23rd EDITION

BWE
German Wind Energy Association

WIND ENERGY MARKET
Yearbook Service, Technology & Markets 2013

- Wind Turbines Over 70 data sheets of wind turbines on- and offshore
- Lease agreements Overview for creating a lease agreement
- Service Overview of service-suppliers

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WIND ENERGY MARKET

Yearbook Service, Technology & Markets

2013

23rd EDITION

Content

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

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

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Shrouded in the morning mist: Enercon wind turbines near Straussberg, Brandenburg. Photo: Paul-Langrock.de

Stable growth in a turbulent global market

The German wind market saw **steady growth** once again last year, further strengthening the positive trend of the previous year. In 2012, **20 percent more wind capacity** went online than in 2011.

In 2012, 1,008 wind turbines with a total capacity of 2,349 megawatts (MW) were connected to the grid in Germany. Although some people had even higher expectations for the sector, German wind energy expansion reached a level not seen since 2003, as shown by figures for 2012 from a manufacturer survey conducted by Deutsche WindGuard on behalf of the German Wind Energy Association (BWE) and VDMA Power Systems (VDMA PS).

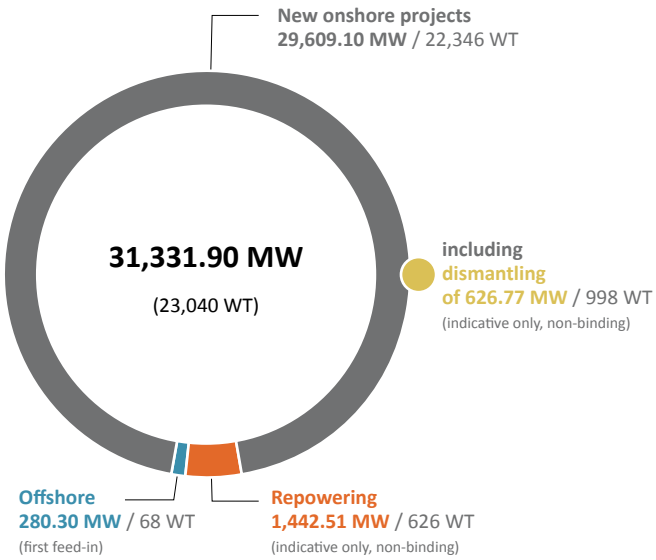
Germany thus not only leads the European rankings, ahead of the UK and Italy – its wind market also plays a major role against the backdrop of global market conditions: "Germany is a pillar of strength in a turbulent global market where wind energy is concerned," commented Thorsten Herdan, managing director of VDMA PS.

German wind energy – a national project

A comparison of expansion figures between the various states clearly shows that wind energy is now being used throughout Germany. Although Lower Saxony and Schleswig-Holstein, with capacity of 361 MW and 333 MW respectively, still hold the top spot in new installations, two federal states in the south – Rhineland-Palatinate (288 MW) and Bavaria (201 MW) – are also chalking up excellent figures. With only nine new wind turbines (18.9 MW) installed in 2012, Baden-Württemberg remains at the bottom of the list among Germany's non-city states. However, this situation is likely to change in the near future. "It usually takes a few years to plan and build a wind farm. Baden-Württemberg changed govern-

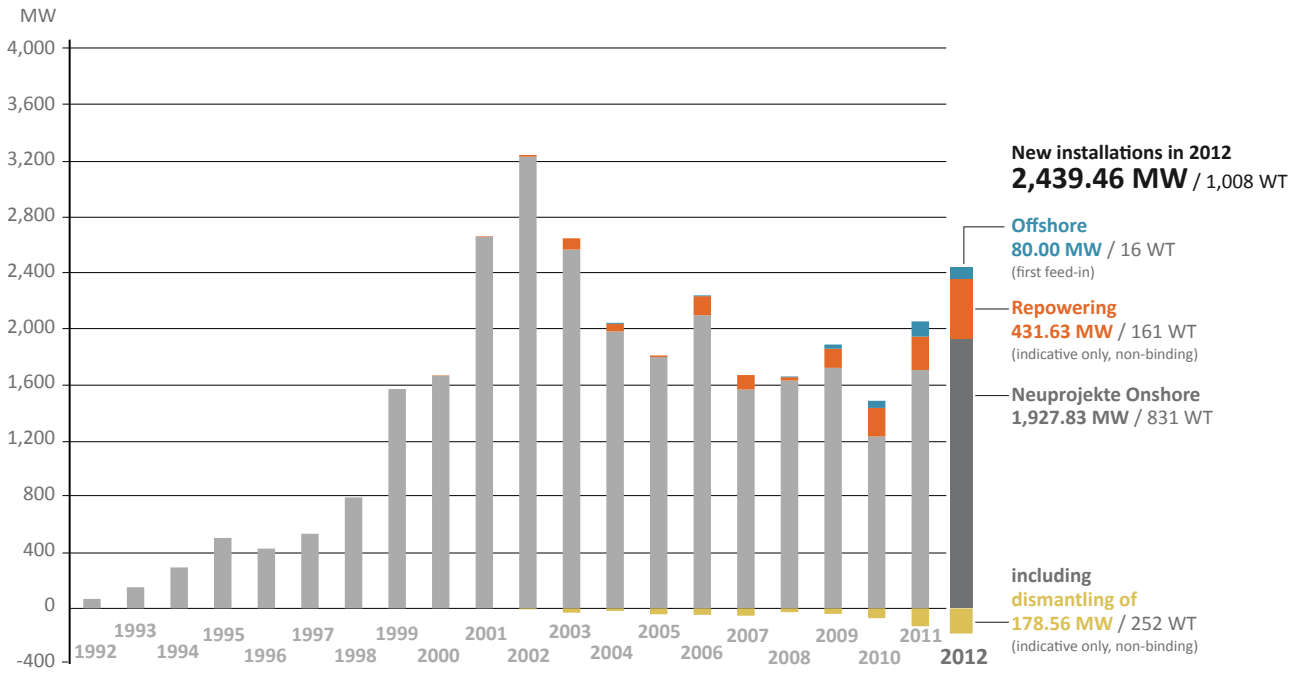
Photo: Jan Oelker

Status of wind energy development – total installed capacity
(as of 31 December 2012)



Source: Deutsche Windguard GmbH
MW = megawatts, WT = wind turbines

Development of annual installed capacity (as of 31 December 2012)



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

MW = megawatts, WT = wind turbines

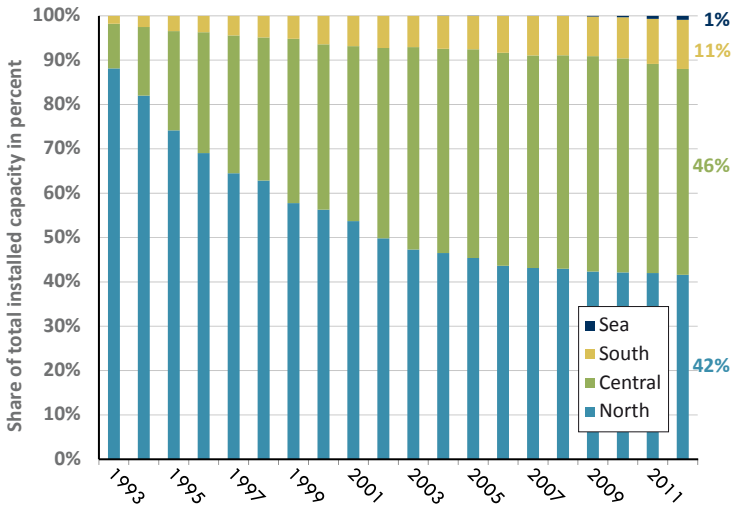
Wind energy installation in the German federal states in 2012

		Newly installed capacity in 2012			Average turbine configuration in 2012		
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	Lower Saxony	360.58	154	14.8%	2,341	84.9	105.5
2	Schleswig-Holstein	332.65	135	13.6%	2,464	84.2	81.7
3	Mecklenburg-Western Pomerania	307.92	124	12.6%	2,483	90.7	108.2
4	Rhineland-Palatinate	287.50	100	11.8%	2,875	96.0	129.1
5	Brandenburg	248.06	110	10.2%	2,255	88.0	113.4
6	Bavaria	200.50	81	8.2%	2,475	94.3	133.9
7	Saxony-Anhalt	180.75	84	7.4%	2,152	86.7	110.6
8	North Rhine-Westphalia	133.55	65	5.5%	2,055	79.8	101.7
9	Hesse	122.40	53	5.0%	2,309	86.8	127.5
10	Thuringia	102.30	47	4.2%	2,177	91.9	114.8
11	Saarland	31.60	15	1.3%	2,107	89.7	102.7
12	Saxony	27.05	13	1.1%	2,081	82.2	97.9
13	Baden-Württemberg	18.90	9	0.8%	2,100	82.9	129.9
14	Bremen	5.70	2	0.2%	2,850	93.0	113.0
15	Hamburg	0.00	0	0.0%	-	-	-
16	Berlin	0.00	0	0.0%	-	-	-
	North Sea	80.00	16	3.3%	5,000	120.0	90.0
	Baltic Sea	0.00	0	0.0%	-	-	-
	Total	2.439.46	1.008	100%	2,420	88.5	109.8

Source: Deutsche Windguard GmbH

Distribution of the total installed capacity in Germany by region

(as of 31 December 2012)



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

ments not too long ago," explained BWE vice president Sylvia Pilarsky-Grosch. "Plans are in full swing in many locations so we expect that results will soon be seen in Baden-Württemberg as well."

Southern Germany sets ambitious targets

Bavaria, Baden-Württemberg, Rhineland-Palatinate and Saarland now account for eleven percent of total installed capacity in Germany. This figure will rise considerably once the southern federal states' expansion targets are met. Baden-Württemberg has an ambitious aim of meeting ten percent of its electricity demand from wind energy by 2020. Bavaria plans to reach between six and seven percent of its demand by 2021, while Rhineland-Palatinate wants to increase its percentage of wind energy fivefold by 2020. Saarland is the only one of the four southern federal states that has not yet set concrete targets.

Another trend can also be observed across the country, one which has support among a large segment of the population: "The slight acceleration we are observing now is proof that the population endorses wind energy and is willing to take charge of Germany's switch to renewables. For some time now, new energy cooperatives and citizens' wind farms have been sprouting up," reported Pilarsky-Grosch.

Huge height differences

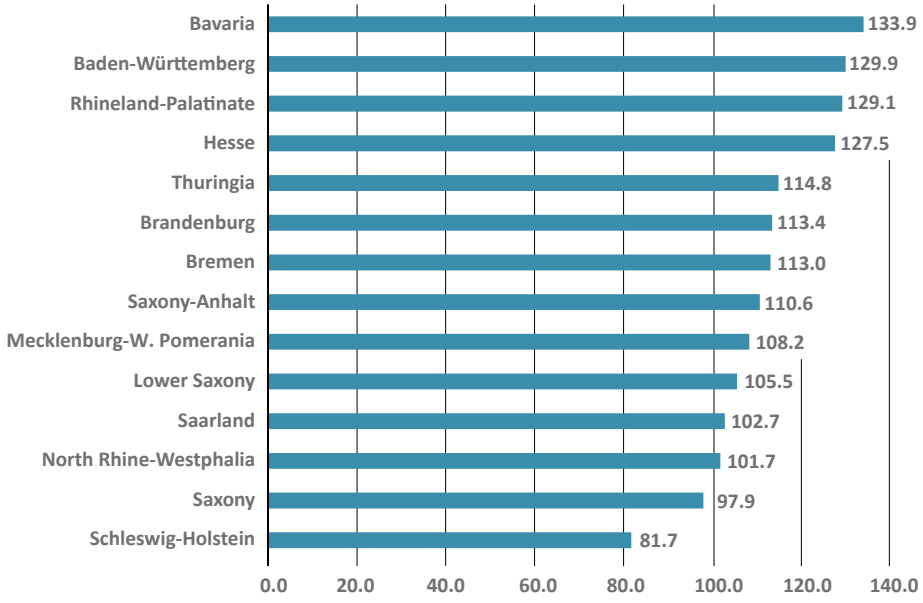
Data on the configuration of newly installed turbines show that tower heights differ greatly among the regions. New turbines in Schleswig-Holstein have an average height of 81.7 meters – the lowest hub height by far – while towers in Bavaria, Baden-Württemberg, Rhineland-Palatinate and Hesse are more than half as tall as this. "This goes to show the huge potential for improvement we face in this area. Taller turbines and larger rotor diameters guarantee higher yields nationwide. With optimum turbine configuration, we can generate more full-load hours all over Germany and make a crucial contribution to grid stability," said Pilarsky-Grosch.

In 2012, the average hub height in Germany was just under 110 metres, while the average rotor diameter measured 88.5 metres. These figures show that the latest turbine technology also makes less windy areas more attractive, thus enabling them to play a greater role in Germany's wind energy production in the long term. In the last few years, turbine manufacturers have responded to this trend by expanding their turbine

Photo: Jan Oelker

Living the energy turnaround: Wind festival at Ballstaedt-Westhausen wind farm in Thuringia.

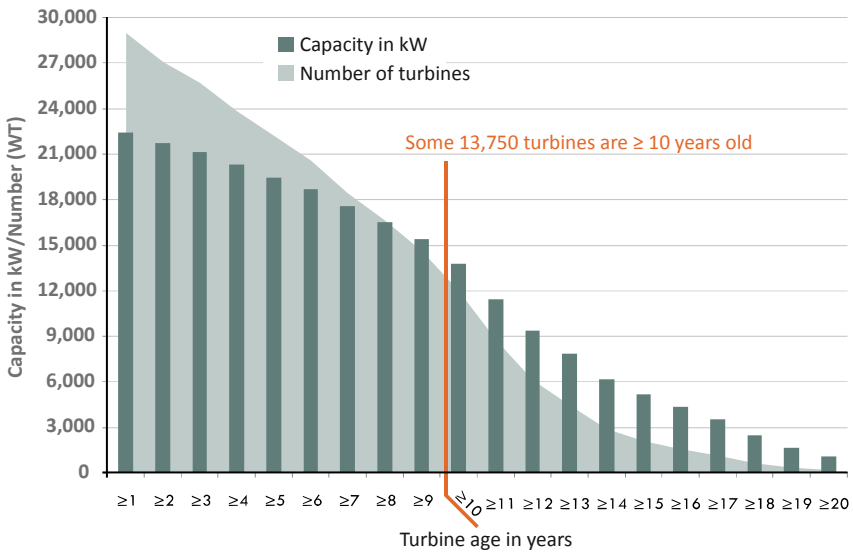
Average hub height of turbines installed in the German federal states in 2012



Source: Deutsche Windguard GmbH

Age of wind turbines installed in Germany

(by capacity and number, as of 31 June 2012)



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

Onshore tripod: Erection of a new lattice steel mast construction for a Vensys wind turbine in Steinburg near Glückstadt.

Photo: Joerg Boethling

portfolio for low-wind areas. “We expect the percentage of wind power produced onshore in Germany to grow substantially in the coming years,” said Pilarsky-Grosch. “Technological innovations will also be a factor in this growth.”

Repowering becoming more important

2012 also saw an upward trend in repowering projects: the replacement of old wind turbines increased capacity growth by over 80 percent compared with last year. Overall, 252 old turbines with capacity of 179 MW were upgraded to 161 more powerful machines with capacity of 432 MW. As before, repowering was mainly carried out in Schleswig-Holstein and Lower Saxony, where most turbines of a repowering age are located. However, older turbines were also replaced by state-of-the-art machines in central and southern German states.

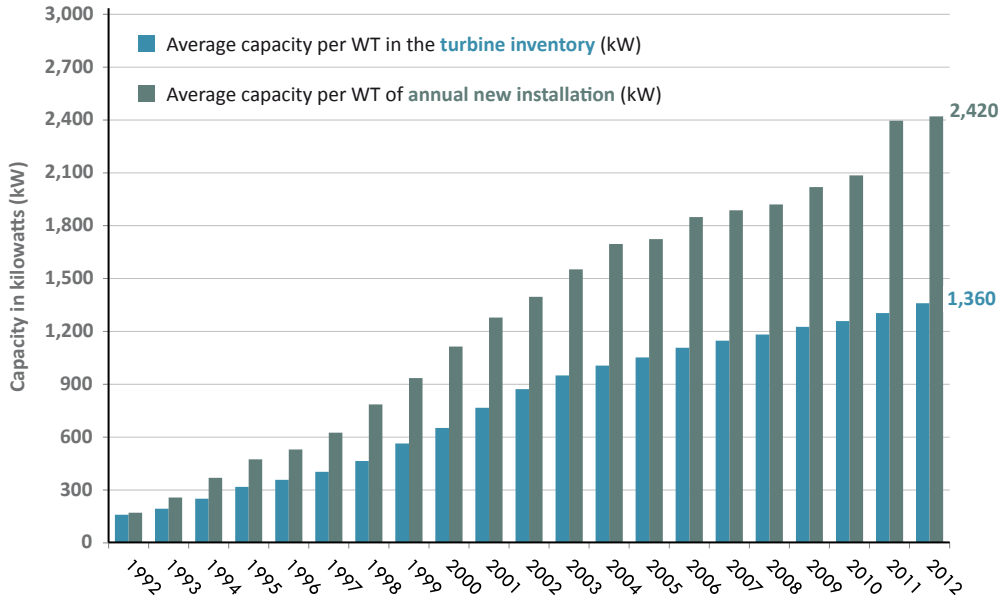
As a result of various factors such as a change of manufacturer between the old and the new project, relocation of the new turbines and the fact that many projects are not listed on a national level, the repowering data should only be viewed as indicative of a trend. However, it is likely that the real figures are even higher.

This could also be one outcome of the current regulations under the Renewable Energy Sources Act (EEG). The amended version from 2012 revoked the previous capacity limits for new turbines. The only current requirement is that the number of newly installed turbines does not exceed the number of dismantled machines.

The extent to which legal conditions will shape the future will become clear in 2013. The potential that can be met by replacing old turbines is still enormous, as all turbines installed before 2002 are eligible for repowering under the Renewable Energy Sources Act. Some 13,750 turbines in Germany, with a total capacity of about 12,000 MW, fall into this category.

Development of the average capacity (in kW) of annual new installations and of the Germany-wide turbine inventory

(as of 31 December 2012)

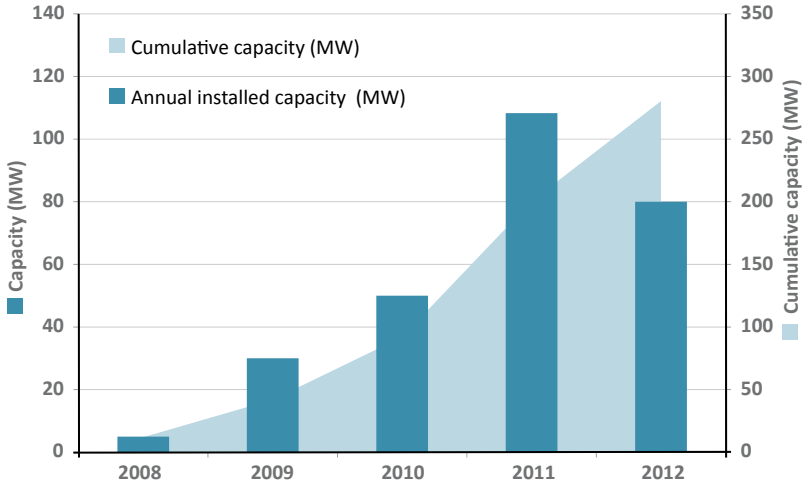


Source: 1992 – 2011: DEWI GmbH / 2012: Deutsche WindGuard GmbH

Development of offshore wind energy in Germany

(as of 31 December 2012)

Status of offshore wind energy development	Capacity in MW	Number
New installations in 2012 (First feed-in)	80.00	16
ITotal installed capacity as of 31 Dec 2012 (Turbines that feed into the grid)	280.30	68
Foundation structures		109



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

Offshore wind still waiting for lift-off

With only 16 newly installed wind turbines, expectations for the offshore wind sector were not met last year either. Unresolved liability issues and sluggish grid expansion were mainly to blame for the delays in offshore expansion.

The amended Energy Industry Act (EnWG), which the Bundesrat and Bundestag approved at the end of 2012, should provide the necessary momentum, particularly since it resolves the liability issues. “2013 will show whether the complications surrounding grid connection have been resolved through the recent clarification of liability issues and whether financing is now secured,” said Herdan.

The conditions for the long-awaited offshore boom have already been created: 2012 saw 109 foundation structures installed in the sea. Six offshore wind farms with over 350 turbines and a total capacity of 1,700 MW were under construction at the end of 2012. If successful, these projects will significantly increase the current total offshore capacity of 280.2 MW within a few years’ time.

The German market as a role model?

Nearly all manufacturers have recently focused to a greater extent on Europe’s core markets, as the situation in the global wind energy sector has taken a turn for the worse. According to estimates by industry insiders, the global market may slump by up to ten percent this year. The US, which enjoyed a record year in 2012, expects to see a decline of over 50 percent. The Chinese market is also not likely to recover this year.

Hence, it is all the more important that the German market remains stable in 2013. “Both the expected slump of the US market in 2013 and the progressive isolation of the declining Chinese market are forcing manufacturers to focus on the European core markets. The systemic modification of the Renewable Energy Sources Act and the electricity market design thus become all the more important. If these goals can be achieved, the framework conditions on the German domestic market will act as a model for Germany’s export markets,” explained Herdan.

What matters most this year in Germany is that these conditions are maintained despite the election campaign so that the sector is prepared if the global market recovers as anticipated in the medium term. A strong domestic market will safeguard future manufacturing capacity for Germany’s wind sector. ■

At the customs warehouse: SWT 2.3 offshore wind turbines by Siemens Wind Power awaiting their export to Puerto Rico.

A good year, but a difficult outlook

While **China** paused for breath, the **US** and **European markets** had exceptionally strong years. According to the Global Wind Energy Council (GWEC), the global wind power market **grew by ten percent** while the world's cumulative installed capacity rose by 19 percent.

The race for global market leadership in 2012 saw an extremely close finish: China and the US were neck and neck, with the former winning by the slimmest of margins. Both countries installed some 13 gigawatts (GW) (China: 13.2 GW/ US: 13.1 GW) of new wind power capacity, according to figures released by GWEC at the beginning of February 2013. A record year in the US and a slowing market in China produced a virtual tie between the two countries in newly added capacity. Nearly 45 GW of new wind power capacity came online globally. "This surpasses the figures from 2011. Never before has so much wind power been installed," said Henning Dettmer, managing director of the German Wind Energy Association (BWE).

Global market growth of ten percent

According to GWEC statistics, the global wind power market grew by ten percent, while the world's cumulative installed capacity rose by 19 percent. By the end of the year, 282 GW were online. Wind farms are now in operation in 84 countries, 24 of which have over 1,000 megawatts (MW) of capacity. This figure is regarded as the barrier that wind power must break through in order to stop being a niche source of energy. "These countries expect wind to play a relevant role in producing climate-friendly electricity," said GWEC chairman Dr Klaus Rave.

Following behind top-ranked China and the US were Germany, India and the UK. With 2.4 GW, Germany was in third place, just ahead of India (2.3 GW). Europe as a whole added 12.4 GW of new capacity. In terms of total generation capacity at the end of 2012, China remained in top place with 77 GW, followed by the US with 60 GW. The EU wind power sector passed the 100-GW milestone last year: by the end of 2012 about 106 GW of capacity had been installed. Topping the list here are Germany (31 GW) and Spain (23 GW).

