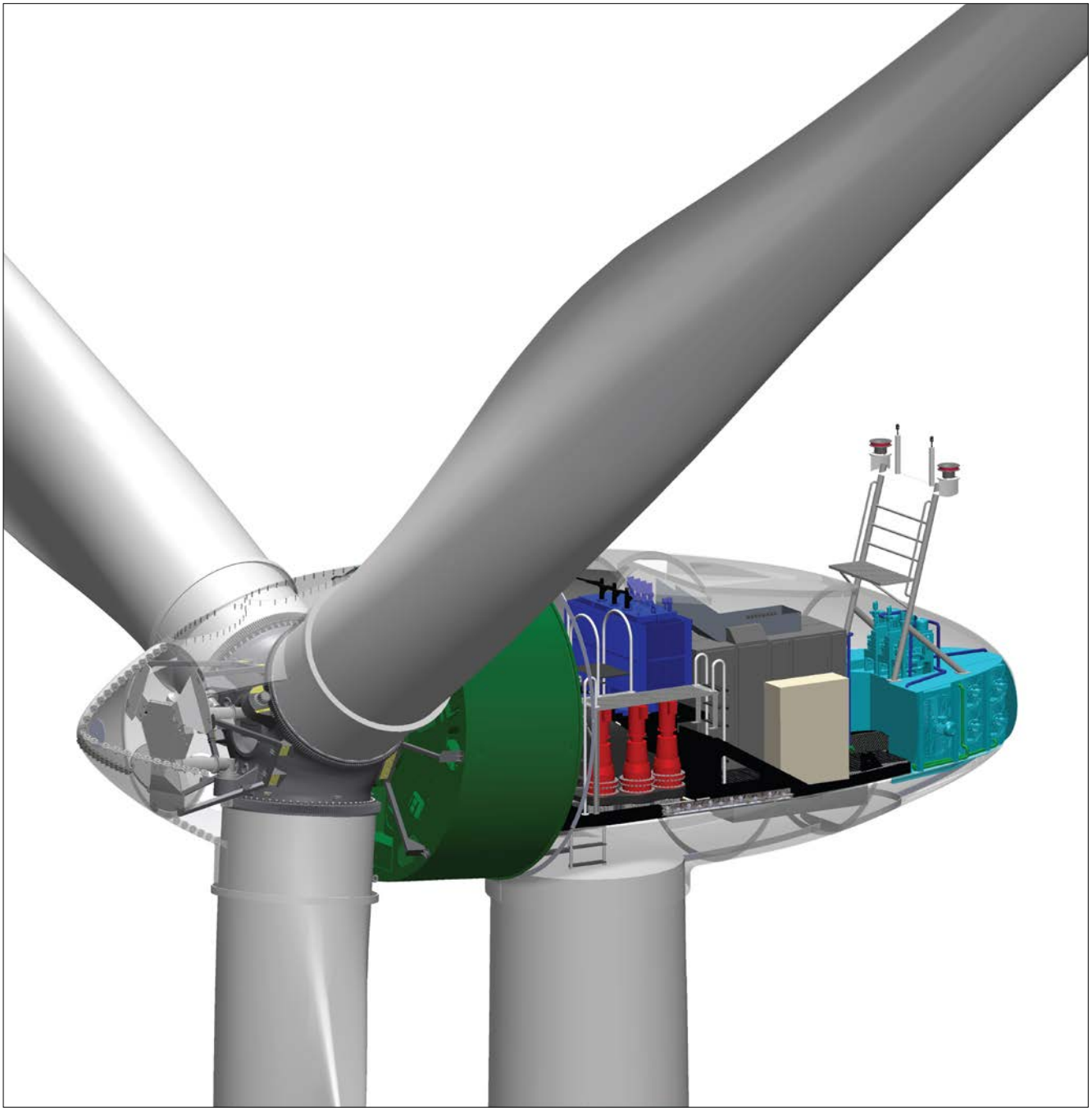
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Beckhoff
SCADA-System	SCADA international

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	99 m			
Type / Shape	steel tubular, conical			
Corrosion protection	coated			
WEIGHT				
Single blade	10,5 t			
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	75.0 t			
Tower	289.0 t			
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa			
Survival wind speed	53 m/s			
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

AV 1010 – 2.3 MW

Cross Section



AVANTIS Energy

E-82 E2

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	2,300 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	82.0 m	Swept area	5.281 m²
Number of blades	3	Rotor speed	6–18 (variable) rpm
Type	E-82 E2		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	6–18 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	78 m	85 m	98 m	108 m
Type / Shape	steel tubular, conical	steel tubular, alternative: concrete tower, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 2.021 First installation in: 2009			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