US: last-minute spurt

The biggest surprise in 2012 was the expansion in the US where over 8 GW were installed in the last three months of the year alone in an expectation-beating late rush brought about by the threat that tax credits would expire at the end of December. The 13 GW added overall in 2012 were a record, topping the previous high of 10 GW in 2010. In comparison, 6.8 GW of new capacity went online in the US in 2011.

"However, the boom in the US will be followed by a massive slowdown in 2013," explained BWE managing director Dettmer. Dire forecasts for the coming year were particularly prevalent

Photo: Paul-Langrock.de

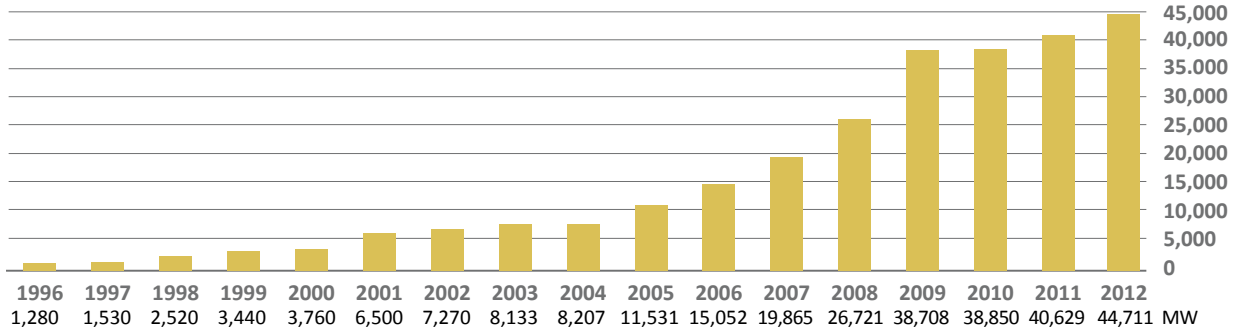
Wind farm in Texas, USA.

in the autumn of 2012 due to the tax uncertainty, as well as the resulting rush of installations. For example, Vestas, the world's largest wind turbine manufacturer, warned that the market could completely collapse.

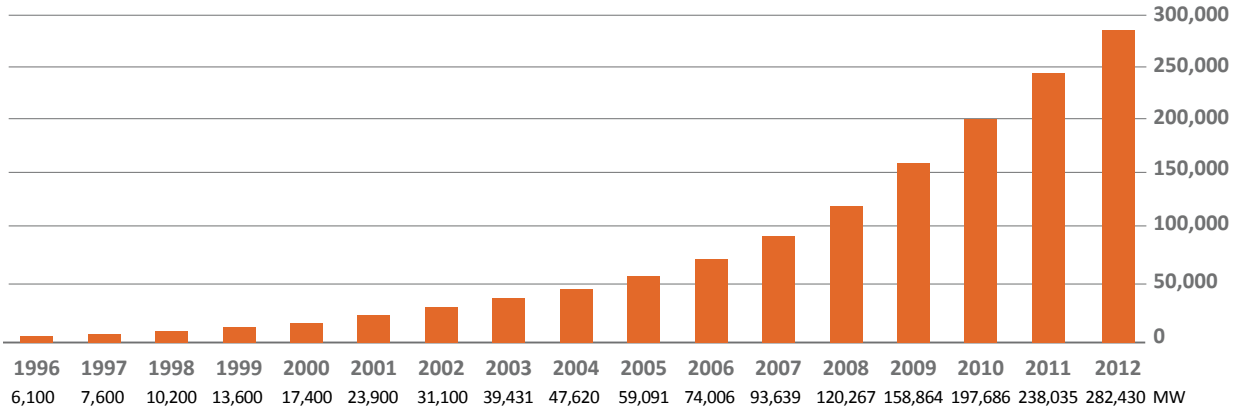
In January 2013, the US government extended the tax credits as part of its fiscal cliff package. However, this decision came too late for 2013. It is likely that positive effects will not be felt until 2014. The anticipated downturn in 2013 was somewhat abated by the decision, but still remains significant. "German manufactures expect installations to drop by far more than half," Dettmer said.

The Chinese market slowed down in 2012. After installing over 17.5 GW in 2011, the global market leader added 13.2 GW in 2011. "This was disappointing for China," commented GWEC chairman Rave. The decline was mainly caused by consolidation in a fast-growing market. "A market adjustment is taking

Global annual new installed wind capacity 1996–2012



Global cumulative installed wind capacity 1996–2012



Source: GWEC

Photo: Mike McPheeters

Pakistan: The 50 megawatt project "Jhimpir", 100 kilometres north east of Karachi.

Photo: Picasa; Nordex

place, one that is both important and resolute," Rave said. In 2013, German companies expect the market to reach about the same level as last year. However, the Chinese market continues to be largely closed to western companies.

A new player in Asia: Mongolia

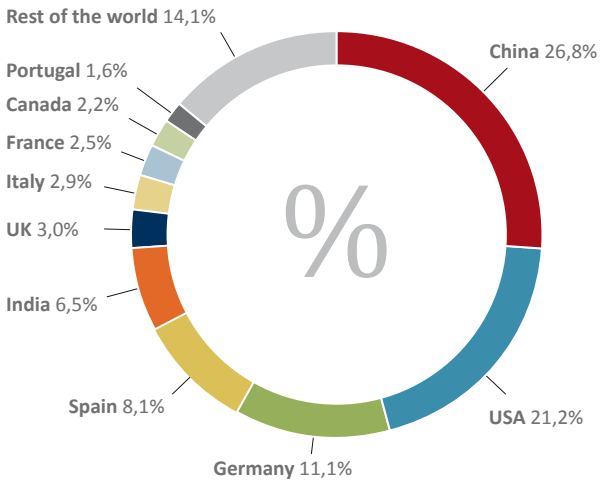
Other figures from Asia show that post-Fukushima Japan has turned out to be a disappointment, with only 88 MW of wind energy installed in 2012. According to GWEC, the shift towards renewable energies was short-lived despite the unimaginable scale of the disaster. "Such plans were substantially scaled back when the government changed hands," explained Rave. India holds fourth spot in the global rankings behind Germany. With 2.3 GW of new capacity, it just missed third place. However, it fell short of its 2011 installation figures of 3 GW.

GWEC chairman Rave singles out Mongolia as the new player to watch in Asia. The county's first wind farm went online in 2012. Moreover, its size was impressive: boasting a capacity of 50 MW, it meets about five percent of Mongolia's annual energy needs. The turbines for this first wind farm project in Salkhit, 70 kilometres from the capital Ulan Bator, were supplied by General Electric. The European Bank for Reconstruction and Development (EBRD) was involved in the financing. The project is part of the Mongolian government's plans to have renewable energies cover 25 percent of the country's total energy consumption by 2020. And, according to GWEC, there is huge potential in this sparsely inhabited country with an area four times larger than Germany, economic growth of 30 percent and annual average wind speeds of 10 metres per second. The same is true for other Central Asian countries like Kazakhstan, Kyrgyzstan and Tajikistan. "These are major markets of the future, as they are to some extent very rich in raw materials and have a very high demand for new power generation capacity. Of course, there are also political risks, but the opportunities should not be underestimated," Rave said.

Latin America: Mexico makes a big leap

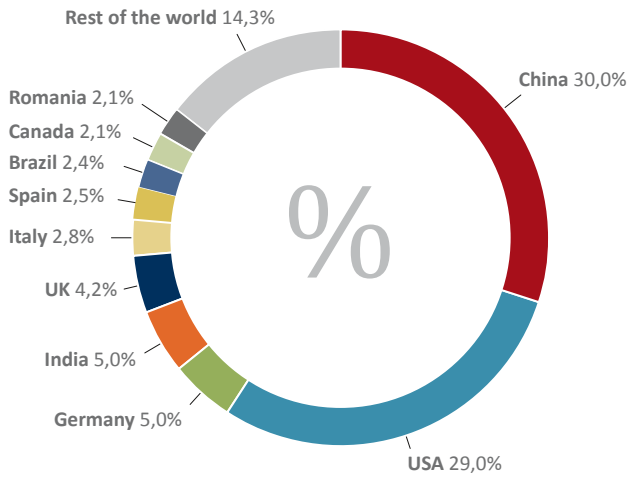
Mexico was the big surprise in Latin America in 2012. With 800 MW of newly installed capacity, the country made an impressive stride forward and crossed the 1,000-MW threshold

TOP 10 new installed capacity 2012



COUNTRY	MW	%
China	75,564	26.8
USA	60,007	21.2
Germany	31,332	11.1
Spain	22,796	8.1
India	18,421	6.5
UK	8,445	3.0
Italy	8,144	2.9
France	7,196	2.5
Canada	6,200	2.2
Portugal	4,525	1.6
Rest of the world	39,853	14.1
Total TOP 10	242,630	85.9
Total WORLD	282,482	100.0

TOP 10 cumulative capacity 2012



COUNTRY	MW	%
China	13,200	30.0
USA	13,124	29.0
Germany	2,439	5.0
India	2,336	5.0
UK	1,897	4.2
Italy	1,273	2.8
Spain	1,122	2.5
Brazil	1,077	2.4
Canada	935	2.1
Romania	923	2.1
Rest of the world	6,385	14.3
Total TOP 10	38,326	85.7
Total WORLD	44,711	100.0

Source: GWEC

by a significant margin. Along with Brazil, which reached over 1,000 MW in 2012, it is setting the pace in the Spanish and Portuguese-speaking countries in the Americas. The latest figures from CFE, Mexico's state-owned power company, report 282 gigawatt-hours (GWh) in November 2012, showing that wind power in Mexico has reached a new record. This figure represents an increase of more than 230 percent over energy consumption (84.5 GWh) in November 2011. The Mexican Wind Energy Association (amdee) estimates national wind power potential at around 30 GW. The region best suited to wind energy production is the Isthmus of Tehuantepec in Oaxaca.

According to GWEC, Mexico's wind energy sector is now at the point that Asia's was at five years ago. The Mexican wind power sector is thus at the beginning of a steep growth curve and can expect to make great strides forward in the coming years. Large corporations such as Walmart, Bimbo, Grupo Modelo, Mittal, Cemex and Herdez, among others, are already having wind farms built for their own use or have plans to do so. The most recent example is the country's largest wind farm to date, with nearly 400 MW of capacity, which the Spanish company Acciona is building for the country's biggest Coca-Cola bottler Femsa, as well as for Heineken.

An emerging market: Africa

To date, little wind power has gone online in Africa, but GWEC regards the continent as a market of the future. 2012 saw, for example, the first commercial wind farm connected to the grid in Sub-Saharan Africa: a 52-MW project in Ethiopia. "This is just the beginning of the African market," said Steve Sawyer, GWEC secretary general, "and with construction started on 500+ MW in South Africa, we expect Africa to be a substantial new market." The development can already be seen in manufacturers' order books. Wind turbine manufacturer Nordex, for example, has received two orders for the installation of wind farms in South Africa. The Hamburg-based manufacturer announced last November that it would supply 32 turbines for the construction of the 80-MW Red Cap Kouga Wind Farm. Before this, Nordex had already been awarded the contract for the installation of a 100-MW wind farm, thus making its entry into the South African market.

EU market: Germany on top with 2.4 GW

Germany led the European market with 2.4 GW of newly installed capacity. The UK came in second with 1.9 GW, followed by Italy, Spain, Romania, Poland, Sweden and France. According to figures from the European Wind Energy Association (EWEA), the EU's wind energy sector added 11.6 GW of new wind turbine capacity in 2012, thus surpassing the previous year's growth of 9.4 GW.

Oaxaca wind farm in Mexico.

Photo: Bernhard Bösel/GIZ

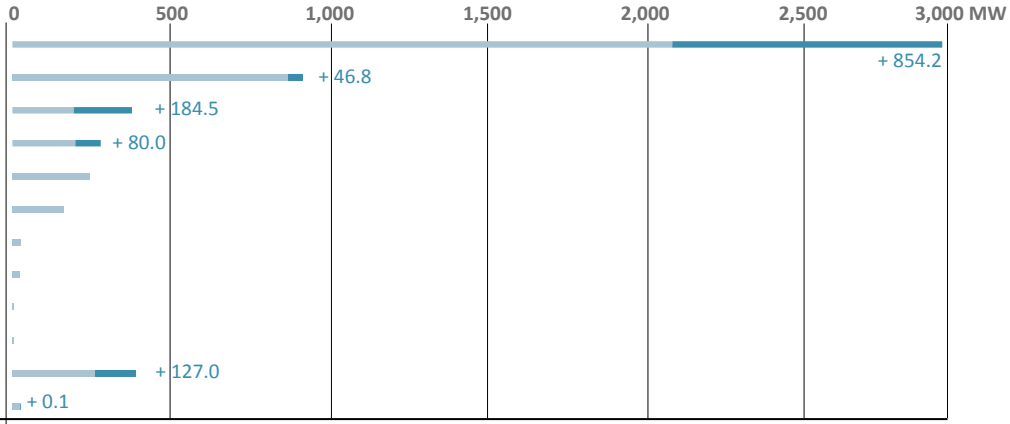
Among the emerging markets in Eastern Europe, both Romania and Poland reported record years, with each country installing about eight percent of Europe's new wind generation capacity. They are proof that wind energy has arrived in Eastern Europe. Also worth highlighting in the current EU rankings are Italy and Sweden, which account for eleven and seven percent respectively of total installed capacity.

Over 90 percent of new offshore capacity in Europe

Europe continues to top the offshore market. With almost 1.2 GW installed, over 90 percent of the world's new offshore wind power capacity of 1.3 GW went online in Europe in 2012. Offshore wind energy accounted for ten percent of EU-wide installations – a one-percent increase over 2011. The UK led the region with 854 MW, followed by Belgium with 184 MW. Germany installed 80 MW, while Denmark reached just under 47 MW of offshore capacity.

Global installed offshore wind capacity in 2011/2012

	Total 2011	Total 2012
UK	2,093.6	**2,947.9**
Denmark	874.3	**921.1**
Belgium	195.0	**379.5**
Germany	200.3	**280.3**
Netherlands	246.8	**246.8**
Sweden	163.7	**163.7**
Finland	26.3	**26.3**
Ireland	25.2	**25.2**
Norway	2.3	**2.3**
Portugal	2.0	**2.0**
China	262.6	**389.6**
Japan	25.2	**25.3**
Total	4,117.3	**5,410.0**



Source: GWEC

Repower-turbine in "Ormonde" offshore wind farm, UK.

Photo: Jan Oelker

However, one thing is true for Europe as a whole: "The 2012 figures reflect orders made before the wave of political uncertainty that has swept across Europe since 2011, which is having a hugely negative impact on the wind energy sector," said Christian Kjaer, CEO of EWEA. "We expect this instability to be far more apparent in 2013 and 2014 installation levels."

Renewables need a big push

GWEC agrees that the sovereign debt crisis is creating uncertainties in the EU market, but believes that Europe's framework legislation and its 2020 targets will provide a degree of stability. According to EWEA's annual statistics for 2012, the EU countries are lagging almost 19 GW behind their National Renewable Energy Action Plan (NREAPs) forecasts from 2010, with just under 196 GW of installed wind power. Eighteen member states are below target, including Slovakia, Greece, the Czech Republic, Hungary, France and Portugal. Sweden, on the other hand, has installed more capacity than expected. "Europe will only be able to reach its climate goals if every member state makes substantial headway in expanding renewable energies," warns BWE managing director Dettmer. ■

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Erecting a Nordex N117 at Stadum-Sprakebüll wind farm in Schleswig-Holstein.

Bigger, taller, more efficient

The market is increasingly demanding turbines for **low-wind sites**. Manufacturers have responded with turbine concepts in which the **tower height** and **rotor diameter** are able to deliver increased power yields. There have also been some improvements in **management** and **condition monitoring**.

Efficient turbines for low-wind sites

Recently, the decisive trend in turbine technology has been for taller turbines with larger rotor diameters, but the same or lower nominal capacity. The new turbine models unveiled by the large and medium-sized manufacturers in the last year are good examples of this.

Nordex was already putting the first prototypes of the new N 117 into operation at the end of 2011. The 2400 kW turbine that was developed on the basis of the N 100 platform has a hub height of 141 m and a rotor diameter of 117 m, and has been specifically engineered for low-wind conditions. "The demand for turbines suitable for low-wind sites has increased considerably and we expect this trend to continue," explains Günter Steininger, Product Manager at Nordex. "Our response to this," he continues, "was to develop a turbine that brings in good yields even at wind speeds of around 6 m/s. This means that even locations with lower wind speeds can become profitable sites." He believes that this is of interest not simply due to the policy decisions of the German federal states, but also because "onshore sites with high wind speeds have become few and far between."

That is also the opinion of most of the other manufacturers too. For example, at Husum Wind, Repower presented the 3.0M122, a turbine that is particularly suitable for the conditions of low-wind sites. The first variant, with a hub height of up to 139 metres, will be on the market from the beginning of 2013, with the prototype due to be erected in the fourth quarter of the same year. Enercon, the German industry leader, has also taken action: its 2.5 MW E 115 with a 115 m rotor diameter was launched in the autumn and the prototype of the E 92 was put into service in December 2012. The latter has a maximum capacity of 2.3 MW and has been specifically designed for low-wind sites.

The global leader Vestas is also focusing on Europe as a target market with its newly developed V 126. Other manufacturers such as Gamesa, Kenersys, Leitwind and Siemens are following suit, all having launched turbines for low-wind conditions over the last year and a half.

Better for the load on the grid

Where there are lower wind speeds, the hub height and rotor size are decisive factors for economic viability. Thanks to their lower rating (watts per m2 of swept rotor area), they enable a greater annual yield with more constant generator output and achieve a far higher capacity factor (full load hours per year).

To allow them to operate profitably even at less windy sites, the turbines must reach their maximum capacity sooner than at coastal sites with high wind speeds. Dieter Fries from the BWE operators' advisory board explains: "That is why many of the latest turbines are designed to reach their nominal capacity at just 10 m/s, while more powerful turbines with greater generator outputs don't reach their maximum until about 14 m/s or more."

In particular at sites in wind zone 3, the light-wind design of the turbines in combination with higher hub heights is also

Photo: Jan Oelker

Onshore: current wind turbines ...

... are built with much lower specific capacity in W/m². For new wind turbines that are specially designed for low-wind sites, the emphasis is on a specific capacity of 200 – 260 W/m².

MODEL	ROTOR			
	Nominal capacity/kW	Dia./m	Swept area/ m²	W/m²
ENERCON				
E 82 - 2,3	2,300	82	5,281	436
E 82 - 2	2,000	82	5,281	379
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
GAMESA				
G90 2 MW	2,000	90	6,361	314
G114 2 MW	2,000	114	10,205	196
KENERSYS				
K 120-2,3 MW	2,300	120	11,310	203
LEITWIND				
LTW77 1 MW	1,000	77	4,656	215
LTW 2-104	2,000	104	8,495	235
NORDEX				
N100/2500	2,500	100	7,854	318
N117/2400	2,400	117	10,157	236
REPOWER				
RE 3 M-122	3,000	122	11,690	257
RE 3,2M-114	3,200	114	10,207	314
MD 77	1,500	77	4,656	322
SIEMENS				
SWT-2,3-93	2,300	93	6,800	338
SWT-2,3-101	2,300	101	8,012	287
SWT-2,3-113	2,300	113	10,015	230
VESTAS				
V 90- 2 MW	2,000	90	6,361	314
V 112-3 MW	3,000	112	9,852	305
V 126-3 MW	3,000	126	12,469	241

Source: Ingenieurbüro Fries

beneficial for the load on the grid. "The power duration curves of low-wind turbines have significantly higher values. This means that the turbines not only run for longer at the nominal load, but that the drop in output is delayed if the wind drops off. This is good for the grids, because the power flows more consistently and extreme power peaks are thus reduced," says Fries.

Smarter technology

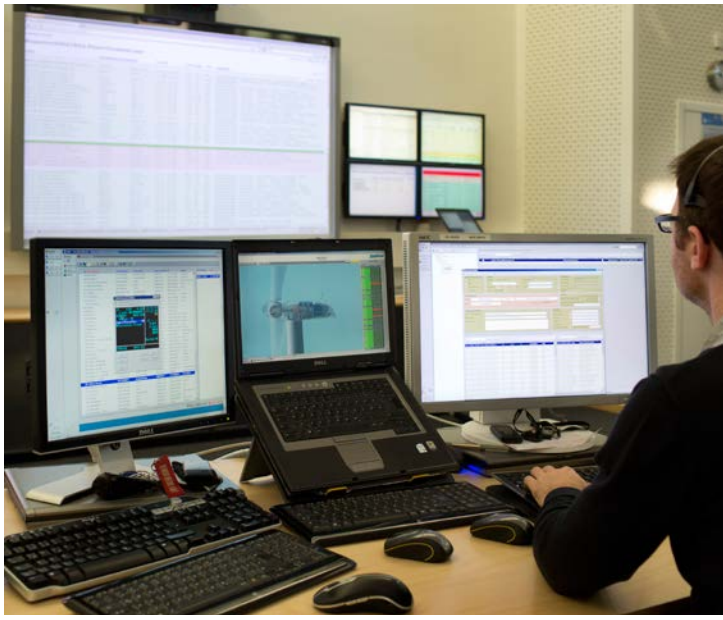
Turbine control systems have also recently brought about advances in development with regard to grid compatibility. Load management, SDL compatibility and remote control are the key concepts here. With the greatly increased requirements for grid technology that have been implemented recently, control technology has also been further developed. "For example, the ability to remotely control wind turbines, in line with the requirements of the power market, simply did not exist a few years ago," explains Ian Paul Grimble, Managing Director of psm GmbH & Co. KG and Vice Chairman of the BWE advisory board of managing directors. "SDL compatibility of turbines is also relatively new," says Grimble, "and the requirements for system services are continuing to rise."

To be able to feed the power directly into the grid, many current wind turbine models are equipped with permanent magnet generators and full-scale converters. This means that the turbine output is fully decoupled from the grid and the turbine can meet essential requirements, such as providing reactive current or responding to grid failures within milliseconds. "There has been a veritable boom in the fitting and retrofitting of turbines with control technology in the last one to two years," reports Ian Paul Grimble. "At the end of the day, technical development has kept pace with the grid requirements and we now need to use it to its full advantage."

Photo: Jan Oelker

More know-how required

The fact that the regulations on feed-in management, SDL compatibility and direct marketing have brought about a noticeable demand effect is also apparent in the development of independent service providers that have recently shown strong growth. According to Grimble, "this is also associated with the fact that the technology that is currently being used is much more complex and sensitive than before." He believes this ultimately increases the requirements on all those who are involved in the operation of wind turbines. "Electrical and electronic components in particular are becoming ever more sophisticated. On the other hand, this naturally requires more know-how as well as time and effort on the part of the operators and their partners, who have to be able to deal with the control technology."

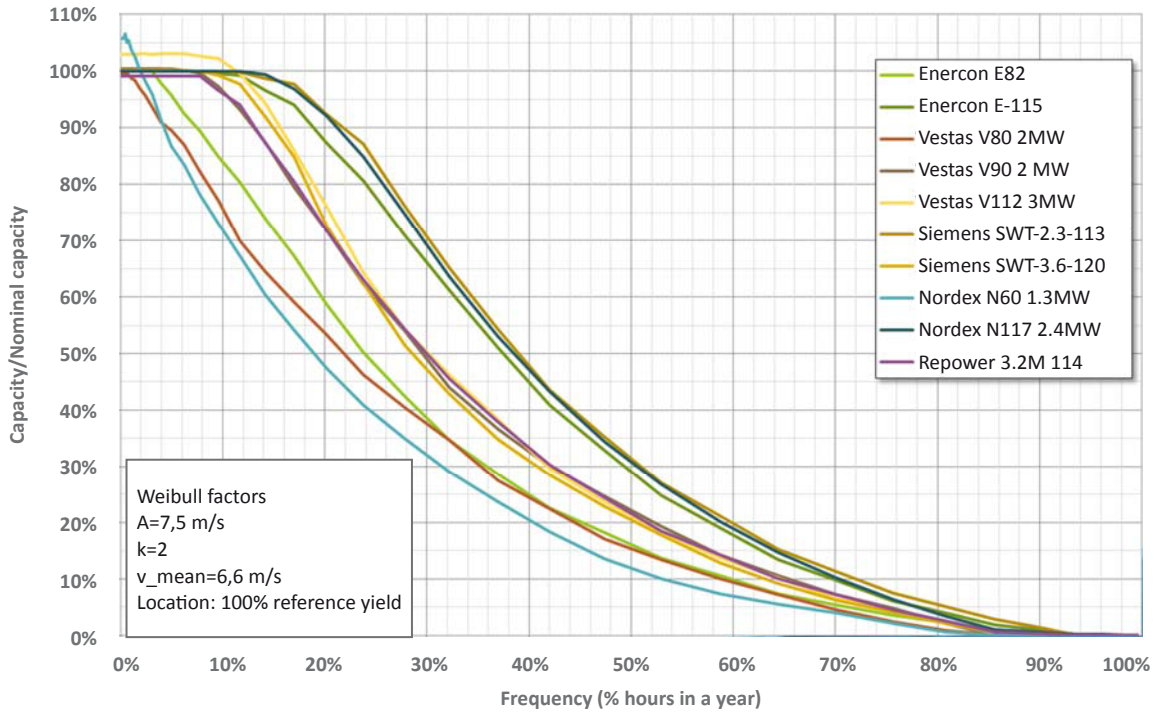


Manned around the clock: The Enertrag control room in Dauerthal.

Photo: Silke Reents

Development of new turbine technology – impact on power duration curves

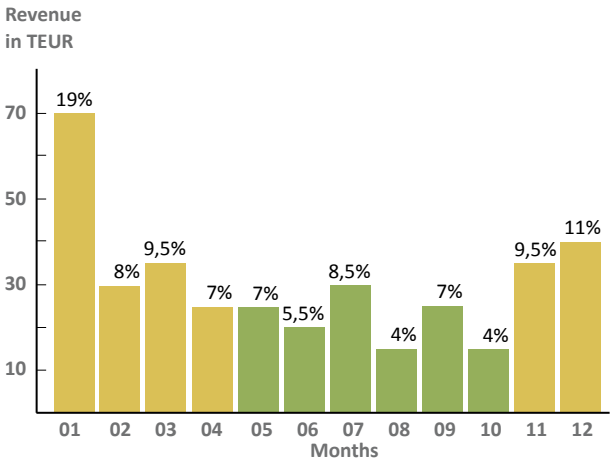
Low-wind turbines achieve more full-load hours at lower wind speeds.



Source: Deutsche Windguard

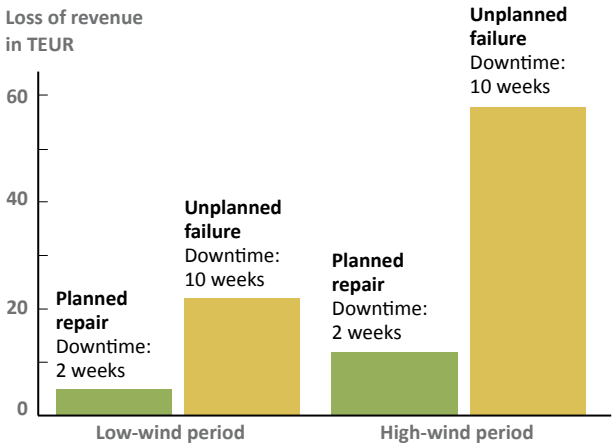
Annual revenue trend and revenue losses

Annual revenue per month



About two thirds of the revenue from a wind turbine are earned during the **winter months**. Example: Distribution of revenue over a year of a 1.5 MW wind turbine

Loss of revenue due to planned and unplanned repairs



Comparison between planned and **unplanned gearbox repairs** to a 1.5 MW turbine during periods of low winds and high winds. If we consider just the drop in revenue, there is an additional loss of approx. 20,000 euros following an unplanned failure during a low-wind period, compared to a loss of over 40,000 euros during a high-wind period.

Source: Bachmann Monitoring

More demand for condition monitoring

As the turbines become more efficient and the control systems more aligned to the grid requirements, it is not only the system relevance that is growing, but also the potential damage that can be caused by a failure. Condition monitoring systems (CMS) play a crucial role in reducing this risk. Around 20 manufacturers offer CMS certified by Germanischer Lloyd or Allianz, which is obligatory for the offshore sector, but demand is increasing onshore too.

However, CMS is intended to be more than just power-train temperature and vibration measurements: "For us, condition monitoring is a complete technology for early detection of any damage that may occur," explains Holger Fritsch from Bachmann Monitoring, a leading provider of the systems. "This is used for diagnostic purposes rather than for monitoring of the turbine technology." This technology has made significant advances recently, in particular in the coupling of the systems with the turbine control system. Bachmann entered onto the market with its integrated CMS about two years ago and the system was certified in 2011. It can be actively coupled to the control system and thus helps to reduce any potential damage that can be detected (e.g. peak loads due to gusts) by responding quickly.

The demand for systems like this has grown immensely: in 2012 alone, Bachmann transferred over 400 CMSs to the web-based CM service, of which a good half were for existing turbines. Holger Fritsch believes that there will be another rise in demand in 2013. "This is also because the structure of the investors and operators has changed significantly," explains Fritsch. "An understanding of the benefits of effective condition monitoring is more widespread among larger investors, such as municipal energy suppliers or other energy providers, than among smaller operators." Turbine manufacturers have

Photo: Jan Oelker

also recognised that the demand is increasing and are offering either their own or system-independent solutions.

An increased technical availability of the turbines of over one per cent (according to Fritsch), combined with generally cheaper insurance premiums means that the use of modern CMSs often pays for itself within a short time, or the first time that damage is detected before it becomes critical. This can be illustrated with the example of a gearbox replacement: if it can be planned, it is likely to entail about five days of downtime, while an unplanned replacement would on average take up to twelve days. According to Holger Fritsch, "the difference in cost between a planned and unplanned repair on a 1.5 MW turbine can be an additional loss of revenue of up to 20,000 euros, even during a period of low winds."

More stability in the energy market

More efficiency and effectiveness has been achieved at less windy sites through increasingly sophisticated technology for control and condition monitoring. The latest turbine technology has made significant advances in its development in recent times and kept pace with the increased market requirements. This means that wind energy is able to make a greater contribution to grid stability and take a more active role on the energy market. In this regard, the development of turbine technology is on the right track to establish wind energy as the most important pillar of the energy revolution. ■

Wangenheim, Hochheim, Wiegleben and Ballstaedt-Westhausen wind farms in Thuringia.

Expert assessment of an Enercon E-58 at Esterwegen wind farm in the Emsland region.

Certifiers wanted

The market for certification is on the move and demands are increasing. This is linked to the Asian market and the international offshore activities, but also to **technological development** and **growing demands** on the German market.

German certifiers for wind energy can't complain about being short of work: "The market has expanded rapidly in recent years," reports Mike Wöbbeking, Vice President of GL Renewable Certification (GL RC). The certification subsidiary of Germanischer Lloyd which focuses on renewable energies has grown by more than 60 employees in the last two years alone, "and we are still looking for qualified experts for certification. We need engineers from all disciplines," says Wöbbeking.

The situation at GL RC is representative of the whole industry of certifiers and testers: in certain cases, the "wind energy" business area is also growing at double-digit rates in other certification bodies, including TÜV Nord. The industry is on the move: in 2012 the German Wind Energy Institute (DEWI) was bought up by the American certification company UL (Underwriters Laboratories). Other certification bodies, such as TÜV Rheinland, work on the accreditation for grid compatibility tests.

The industry is facing a larger field of activity which is becoming ever more complex. "The growing demands on certification are also apparent in our own guidelines for wind turbines. They are adapted to technical developments around every five to seven years and therefore include new criteria with every new edition," says Wöbbeking. With every development step, the turbines are not only getting better, but also becoming more complex, which must be reflected in the guidelines. In addition to the GL guideline, the regulations of the International Electrotechnical Commission (IEC) headquartered in Geneva, which are updated every seven to ten years, are relevant for many markets.

Type and project certification: worldwide growth

Jürgen Holzmüller, Managing Director of 8.2 AG and member of the BWE's expert advisory council, also confirms that the requests for type and project certification are sharply increasing around the world. "A particularly large increase was apparent around 2005, when the Asian market really started to develop its own turbines." Certification according to rules such as the IEC 61400 series of guidelines or the GL Guideline 2010 are given high priority in Asia, as they facilitate access to important international markets.

"Development in offshore wind energy is also another key factor," says Holzmüller. "It is not just new and different technology which is used here, but in Germany, for example, the projects must also be certified as a whole; this is a condition for BSH construction approval." Things that are imperative offshore are only occasionally requested onshore: "The onshore wind industry has already developed to such an extent in Germany that comprehensive type and project certification is not normally carried out," says Holzmüller.

Mandatory in Germany: unit and system certificates

With regard to the grid connection, the conditions for wind energy have changed considerably in recent years. The requirements of the guideline of the Bundesverband der Energie- und Wasserwirtschaft e.V. (BDEW) for "Generating Plants Connected to the Medium-Voltage Grid" have been mandatory since 2009 and can only be certified by accredited bodies.

Jens Rauch, Managing Director of FGW e.V. (Federation of German Windpower and other Renewable Energies)

Photo: Jens Meier

Video endoscopy to inspect the gearbox of a Repower MM82 at Drohndorf wind farm.

explains: "The BDEW guideline requires unit and system certificates. These are not just a seal of quality. They are necessary for grid connection consent from the grid operator and for approval by the German Federal Network Agency, which are basic requirements for feeding into the grid."

In addition to the legal necessity of this process, the representative of FGW e.V. sees the effort as justified, primarily due to the fact that "with around 600 distribution grid operators, hundreds of installation planners and manufacturers, we have many stakeholders who need a standard procedure based on the BDEW guideline and the extended technical connection conditions of the distribution grid operators. This can limit communication between the parties."

In Rauch's opinion, the mandatory aspects for the medium-voltage range will also become the rule for the high-voltage grids: "We expect system certificates to also become necessary for many suppliers in the high-voltage range in the near future."

In all likelihood, the eleven currently accredited and approved certification bodies which work according to the BDEW guidelines will face further challenges in the future.

A Europe-wide standard for grid connections?

Currently, test regulations for onshore grid connections are only mandatory in a few European countries, including Spain and Denmark, in addition to Germany. This is likely to change: the

Overview of wind energy certificates

Type	Type certificate	Project certificate	Unit certificate	Installation certificate
Object	Type of wind turbine	Whole project	Type of wind turbine	All installed units on a grid connection point
Subject of the certification	Load assumptions System technology Operational safety QM system Effectiveness of the turbine	Building criteria Effectiveness of the project Operating conditions Location conditions Manufacture	Proof of the electrical properties of the unit in accordance with the requirements of the German grid connection guidelines	Proof of the electrical properties of the installation in accordance with the requirements of the German grid connection guidelines and SDLWindV
Ordered by	Manufacturer	Developer or wind turbine operator	Manufacturer	Developer or wind turbine operator
Relevance in Germany	Market significance Prerequisite for approval	Market significance Offshore: mandatory	Mandatory for connection consent (medium-voltage grid, also high-voltage grid in the near future)	Mandatory for connection consent (medium-voltage grid, also high-voltage grid in the near future)

For onshore wind energy, type testing is a prerequisite in Germany. Among other things, part of the type certification testing includes the construction and specifications of the installation as well as precalculations for its operation.

Photo: Jens Meier

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List of recommendations for assessing and certifying new installations

(according to TR8, Rev. 5) As of 30 November 2012; Source: FGW e. V.

Definitively approved and accredited certifiers

Company	Contact	Address
ABE Kunze Engineering GmbH	Dipl.-Ing. Stefan Maaß	Großer Kamp 1c 22885 Barsbüttel
ABE Kunze Engineering GmbH	Dipl.-Ing. Sebastian Gerbig	Großer Kamp 1c 22885 Barsbüttel
FGH e.V. Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft	Dipl.-Ing. Bernhard Schowe-von der Brelie	Hallenweg 40 68219 Mannheim
Germanischer Lloyd Industrial Services GmbH Erneuerbare Energien Zertifizierung / Gruppe Elektrotechnik	Dipl.-Ing. (FH) Tobias Bublat	Brooktorkai 18 20457 Hamburg
Germanischer Lloyd Industrial Services GmbH Erneuerbare Energien Zertifizierung / Gruppe Elektrotechnik	Dipl.-Ing. Tobias Gehlhaar	Brooktorkai 18 20457 Hamburg
KEMA Zertifzierungsgesellschaft mbH	Dipl.-Ing. (FH) Bernd Hinzer	Gostritzer Straße 63 01217 Dresden
M.O.E. Moeller Operating Engineering GmbH	Dipl.-Ing. Jochen Möller	Fraunhoferstraße 3 25524 Itzehoe
M.O.E. Moeller Operating Engineering GmbH	Dipl.-Phys. Lennart Reeder	Fraunhoferstraße 3 25524 Itzehoe
M.O.E. Moeller Operating Engineering GmbH	Dipl.-Ing. (FH) Bernd Rüßmeier	Fraunhoferstraße 3 25524 Itzehoe
M.O.E. Moeller Operating Engineering GmbH	Dipl.-Ing. Michael Voß	Fraunhoferstraße 3 25524 Itzehoe
TÜV NORD CERT GmbH	Dr.-Ing. Ralf Kotte	Postfach 81 05 51 30505 Hannover
TÜV SÜD Industrie Service GmbH	Dipl.-Ing. Torsten Scheller	Westendstraße 199 80686 München
VDE Prüf- und Zertifizierungsinstitut GmbH	Prof. Dr.-Ing. Jürgen Pannicke	Merianstraße 28 63069 Offenbach
WIND-certification GmbH	Dipl.-Ing. Matthias Hickisch	Reuterstraße 10 18211 Bargeshagen
WindGuard Certification GmbH	Dipl.-Ing. (FH) Rainer Klosse	Oldenburger Str. 65 26316 Varel

Accredited and not yet definitively approved certifiers

ENC² GmbH	Dipl.-Ing. Friedel Bläser	Werftstraße 23 40549 Düsseldorf
FGH e.V. Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft	Dr.-Ing. Karl-Heinz Weck	Hallenweg 40 68219 Mannheim
FGH GmbH	Dr.-Ing. Mark Meuser	Hallenweg 40 68219 Mannheim
KEMA Zertifizierungsgesellschaft mbH	M. Sc. Albrecht Gerber	Gostritzer Str. 63 01217 Dresden
M.O.E. Moeller Operating Engineering GmbH	Dipl.-Ing. Holger Becker	Fraunhoferstraße 3 25524 Itzehoe
VDE Prüf- und Zertifizierungsinstitut GmbH	Dr.-Ing. Jörg Helmer	Merianstraße 28 63069 Offenbach

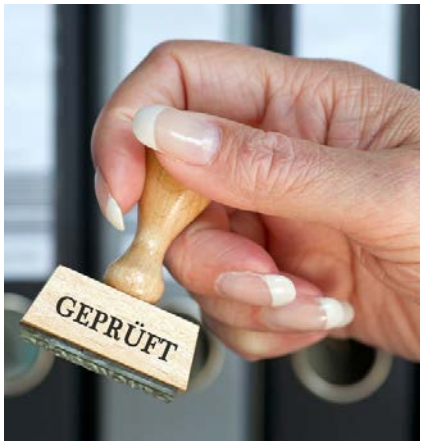


Photo: ddp images

organisation of European grid operators, ENTSO-E, is working on behalf of the EU on Europe-wide criteria for grid connections, which should become EU law in a regulation.

With the growing production of renewable energies throughout Europe, standardising the test regulations is becoming a central criterion for a secure supply. "Rules in force across Europe for grid connection are essential if we want to achieve network stability in Europe whilst increasing the proportion of renewable energy sources," says Stefan Grothe, technology expert at the BWE. "This means that system and unit certification will remain a market with many challenges and opportunities for years to come."

An urgent need for standardisation

Developments in grid connection and compatibility at a European level will advance current construction, manufacture, assembly and operation of wind turbines in Germany. Currently, the certifiers work based on guidelines which comply with the requirements of the German Federal Maritime and Hydrographic Agency (BSH) for offshore projects and those of the German Institute for Building Technology (DIBt) for onshore projects. These are already

partly based on standards like the Eurocodes. Deutsche Institut für Normung e.V. (DIN) is actively working to significantly increase the proportion of referenced standards.

"At present, there are relatively few standards for installations or wind farms, except for electrical standards, in Germany, Europe or around the world," reports Dr Bärbel Schambach from DIN, "and this is what we are working on now together with the BSH and the DIBt." A number of standards committees of the DIN, including those for construction, welding technology, ships and marine technology, and even coatings, are currently working to standardise installations and wind farms. According to Dr Schambach, the target is to publish the first standards by the end of 2014 at the latest.

For the certifiers and their customers, this may be a considerable relief, as "it means that it is easier to compare the different certificates for the same trades. And the certifiers can base their work on the standards," explains Bärbel Schambach. Another aim of DIN is to enforce the resulting standards on an international scale as soon as possible; at its instigation, for example, in "Technical Committee 8" of the ISO (ISO/TC 8) "Ships and marine technology", projects have already been started for the offshore area.

The coming standardisation will make the certification bodies' work easier, permanently, but changing over to the standards will require additional resources. The industry will also need to make an effort to find qualified personnel in the future. ■

Power for six high speed trains: Märkisch Linden wind farm owned by Deutsche Bahn AG.

Setting the right course

The lease agreement is established right at the outset of a wind farm project. When it is signed, it already lays down important prerequisites that determine whether **financing** may be obtained for a turbine, as well as influencing its **profitability** and **acceptance** at the site.

"Lease agreements for the land on which wind turbines are sited apply over a long period of at least 20 years," Franz-Josef Tigges, BWE board member and chair of the legal advisory board, reminds us. "So it is particularly important that both parties are happy." On the whole, it is advisable to follow a balanced approach that considers both the interests of the planners and the land owners. Because the lease agreements are concluded at a very early point in the project planning process, it is also necessary to act with a certain degree of foresight. Tigges, whose main occupation is as a partner for Engemann und Partner, Lippstadt, a law firm that specialises in renewable energy, explains why: "The bank providing the financing does not usually enter the process until after the lease agreement has been signed." However, it is important to make sure from the outset that the agreement also takes account of the bank's interests and that financing remains viable. When agreeing rents, it is necessary to keep an eye of the profitability of the project.

Franz-Josef Tigges answers some important questions for planners and developers together with Philipp von Tettau, Head of the Renewable Energies Division at the law firm Müller-Wrede und Partner, Berlin, and Jann Berghaus, partner at Berghaus, Duin & Kollegen, Aurich:

1

What security does the bank require?

"For the bank, it is important to secure the turbine itself, as well as its continued operation at the site in question," explains Philipp von Tettau. It will insist that appropriate regulations are included in the leasing contract with regard to the ownership structures and the acquisition or transfer options. One specific demand of the bank will be the contractual separation of the turbine from the land. Otherwise, anything erected on the land would automatically become the property of the lessor. The wind turbine is assigned to the bank by the lessor by way of collateral.

To ensure the continued operation at the site, the bank may insist, among other things, on the following agreements: The lessor declares that all obligations from the leasing contract will be transferred to the buyer in the event that the land is sold. If the turbine is sold, all rights are transferred to the buyer. In addition, the landowner waives any right to exercise a landlord's lien on the wind turbine with regard to the financing institution.

"The rights of the lessor and the financing institution are secured by the registration of limited personal easements in the land register for the plot of land concerned," von Tettau continues. This must be the case regardless of the continuance of the leasing contract. Otherwise, a premature termination of the leasing contract would also entail a cancellation under land registry law.

Photo: Paul-Langrock.de

2

Individual or area lease?

In most cases, an area lease is the advised format. This means that the operator does not conclude lease agreements for the individual turbines, but rather for the entire wind farm. This increases acceptance of the project enormously. Tigges explains why: "If a landowner gets 30,000 euros a year, for example, and the neighbour gets nothing, this generates a great deal of envy." In turn, this can cause strong resistance to the project. In the case of an area lease, 70 to 80 per cent of the lease is allotted purely according to the proportion of the land area. The remaining 20 to 30 per cent goes to those landowners who actually have a turbine erected on their land. A further positive effect of this approach is that the entire area is secured and there is no risk of competing offers and projects.

3

What is a realistic rent?

There is a high level of competition for land where a wind turbine can be erected. The experts have observed that planners are offering landowners rental amounts of up to 13 per cent of the net power yields. However, this is short-sighted. Rents at this level jeopardise the commercial success of the project or the returns for the stakeholders. According to Jann Berghaus, initial rents of 5 %, 6 % or 7 % are usual, with an increase to 7 %, 8 % or 9 % after a certain number of years (see also the overview).
The rents are generally somewhat lower if the landowners are granted the opportunity to participate financially. In southern Germany, the rent is on average 1 % lower than in northern Germany.
In any case, it is advisable to keep the rents realistic from the start, as the obstacles are considerable when it comes to renegotiation.

4

What risks are lurking behind the option to withdraw?

The landowner may withdraw from the agreement if the planner does not erect the turbine within a certain period. It is important that this period is not too short in the lease agreement. Otherwise, if the owner has the option to withdraw from the agreement after two years, for example, he may be giving notice right in the middle of the planning phase of a major project. "A period of four to five years is therefore usually more appropriate," explains Tigges. In general, the option to withdraw must be balanced for both the lessor and the landowner. The economic risks must not then be passed on to the lessor, for example. As von Tettau explains: "otherwise, the contract will not stand up to legal examination."

5

What needs to be considered with regard to the agreement term?

The agreement is concluded for a period of at least 20 years, often 25 years. "So that this period is clearly defined, the start of the agreement should not be tied to an uncertain event," advises von Tettau. This means that the term should start with the signing of the agreement, not with the start of construction or the commissioning of the turbine.

6

Is it advisable to pay a retention fee?

For relatively long planning periods, it is often advisable to pay landowners a retention or reservation fee. This may be considerably lower than the subsequent lease and lies in the the three-digit range. Von Tettau points out that "these payments increase contractual certainty."

7

How can acceptance be increased in the communities?

Once area contracts have been concluded and financial participation opportunities agreed for landowners and local residents, it is worthwhile creating a foundation model from which the community can benefit. "The agreement then shows from the outset that a certain part of the rent will go towards a foundation that will be set up to promote social institutions in the community," explains Tigges.