Senvion MM92

Senvion SE
Hamburg, Germany

POWER			
Rated power	2,300 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	92.5 m	Swept area	6.720 m²
Number of blades	3	Rotor speed	7.8–15.0 rpm
Type	diverse		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:120.0 (50Hz) 1:96.0 (60Hz)
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	900–1,800 rpm (50Hz) / 720–1,440 rpm (60Hz)	- Grid frequency	50 / 60 Hz
- Voltage	690 V (50Hz) / 575 V (60Hz)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	69 m (60 Hz)	80 m	100 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	7.9 t	7.9 t	7.9 t	
Hub (incl. installed equipment)	17.5 t	17.5 t	17.5 t	
Rotor (incl. hub)	40.7 t	40.7 t	40.7 t	
Nacelle (without rotor & hub)	69.0 t	69.0 t	69.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIa/DIBt 3	IEC IIa/DIBt 2	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)		6,035,857 manufacturer information	6,407,390 manufacturer information	
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	

REFERENCES 31/12/2012	Installed turbines worldwide: 1,883 First installation in: 01.08.05
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Optional: Cold Climate Version (CCV) and Hot Climate Option (HCO); Diverse country-specific grid connection solutions, e.g. EEG-package for Germany; Sound reduced operation modes
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse Options and service packages on request.

Siemens SWT-2.3-108

Siemens Wind Power
Hamburg

POWER			
Rated power	2,300 kW	Cut-in wind speed	3 -4 m/s
Rated wind speed	11–12 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	108.0 m	Swept area	9.161 m²
Number of blades	3	Rotor speed	6–16 rpm
Type	B53		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	0
- Manufacturer	Winergy / Hansen		
Generator / Type	asynchronous		
- Number	1	- Grid connection	via converter
- Speed	600–1,800 rpm	- Grid frequency	50 Hz
- Voltage	750 V at 1,550 rpm	- Manufacturer	ABB, Loher

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	KK-Electronic A/S
SCADA-System	WPS

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	80 m	100 m	115 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	82.0 t	82.0 t	82.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIB	IEC IIB	IEC IIB	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	
WARRANTY	5 years	5 years	5 years	
REFERENCES 31/12/2012	Installed turbines worldwide: 692 First installation in: 2009			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

E-92

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	2,350 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	92.0 m	Swept area	6.648 m²
Number of blades	3	Rotor speed	5–16 (variable) rpm
Type	E-92		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer			
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	5–16 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	78 m	85 m	98 m	108 m
Type / Shape	steel tubular, conical	steel tubular, alternative: concrete tower, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 43 First installation in: 2012			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

Nordex N117/2400 IEC 3a

Nordex SE
Hamburg, Germany

POWER			
Rated power	2,400 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.5 m/s	Cut-out wind speed	20.0 m/s
ROTOR			
Diameter	117.0 m	Swept area	10.715 m²
Number of blades	3	Rotor speed	7,5 –13,2 rpm
Type	NR 58.5		
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	Nordex		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages		- Ratio	
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	740–1300 (50Hz) / 890–1560 (60Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	660 ± 10% V	- Manufacturer	Several

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	Nordex

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	91 m	120 m	141 m	
Type / Shape	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	concrete tower, hybrid tower, combined concrete/tubular steel tower, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	on request	on request	on request	
Hub (incl. installed equipment)	on request	on request	on request	
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC 3a	DIBt 2/IEC 3a	DIBt 2/IEC 3a	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	43.382.894 manufacturer information	46.050.220 manufacturer information	47.476.185 manufacturer information	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 145 First installation in: 01.12.11			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Nordex Anti Icing System; Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific Ma			
MISCELLANEOUS				

AV 928–2.5 MW

AVANTIS
Hamburg, Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.6 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	93.2 m	Swept area	6.822 m²
Number of blades	3	Rotor speed	16 rpm
Type	AVANTIS AB 92		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	AVANTIS		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, permanent magnet Permanent magnets, synchronous		
- Number	1	- Grid connection	
- Speed	16 rpm	- Grid frequency	50 / 60 Hz, Converter (AC-DC-AC)
- Voltage	690 V	- Manufacturer	GDS

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	5 electric gear motor(s)
Manufacturer of control system	Beckhoff
SCADA-System	SCADA international

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	80 m	99 m		
Type / Shape		steel tubular, conical	steel tubular, conical	
Corrosion protection		coated	coated	
WEIGHT				
Single blade		9.8 t	t	
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	75.0 t	75.0 t		
Tower	170.0 t	359.0 t		
Total weight				
TYPE APPROVAL				
Guideline, Class		IEC IIa	IEC IIa	
Survival wind speed	60 m/s	60 m/s		
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 20 First installation in: 01.05.09			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	WTG uses the state-of-the-art technology for wind speeds up to 70 m/s.			

GE 2.5-100

GE Energy
Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.854 m^2
Number of blades	3	Rotor speed	14.1 (rated power) rpm
Type	GE48.7/ LM 487		
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:111.5 (50Hz) 1:89 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	1.500 (rated speed) rpm	- Grid frequency	50 / 60 Hz
- Voltage	6kV/690V V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	75 m	85 m	98 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIb	IEC IIb/DIBt	IEC IIIa/DIBt	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)			36.192 MWh according to FGW	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide: >1000 First installation in: 01.08.06
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) WindRIDE-THRU« Anlagenbetriebssystem
MISCELLANEOUS	- WindControl« Leistungsregelsystem–WindFREE« Reactive Power Blindleistungssystem–WindSCADA System–WindINERTIA Control

Nordex N100/2500 IEC 2a

Nordex SE
Hamburg, Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.823 m²
Number of blades	3	Rotor speed	9.6–14.9 rpm
Type	NR 50, LM 48.8		
Material	glas-fibre reinforced plastic		
Manufacturer	Nordex, LM		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	3	- Ratio	1:77.4 (50Hz) 1:92.9 (60Hz)
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	740–1,300 (50 Hz) / 890–1,560 (60 Hz) rpm	- Grid frequency	50 / 60 Hz via IGBT-converter
- Voltage	660 ± 10% V	- Manufacturer	Several

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	100 m	80 m	75 m	
Type / Shape	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	on request	on request	on request	
Hub (incl. installed equipment)	on request	on request	on request	
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIa	IEC IIa	
Survival wind speed				
Tested (month/year)	01.04.11	01.03.12	01.03.12	
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 790 N100/2500 First installation in: 01.03.08			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Nordex Anti Icing System; Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific Ma			
MISCELLANEOUS				

Nordex N90/2500 IEC 1a

Nordex SE
Hamburg, Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	90.0 m	Swept area	6.362 m²
Number of blades	3	Rotor speed	10.3–18.1 rpm
Type	NR 45, LM 43.8		
Material	glas-fibre reinforced plastic		
Manufacturer	Nordex, LM		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	3	- Ratio	1:71.9 (50Hz) 1:86.3 (60Hz)
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	740–1,300 rpm	- Grid frequency	50 / 60 Hz
- Voltage	660 ± 10% V	- Manufacturer	Several

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	3 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	65 m	80 m	70 m	
Type / Shape	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	on request	on request	on request	
Hub (incl. installed equipment)	on request	on request	on request	
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	IEC Ia	IEC Ia	IEC Ia	
Survival wind speed				
Tested (month/year)	01.02.12	01.12.11	01.04.13	
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 1117 N90/2500 First installation in: 01.02.06			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific Markings; Further Options on			
MISCELLANEOUS				

VENSYS 100

VENSYS Energy AG
Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	99.8 m	Swept area	7.823 m²
Number of blades	3	Rotor speed	6.5–14.5 rpm
Type	LM 48.8		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	6.5–14.5 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	VENSYS Energy AG

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor
Main break	individual blade pitch control
Second brake system	individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	VENSYS Energy AG
SCADA-System	VENSYS SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	100 m			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/DIBt 2			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	7,289,000 manufacturer information			
SCOPE OF SUPPLY				
WARRANTY	2 years			
REFERENCES 31/12/2012	Installed turbines worldwide: 1 First installation in: 2009			
SPECIAL FEATURES				
MISCELLANEOUS				

Vensys 109

VENSYS Energy AG
Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	10.0 –12.5 m/s	Cut-out wind speed	30.0 m/s
ROTOR			
Diameter	109.0 m	Swept area	9.331 m²
Number of blades	3	Rotor speed	6.5–14.0 rpm
Type	LM 53.2		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber a/s		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator, permanent magnet		
- Number		- Grid connection	via converter
- Speed	6.5–14.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	VENSYS Energy AG

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor
Main break	individual blade pitch control
Second brake system	individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	145 m			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/Dibt 3			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	ice sensor			
MISCELLANEOUS				

Vensys 112

VENSYS Energy AG
Deutschland

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	10 –11.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	112.5 m	Swept area	9.940 m²
Number of blades	3	Rotor speed	6.5–13.6 rpm
Type	SI 55		
Material	glas-fibre reinforced plastic		
Manufacturer	LM Glasfiber a/s		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator, permanent magnet		
- Number		- Grid connection	via converter
- Speed		- Grid frequency	50 / 60 Hz
- Voltage		- Manufacturer	

CONTROL- AND PROTECTION SYSTEM				
Power limitation	pitch			
Speed control	variable via microprocessor			
Main break	individual blade pitch control			
Second brake system	individual blade pitch control			
Yaw control system	4 electric gear motor(s)			
Manufacturer of control system				
SCADA-System				
POWER CURVE		**SOUND POWER LEVEL**		**ELECTRICAL CHARACTERISTICS**
on request		on request		on request
TOWER/HUB HEIGHT	**143 m (Onshore)**			
Type / Shape	steel tubular, hybrid, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/ICE IIIa			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years			
REFERENCES 31/12/2012				
SPECIAL FEATURES	ice sensor			
MISCELLANEOUS				