Current rent trend – Turbine type 3 MW, 135 m HH, approx. 100 m RD

1 | Forecast yield: approx. 7,000,000 kWh/turbine
5 % by end of 12th full year of operation, min. € 33,000/turbine
7 % from start of 13th full year of operation, min. € 44,000/turbine
With participation option for landowners

2 | Forecast yield: approx. 7,000,000 kWh/turbine
6 % by end of 12th full year of operation, min. € 30,000/turbine
8 % from start of 13th full year of operation, min. € 40,000/turbine
Without participation option for landowners

3 | Forecast yield: approx. 9,000,000 kWh/turbine
6 % by end of 12th full year of operation, min. € 30,000/turbine
7 % from start of 13th full year of operation, min. € 40,000/turbine
With participation option for landowners

4 | Forecast yield: approx. 10,000,000 kWh/turbine
5 % by end of 5th full year of operation, min. € 30,000/turbine
7 % from start of 6th full year of operation, min. € 30,000/turbine
9 % from start of 11th full year of operation, min.
Without participation option for landowners

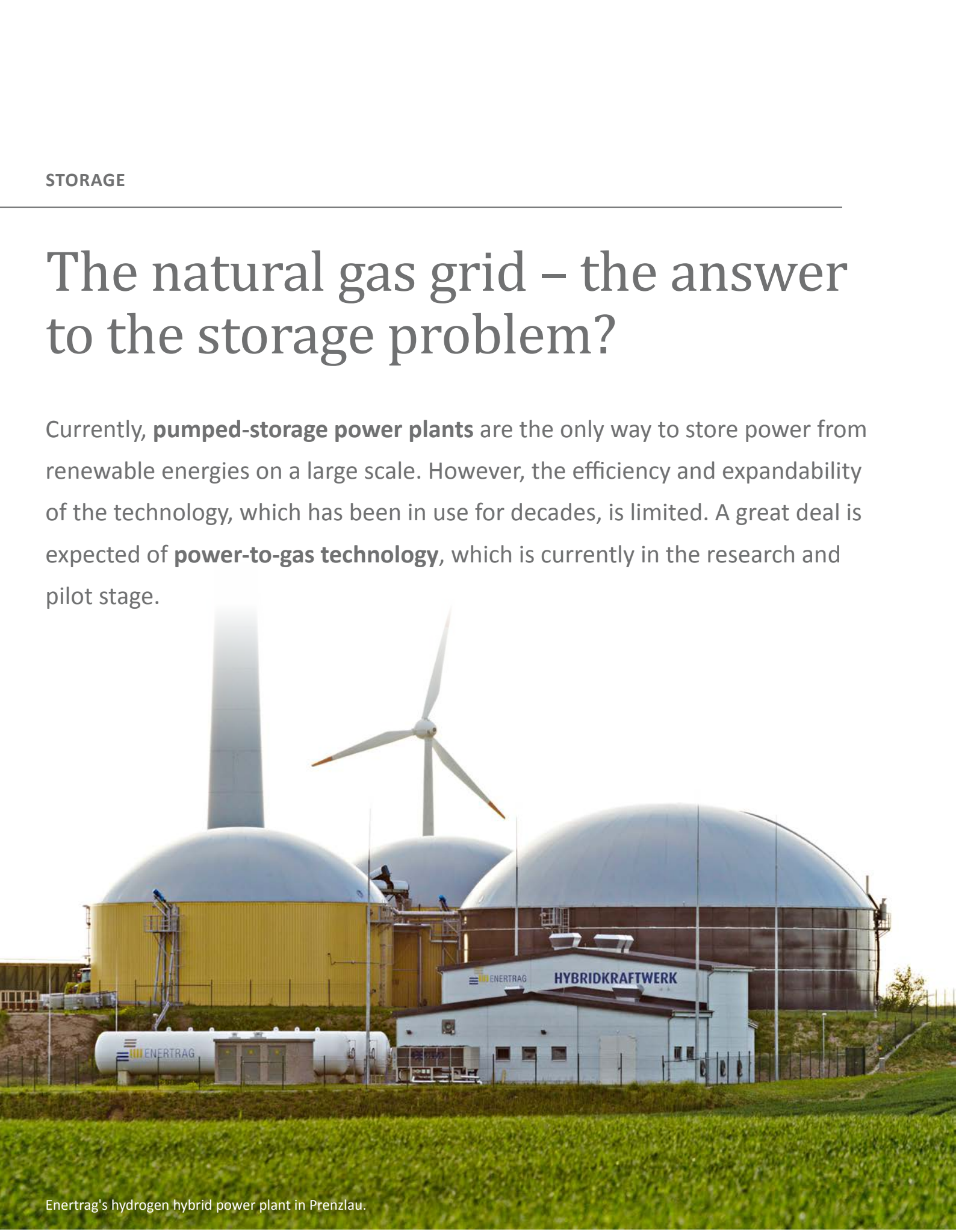
Source: Jann Berghaus, RAe Berghaus, Duin & Kollegen, Aurich

The questions answered:

Franz-Josef Tigges, Lawyers Engemann and Partners, Lippstadt
Philipp von Tettau, Müller-Wrede and Partners Rechtsanwälte, Berlin
Jann Berghaus, Law firm Berghaus, Duin & Kollegen, Aurich

The natural gas grid – the answer to the storage problem?

Currently, **pumped-storage power plants** are the only way to store power from renewable energies on a large scale. However, the efficiency and expandability of the technology, which has been in use for decades, is limited. A great deal is expected of **power-to-gas technology**, which is currently in the research and pilot stage.

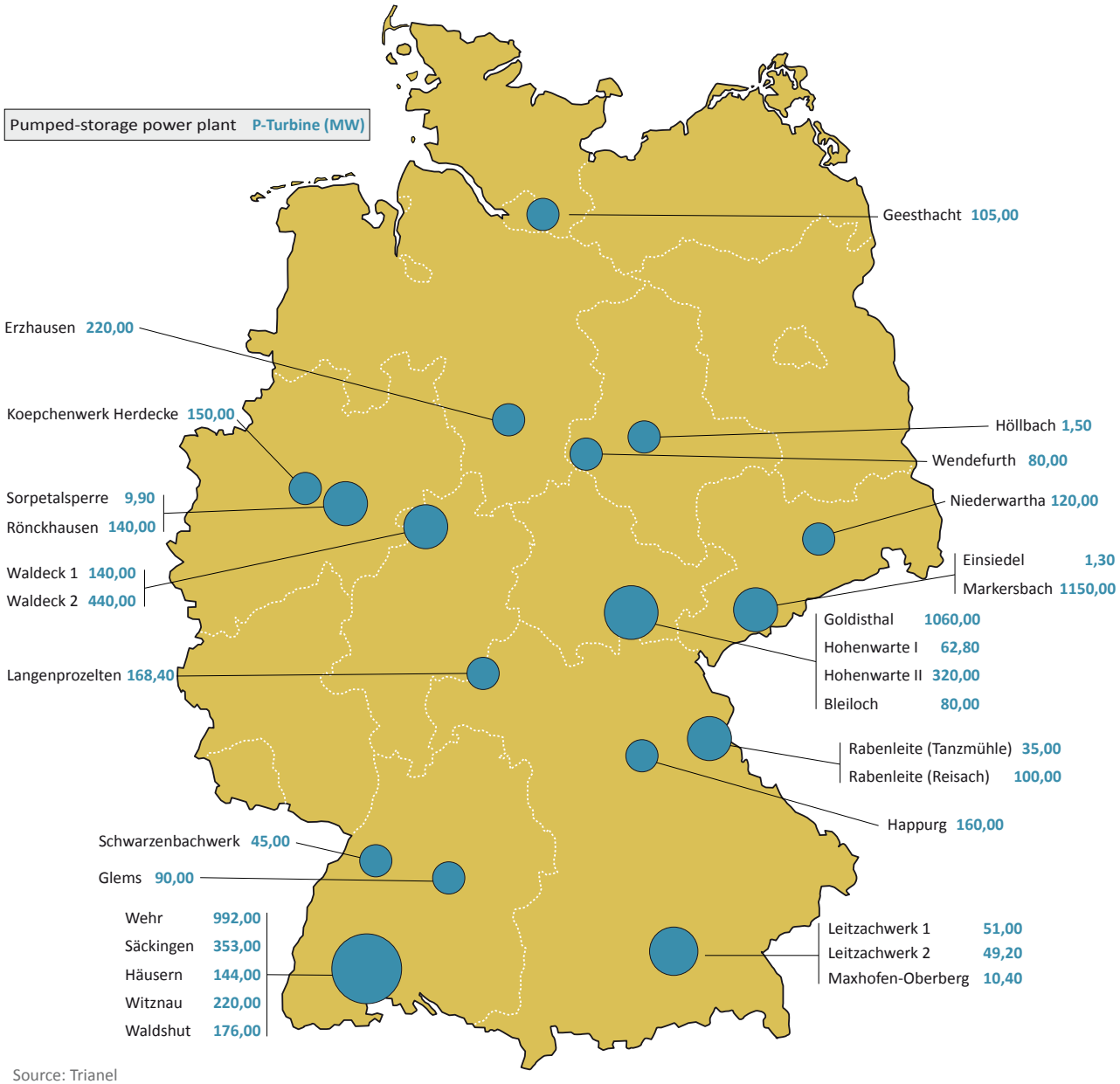


Enertrag's hydrogen hybrid power plant in Prenzlau.

When the pumped-storage plant in Geesthacht was recommissioned in autumn 2011, Jost de Jager, the finance minister of Schleswig-Holstein at the time, declared the plant an important pillar in the development of renewable energies. "The energy turnaround won't work without storage like this," he said. Pumped storage, which has been used since the 1920s, is in fact the only way to store power efficiently and economically on a large scale, and to balance out fluctuations in wind and solar energy.

Pumped-storage plants have an efficiency rate of up to 85 percent. There are currently 30 plants in Germany, predominantly in the south. Around a dozen more are currently planned, by the Trianel municipal utility association among others. The expansion of capacity, however, is very limited. This is due to a lack of suitable locations, which are mainly restricted to low mountain ranges. In addition, pumped storage often involves serious impact on the environment.

Pumped-storage power plants in Germany



Source: Trianel

Photo: Paul-Langrock.de

Pumped storage plant in Waldek, Hesse.

Calculations: pumped storage limits

Another aspect: though the pumped-storage plants have great potential as daily storage reservoirs, they are not adequate as long-term storage for the surpluses from renewable energy. A study carried out by the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) commissioned by Greenpeace Energy provides impressive evidence. It states that the overall power storage capacity currently available is only 0.04 TWhel. In purely mathematical terms, pumped storage could therefore only cover all of Germany's power for less than an hour. If, however, 80 percent of power should come from renewable sources by 2050, as planned by the German government, the IWES estimates that Germany would need storage capacities for 40 TWh of power in order to balance out seasonal fluctuations in wind and solar energy.

"This gap can be closed by the power-to-gas principle in future," explains Jochen Bard, an expert from the IWES institute. This is designed to convert wind power into synthetic natural gas. It involves water being broken down into its component parts, hydrogen and oxygen, in an electrolysis process by means of wind power. Using CO_2, the hydrogen is then converted to methane (CH_4) in a second step. The degree of efficiency in the conversion of power to natural gas is around 60 percent. The synthetic natural gas can be fed into the natural gas grid for generating heat or electricity, but can also be used for renewable mobility solutions. It is also possible to feed the hydrogen into the natural gas grid without methanation. At present, a maximum volumetric proportion of up to five percent hydrogen in the natural gas grid is compliant with the rules. According to the German Energy Agency (dena), current research results clearly indicate that this proportion could be increased to up to 15 percent by volume.

The natural gas grid: huge storage capacities

Power-to-gas technology is interesting in the long term due to the huge storage capacities in the existing natural gas grid. According to the IWES study, they amount to around 220 TWhth, which represent 120 TWhel of electrical storage capacity through an efficient reconversion of 55 percent. This can cover the energy supply needs in Germany for two to three months, according to the IWES. "Before the natural gas reservoir is needed though, the technology could already become important to the mobility sector," says Norman Gerhardt from the Energy Industry and Grid Operation division of the IWES, adding that wind energy could even be deployed independently from the renewable energy surpluses.

The technology is still in a phase of being researched and put to the test. "The power-to-gas system solution is currently being tested in a growing number of pilot and demonstration plants

Photos: Martin Leissl

and the output is developing step-by-step," reports Annegret Agricola, Area Manager of Energy Systems and Energy Services at dena. The objective must be to make the power-to-gas system solution available on an economically viable industrial scale by around 2020.

Research and demonstration plants launched

The SolarFuel Alpha plant in Stuttgart is one of the existing research and development plants, which was inaugurated at the end of October 2012 by the Centre for Solar Energy and Hydrogen Research (ZSW) in Baden-Württemberg. With a rated electrical output of 250 KW, the research plant for methanation is the largest of its type worldwide, according to the institute. The launch of the E.ON pilot plant in Falkenhagen, Brandenburg, is just one of the projects announced for 2013. Equipped with a 2 MW electrolyser, it should feed hydrogen into the municipal gas grid.

The Enertrag hybrid power plant in Prenzlau was connected to the grid as early as October 2011. The power from three wind turbines is converted into hydrogen in a 500 KW pressure electrolyser here, stored in several large tanks and partly mixed with the methane for the connected cogeneration plants. A smaller amount is available for powering cars. In addition, it should be connected to the local gas grid in 2013. Enertrag is already putting hydrogen plants into pre-series production with a subsidiary company. Three 2 MW electrolysers have already been delivered to customers. SolarFuel is also expecting a large demand for its

Elektrolyser at the Enertrag hybrid power plant in Prenzlau.

Power-to-Gas pilot plant at the Centre for Solar Energy and Hydrogen Research (ZSW), Baden-Wuerttemberg.

Photos: Clean Energy Partnership / Caroline Scharff (oben), ZSW (unten)

plants. It is planned to bring units onto the market with up to 20 MW capacity from 2015.

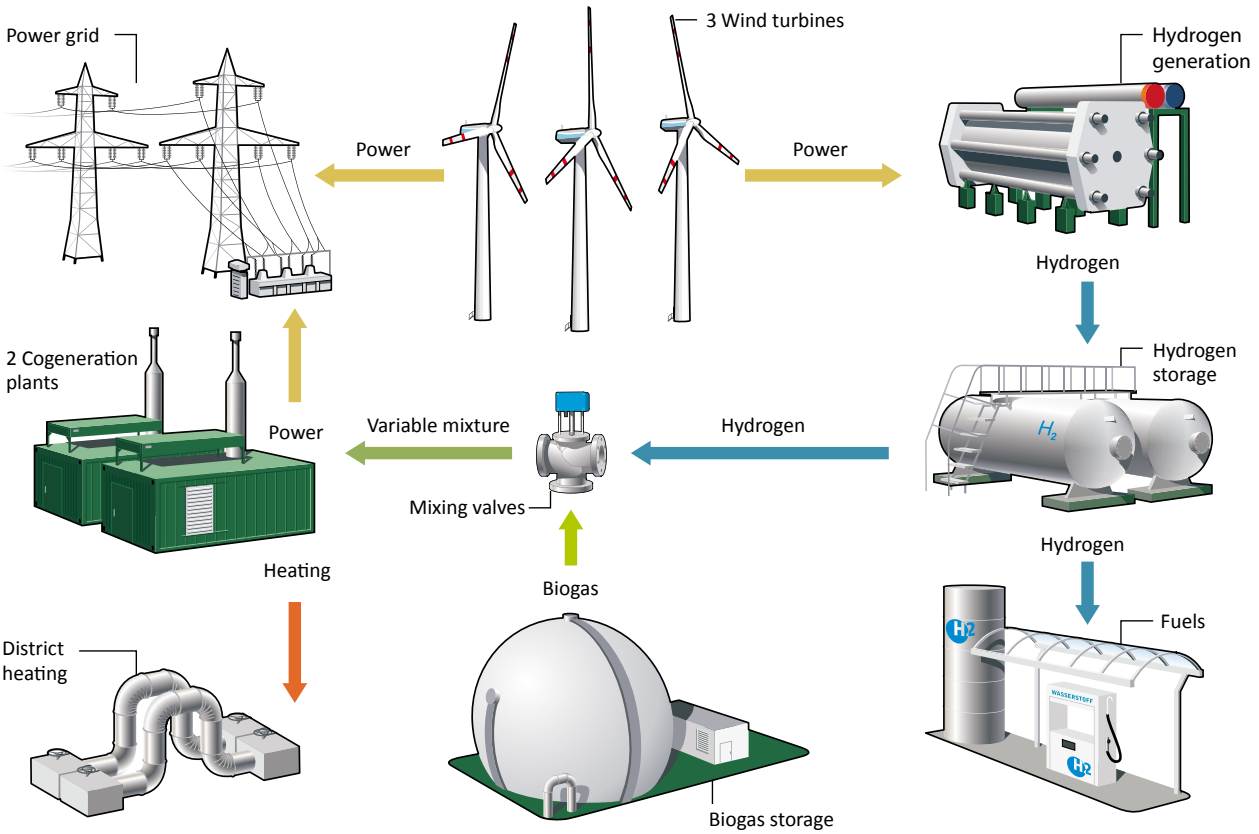
Audi car manufacturer: wind in the tank

SolarFuel is currently building the world's first 6 MW power-to-gas plant on behalf of the car manufacturer Audi in Werlte in Lower Saxony. The topping out ceremony took place in December 2012. The plant is due to go into operation in summer 2013. By adding CO_2 from an adjacent waste biogas plant, thereby preventing the CO_2 from going directly into the atmosphere, so-called e-gas is formed here as a purely regenerative and synthetically produced natural gas substitute. This e-gas will be used to power the new Audi A3 TCNG (Turbo Compressed Natural Gas). "For us, this is an important step towards carbon-neutral mobility. The e-gas vehicles release the exact amount of CO_2 that was previously absorbed in methanation," explains Dr Hermann Pengg, Head of e-fuels Project Management at Audi.

To operate the plant, power from renewable sources is used in periods of low demand. According to Audi, with the storage function, the power-to-gas

technology is able to offer an important contribution to the energy revolution and the fluctuating supply on the basis of renewable energy linked to it. The plant should produce around 1,000 tons of e-gas annually in the coming years.

The ENERTRAG Hybrid power plant



Source: ENERTRAG

Photo: AUDI AG (oben)

This would be enough to drive 1,500 A3 TCNG cars 15,000 kilometres every year, plus feed 150 tons of e-gas into the municipal grid. In order for the concept to work, car buyers also need to have confidence in the new fuel. As yet, the price has not been set. By 2020, it should correspond to the price for biogas, according to Pengg.

Greenpeace Energy: 7,000 customers for the wind gas tariff

Wind gas has already reached end consumers at Greenpeace Energy: the energy cooperative has 7,000 customers on the "proWindgas" tariff (as of December 2012). On this tariff, customers pay a surcharge of 0.4 cent per KWh in order to advance hydrogen technology. "Wind gas is an essential component of a successful energy revolution in Germany," Susanne Grabler, Board member of Greenpeace Energy, explains. The energy cooperative has signed a contract with the company Enertrag. As soon as the hybrid power plant is connected to the natural gas grid, Greenpeace Energy wants to obtain hydrogen from here.

However, Greenpeace withdrew from a planned electrolyser project in Suderburg, Lower Saxony, at the end of 2012. The financial investment and business risk were said to be too high. Furthermore, however, advancing the construction of electrolysers to develop hydrogen production is one of Greenpeace's particular aims. The energy cooperative wants to check alternatives, in which the costs and risks of such a construction project would not be borne by Greenpeace alone, but would be split between several project partners. ■

Laying cables in the Wadden Sea: An 800 MW strong and 200 km long direct current connection as part of the BorWin2 project.

The quicker the better

The number of forced **shutdowns** of wind turbines has increased. This proves once again: grid expansion is the **bottleneck** of the energy turnaround and should be tackled as quickly as possible, not least to save costs in the long term.

Wind farm operators are now realising more than ever before that the grids in Germany are growing too slowly. According to a study carried out by the Ecofys consulting firm commissioned by the Bundesverband WindEnergie (BWE) in December 2012, forced shutdowns of wind farms in 2011 increased by nearly 300 percent due to insufficient grid capacity. This lost a record value of up to 407 gigawatt hours of wind power. In 2010 the figure amounted to 150 gigawatt hours. This power which was not fed into the grid could have supplied around 116,000 households with power for a year.

The key reason for the record forced shutdowns was the wind supply, which was a quarter higher in 2011 with 48 TWh, compared to 36 TWh in 2010. Based on conservative estimates, around one percent of wind power generated in Germany is not fed into the grid. This doesn't sound too dramatic across the country, but hits turbines in the north and east of Germany particularly hard. "Some regional grid operators account for 30 to 40 percent of energy not fed into the grid," explains Dr Stephanie Ropenus, consultant for grid integration at the BWE.

Hardly any investment in grid infrastructure

Overall, the results of the study lead to criticism: "The reason for the bottleneck is that the German grid operators have hardly invested in their grid infrastructure for nearly 30 years, and also mainly refuse grid optimisation options which can be quickly implemented," criticises Hermann Albers, Chairman of the BWE. The federation has put forward important proposals to speed up the grid expansion. This includes the expansion of special feed-in grids, which connect one or several wind farms directly to the transmission grid and supplement the distribution grid (110 kV). According to the BWE, modern high-temperature conductors should be used at all grid levels to strengthen existing paths.

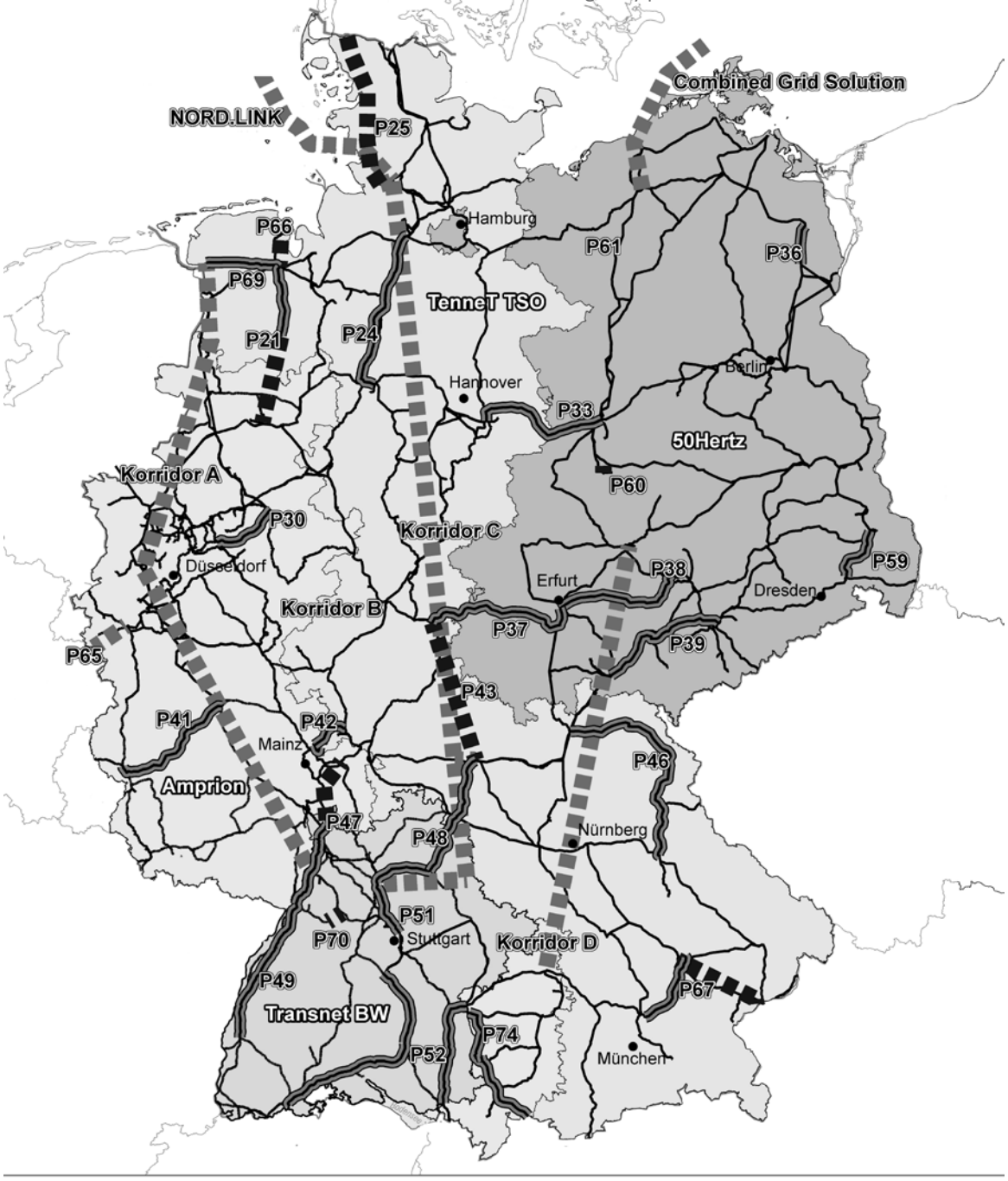
Grid development plan approved in 2012

With regard to the high-voltage expansion, the German Federal Network Agency approved the grid expansion plan of the four large transmission grid operators at the end of November 2012. It sets out the expansion requirement for the coming ten years. A key part of this is the three planned high-voltage direct current transmission routes (HVDC), which transport large amounts of power from north to south and link the offshore farms in the north with the industrial centres in the west and south (see graphic). An originally planned fourth "power highway" from near Bielefeld to

Photo: Tennet

Grid development plan: Confirmation from the German Federal Network Agency

The German Federal Network Agency approved the grid development plan at the end of November 2012. Another HVDC route from near Bielefeld to Greater Frankfurt was originally planned.