GE 2.5-103

GE Energy
Germany

POWER			
Rated power	2,530 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	103.0 m	Swept area	8.332 m²
Number of blades	3	Rotor speed	4.7-13.7 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:111.5 (50Hz) 1:89 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed	1.500 rpm	- Grid frequency	50 / 60 Hz
- Voltage	6kV/690 V V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	GE WindSCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	85 m	98 m		
Type / Shape	steel tubular, conical	steel tubular, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	82.0 t	82.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIb	IEC IIIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	manufacturer information	manufacturer information		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer		
WARRANTY				
REFERENCES 31/12/2012	2009			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	- WindControl« Powermanagement System–WindFREE« Reactive Power System–WindSCADA System–WindINERTIA Control–WindRIDE-THRU« System			

GE 2.5-120

GE Energy
Germany

POWER			
Rated power	2,530 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	120.0 m	Swept area	11.310 m²
Number of blades	3	Rotor speed	5-13 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed	1.500 rpm	- Grid frequency	50 / 60 Hz
- Voltage	6kV/690V V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	110 m	139 m	120 m	
Type / Shape	steel tubular, conical	customisedhybrid pre-cast concrete/steel tower, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	82.0 t	82.0 t	82.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIb/DiBt 2	DiBt 2/IEC III	DiBt 2	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance, foundation	delivery, erection, remote data control, maintenance, transformer	
WARRANTY				
REFERENCES 31/12/2012	2013			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	- WindControl« Powermanagement–WindFREE« Reactive Power System–WindSCADA System–WindINERTIA Control–WindRIDE-THRU« System			

GE 2.85-100

GE Energy
Germany

POWER			
Rated power	2,850 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.854 m²
Number of blades	3	Rotor speed	4.7-14.8 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:111.5 (50Hz) 1:89 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed		- Grid frequency	50 / 60 Hz
- Voltage	6kV/690 V V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	GE WindSCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	75 m	85 m	98 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	82.0 t	82.0 t	82.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIb	IEC IIb	IEC IIIa	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	manufacturer information	manufacturer information	manufacturer information	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	- WindControl« Leistungsregelsystem–WindFREE« Reactive Power System–WindSCADA System–WindINERTIA Control -WindRIDE-THRU« System Can be operated with 2.75MW rated power.			

GE 2.85-103

GE Energy
Germany

POWER			
Rated power	2,850 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	103.0 m	Swept area	8.332 m²
Number of blades	3	Rotor speed	4.7-14.8 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:111.5 (50Hz) 1:89 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed		- Grid frequency	50 / 60 Hz
- Voltage	6kV/690 V V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	GE WindSCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	85 m	98 m	124 m	
Type / Shape	steel tubular, conical	steel tubular, conical	concrete towerhybrid concrete/ steelconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	85.0 t	85.0 t	85.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIb	IEC IIb	IEC IIIa	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	manufacturer information	manufacturer information		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	- WindControl« Powermanagement System–WindFREE« Reactive Power System–WindSCADA System–WindINERTIA Control–WindRIDE-THRU« System			

E-115

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	115.0 m	Swept area	10.387 m²
Number of blades	3	Rotor speed	4–12.8 (variable) rpm
Type	E-115		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer			
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	4–12.8 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	12 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	149 m			
Type / Shape	concrete tower, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request			
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation			
WARRANTY				
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

E-82 E3

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	82.0 m	Swept area	5.281 m²
Number of blades	3	Rotor speed	6–18 (variable) rpm
Type	E-82 E3		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer			
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	6–18 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	78 m	85 m	98 m	108 m
Type / Shape	steel tubular, conical	steel tubular, alternative: concrete tower, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 195 First installation in: 2010			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

E-82 E4

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	82.0 m	Swept area	5.281 m²
Number of blades	3	Rotor speed	6–18 (variable) rpm
Type	E-82 E4		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer			
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	6–18 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	6 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	78 m	84 m		
Type / Shape	steel tubular, conical	concrete tower, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation		
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: (see E-82 E3) First installation in: 2012			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

Nordex N117/3000 IEC 2a

Nordex SE
Hamburg, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	
ROTOR			
Diameter	m	Swept area	10.715 m²
Number of blades	3	Rotor speed	8.0–14.1 rpm
Type	NR58.5		
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	Nordex		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:92 (50Hz) 1:111 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	700–1,300 (50 Hz) / 840–1,560 (60 Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	660 V V	- Manufacturer	Several

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	91 m	120 m	141 m	
Type / Shape	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	concrete tower, hybrid tower, combined concrete/tubular steel tower, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	on request	on request	on request	
Hub (incl. installed equipment)	on request	on request	on request	
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	IEC IIa/DiBt 3	IEC IIa/DIBt 2	IEC IIIa/DIBt 2	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				

REFERENCES 31/12/2012	**Installed turbines worldwide:** 5 **First installation in:** 01.07.13
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Nordex Anti Icing System; Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific
MISCELLANEOUS	

Nordex N131/3000 IEC 3a

Nordex SE
Hamburg, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.1 m/s	Cut-out wind speed	20.0 m/s
ROTOR			
Diameter	131.0 m	Swept area	13.478 m²
Number of blades	3	Rotor speed	6.5–11.6 rpm
Type	NR 65.5		
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	Nordex		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:113 (50Hz) 1:135.5 (60Hz)
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number		- Grid connection	via converter
- Speed	730–1,315 rpm (50 Hz) / 876–1,578 rpm (60 Hz)	- Grid frequency	50 / 60 Hz
- Voltage	660 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	99 m	114 m	134 m	
Type / Shape	steel tubular, cylindrical, top segment conical	steel tubular, cylindrical, top segment conical	concrete tower, hybrid tower, combined concrete / tubular steel tower, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	on request	on request	on request	
Hub (incl. installed equipment)	on request	on request	on request	
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	IEC IIIa/DIBt 2	IEC IIIa/DIBt 2	DIBt 2	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	
WARRANTY				
REFERENCES 31/12/2012	Q4/2014			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Nordex Anti Icing System; Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific			
MISCELLANEOUS				

Senvion 3.0M122

Senvion SE
Hamburg, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.5 m/s	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	122.0 m	Swept area	11.690 m²
Number of blades	3	Rotor speed	11 rpm
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:106.6
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	650–1,200 U rpm	- Grid frequency	50 Hz
- Voltage	950 V (stator)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	139 m			
Type / Shape	concrete tower, hybrid tower, conical, steel/concrete			
Corrosion protection	multi-coated			
WEIGHT				
Single blade	approx. 15.0 t			
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 68.0 t			
Nacelle (without rotor & hub)	approx. 104.0 t			
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/DIBt WZ3			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years			
REFERENCES 31/12/2012	2013 (Prototype)			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) permanent yaw lubrication system, divers country-specific grid connection solutions, e.g. EEG-package for Germany			
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control (?fail-safe? design). Divers options and service packages on request. Tower heights are effective hub heights. Hub heigth can be modified by changing the foundation.			

Siemens SWT-3.0-101

Siemens Wind Power
Hamburg

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12 -13 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	101.0 m	Swept area	8.012 m²
Number of blades	3	Rotor speed	6-16 rpm
Type	B49		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, permanent magnet		
- Number		- Grid connection	via converter
- Speed		- Grid frequency	50 / 60 Hz
- Voltage	750 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	80 m	90 m	100 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	77.0 t	77.0 t	77.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt WZ3 (2004)	IEC IIa	IEC Ia/DIBt WZ3 (2004)	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	
WARRANTY	5 years	5 years	5 years	
REFERENCES 31/12/2012	Installed turbines worldwide: 172 First installation in: 2009			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

Siemens SWT-3.0-113

Siemens Wind Power
Hamburg

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12 -13 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	113.0 m	Swept area	10.029 m²
Number of blades	3	Rotor speed	6-14 rpm
Type	B55		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, permanent magnet		
- Number		- Grid connection	
- Speed		- Grid frequency	50 / 60 Hz
- Voltage	750 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	
Main break	
Second brake system	hydraulic fail-safe disk brake
Yaw control system	8
Manufacturer of control system	KK-Electonric A/S
SCADA-System	WPS

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	92 m	79 m	122 m	142 m
Type / Shape	steel tubular, conical	steel tubular, conical	steel shell tower, conical	steel shell tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	77.0 t	77.0 t	77.0 t	77.0 t
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt WZ3 (2012)	IEC IIa	IEC IIa/DIBt WZ3 (2012)	IEC IIa/DIBt WZ3 (2012)
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance	delivery, maintenance, transformer, foundation
WARRANTY	5 years	5 years	5 years	5 years
REFERENCES 31/12/2012	Installed turbines worldwide: 7 First installation in: 2013			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

E-101

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	3,050 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	101.0 m	Swept area	8.012 m²
Number of blades	3	Rotor speed	4–14.5 (variable) rpm
Type	E-101		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	4–14.5 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch controlrotor brake and rotor lock
Yaw control system	12 electric gear motor(s)active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	99 m	124	135 m	149 m
Type / Shape	concrete tower, conical	concrete tower, conical	concrete tower, conical	concrete tower, conical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade	t			
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request	on request	on request
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 371 First installation in: 2010			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

Senvion 3.2M114

Senvion SE
Hamburg, Germany

POWER			
Rated power	3,200 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	22.0 m/s
ROTOR			
Diameter	114.0 m	Swept area	10.207 m²
Number of blades	3	Rotor speed	approx. 12.6 rpm
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:99.5
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	640–1,200 rpm	- Grid frequency	50 Hz
- Voltage	950 V (stator)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	diverse
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	93 m	123 m	143 m	
Type / Shape	steel tubular,conical	concrete tower, hybrid tower concrete-steel, conical	concrete tower, hybrid tower concrete-steel, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	approx. 15.0 t	approx. 15.0 t	approx. 15.0 t	
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 68.0 t	approx. 68.0 t	approx. 68.0 t	
Nacelle (without rotor & hub)	approx. 104.0 t	approx. 104.0 t	approx. 104.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/DIBt WZ3	IEC IIIa/DIBt WZ3	IEC IIIa/DIBt WZ3	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	