Publisher: Bundesnetzagentur
Source reference:
© GeoBasis-DE/BKG 2011
Data basis: Transmission grid operator as of 26 November 2012

Greater Frankfurt is not to be built for the time being. The utilisation by future offshore wind farms in the North Sea is not considered to be sufficiently demonstrated at present.

"By setting an additional test criterion, the German Federal Network Agency has determined the urgently required measures which will serve as a foundation for the German Federal Consumption Plan," explain the transmission grid operators in a joint statement. Implementation could thus be begun. Further measures provided in the draft of the grid development plan remain necessary in the medium to long term, and would not be excluded by the weighting of the German Federal Network Agency. Due to the mandatory annual adaptation of the grid development plan, it is possible to constantly readjust the determined need for grid expansion.

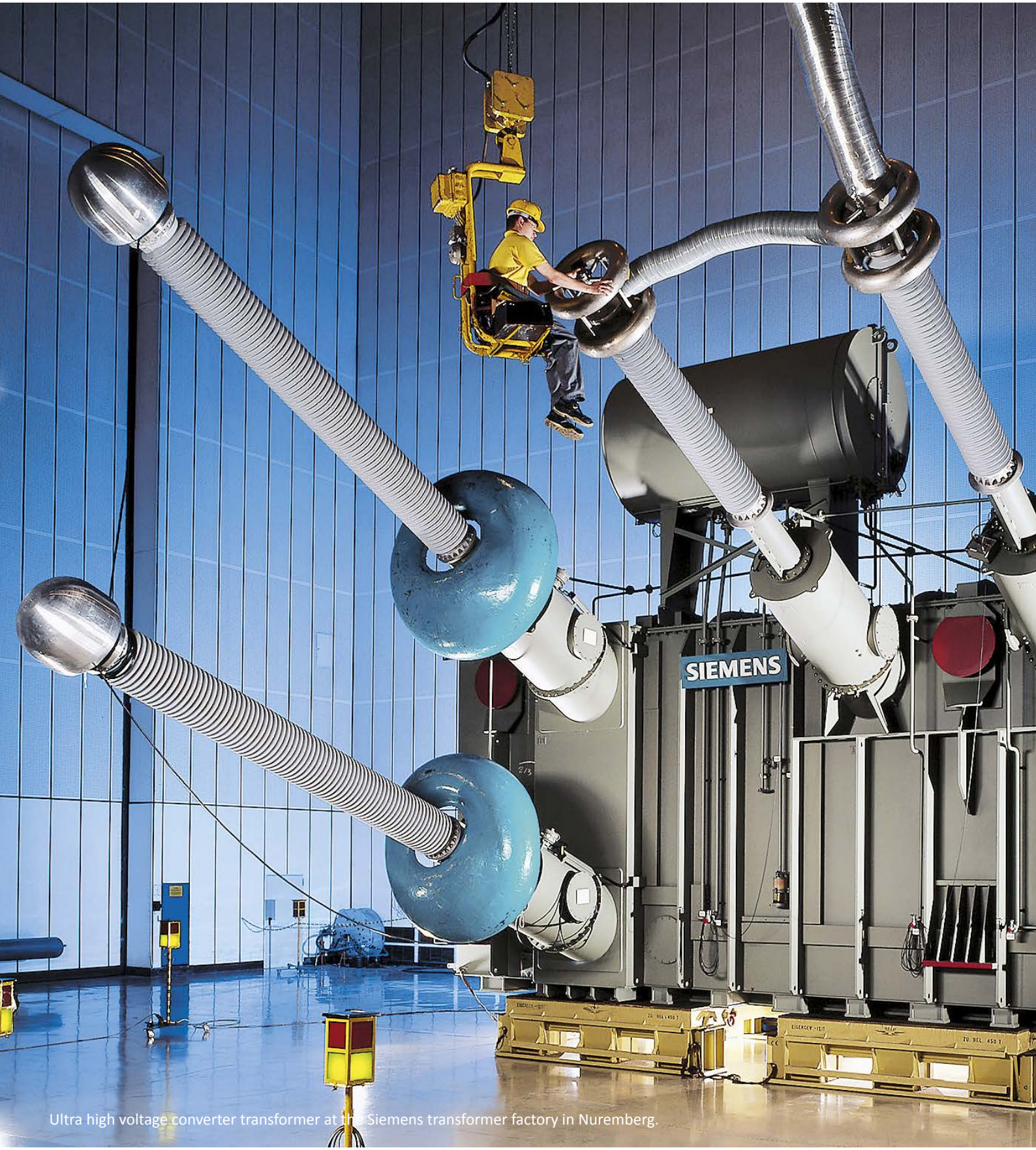
"The grid development plan is an important step for the turnaround in energy policy," adds Stephanie Ropenus from the BWE. It is important that it is now implemented quickly. As a matter of principle, its annual review and adjustment are also welcomed. In addition to the requirements set out in the energy industry law (EnWG), the BWE recommends increasing the emphasis on a long-term optimisation of the grids. Additional flexibility options should be sought – for example, future-oriented storage technologies like Power to Gas, or the interconnection of the high-voltage grid with distribution and feed-in grids.

More acceptance with partial underground cabling

The grid development plan also comes under fire as it only includes overhead lines, which adversely affect public acceptance of projects and delay construction. Partial underground cabling, however, could accelerate grid expansion with the same costs, as shown by a study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. From an overall economic perspective of all costs (investments/transmission losses/grid congestion) it is apparent that for an assumed one-year acceleration of grid expansion by partial underground cabling, the costs are equal to those of

Photo: 50Hertz

Boris Schucht, CEO 50Hertz, German Federal Chancellor Angela Merkel and Prime Minister Erwin Sellering (left to right)



Ultra high voltage converter transformer at the Siemens transformer factory in Nuremberg.

straightforward construction with overhead lines.

In discussion: limitation of feed-in peaks

A striking critical opinion on the grid expansion plan comes from the German Environmental Aid Association (DUH). The grid expansion plan, they argue, is calculated so that every kilowatt hour of energy generated is actually fed into the grid. A key possibility for avoiding grid overloads, it is argued, would be to limit the feed-in peaks of wind farms, which only occur for a few hours a year. An analysis carried out by TU Clausthal states that curtailing onshore wind turbines by just two percent of their annual output could save over 30 percent of grid capacity. The BWE recommends closely examining the respective sensitivities in the range of one to three percent. Instead of simply limiting the generation peaks, they could be put to good use in the future by using new storage technologies.

Quick expansion reduces costs

Industry stakeholders agree that the grids should be expanded very quickly. Bernhard Schucht, head of the 50Hertz grid operator, explains that the costs explode for slow grid expansion. Ever more frequently, interventions are required in the grid and therefore in the operation of power plants and renewable energy plants in order to keep the grid stable. Dr Gerd Rosenkranz, policy counsel and spokesman of the German Environmental Aid Association (DUH) warns: "It is a fundamental error to believe that the energy revolution will become cheaper if it is slower." The opposite is the case: "The longer we operate the old and new energy systems in parallel, the more expensive it becomes for society, future generations and the environment." ■

Photo: Siemens AG

Nacelles for Repower offshore-windturbines in Bremerhaven. Photo: Jan Oelker

Starting shot for the second attempt at gold

2012 was an unsatisfactory year for German offshore wind energy. Whilst the system technology continues to develop and the industry is ready and waiting in the starting blocks, the **expansion of the grid** is still lagging behind the ambitious expansion plans. This can and must change in 2013. The first steps have already been taken.

Expansion in Germany

The developments in installations of German offshore wind farms in 2012 are summarised quickly below: Of the current 29 approved farms, a total of 56 turbines with a total rated capacity of around 220 MW were on the grid at the end of 2012. Compared with the previous year, very little has been done in this regard; the only newly connected wind turbines are in the Bard Offshore 1 wind farm, which was connected to the grid with 100 MW in November. Of the 55 previously installed Bard turbines, 22 were connected to the grid in December.

Projects with around 1.6 GW are under construction, also including the three wind farms Nordsee Ost, Global Tech 1 and Meerwind Süd/Ost, on which construction began in 2012. Furthermore, Borkum Riffgat and Baltic II are under construction in the Baltic Sea, and the DanTysk wind farm is in the preparation stage. One new project was approved in 2012: the RWE wind farm Innogy 1, but this was put on hold by the RWE group in the summer.

Alstom's prototype of the 6 MW class.

Technology: new large turbines for use on the high seas

Recently, many manufacturers have put their money where their mouth is following their announcements of more powerful turbines:

- In April, the first 6.15 MW turbine by **Repower Systems** was put into operation 28 km off the Belgian coast; at the end of July, the second expansion phase was completed at "Thornton Bank" with 30 turbines in the 6 MW class.
- In the autumn of last year, **Siemens** began testing the gearless 6 MW turbine, which is now equipped with a 154-metre rotor diameter, in Denmark.
- In 2012, **Areva Wind** delivered the initial forty 5 MW turbines for the Borkum West II wind farm, and will start construction of the 80 M5000 turbines for "Global Tech 1" in 2013. Other projects are also in the pipeline.
- In spring 2012, **Alstom** set up its first prototypes of the 6 MW class onshore in France; a second turbine should commence operation shortly off the Belgian coast.
- **Gamesa** has announced that it will put its first 5 MW turbines into the water in mid-2013.
- World market leader **Vestas** plans to put an 8 MW prototype into operation in 2014, in cooperation with Dong Energy.
- **Bard** installed two 6.5 MW turbines in the existing Bard 1 offshore farm in 2011.
- **Asian manufacturers** have also adapted their wind turbines to the current performance requirements and installed turbines of the 5 and 6 MW class, in some cases as prototypes and in others for normal operation.

German offshore industry in an excellent position

The supply industry, logistics providers and ports have already adjusted to the expected offshore boom. The production capacities for all types of components have been increased, ships such as the "Innovation" – currently the most powerful installation ship for offshore turbines – have been launched, and the ports, especially those on the North Sea coast, are adapting their infrastructure to the needs of the offshore industry. For example, in December 2012, the financing was agreed for the Bremerhaven offshore terminal with direct North Sea access.

According to the estimations of the wind energy agency WAB e.V., around one billion euros have been invested in industrial capacities and infrastructure to date, mostly by medium-sized companies, but also by local authorities, the states and the federal government.

The northern region of Germany arguably has a world-leading concentration of skills for developing, constructing and operating offshore wind farms. The majority of the German offshore industry operates worldwide or across Europe and therefore plays a leading role in the sector. In the north of Germany alone, well over 3,000 people work in the offshore sector, with the number of jobs expected to increase considerably. The whole of Germany benefits from this, but particularly the south of the country which has a strong engineering sector.

2012 – A lean year

Technology and infrastructure are already available or in development, but the expected boom failed to materialise in 2012. This is primarily due to the expansion of the grid, which virtually came to a standstill in 2012 due to unresolved liability and financing issues. "In 2012, the offshore industry has mainly been battling with the grid connection issue,"

Photo: Alstom 2012 Eric Lamperti (left) Jens Meier (right)

22 turbines were connected to the grid: Bard Offshore 1 wind farm.

German offshore wind farms in the North Sea

Operational	
1	alpha Ventus
2	BARD Offshore 1
3	Dollart Emden
4	Hooksiel
A	
5*	Amrumbank West
6**	BARD Offshore 1
7	Borkum Riffgat
8	Borkum Riffgrund I
9	Borkum Riffgrund West
10*	Borkum West II
11*	Butendiek
12*	DanTysk
13*	Delta Nordsee 1 und 2
14*	Deutsche Bucht
15	EnBW He Dreiht
16	EnBW Hohe See
17*	Global Tech I
18	Gode Wind I
19*	Gode Wind II
20	Gode Wind III
21	Meerwind Süd
22*	Meerwind Ost
23*	MEG 1
24*	Nordergründe
25*	Nördlicher Grund
26*	Nordsee Ost
27*	Sandbank 24
28*	Veja Mate

* In operation up to 2013

** In operation up to 2015

Wind Farms undergoing licensing procedures	
29	Aiolos
30	Albatros
31*	Albatros 1
32	Aquamarin
33	Area C I
34	Area C II
35	Area C III
36	Austerngrund
37	Bernstein
38	Bight Power I
39	Bight Power II
40	Borkum Riffgrund II
41	Borkum Riffgrund West II
42	Citrin
45	Diamant
46	Euklas
47	GAIA I
48	GAIA II
49	GAIA III
50	GAIA IV
51	GAIA V
52	Global Tech II
53	Global Tech III
54	He Dreiht II
55	Hochsee Testfeld Helgoland
56	Horizont I
57	Horizont II
59	OWP Gannet
60	OWP Heron
61	OWP Seagull
62	OWP Petrel
63	Innogy Nordsee I
64	Jules Verne
65	Kaikas
66	Kaskasi
67	Meerwind West
68	Nautilus
69	Nemo
70	Nordpassage
71	Notos
72	NSWP 4
73	NSWP 5
74	NSWP 6
75	NSWP 7
76	OWP West
77	Sandbank 24 Extension
78	Sea storm I
79	Sea storm II
80	Sea Wind I
81	Sea Wind II
82	Sea Wind III
83	Sea Wind IV
84	Skua
85	Weiße Bank (Cancelled)
86	Witte Bank
109	Prowind 1
110	Prowind 2
111	Prowind 3
112	Neptun (A)
113	Neptun (B)
114	Neptun (C)
115	Neptun (D)
116	Neptun (E)
117	Enova Offshore NSWP
118	TAGU
119	Mainstream
120	Norderland

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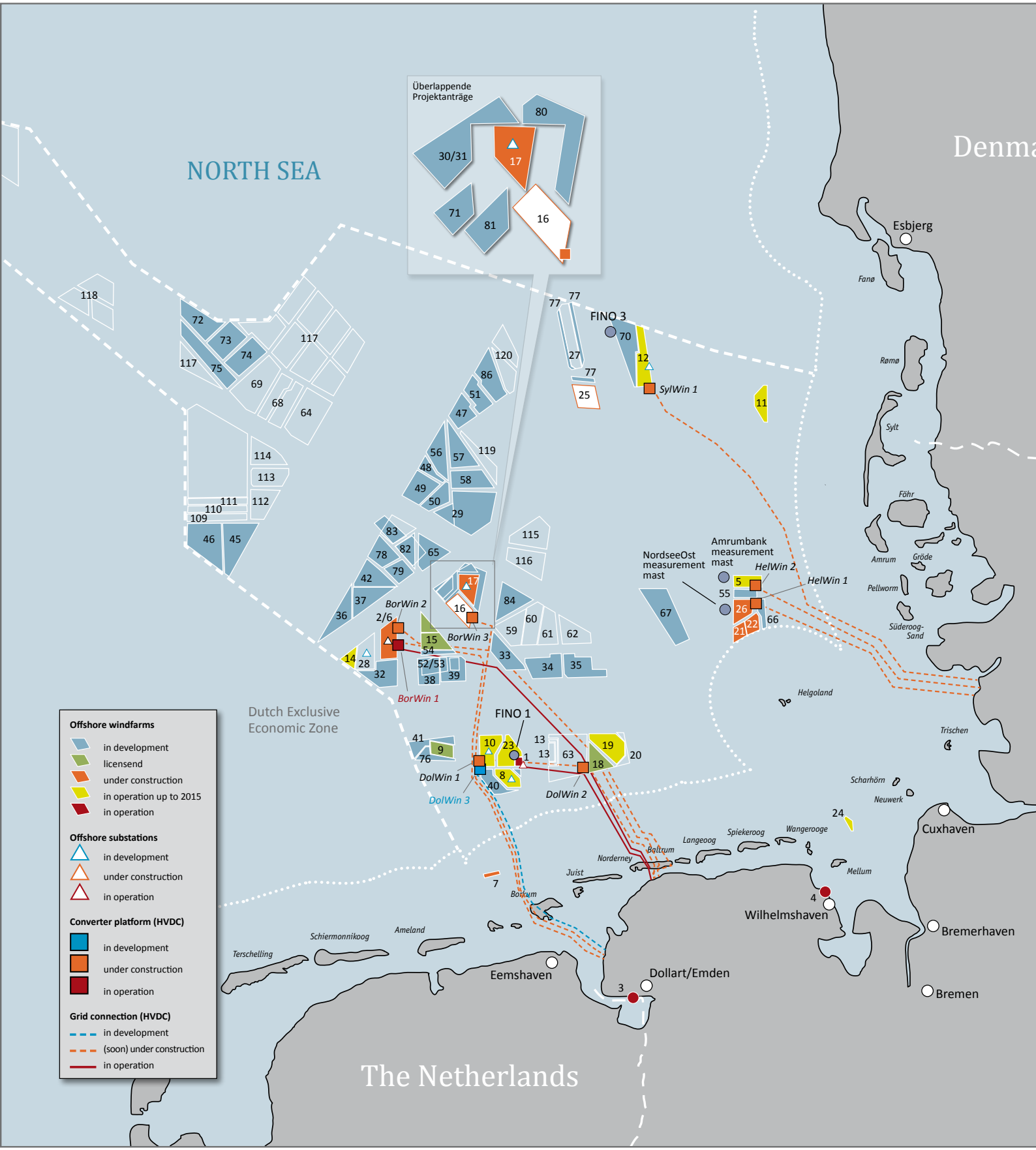

NORTH SEA
Überlappende Projektanträge
80
30/31
17
71
81
16
Denma
Esbjerg
Fanø
Rømø
Sylt
Föhr
Amrum
Gröde
Pellworm
Süderoog-Sand
Helgoland
Trischen
Scharhörn
Neuwerk
Cuxhaven
Wilhelmshaven
Bremerhaven
Bremen
Dollart/Emden
Eemshaven
Schiermonnikoog
Ameland
Terschelling
Juist
Norderney
Baltrum
Langeoog
Spiekeroog
Wangerooge
Borkum
Mellum
FINO 3
SylWin 1
NordseeOst measurement mast
Amrumbank measurement mast
HelWin 2
HelWin 1
BorWin 2
BorWin 3
BorWin 1
FINO 1
DolWin 1
DolWin 2
DolWin 3
Dutch Exclusive Economic Zone
The Netherlands
Offshore windfarms
in development
licensend
under construction
in operation up to 2015
in operation
Offshore substations
in development
under construction
in operation
Converter platform (HVDC)
in development
under construction
in operation
Grid connection (HVDC)
in development
(soon) under construction
in operation

The installation vessel "Innovation" in Bremerhaven.

says Ronny Meyer, Managing Director of WAB. "The incessant delays and lack of a reliable grid connection are the biggest risk for offshore projects."

To some extent, the foreseeable effects of this are already being felt: investors such as Dong Energy, RWE Innogy and EnBW Erneuerbare Energien have put some of their projects on hold. The municipal utility group Südweststrom has postponed its commitment to Bard Offshore 1 until further notice, partly due to a change in ownership structure.

The reasons for the (partial) withdrawal of investors are understandable: "We need legislative clarity and reliable framework conditions before we make a decision to invest well over 1.5 billion euros," says Dr Hans-Josef Zimmer, Chief Technology Officer of EnBW, in a press release. However, EnBW as well as Dong Energy and RWE stress that they want to maintain their links to the high sea Borkum Riffgrund and Innogy Nordsee projects.

"The offshore industry has lost a lot of time in 2012. The new regulations on grid expansion should be implemented as quickly as possible in 2013, so that we have no more lean years like 2012," concludes Meyer.

Rays of hope

Whilst the majority of operators are battling with insecure framework conditions and delays, Windreich AG appears to be immune; the company from Wolfschlugen in Baden-Württemberg is fully on track with its three offshore projects Deutsche Bucht, Global Tech 1 and MEG 1: "We were even able to start construction of Global Tech 1 earlier than originally planned," reports Willi Balz, sole shareholder of Windreich AG. "All three farms already have unconditional connection consent. We will therefore also be able to start constructing Deutsche Bucht and MEG1 on time," says Balz.

In the Windreich chairman's opinion, grid connection is not the only reason for the existing construction delays for market participants: "If an operator fulfils all obligations, therefore paving the way for the grid connection commission by the German Federal Network Agency, he can sue if this is not done." Balz took this approach himself for Global Tech 1. In his opinion, this procedure can also lead to success in other projects.

In any case, the grid problem is somewhat over-dramatised, but Windreich is also acting with foresight here: "When our three current projects are in the water and on the grid, we will turn our attention to the Baltic Sea from 2017. With larger turbines, we can also achieve attractive returns there, and the grid connection will be considerably easier than in the North Sea," says Willi Balz.

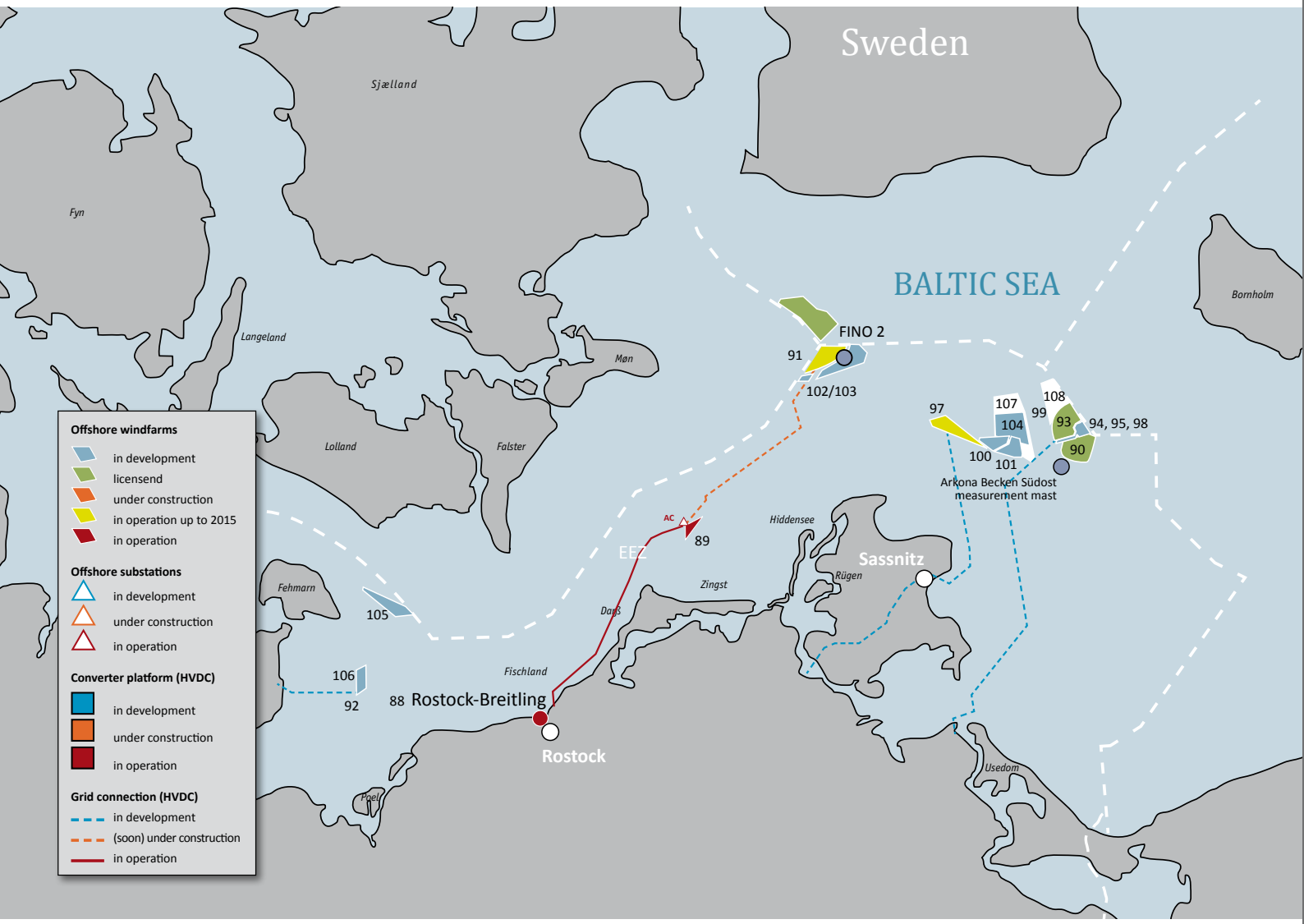
Good news also came from other market participants in 2012, for example from PNE AG: the project developer from Cuxhaven has sold all of his Gode Wind I to III wind farms to DONG Energy, and will support the energy company in the coming five years as a service provider for their implementation.

New energy industry law: a breakthrough?

The revised energy industry law (EnWG-E), passed by the German Bundestag and Bundesrat at the end of 2012, should create the reliable framework conditions for further offshore expansion which

Photo: HGO InfraSea Solutions

German offshore wind farms in the Baltic Sea



Operational	
88	Breitling / Rostock
89	Baltic 1
Licensed Wind Farms	
90	Arkona Becken Südost
91	Baltic 2
92	Geofree
93	Wikinger (ehem. Ventotec Ost 2)

Wind Farms undergoing licensing procedures	
94	Adlergrund 500
95	Adlergrund GAP
96	Adlergrund Nordkap
97	Arcadis Ost 1
98	Arcadis Ost 2
99	ArkonaSee Ost
100	ArkonaSee West

101	ArkoneSee Süd
102	Baltic Power East
103	Baltic Power West
104	BalticEagle
105	Beltsee
106	Beta Baltic
107	Strom-Nord
108	Windanker

Map and table with kind support of: wab windenergie agentur

are necessary from the perspective of all stakeholders. Among other things, it regulates the system changeover in grid expansion, so there will be an offshore grid expansion plan, which is to be presented by the grid operator every year in March. Currently, the construction of the grid connection is triggered by the construction approval of the wind farm, which has led to considerable delays in some cases.

In addition, the law also contains new rules regarding the issues of liability; the grid operator's liability for compensation for connecting offshore wind farms to the power grid is limited to 17.5 million euros per damaging event in cases of simple negligence, and the maximum amount of compensation is capped at 110 million euros.

There is a consensus that this law had to happen, even though some important issues still urgently need to be resolved: "It still doesn't clarify how the upcoming grid expansion measures are paid for," says Andreas Wagner from the German Offshore Wind Energy Foundation. "If TenneT's financing problems are not resolved quickly, the law will be in vain." The industry's demands for the state and the KfW banking group to take a stake could be a way to resolve TenneT's financing problems.

A milestone for offshore expansion

The regulation that the grid operator will create the grid development plan in the future is also assessed critically: "In a system changeover, the German Federal Network Agency must ensure that all relevant stakeholders, and above all the wind farm operators, are also included in the planning," says Wagner. Another important point is the issue of "intermeshing" the offshore grid, which could be counterbalanced with possible power failures. The German Federal Network Agency is also required to structure the implementation of the law accordingly.

Construction of Ormonde offshore wind farm in the Irish Sea.

Photo: Jan Oelker / Repower

Overall, the revision of the EnWG is vitally important: "The law clearly still has some weaknesses and does not clarify all the important issues," explains Henning Dettmer from the Bundesverband WindEnergie. "However, it was urgently needed and is an important milestone for further expansion." It is therefore crucial that it is implemented quickly, that all key stakeholders are included and that further delays are consistently prevented. If this is done, a big step can be taken towards our aim of 10 GW by 2020. Dettmer: "The law can be the starting shot for offshore energy's second attempt at gold." ■

Service staff at Uthlede wind farm, Lower Saxony.

Service companies stay on the ball

For service providers, the market has been kept on the move by the growing **age of turbines**, **increasing demands** and the trend towards **full servicing**.

For most independent service providers there was no shortage of work in 2012. Some even showed marked growth. Out of the companies that participated in the survey for two years, about half reported an increase in their workforce, some of which was considerable.

The great majority of the participating companies expect business to continue to grow for independent service providers, although growth will be slightly less dynamic than in the recent past. "Due to the greater focusing of the onshore market we expect the rapid growth of recent years to slow down", explains Dinah Timmerhues, commercial manager of Hamm-based UTW Dienstleistungs GmbH.

The market remains exciting

The service and maintenance market was on the move in 2012. Deutsche Windtechnik took over Winstrom Service SH GmbH as early as January. In July, the takeover of Voith's wind service activities by Availon was announced. And in November, the German subsidiary of the international service provider GES took on the servicing branch of Hamburg-based manufacturer Hamburger Powerwind GmbH as a consequence of their insolvency proceedings.

These examples amply illustrate the continued dynamism of the sector. Changes in the operator structure and the unbroken trend towards full service contracts are important reasons for this, as Matthias Brandt, Director of Deutsche Windtechnik AG explains: "The structure of operators and investors in wind energy has changed considerably over the last years. Today we have more medium-sized and larger operators which not only place greater demands on quality but also increasingly call for all-in-one solutions." In his company, over half of the new business acquired over the last two years is in the form of full servicing contracts. "In addition, contracts have a greater overall volume since the portfolios of wind turbines contracted out in one batch have grown", Brandt adds.

Matthias Brandt knows his field. His company is one of the largest independent service providers which in December 2012 took on the full service of 24 Vestas V80 plants in Germany and Poland, respectively. In July, Availon, another large player in the sector, concluded agreements with the Danish Momentum Gruppen S/A for the full service of Vestas and GE turbines in Germany amounting to a total of 30 MW.

The increasing demand for independent service may also be due to the difficult economic situation some manufacturers are still finding themselves in. As a consequence, trust has waned in the ability of these manufacturers to comply with service contracts that often extend over 10 years or more. Against this background, the market share of independent service providers, currently at around 20%, can be expected to grow.

Increasing demands

The growing specific needs brought about by technological developments and the changing legal framework may be another reason why independent service providers can benefit. System service bonus, direct marketing, remote control and higher demands of grid operators have led to a veritable boom in the refitting and retrofitting of existing

Photo: Jens Meier

Servicing a Siemens turbine at Uthlede wind farm, Lower Saxony.

turbines. This trend is set to continue. "Last year we intensively dealt with potential direct marketing concepts for our wind farms", Axel Groskreutz reports, Director of commercial management at ABO Wind. "Next is the technical retrofitting of turbines", he says. Groskreutz confirms that the rules for direct marketing require considerable additional know-how: "The ever more demanding rules for grid balancing and direct marketing increase the demands placed on operational management, service and maintenance. This applies to technical aspects as well as to commercial management."

Higher demands on turbine technology are a key aspect here, as are increasing hub heights and rotor diameters. Henning Thormälen of Strategieberatung Oliver Wymann, a strategic adviser to wind energy companies in optimizing their service business, sees a bright future for larger independent providers: "With a certain overall size and a service portfolio geared towards added value, independent service providers can achieve attractive margins." Smaller providers on the other hand which can only offer individual repairs may more readily come under pressure.

Specialization as a key success factor

At present there is no evidence for small providers coming under pressure. They continue to play a key role in the service business.

Not least, this applies to companies which service specific, often older types of turbine. The long-standing competence built up by such service providers is particularly important for turbines whose manufacturers are no longer on the market or no longer offer comprehensive service. "As turbines age our service is becoming ever more important", says Christof Schinke, managing director of Speedwind GmbH. "Repairs tend to be cheaper than new replacement parts and bring considerable cost advantages especially where older turbines are concerned. Furthermore", states Schinke, "our customers have no choice for some of their turbines as replacement parts are no longer manufactured." In order to be ready for such cases, Speedwind cooperates with smaller providers: "This allows us to react very fast and flexibly when it matters."

The growing number of larger operators is also an opportunity for service providers specializing in individual components or processes. Large and experienced wind farm operators are building up in-house service units in order to shoulder more tasks themselves and to reduce their dependence on the services provided by the manufacturer.

Highly specialized services in individual areas such as controls, gears and rotor blades are much in demand. "As specialists for rotor blades we can build on years of expertise", explains Ingo Laabs of Windigo GmbH, "which is why operators providing part of the service in-house are very open towards our offer, especially when their portfolio comprises several turbine types." Regular customers of his company include smaller and larger operators as well as manufacturers and larger independent service providers.

Many other specialists are also characterized by a heterogenous customer structure. "Our know-how is utilized by manufacturers and full service contract providers as well as small and large operators", states Dinah Timmerhues of UTW. Her company concentrates on all safety-related aspects of the turbine and therefore faces an optimistic future. "Safety and proof of safety are becoming ever more important", Timmerhues continues, "so our independent expert knowledge is just as important for existing turbines as it is for new developments."

Expectations offshore

While there is continuous, although less steep development for the majority of service companies in the onshore

Photos: Jens Meier

market, expectations are very high with respect to the imminent offshore service business. “Offshore wind energy will pick up speed again, not least on account of the new law passed in late 2012 to regulate the problem of liability”, Silke Steen of WKA-Service-Fehmarn GmbH expects.

Her company is prepared for this: “At present, offshore service and maintenance only make up a small percentage of our overall turnover. This will probably change considerably this year, which is why we will increasingly focus our activities on offshore wind”, she reports. The subsidiary of the GES group has been active offshore for about two years, mostly in international rather than German waters. “On the high seas, individual service and maintenance concepts are particularly important when it comes to planning for turbine maintenance. Unplanned service can become very expensive here.” This is why the know-how of highly specialized providers is of vital interest to investors and operators.

Diversification before consolidation

Apart from increased pressure on prices, which was noted by many of those active in the field, overall analysis of the service market shows two opposing trends. On the one hand, the increasing demand for full service contracts and longer contract periods will enable larger independent service providers to expand their business for the foreseeable future. On the other hand, the growing age of existing turbines and the growing demand for highly specialized knowledge also promises a bright future to small specialized service providers.

“Although the market for service providers is extremely competitive, there is no real consolidation yet”, explains Dieter Fries of the BWE operators’ advisory board. “We are in a phase of diversification, with service quality increasing all the time on account of increasing competition. This primarily benefits operators, but also independent service companies of any size, as long as they keep up with market demands.” ■

Overview of service-suppliers

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
ABO Wind	Germany: 220, abroad: 110	Engineers: 11 Technicians: 11	Germany, France, the United Kingdom, Ireland, Bulgaria	Central remote monitoring and operation management in Heidesheim for Germany, the United Kingdom and Ireland, locally in France and Bulgaria. An employee is also on-site in the UK and Ireland. 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, N90, N100, N80, N117; Repower: MD77, MM92; SeeBa/Nx N43; Siemens AN Bonus; Vestas: NM1000, V80, V82, V90
Availon	Germany: 950 Abroad: 250	Engineers: 20 Technicians: 145	Worldwide with a focus on Germany, Austria, Italy, Spain, Poland, other European countries and the USA.	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.
AEROCONCEPT AEROCONCEPT Ingenieurgesellschaft für Luftfahrttechnik und Faserverbundtechnologie mbH	Approx. 200 turbines/year for individual orders across Europe	Engineers: 6 Technicians: 20	Europe, Turkey Worldwide on request (e.g. USA)	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.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
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 the turbine.	Generally three years, can also be arranged individually	Technical and commercial management, inspection and technical status 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, organisation optimisation: introduction of a computer-aided customer, inspection and order management system and a content management system.
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.
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. 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, offshore entry, adaptation of our patented AEROCLIMB operating platform technology for additional turbine types and size classes, expansion of consulting.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
Rexroth Bosch Group Bosch Rexroth AG - Service Renewable Energies	-	Technicians: 20 (EU) Engineers: approx 20 (DE)	Worldwide	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).
C&D ÖLSERVICE C&D Ölservice GmbH	Germany: approx. 1500; abroad: approx. 900	Technicians: 15 Engineers: 1	Germany and all EU countries	Central organisation in Oldenswort.	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	Germany: approx. 450 Abroad: approx. 150	Engineers: 8 Technicians: 35	Worldwide	Central	All manufacturers and types of turbine.
DEUTSCHE WINDTECHNIK Deutsche Windtechnik	January 2013: Fixed maintenance contracts for over 1,200 wind turbines, including full maintenance for over 200 turbines; 50 substations under contract; alongside rotor blades, repairs, assessment, safety checks and much more for around a further 1,500 turbines.	280 employees in total, including technicians and engineers.	Primarily Germany, neighbouring countries.	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.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
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 reaction time	Standardised service contracts, up-tower gear replacement, ongoing upgrades.
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.	Commissioning another truck and 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.
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). Further stepping up training and qualification (including on the job training), further offshore activities and international orders.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
EEG Service & Technik GmbH	Germany: 46	Engineers: 2 Technicians: 4	Schleswig-Holstein	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.
ENERCON GmbH	Over 20,000 ENERCON wind turbines worldwide.		ENERCON sales area	Worldwide, decentralised service network with headquarters and several branches and service stations.	All ENERCON turbine types
ENERTRAG Service	Germany: approx. 750 Abroad: approx. 250	80 service engineers, 30 employees in sales administration.	Across Germany, Benelux, France, Austria, Poland, the rest of Europe on request.	Decentralised service support points in 20 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 up to 2.5 MW; NEG-Micon up to NM64; Repower: MD70/77; Fuhrländer FL70/77, FL2.5 EV2500; Nordex: N70/77; Südwind: S70/77

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Service contracts only as full service packages including repairs, remote monitoring, fault clearing at a flat rate. Restriction in 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.
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.	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.	For full maintenance contracts over the whole contractual period.		Further development of service products and service concepts, services after the 20th year of operation, support in the implementation of legal guidelines and regulations in the wind energy sector, expanding the service network, increasing training capacities, introducing a European central warehouse.
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.	Around-the-clock remote data monitoring, repairs and inspection according to the manufacturers' guidelines, servicing, technical support, spare part management with online sales, repairs to converters and transformer stations, drive train analysis by video endoscopy and vibration measurement, oil change service, expert testing, rotor blade service (inspection/ repairs), replacement of major components, retrofit measures.	No. Depends on the number of turbines and the service package.	Failure analysis and immediate repair where appropriate within 6 hours between 6 am and 5 pm on working days and within 12 hours at other times. For fault messages which arrive by 12 noon, action will be taken on the same day. For fault messages which arrive after 12 noon, action will be taken at the latest by 10 am the next day.	Operational and administrative processes will be modified to improve the quality of service. Service operations will be given technical support with a view to increasing efficiency. Setting up an online spare parts shop.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
GES Global Energy Services	12,100 MW worldwide (most important markets are Germany, Spain, the USA, Italy, Portugal, Poland and Central and South America)	190	Worldwide, apart from Asia and India	Worldwide, currently not including Asia and India	All Vestas, Gamesa, GE, Repower, Made, Areva (Multibrid), Acciona, Alstom and Powerwind wind turbine types.
GE Wind Energy	Germany: approx. 1,500 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.
Dirk Hansen Elektro- und Windtechnik	Approx. 180 wind turbines worldwide	21 technicians and engineers	Germany and Europe	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

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Individual selection from different service modules or service packages. From straightforward technical consulting to remote monitoring and operation, maintenance, wearing parts, performance reports and fault clearance.	Individual, depending on the project / request.	Terms optionally fixed or individually on a modular basis.	Onshore: planning, turn-key construction, installation, maintenance and servicing; incl. rotor blades. Offshore: installation, servicing and maintenance, incl. rotor blades.	By negotiation.	Depends on location / project	For 2013: further development of the service portfolio, 2nd level support, expansion of German site.
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 turbine availability, retrofitting to comply with grid connections, guarantee of availability, repairs, major component repair and replacement, blade maintenance.	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 production 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.
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.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
L&L Rotorservice GmbH	Approx. 1,800. Abroad: approx. 250	Engineers: 3 Technicians: 60	Europe-wide	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.
LTB Hochsauerland GmbH	Germany: approx. 1000, Abroad: approx. 200	Approx. 40	Across Germany and Europe	Preferably from the manufacturer and in free trade.	Rotor blades and other fibre-composite components of all types.
Nordex SE	Worldwide, approx. 5,000 turbines, of which approx. 1,700 are in Germany.	Approximately 140 technicians and engineers	Across Germany, worldwide in all countries where Nordex turbines are in operation.	24/7 remote monitoring and technical support are operated in the Hamburg headquarters and in Rostock. Our CSOs around the world are supplied by our central warehouse for spare parts. In the Germany Service Area, which also includes Benelux and Poland, there are five other warehouses in our Customer Service Offices. Other spare parts are in the 37 service points on site, which are near to the Nordex wind farm. Nordex Service has approximately 100 service points worldwide.	The whole Nordex product portfolio (N27-N100/ N117) and the former Südwind portfolio (S46-S77).

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
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.	Rotor blade inspection, maintenance, care, optimisation, GRP repairs on site / in the factory, coating. Tower and nacelle: cleaning works, maintenance, safety check. Repowering: storage of components, complete disassembly of wind turbines, disposal of rotor blades. Heavy transport logistics. Training in our own academy. Research and development. All services are certified according to DIN ISO 9001 from 2013.	Rotor blade set replacements available for a range of wind turbine types.	Within 24 hours in emergency situations.	Further specialised staff will be recruited for heavy haul logistical operations and the vehicle fleet will be expanded by adding additional trucks and trailers for rotor blades of the 60+ dimension.
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 and fibre composite technology, as well as repairs to halls and platforms, mobile workshop for major repairs on site.	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.
Four concepts with different terms and contents: Basic, Extended, Premium and Premium Light. The contracts offer variable package solutions such as, for example, the Nordex Basic contract, which includes regular maintenance work as well as 24/7 remote monitoring. The Nordex Extended contract expands this to an availability guarantee and regular reporting. Finally, the Nordex Premium contract covers all costs for maintenance, repairs and delivery of spare parts. The new Nordex Premium Light contract combines the preferences of the Premium contract with co-payments for selected components and repairs. This allows operators to manage their risk coverage more cost-effectively and according to their needs. (In the event that a major component needs to be repaired, Nordex will submit a specific offer.) 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, a number of factors are considered such as expected annual production in kWh, the regional situation of the turbines, the terms of the contract, the level of guaranteed availability, etc.	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 which are specific to the project and country can vary.	Extensive range of services and complete solutions such as 24-hour remote monitoring, preventive maintenance, retrofit packages or also full modernisations; for every turbine, quick to arrive on site thanks to the decentralised network.	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.	Focus on continual improvement of the service quality and the development of the German service locations.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
N.T.E.S. GmbH	Germany: 200	Technicians: 20	Germany	Central remote monitoring and operation control in Bremervörde. Service station in Hohenhameln. Central procurement of spare parts.	Bonus/Siemens 150 KW - 2.3 MW
psm Nature Power Service & Management	400 with technical service, in total 220 with maintenance contract.	50	Across Europe, with a focus on Germany, France, Italy and Portugal.	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.	Fuhrländer, Repower, Nordex, (MD series); DeWind; NEG Micon; WindWorld;
Renertec GmbH	80 turbines, approx. 130 MW total installed capacity.	4	Germany	Full maintenance contracts with turbine manufacturers, coordination of maintenance teams.	Enercon, Vestas, GE, Fuhrländer
Repower Systems	Germany: 1,280 (onshore) Abroad: almost 90.	"Operations" division (maintenance and repairs): around 130 technicians and twelve foremen.	For every REpower turbine worldwide.	18 service support points with material store in Germany. Also 75 service vehicles with material, which are supplied with spare parts from the service warehouses as required. Rapid service is guaranteed with SAP-controlled, project-specific spare parts lists. Major components are also replaced in-house by an independent, specialised service unit.	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.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
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.
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 and repair, technical management, commercial management, consultancy, replacement of major components, gearbox videoscopy, repowering (turbine assembly/disassembly), transformer service, converter service, fault clearance, remote monitoring, day and night warning light.	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.	Consolidating the position as an independent service provider and highly regarded service company, further expansion of service structures and range of services.
Technical and commercial 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.
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.	ISP guarantees fixed turbine availability for the contract period. This means that fixed fees are agreed with customers for downtimes or missed targets, as well as bonuses in the event that they exceed expectations. At least one year's guarantee for all services.	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 and new projects. A contract type is planned which would offer contractual technical support services to customers who do not wish to extend their contracts when they expire. REpower will offer a production guarantee as a new product.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
Rewitec GmbH	Germany: approx. 100 Abroad: approx. 30	Technicians: 1 Engineers: 2	Worldwide	Service operations and procurement of spare parts for customers organised centrally from the company headquarters in Lahnau (situated in the central Germany).	All geared turbines by all manufacturers.
Rotor Control GmbH	Repairs and assessments for approx. 400 turbines.	13 employees, including 10 technicians.	Across Germany and neighbouring countries, assessment using rope access technology, EU, USA and Canada.	Central	All manufacturers and types of turbine.
Seilpartner Windkraft GmbH	Approx. 750 in Germany and 600 abroad	2 engineers 20 technicians	Worldwide	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.
Service4Wind GmbH & Co. KG	60	8	Germany	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.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
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 6,400 euros. Coating lubricant costs 500 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 original equipment manufacturers (OEMs) and service companies, further product optimisation, patenting
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.
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.
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.	Immediately via remote monitoring, introduction of measures within 8 hours, on-site operations within 24 hours.	FL 2500 service contracts, full maintenance contracts for certain wind turbine types.