REFERENCES 31/12/2012	First installation in: 01.12.11
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) permanent yaw lubrication system, divers country-specific grid connection solutions, e.g. EEG-package for Germany
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control ("fail-safe" design). Divers options and service packages on request. Tower heights are effective hub heights. Hub heigth can be modified by changing the foundation.

Nordex N100/3300 IEC1a

Nordex SE
Hamburg, Germany

POWER			
Rated power	3,300 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	14.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	100.0 m	Swept area	7.823 m²
Number of blades	3	Rotor speed	9.0–16.1 rpm
Type	NR 50		
Material	glas-fibre reinforced plastic		
Manufacturer	Nordex		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:81 (50Hz) 1:97 (60Hz)
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	700–1,300 rpm (50 Hz) / 840–1,560 rpm (60 Hz)	- Grid frequency	50 / 60 Hz
- Voltage	660 V V	- Manufacturer	Several

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	
SCADA-System	

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	75 m	100 m		
Type / Shape	steel tubularcylindrical	steel tubularcylindrical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	on request	on request		
Hub (incl. installed equipment)	on request	on request		
Rotor (incl. hub)	on request	on request	on request	
Nacelle (without rotor & hub)	on request	on request	on request	
Tower	on request	on request	on request	
Total weight	on request	on request	on request	
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt 3	IEC Ia/DIBt 3		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request	on request		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation	delivery, erection, remote data control, maintenance, transformer, foundation		
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 2 First installation in: 01.07.13			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Nordex Anti Icing System; Drive Train Condition Monitoring System (CMS); Ice Detection; Fire Detection- and Extinguishing System; Burglar Alarm; Bat Protection Module; Shadow Flicker Protection Module; Radar Friendly System Operation; Customer Specific			
MISCELLANEOUS				

Senvion 3.4M104

Senvion SE
Hamburg, Germany

POWER			
Rated power	3,400 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	13.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	104.0 m	Swept area	8.495 m²
Number of blades	3	Rotor speed	7.1–13.8 rpm
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	diverse		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:87
- Manufacturer	diverse		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	600–1,200 rpm	- Grid frequency	50 Hz
- Voltage	950 V (stator voltage)	- Manufacturer	diverse

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	divers
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	80 m	93 m	100 m	
Type / Shape	steel tubular, conical	steel tubular, conical	steel tubular, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	ca. 11.0 t	ca. 11.0 t	ca. 11.0 t	
Hub (incl. installed equipment)				
Rotor (incl. hub)	ca. 56.0 t	ca. 56.0 t	ca. 56.0 t	
Nacelle (without rotor & hub)	approx. 104.0 t	approx. 104.0 t	approx. 104.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib/DIBt 4	IEC Ib	IEC IIa/DIBt 4	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	
REFERENCES 31/12/2012	Installed turbines worldwide: 48 First installation in: 01.01.09			
SPECIAL FEATURES	lightning protection system, condition monitoring system (CMS) Permanent yaw lubrication system, divers country-specific grid connection solutions, e.g. EEG-package for Germany; Sound-reduced operation modes			
MISCELLANEOUS	Gear box: acc. to Senvion gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse options and service packages on request. Tower heights are effective hub heights. Hub height can be modified by changing the foundation.			

eno 114

eno energy systems GmbH
Rostock, Germany

POWER			
Rated power	3,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	114.9 m	Swept area	10.369 m²
Number of blades	3	Rotor speed	4–13.2 rpm
Type	eno energy		
Material	glas-fibre reinforced plastic		
Manufacturer	eno energy systems GmbH		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	3	- Ratio	1:119
- Manufacturer	Winergy, Eickhoff		
Generator / Type	synchronous		
- Number	1	- Grid connection	
- Speed	480–1410 rpm	- Grid frequency	50 Hz
- Voltage	600 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Schaefer
SCADA-System	eno energy

POWER CURVE	**SOUND POWER LEVEL**	**ELECTRICAL CHARACTERISTICS**
on request	on request	on request