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
SIEMENS Siemens Wind Power	12 GW in service worldwide.	Around 2,500 service employees worldwide.	In 20 countries worldwide, in America, the UK & Ireland, Asia Pacific, Europe, the Middle East and Africa.	Spare parts and main components are delivered from the central warehouse in Tinglev (DK) with a storage area of 35,000 m²; additional service warehouses in other regions and countries.	Siemens: all types
speedwind Speedwind	Germany: 52	Technicians: 5	North and central Germany	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 NEG Micon: NM1000 Siemens, ANBonus: AN 1300, SWT2000; Vestas: V47
UTW UTW Dienstleistungs GmbH	Approx. 550	30	Europe	Not specified	GE, Nordex, Gamesa, Vestas, amongst others.
WINDIGO Wind Power Services Windigo GmbH	Approx. 400 wind turbines	35 technicians and engineers	Worldwide	5 service stations: Berlin, Hamburg, Dortmund, Erfurt, Neunkirchen	All wind turbines and all blade types; specialist for LM blades.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Five service programmes: SWPS-100B (Basic), SWPS-200A (Availability), SWPS-300W (Warranty), SWPS-420O (Offshore Availability) and SWPS-430O (Offshore Warranty) as well as additional special service products (e.g. remote diagnostics, training, modifications and upgrades) for all customer segments.	Specific to the project and dependent on scope of service.	Depending on the service agreement, contract periods from 2 to 20 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-specific access concepts, product and safety training; optimisation and upgrades, rotor blade service, turn-key service.	Yes, except in the SWPS-100B Basic programme	Yes, for standard maintenance works; start of work within 24 hours; response times for main components depend on contract type and individual agreement.	
Individual contracts after consultation with the customer.	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 (new remote data monitoring system introduced); 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.	No	12 to 24 hours	Building a network from different independent service companies, forming a purchasing group (reduction of procurement costs for spare parts and material), adding a service support point in northern Germany, developing a concept for a full maintenance contract for wind turbines.
Expert checks of all safety-relevant elements of a wind turbine.	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	BGV A3 testing
Inspection modules which cover all externally required tests (periodic inspections, condition-oriented maintenance, safety); "Inspection and repair" combination packages.	Fixed prices for inspections; repairs, generally on a time and material basis; the required works can be prioritised according to the budget.	Individually - 4 or 8 years recommended; proposals on request	Service for rotor blades, tower and ladder: assessments, inspection, maintenance and repair (onshore & offshore); Expert report on the whole wind turbine; Development of manufacturers' projects; Rotor blade training and seminars; Platforms and rope-access technology; Certification: GL, ISO 9001, SCC**; 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.	Offshore service rope; Rotor blade training courses with training on the job on wind turbines;Service in Turkey and the USA; 3XM-controller training

Company	No. of turbines in service	No. of technicians and engineers in Germany	Application area	Service network and procurement of spare parts	Types of turbine
WKA-Service-Fehmarn GmbH	Germany: approx. 900 / approx. 1000	Approx. 160/170 technicians and engineers • i.e. around 45/47 qualified service and repair teams • around 3-5 teams for inspections using rope-based access technology • training more skilled fitters with offshore qualifications	• Onshore: national and international • Offshore: national and international	Central supply and team coordination. Decentralised, locally-working teams are supported from the headquarters.	Maintenance and servicing of all current rotor blade series.
ZOPF Energieanlagen GmbH	Not specified	Technicians: 5 Engineers: 5	Across Germany	Central stock, supply of spare parts primarily in a circular exchange process, components for maintenance, control and electronics in the workshop.	GE, Nordex, Repower, Fuhrländer, Tacke, Dewind, Südwind.

Contracts offered	Pricing	Contract periods	Services	Availability guarantee	Guaranteed response times	Planned developments for 2013
Individual contracts for operators, managing directors and manufacturers. Recurring, regular service, optionally by abseiling techniques (assessment) or service with separate work platform - according to customer specifications. Concepts for wind farms or individual turbines. All variants include extensive customer consultations.	A fixed price is agreed for the respective service contract. Additional repair and maintenance works are billed separately according to the conditions defined when the contract is concluded.	Individual - in general, periods of between two and six years have proved their worth.	Individual service and repair concepts for rotor blades, according to the customer needs and the condition of the rotor blades. On/offshore rotor blade inspections, repairs to the lighting protection system, tower renovations.	24 months for all commissioning works	Within 24 hours, depending on team availability and region.	• Successive increase of market presence and service technicians in agreement with the needs of the coordination partner, expansion of international business, internal process optimisations. • Uniform and constant growth of the company • Expansion of the service business and service locations • Preferred framework contract / cooperation partner of all named wind turbine manufacturers, energy companies, operating companies and operators Both onshore and offshore.
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.

BWE service survey

This was the **thirteenth BWE service survey**. Set up as a means of identifying and resolving problems between operators and manufacturers or service providers, the survey also ensures greater transparency and quality on the service market. In addition to this, the survey complements the various operator forums.

This year, questionnaires were sent to **2,099 operators** registered with the BWE. With **985 completed questionnaires returned** to the association, the survey had a **response rate of almost 50 percent**. Since it is not uncommon for operators to have various types of turbines in their portfolio, many companies filled out several questionnaires. Overall, data was collected on **4,984 turbines**. For better comparability, small companies for which fewer than ten questionnaires were returned were not included in the evaluation.

Manufacturers slowly gaining ground

As in 2011, INTW evaluated the results of this year's BWE service survey. As last year's evaluation method proved so successful, the same method was used once again this year. This means that the 2012 survey does not differentiate between turbine type or turbine age.

As in the past several years, independent service providers achieved the best marks for service. **N.T.E.S** was able to improve on its good performance in 2011 to secure this year's top spot. The small firm received the outstanding grade of 1.37 (1.76 in 2011) from its customers. Last year's winner **Wind MAX** could not quite repeat its exceptional performance, but still claimed runner-up honours with a very good rating of 1.49.

Also on the winner's podium with the third best score was – as in 2011 – **Enertrag Service**, whose grade fell slightly to 1.85 from 1.79 in 2011. **Availon** brought up the rear among the independent service providers rated this year. The company took over **Voith**, which received the lowest mark last year, in July 2012. With a grade of 3.36 in 2011, Voith was sharply reprimanded by its customers. The takeover by Availon had a positive impact: many processes were optimised and service packages were better tailored to customer needs. The evaluation results reflect these improvements. Availon/Voith managed to earn a fairly respectable grade of 2.53 in the 2012 survey. None of the independent service providers need to shy away from comparisons with manufacturers. Together, the small independent service providers had an average score of 1.88 – almost a full grade higher than manufacturers, who had to settle for an average mark of 2.71.

Dieter Fries, chairperson of the BWE's operator committee, thinks highly of independent service providers: "They are clearly important because they can be on site faster." He points out that many non-affiliated companies have amassed considerable expertise, which can even be helpful in taking the burden off manufacturers and improving overall service. Fries cites an example from Denmark, where Vestas has outsourced part of the servicing of its older turbines to independent firms. "That is a sensible solution because it allows Vestas to concentrate on larger turbines and to make savings on services."

However, the response rates show that the small companies have a much smaller share of the market. While Enercon had the highest response with 44 percent and turbine manufacturers' service teams generated over 80 percent of all responses, the non-affiliated companies accounted for substantially fewer responses.

The service providers only managed to achieve response rates ranging from 1.2 to 5.7 percent. Moreover, some of the providers were graded by companies from their own group: Enertrag management evaluated Enertrag-Service, while WPD rated its in-house service providers PSM and Deutsche Windtechnik Service in several questionnaires.

Photo: Jens Meier

Manufacturer	Enercon	GE Energy	Nordex	Repower	Vestas	Siemens	Ø
Overall score 100%	**1.96**	**2.64**	**2.70**	**2.75**	**3.04**	**3.14**	**2.71**
Maintenance **33.3 %**	2.09	2.31	2.57	2.75	2.92	2.86	2.58
Arrangement and keeping of maintenance appointments	1.92	1.98	2.37	2.69	2.96	2.54	2.41
Quality of the work	1.62	2.07	2.49	2.13	2.45	2.43	2.2
Feedback on maintenance (reports, logs)	2.34	2.33	2.56	3.33	3.07	2.89	2.75
Satisfaction as regards value for money	2.49	2.89	2.84	2.87	3.19	3.60	2.98
Unscheduled repairs **33.3 %**	1.94	2.38	2.54	2.92	2.76	2.93	2.58
Service team availability	1.66	1.85	2.05	3.42	2.47	2.46	2.32
- Speed of repairs to essential parts	1.64	2.28	2.44	2.72	2.65	2.85	2.43
- Speed of repairs to all other parts	1.87	2.80	2.74	2.79	3.01	3.29	2.75
Quality of the repairs	1.57	2.22	2.41	2.21	2.38	2.32	2.18
Feedback on repairs (reports, logs)	2.42	2.37	2.64	3.44	2.85	3.00	2.79
Satisfaction as regards value for money	2.49	2.75	2.89	2.90	3.17	3.73	2.99
Additional services **33.3 %**	1.85	3.11	3.12	2.60	3.30	3.55	2.92
Complementary improvements (updates, etc.)	1.72	3.10	3.22	2.59	3.18	3.62	2.91
Willingness to make gestures of goodwill	2.00	3.14	3.00	2.66	3.42	3.56	2.96

Following on from last year's big leap forward, manufacturers once again made progress compared with 2011, albeit at a slower rate. **Enercon** successfully defended its top ranking, achieving a positive grade of 1.96. Enercon customers particularly praised the turbine manufacturer for the high quality of its maintenance work and repairs. This helped the Aurich-based manufacturer to attain a grade of 1.57 in the quality category compared with 1.71 in 2011. Enercon again suffered its worst rating in the area of value for money, but was able to make a slight improvement here from 2.65 to 2.49.

GE Energy ousted REpower from second place this year. With a grade of 2.64, GE Energy only recorded a slight increase over 2011 when its score of 2.68 secured the third spot. However, the company benefited from REpower's decline. GE Energy service director Uli Schulze Südhoff says that the good mark is not just down to luck. He explains that much is being done to continuously improve the quality of service. The manufacturer, which is based in Salzbergen, near Münster, has organised Germany into eight service areas, in which technicians and customer care staff deal exclusively with operators' questions. This unique approach creates a competitive advantage for the company.

Nordex was able to place third among manufacturers this year. The company thus continues to be impressively consistent: it improved its grade to 2.70 after scoring 2.86 last year. Independently of one another, two operators heaped praise on the competence of Nordex's service personnel. Customers singled out the technicians' conscientiousness, the quality of their work, and the company's good reachability for praise. This can also be seen in the survey results. Nordex achieved its top score and biggest improvement in the reachability category, raising its grade to 2.05 from 2.34 last year.

Last year's manufacturer runner-up **REpower** had to make do with the fourth spot in 2012. Its grade dropped to 2.75 from 2.38 in 2011. The de-

Independent companies*	Availon	DWTS	Enertrag	NTES	PSM	Wind Max	Ø
Overall score 100%	**2.52**	**2.07**	**1.85**	**1.37**	**1.87**	**1.59**	**1.88**
Maintenance **33.3 %**	2.50	1.91	1.76	1.35	1.78	1.44	1.78
Arrangement and keeping of maintenance appointments	2.31	2.05	1.71	1.67	1.93	1.35	1.85
Quality of the work	2.47	1.71	1.67	1.33	1.97	1.29	1.74
Feedback on maintenance (reports, logs)	2.44	1.74	1.79	1.25	1.30	1.59	1.64
Satisfaction as regards value for money	2.78	2.14	1.87	1.17	1.93	1.53	1.9
Unscheduled repairs **33.3 %**	2.28	1.81	1.78	1.38	1.76	1.52	1.75
Service team availability	1.88	1.63	1.49	1.42	1.53	1.18	1.54
- Speed of repairs to essential parts	2.26	1.66	1.89	1.00	1.73	1.47	1.66
- Speed of repairs to all other parts	2.44	1.87	1.97	1.45	1.93	1.71	1.88
Quality of the repairs	2.28	1.73	1.63	1.27	2.07	1.35	1.71
Feedback on repairs (reports, logs)	2.22	1.87	1.66	1.50	1.37	1.69	1.69
Satisfaction as regards value for money	2.59	2.13	1.97	1.17	1.93	1.76	1.92
Additional services **33.3 %**	2.77	2.37	2.07	1.38	2.07	1.78	2.1
Complementary improvements (updates, etc.)	2.90	2.42	2.17	1.55	2.24	1.81	2.21
Willingness to make gestures of goodwill	2.53 (2.83)	2.38	1.97	1.17	1.93	1.71	1.96

* **Enertrag Service** / Member of Enertrag AG. **psm** Nature Power Service & Management /Member of WPD Group
Deutsche Windtechnik AG/ Member of WPD Group. **Voith** Industrial Services GmbH was taken over by **Availon** Technical Services GmbH

cline reported by customers in the regular maintenance work category was a particularly serious factor. After awarding a satisfactory score of 2.5 in this category in 2011, REpower operators doled out a poor mark of 3.33 this year. But this cannot be blamed on the service teams: some operators were very satisfied with the customer service orientation and friendliness of REpower's personnel. REpower also performed well in the quality category, scoring a not too shabby 2.13, even if last year's mark of 1.92 was somewhat better.

Vestas took fifth place. The marks given by operators only worsened slightly to 3.04 from 3.0 in 2011. The company can be pleased about one thing: it improved a quarter of a grade point in the speed category. After awarding a mark of 3.27 last year, customers now gave a score of 3.01.

Once again, Vestas garnered criticism for its lack of goodwill. The manufacturer's performance remained stagnant in this category – its 2012 grade of 3.42 was at the same level as last year. However, Vestas Forum spokesperson Siggi Schlüter does not believe that the company has a fundamental problem with service work. Vestas' organisational structure does not include a dedicated service team; instead operators always have to deal with different technicians. Some operators are critical of this practice. One Vestas customer, for example, told how the constantly changing technicians often have to start the troubleshooting process all over again because they are not familiar with the existing problem.

Just like last year, **Siemens** finished last in the manufacturer service ratings. But progress was made here as well: the company improved to a mark of 3.14 from 3.37 in 2011. It looks like the "satisfaction offensive" Siemens launched two years ago is bearing its first fruit.

Siemens picked up points in the speed category, improving its grade in this area to 3.01 from 3.27 last year. Operators are also more satisfied with feedback on completed work than in previous years. The

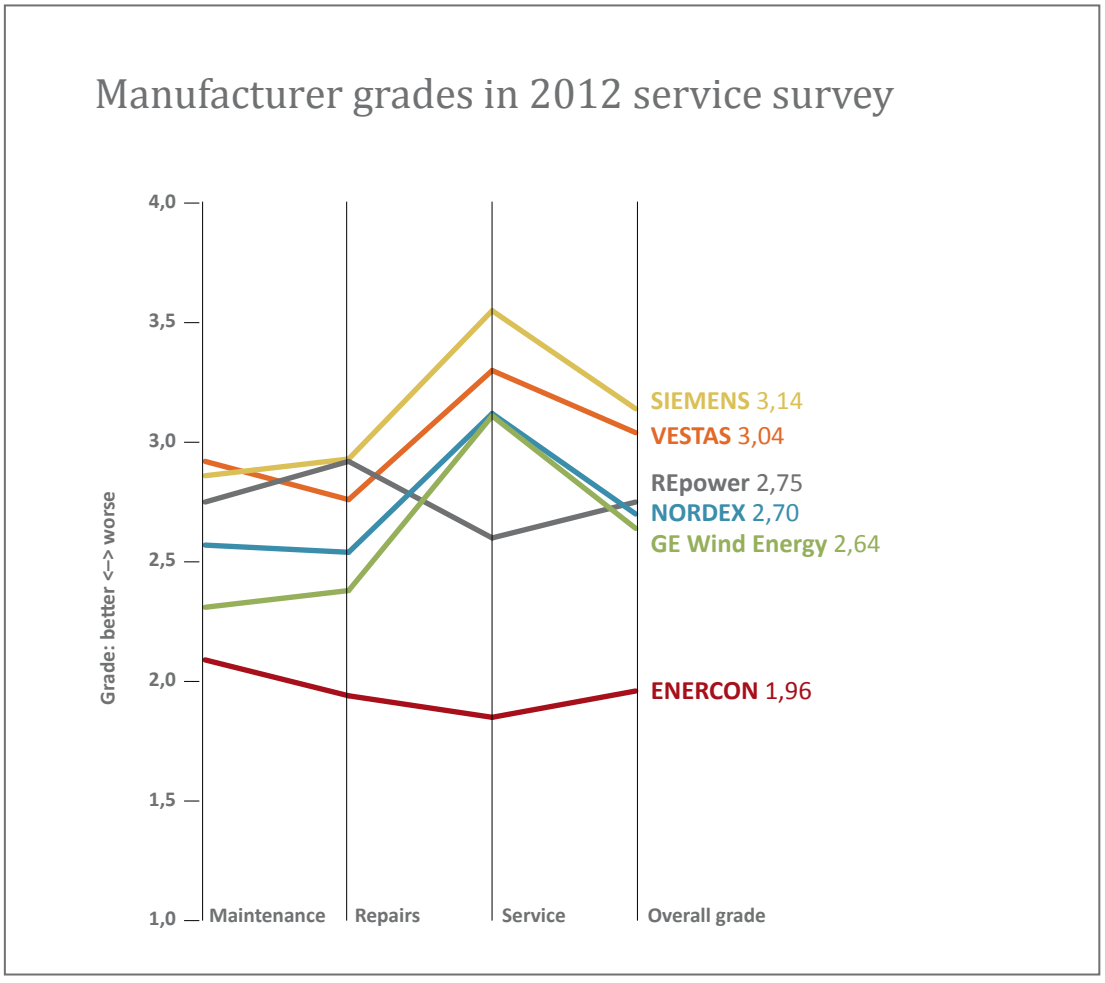
progress made by the Bremen-based manufacturer in terms of arranging and keeping appointments is particularly striking: while operators were still very dissatisfied last year, Siemens was able to improve a full grade to 2.54 in this category in 2012.

In this graph depicting the three main focuses of the survey – maintenance, repairs and service – there is one glaring difference among the manufacturers: the ratings in the area of service. This includes the categories of goodwill and improvements. The best and worst manufacturer marks vary most widely in this area. With a grade of 1.8, Enercon performed better than all other manufacturers, while Siemens just missed earning a mark of 3.5. Nordex, GE Energy and Vestas also failed to obtain a grade two in this discipline. The reason given by most service providers was that operators cut them no slack in charging for service work.

Many small independent service providers, on the other hand, come off better here, even though they lack the financial resources to provide expensive extras free of charge. Their good marks indicate that many turbine operators consider goodwill and improvements to primarily mean being listened to and getting a fair deal. These things don't cost a lot, but are highly valued by turbine operators.

The differences in the maintenance category are not as great as those in service. But Enercon is also well ahead here with a grade of 2.09 compared with other manufacturers whose marks ranged from 2.31 to 2.92 in this area.

All manufacturers showed improvement in the repairs category except for GE Energy and Vestas, but even these two turbine manufacturers only saw minimal changes over the previous year. Another positive development is that nearly all manufacturers made progress in reachability. Only Vestas showed no improvement in this area. ■



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Developments in German wind energy law in 2012

Amended legislation

The extensive amendments to Germany's Renewable Energy Sources Act (EEG), which came into force on 1 January 2012, did not include specific changes for the wind sector in 2012. Now, in 2013, announcements for comprehensive changes to the EEG's system of tariffs are nothing short of chaotic. We will have to wait and see how much of that is down to this year's election, and whether or not the government will (be able to) push through any changes in the current electoral term.

Looking at the public sector, the most interesting developments are happening in the states. After elections were held in Baden-Württemberg, Rhineland-Palatinate and North Rhine-Westphalia, the new governments implemented or introduced specific legislative measures under which it is no longer possible for regions to plan exclusion zones. This means that in these states it will only be possible to submit isolated plans for areas suitable for turbines. If these plans include so-called wind-energy priority areas, they must serve as the minimum standard in subsequent municipal land-use planning. The actual planning for wind turbine zones (which involves designating zones for wind farms and closing the rest of the planning area to wind turbines) then lies with the municipalities. Interesting legal issues that have not yet been clarified by the high court will arise when the relevant transitional provisions are applied and old and new plans that exist at different stages come into competition with each other.

North Rhine-Westphalia also introduced its own climate protection law, which sets out climate targets for the state, in February 2013. The targets are binding for the NRW government, but at the planning level they still need to be implemented through the state development plan and/or spatial planning programmes.

Renewable Energy Sources Act (EEG)

On 10 October 2012 the Federal Court of Justice (BGH) issued its long-awaited decision on the most favourable grid connection point under Section 5 of the EEG (BGH - VIII ZR 362/11 -, ZNER 2012, p. 612). A series of second-instance rulings had said that wind turbines should be connected to the grid at the point that is most suitable in terms of voltage level and that has the shortest linear distance to the turbine. These requirements have priority over choosing the most technologically and economically favourable connection point. The BGH rejects this opinion and stresses that the grid operator's obligation to connect turbines to the grid at the point most favourable from the overall economic perspective also applies if the connection point is part of the operator's grid. Although the decision applies to the 2009 version of the EEG, it is likely to be transferred to the 2012 EEG. However, the decision also raises new questions. In its second official headnote, the BGH stresses that turbine operators can also choose the connection point that lies at the shortest linear distance to the grid. However, this choice could be opposed as an abuse of the law if the resulting costs to the grid operator "more than insignificantly" exceed the costs of connecting the turbine to the point that is most favourable from an overall economic perspective.

The BGH states in its decision of 28 February 2012 (VIII ZR 267/11 -, ZNER 2012, p. 396) that when it comes to expanding the grid – which, unlike connecting individual turbines to the grid, is the responsibility of the grid operators – even setting up a parallel line alongside an existing connection line constitutes strengthening the grid as part of a qualitative expansion. In its decision of 27 March 2012 (Enwr 8/11, ZNER 2012, p. 394), the BGH makes it clear that, even in cases where electricity is sourced for purely commercial and accounting purposes, the charge for feeding electricity from renewable sources into a grid system for general electricity supply still applies. Electricity that is consumed either by the producer or in an upstream private grid is subject to grid charges.

Planning law

Spatial plans that include plans for wind turbine zones often turn out to be an agreement based on the lowest common denominator. That means they are all the more prone to errors. For instance, the Mittelhessen regional plan (VGH Kassel, ruling of 10.05.2012 - 4 C 841/11 -, ZNER 2012, p. 424), the southwest Saxony regional plan (OVG Bautzen, ruling of 19.07.2012 - 1 C 40/11 -, ZNER 2012, p. 555) and the Lake Constance-Upper Swabia regional plan (VGH Mannheim, ruling of 09.10.2012 – 8 p. 1370/11) were all overturned in 2012. The Federal Administrative Court of Germany ruled on 13 Dec 2012 (BVerwG 4 CN 1.11) that when planning wind turbine zones it is obligatory to differentiate between "hard" zones (where wind energy deployment is out of the question) and "soft" zones (where wind energy deployment is subject to municipal assessment). The court said that municipalities must familiarise themselves with, and document, the two different types of zones so that they can avoid errors of judgement.

Section 15(3) of the Federal Building Code (BauGB) gives municipalities the option of postponing approval procedures for wind turbines by up to a year if they can demonstrate that these would significantly impede the aims of an already initiated land-use plan for creating or changing wind turbine zones. Bavaria's higher administrative court states in its decision of 20 April 2012 (22 CS 12.310 -, ZNER 2012, p. 522) that a review to establish whether this is the case can only be carried out in cases where the municipality's ideas for the plan have begun to take shape. At the time the postponement decision is made, the ideas must give a minimal indication of what the content

of the upcoming land-use plan will be. Simply citing an ongoing process to amend land-use planning, a reason often given in actual postponement applications, is not enough. The court also issued a very far-reaching requirement which says that the planning must be far enough advanced to show that it will create an ample chance for wind energy deployment.

Municipalities are increasingly discovering that wind energy deployment can help them create value at a local level. However, in its ruling of 24 May 2012 (6 A 108/11 -, ZNER 2012, p. 536) the Schleswig administrative court said that zoning plans go too far if they only accept turbines that will be installed and operated as part of a 100% community-owned wind farm. It said that this kind of attempt to "communize wind" was unenforceable.

Finally, a Federal Administrative Court decision of 17 October 2012 (BVerwG 4 C 5.11 -, ZNER 2013, p. 61) declared that, on its own merits, the current practice of making the granting of a license under the Federal Immission Control Act (BimSchG) dependent on a collateral provision which requires a surety to guarantee financing for the dismantling obligation was largely unproblematic. Nonetheless, the level of the surety will doubtless continue to be the subject of spirited debate in individual cases in the future.