TOWER/HUB HEIGHT	**127 m**	**142 m**	**92 m**	
Type / Shape	customised steel tube, conical	customised concrete-steel hybrid, conical	customised steel tube, conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)	33.0 t	33.0 t	33.0 t	
Rotor (incl. hub)	77.1 t	77.1 t	77.1 t	
Nacelle (without rotor & hub)	67.0 t	67.0 t	67.0 t	
Tower	444.2	425.0 t	255.0 t	
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 3/IEC IIs	DIBt 3/IEC IIs	DIBt 3/IEC IIs	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer	
WARRANTY	2 years	2 years	2 years	
REFERENCES 31/12/2012	Installed turbines worldwide: 1 First installation in: 01.12.13			
SPECIAL FEATURES	lightning protection system, ice sensor Condition Monitoring System as standard, shadow cast module, options on request			
MISCELLANEOUS				

eno 126

eno energy systems GmbH
Rostock, Deutschland

POWER			
Rated power	3,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	13.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	126.0 m	Swept area	12.469 m²
Number of blades	3	Rotor speed	4–12.8 rpm
Type			
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	eno energy systems GmbH		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:119
- Manufacturer	Winergy, Eickhoff		
Generator / Type	synchronous		
- Number	1	- Grid connection	
- Speed	470–1360 rpm	- Grid frequency	50 Hz
- Voltage	800 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Schafer
SCADA-System	eno energy systems GmbH

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	117 m	137 m		
Type / Shape	01.12.13	customised concrete-steel hybrid, conical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)	33.0 t	33.0 t		
Rotor (incl. hub)	75.0 t	75.0 t		
Nacelle (without rotor & hub)	115.0 t	115.0 t		
Tower	412.6 t			
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC IIIs	DIBt 2/IEC IIIs		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer	delivery, erection, remote data control, maintenance, transformer		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor Condition Monitoring System as standard, shadow cast module, options on request			
MISCELLANEOUS				

Siemens SWT-3.6-120

Siemens Wind Power
Hamburg

POWER			
Rated power	3,600 kW	Cut-in wind speed	3-5 m/s
Rated wind speed	12 -13 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	120.0 m	Swept area	11.310 m²
Number of blades	3	Rotor speed	5–14 rpm
Type	B58		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:119
- Manufacturer	Winergy		
Generator / Type	asynchronous		
- Number	1	- Grid connection	via converter
- Speed	500–1,550 rpm	- Grid frequency	60 Hz
- Voltage	750 V at 1,550 rpm	- Manufacturer	ABB

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	KK-Electronic A/S
SCADA-System	WPS

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	90 m			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	140.0 t			
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt WZ 3 (2004)			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance			
WARRANTY	5 years			
REFERENCES 31/12/2012	Installed turbines worldwide: 435 First installation in: 2009			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	Wind turbine also available with 107 m rotor diameter. References: SWT-3.6-107 = 454, SWT-3.6-120 = 74 (as of Oct 2012).			

Siemens SWT-4.0-130

Siemens Wind Power
Hamburg

POWER			
Rated power	4,000 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	
ROTOR			
Diameter	130.0 m	Swept area	13.273 m²
Number of blades	3	Rotor speed	5-14 rpm
Type	B 63		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages		- Ratio	1:119
- Manufacturer	Winergy		
Generator / Type	asynchronous		
- Number	1	- Grid connection	via converter
- Speed	600–1.800 rpm	- Grid frequency	50 Hz
- Voltage	750 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM				
Power limitation	pitch			
Speed control				
Main break	individual blade pitch control			
Second brake system	hydraulic fail-safe disk brake			
Yaw control system	electric gear motor(s)			
Manufacturer of control system	KK-Electronic A/S			
SCADA-System	WPS			
POWER CURVE		**SOUND POWER LEVEL**		**ELECTRICAL CHARACTERISTICS**
on request		on request		on request
TOWER/HUB HEIGHT				
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	140.0 t			
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib/pending			
Survival wind speed				
Tested (month/year)	pending			
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, foundation			
WARRANTY	5 years			
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

Multibrid M5000

AREVA Wind GmbH
Bremerhaven, Germany

POWER			
Rated power	5,000 kW	Cut-in wind speed	4.0 m/s
Rated wind speed	12.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	116.0 m	Swept area	10.568 m²
Number of blades	3	Rotor speed	5.9–14.8 ± 10% rpm
Type			
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	AREVA Blades		
NACELLE			
Design	integrated		
Gear box / Type	planetary, One-step-planetary gear, helical		
- Stages	1	- Ratio	1:10
- Manufacturer	RENK AG		
Generator / Type	synchronous, permanent magnet, liquid-cooled		
- Number	1	- Grid connection	
- Speed	45.1–148.5 rpm	- Grid frequency	50 Hz
- Voltage	3.300 V	- Manufacturer	ABB / CONVERTEAM

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	redundant blade pitch control
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	Beckhoff
SCADA-System	AREVA Wind GmbH

POWER CURVE		SOUND POWER LEVEL		ELECTRICAL CHARACTERISTICS
TOWER/HUB HEIGHT	**90 m**			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade	16.5 t			
Hub (incl. installed equipment)	62.0 t			
Rotor (incl. hub)	112.0 t			
Nacelle (without rotor & hub)	233.0 t			
Tower	350.0 t			
Total weight	757.0 t			
TYPE APPROVAL				
Guideline, Class	GL TK 1			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 10 First installation in: 01.12.04			
SPECIAL FEATURES	lightning protection system, condition monitoring system (CMS) for drive train and rotor blades			
MISCELLANEOUS	Individual electrical blade pitch control (fail safe design). Tower height (offshore) denotes tower height above LAT. Redundant Systems.			

Siemens SWT-6.0-154

Siemens Wind Power
Hamburg

POWER			
Rated power	6,000 kW	Cut-in wind speed	3–5 m/s
Rated wind speed	12–14 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	154.0 m	Swept area	18.627 m²
Number of blades	3	Rotor speed	5–11 rpm
Type	B75		
Material			
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed		- Grid frequency	50 Hz
- Voltage	750 V	- Manufacturer	

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	10 electric gear motor(s)
Manufacturer of control system	KK-Electronic A/S
SCADA-System	WPS

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	120 m (Onshore)			
Type / Shape	steel tubular, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt WZ3 (2004), both pending			
Survival wind speed				
Tested (month/year)	pending			
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 2 First installation in: 2011			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

Senvion 6.2M126

Senvion SE
Hamburg, Germany

POWER			
Rated power	6,150 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	14.5 m/s (Onshore) / 14.0 m/s (Offshore)	Cut-out wind speed	25.0 m/s (Onshore) / 30.0 m/s (Offshore)
ROTOR			
Diameter	126.0 m	Swept area	12.469 m^2
Number of blades	3	Rotor speed	12.1 rpm (at rated power)
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	LM Glasfiber, PowerBlades		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:87
- Manufacturer	Winergy AG, ZF Wind Power		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	750–1,170 rpm	- Grid frequency	50 Hz
- Voltage	660 / 6,600 V	- Manufacturer	VEM

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control, individual blade pitch control
Second brake system	disk brake
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	Bonfiglioli
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	95 m	117 m		
Type / Shape	steel tubular, cylindrical	steel tubular, cylindrical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	20.0–23.0 t	20.0–23.0 t		
Hub (incl. installed equipment)	71.0 t	71.0 t		
Rotor (incl. hub)	130.0–135.0 t	130.0–135.0 t		
Nacelle (without rotor & hub)	325.0 t	325.0 t		
Tower	site specific	site specific		
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib/S-Classes	DIBt WZ4		
Survival wind speed	70 m/s	60 m/s		
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 55 First installation in: 01.03.09			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) fire detection and extinguishing system, oil particle counter			
MISCELLANEOUS	Offshore tower height is site-specific with a hub height of 85.0 to 95.0 m.			

Senvion 6.2M152

Senvion SE
Hamburg, Deutschland

POWER			
Rated power	6,150 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	12.0 m/s (Onshore) / 11.5 m/s (Offshore)	Cut-out wind speed	25.0 m/s (Onshore) / 30.0 m/s (Offshore)
ROTOR			
Diameter	152.0 m	Swept area	18.146 m²
Number of blades	3	Rotor speed	10.1 rpm (at rated power)
Type			
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	PowerBlades		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	750–1.170 rpm	- Grid frequency	50 Hz
- Voltage	660 / 6,600 V	- Manufacturer	VEM

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control, individual blade pitch control
Second brake system	disk brake
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	
SCADA-System	Senvion SCADA Solutions

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	121 m	124 m		
Type / Shape	steel tubular, cylindrical	steel tubular, cylindrical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	350.0 t	350.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib	DIBt 1		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: Under development First installation in: Q4/2014			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) fire detection and extinguishing system, oil particle counter			
MISCELLANEOUS	Offshore tower height is site-specific with a hub height of 95.0 to 110.0 m.			

E-126

ENERCON
Aurich, Germany

POWER			
Rated power	7,580 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	28.0–34.0 m/s
ROTOR			
Diameter	127.0 m	Swept area	12.668 m²
Number of blades	3	Rotor speed	5–11.7 (variable) rpm
Type	E-126		
Material	glas-fibre reinforced plastic, epoxy resin		
Manufacturer	ENERCON		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	
- Manufacturer			
Generator / Type	synchronous, ring generator		
- Number	1	- Grid connection	via converter
- Speed	5–11.7 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	individual blade pitch control
Second brake system	rotor brake and rotor lock
Yaw control system	12 active via adjustment gears, load-dependent damping
Manufacturer of control system	ENERCON
SCADA-System	ENERCON Scada

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
on request	on request	on request

TOWER/HUB HEIGHT	135 m			
Type / Shape	concrete tower, conical			
Corrosion protection	multi-coated			
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	on request			
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transformer, foundation			
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide: 22 (E-126/6MW) / 31 (E-126/7.5 MW) First installation in: 2007			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			


E-126

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AREVA Wind is a manufacturer of wind energy converters for offshore projects. The company develops and produces the 5MW offshore plant M5000 in Bremerhaven/ Germany.

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GE imagination at work

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