Species and habitat protection

Within the field of nature conservation legislation, discussions on the conflict potential of wind turbines will continue for a long time to come. To this day, no high-court decision exists on whether or not the authorities actually have a right of assessment (Einschätzungsprärogative) concerning nature conservation. However, a number of decisions reveal a welcome tendency on the part of the courts to engage with the latest scientific findings.

A decision by Hanover administrative court of 22 November 2012 (12 A 2305/11 -, ZNER 2012, p. 656) states that rigid distance criteria (including those set out in the NLT paper) cannot replace an individual review of the way relevant bird species use the space in question. Overall, the court found untenable the assumption that wind turbines significantly increase the risk of black storks suffering collisions. It also said that imposing limits on operating hours to protect bats would only be permissible if the turbines were installed in an important hunting ground or flight route.

The Arnsberg administrative court passed a ruling on habitat protection on 22 November 2011 (7 K 2633/10 -, ZNER 2013, p. 66). It said that a turbine planned for a site about 60 m outside a bird conservation area would only count as significantly interfering with the habitat if it prevented the protected birds from reaching the habitat or if it reduced the size or quality of the conservation area. However, the court said that this was not the case if the birds (e.g. red kites) showed no signs of avoiding the area because of the turbines. If individual birds did collide with turbines outside the conservation area, this would not be cause for concern that the turbines were interfering with the functions inside the area. The court said that the requirement under Federal Administrative Court case law to justify a killing ban by establishing proof of a significant increase in the risk of death presupposes that the nature conservation statements show roughly how high the injury or death rate of the birds in question would "normally" be and that this rate would increase significantly once the turbine began operating.

Public nuisance legislation (Nachbarrecht)

A decision by Lüneburg's higher administrative court of 16 July 2012 (12 LA 105/11 -, ZNER 2012, p. 441) stated that a neighbour could not challenge the approval of a wind turbine by arguing that it would reduce his scope for further emissions and thus limit the potential for developing his farm. In its decision of 17 July 2012 (1 EO 35/12 -, ZNER 2012, p. 443) Weimar's higher administrative court addressed the conflict that exists between approvals issued under the Federal Immission Control Act and provisional decisions. The specific case concerned a turbine that had received (full) approval under the Act, and a turbine of a competing operator that had received a preliminary decision for approval. The full approval was issued at a later date than the preliminary decision and, under the court's ruling, failed to "overtake" the preliminary decision.

Section 15 of the Federal Immission Control Act creates scope for freeing a wind turbine operator seeking a change to the license issued under the Act from the requirement to initiate another process under the Act, providing that the desired change does not interfere with the substance of the Act. In its ruling of 7 August 2012, the Federal Administrative Court (C 7.11 -, ZNER 2012, p. 647) stated that a neighbour cannot lodge an objection against a declaration of exemption issued under these circumstances. The neighbour would have to seek legal remedy from other licenses, such as the building permit, that the operator would potentially still have to obtain after being granted exemption.

Minden administrative court has stated that if the wake turbulence at the leeward side of a turbine rotor lies above the conductor line of a passing high-voltage overhead power line, then the requirements set out in DIN-EN 50341-3-4 (which correspond to VDE 2010-3) concerning minimum distances do not apply. The court's decision of 13 December 2012 (11 L 529/12 -, ZNER 2013, p. 71) says that in these cases, turbines cannot routinely be required to ensure a distance of one rotor diameter from the high-voltage lines even through reference to general turbine risks such as rotor-blade damage and ice throw.

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

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

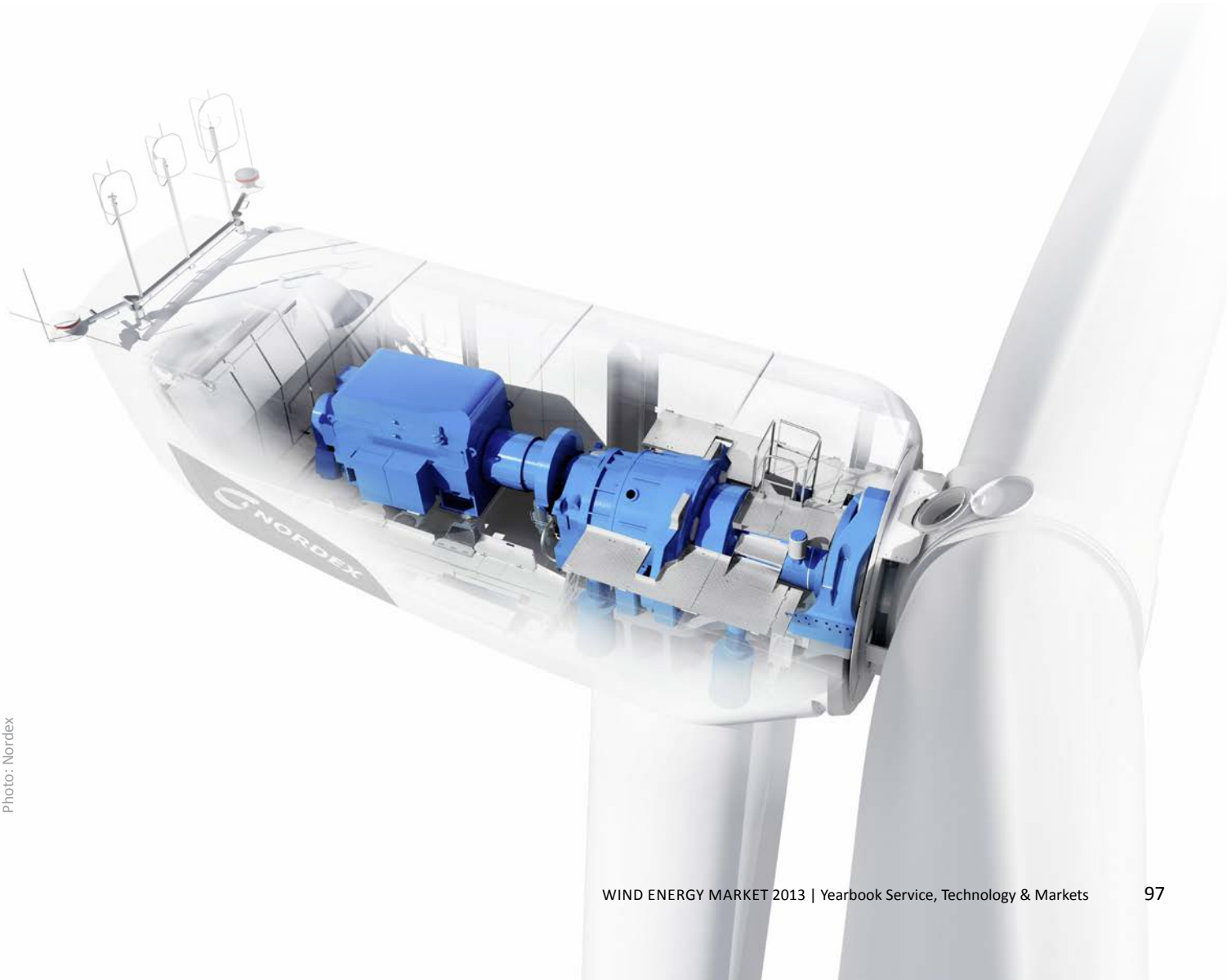

Photo: Nordex

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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11

REpower Systems 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	5,281.02 m²
Number of blades	3.0	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	divers		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	900 – 1,800 (50Hz) / 720 – 1,440 (60Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	690(50) / 575(60) V	- 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	REguard

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

TOWER/HUB HEIGHT	59.0 m	69.0 m	80.0 m	100.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade	6.4	6.4 t	6.4 t	6.4 t
Hub (incl. installed equipment)	17.5 t	17.5 t	17.5 t	17.5 t
Rotor (incl. hub)	36.0	36.0 t	36.0 t	36.0 t
Nacelle (without rotor & hub)	69.0 t	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	IEC IIIa/DIBt 3
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	4,611,421 manufacturer information		5,121,056 manufacturer information	5,475,407 manufacturer information
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	2 years

REFERENCES 31/12/2012	Installed turbines worldwide 1.9 First installation in: 37,742.0
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 REpower gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse options and service packages on request.

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).

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The global wind energy sector has a wide range of innovative technologies, products, services and synergies with related industries, which will be presented from 23 to 26 September 2014 at the international WindEnergy Hamburg expo. This exhibition reflects the dynamism of the wind power industry and developments in current and future key markets and is the perfect platform for global business and exchange. WindEnergy Hamburg is completely geared to the key topics of the wind energy industry in order to provide an ideal forum for international experts and for growing markets such as offshore wind energy.

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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	44.0 m	Swept area	1,520.53 m^2
Number of blades	3.0	Rotor speed	12 - 34 (variabel) 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	12 - 34 (variabel) 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 control
Yaw control system	4 electric gear motor(s)
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	45.0 m	55.0 m		
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
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 1,826.0 First installation in: 2,007.0			
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	2,197.87 m²
Number of blades	3.0	Rotor speed	11-29.5 (variabel) 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 (variabel) 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 control
Yaw control system	4 electric gear motor(s)
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	60.0 m	73.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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 1,043.0 First installation in: 2,006.0
SPECIAL FEATURES	lightning protection system
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	48.0 m	Swept area	1,809.56 m²
Number of blades	3.0	Rotor speed	16 - 31 (variabel) 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	16 – 31 (variabel) 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 control
Yaw control system	4 electric gear motor(s)
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	50.0 m	55.0 m	60.0 m	76.0 m
Type / Shape	steel tubularconical	steel tubularconical		
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 514.0 First installation in: 2,004.0			
SPECIAL FEATURES	lightning protection system on request			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

LEITWIND LTW77

LEITWIND AG
Sterzing, Italy

POWER			
Rated power	1,000 - 1,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.5 - 12.0 m/s	Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	76.7 m	Swept area	4,620.41 m^2
Number of blades	3.0	Rotor speed	6 - 18.0 (variabel) rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			

NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	1:1
- Manufacturer	LEITWIND		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	6 - 18.0 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	640 V	- Manufacturer	LEITWIND

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, individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	LEITWIND
SCADA-System	LEITWIND SCADA

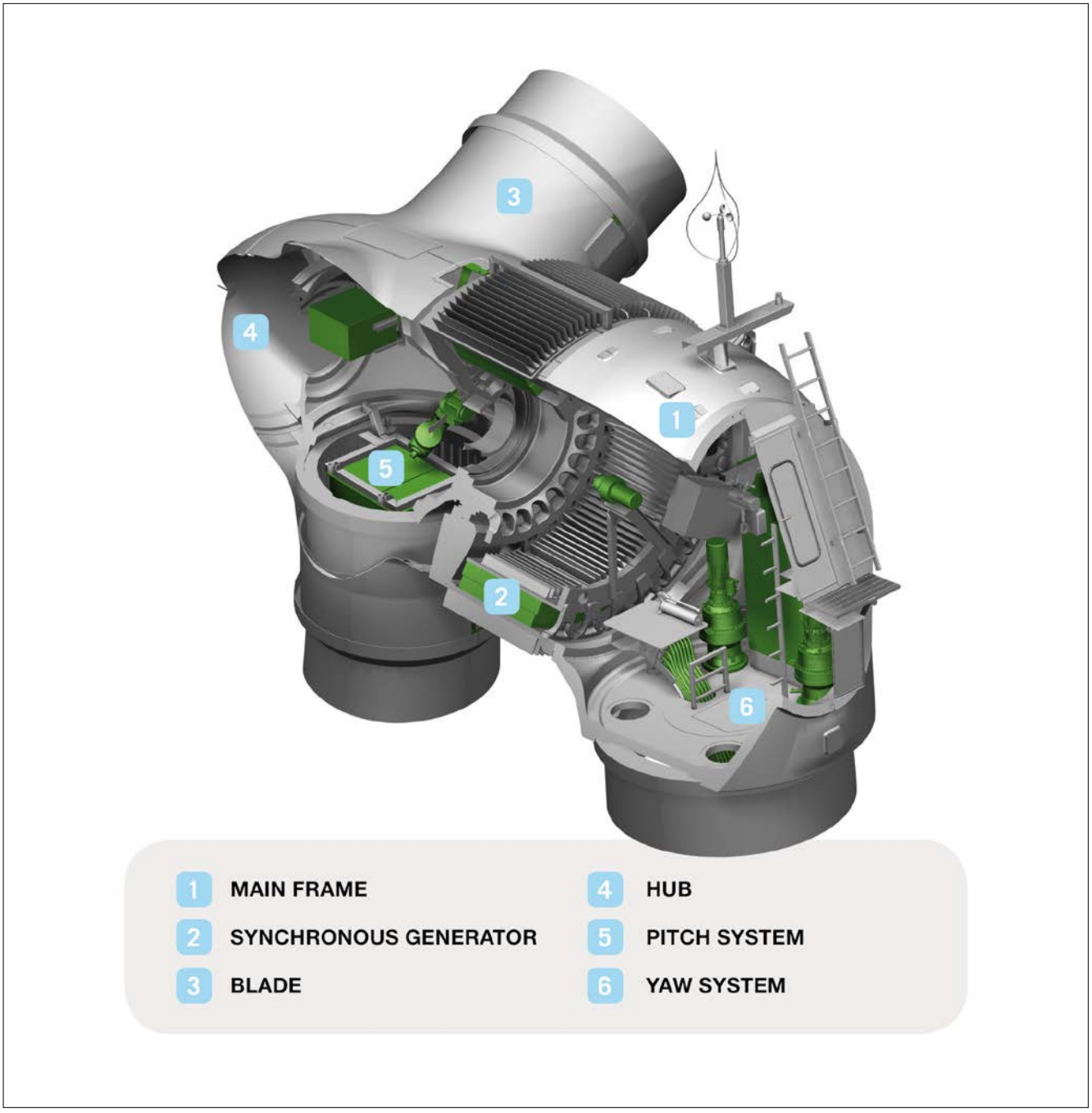
POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
yes	yes	yes

TOWER/HUB HEIGHT	61.5 m	65.0 m	80.0 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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/GL	IEC IIa/GL	IEC IIa/GL	
Survival wind speed				
Tested (month/year)		39.845,0	39.845,0	
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 187.0 First installation in: 2,005.0
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
MISCELLANEOUS	

LEITWIND LTW77

Cross Section



GE 1.5-77

GE Energy
Germany

POWER			
Rated power	1,500 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	14.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	77.0 m	Swept area	4,656.63 m²
Number of blades	3.0	Rotor speed	10-20 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:98 (50Hz) 1:78 (60Hz)
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	1,500 – 1,800	- 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	65.0 m	80.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)	31.0 t	31.0 t		
Nacelle (without rotor & hub)	57.0 t	57.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib	IEC Ib		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	3,720,883 manufacturer information	4,045,031 manufacturer information		
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance		
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 2.2 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS	WindControl® Leistungsregelsystem, WindFREE® Reactive Power Blindleistungssystem, WindSCA DA System, WindINERTIA Control			

LEITWIND LTW86

LEITWIND AG
Sterzing, Italy

POWER			
Rated power	1,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.0 m/s	Cut-out wind speed	20.0 m/s

ROTOR			
Diameter	86.3 m	Swept area	5,849.40 m^2
Number of blades	3.0	Rotor speed	6 - 15.8 (variabel) rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			

NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	1:1
- Manufacturer	LEITWIND		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	6 - 15.8 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	660 V	- Manufacturer	LEITWIND

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, individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	LEITWIND
SCADA-System	LEITWIND SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
yes	yes	yes

TOWER/HUB HEIGHT	80.0 m	100.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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/GL	IEC IIIa/GL		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 1.0 First installation in: 2,011.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

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	76.8 m	Swept area	4,637.29 m²
Number of blades	3.0	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

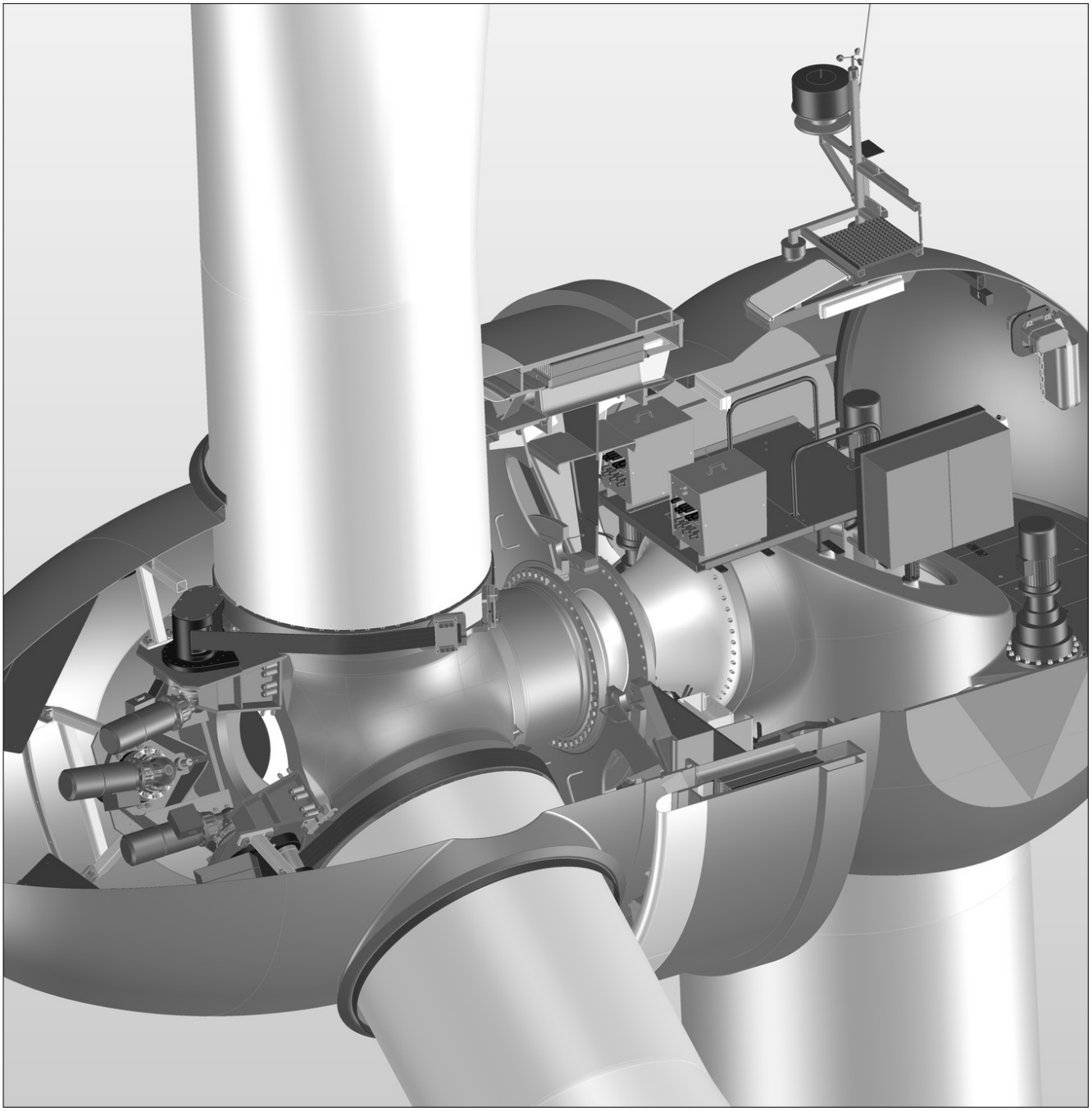
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor
Main break	individual blade pitch control
Second brake system	individual blade pitch control
Yaw control system	3 electric gear motor(s)
Manufacturer of control system	VENSYS Energy AG
SCADA-System	VENSYS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

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

TOWER/HUB HEIGHT	61.5 m	85.0 m	100.0 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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 1,019.0 First installation in: 39,203.0			
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	82.3 m	Swept area	5,324.90 m²
Number of blades	3.0	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	85.0 m	100.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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 IIIa/DIBt 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 218.0 First installation in: 2,008.0			
SPECIAL FEATURES	optional Eissensor			
MISCELLANEOUS				

LEITWIND LTW80

LEITWIND AG
Sterzing, Italy

POWER			
Rated power	1,500 - 1,800 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	10.4 - 11.6 m/s	Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	80.3 m	Swept area	5,064.32 m^2
Number of blades	3.0	Rotor speed	6 - 17.8 (variabel) rpm
Type			
Material	epoxy resin		
Manufacturer			

NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	1:1
- Manufacturer	LEITWIND		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	6 - 17.8 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	630 - 675 V	- Manufacturer	LEITWIND

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, individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	LEITWIND
SCADA-System	LEITWIND SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
yes	yes	yes

TOWER/HUB HEIGHT	65.0 m	80.0 m	100.0 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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/GL	IEC IIa/GL	IEC IIa/GL	
Survival wind speed				
Tested (month/year)		40.519,0	40.519,0	
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	**Installed turbines worldwide** 46.0 **First installation in:** 2,009.0
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
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	7,853.98 m^2
Number of blades	3.0	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		- 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	80.0 m	96.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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	Installed turbines worldwide First installation in:			
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	5,345.62 m^2
Number of blades	3.0	Rotor speed	16.8 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		- 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	65.0 m	80.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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	Installed turbines worldwide First installation in:			
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			

Vestas V100 – 1.8 MW

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	1,800 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	100.0 m	Swept area	7,853.98 m²
Number of blades	3.0	Rotor speed	9.3 - 16.6 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		
NACELLE			
Design	integrated		
Gear box / Type	combined spur / planetary gear		
- Stages	1	- Ratio	1:113
- Manufacturer	divers		
Generator / Type	asynchronous, double fed induction slip ring rotor, slip rings		
- Number	1	- Grid connection	via converter
- Speed	1,680.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	divers

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	80.0 m	95.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	coated	coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa/IEC S	IEC IIIa/IEC S		
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		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Options on request			
MISCELLANEOUS				

Vestas V100 – 1.8 MW

Cross Section

Vestas®
Wind. It means the world to us.

REpower MM100

REpower Systems SE
Hamburg, Germany

POWER			
Rated power	1,800 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	10.5 (60), 11.0 (50) m/s	Cut-out wind speed	22.0 m/s

ROTOR			
Diameter	100.0 m	Swept area	7,853.98 m^2
Number of blades	3.0	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 (60). 1:129.6 (50)
- Manufacturer	divers		
Generator / Type	asynchronous, double fed induction, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	720 – 1,440 (60Hz). 900 – 1,800 (50Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	575(60), 690(50) V	- 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	REguard

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

TOWER/HUB HEIGHT	80.0 M (60)	100.0 m (50 u. 60)		
Type / Shape	steel tubularconical	steel tubularconical		
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			
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	Installed turbines worldwide First installation in:
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
MISCELLANEOUS	Gear box: acc. to REpower gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse Options and service packages on request.

D9.1

DeWind
Luebeck, Germany

POWER			
Rated power	2,000 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	93.0 m	Swept area	6,792.91 m²
Number of blades	3.0	Rotor speed	15.7 rpm
Type			
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	DeWind, divers		

NACELLE			
Design	separated		
Gear box / Type	planetary		
- Stages	3	- Ratio	1:108
- Manufacturer	divers		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	1,700.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	divers

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 control, hydraulic fail-safe disk brake
Yaw control system	electric gear motor(s)
Manufacturer of control system	DeWind
SCADA-System	DeWind eOS

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

TOWER/HUB HEIGHT	80.0 m	100.0 m		
Type / Shape	steel tubularconicalbellied contour	steel tubular, tubular steel tower-conicalbellied contour		
Corrosion protection	painted	painted		
WEIGHT				
Single blade	8.8 t	8.8 t		
Hub (incl. installed equipment)	22.5 t	22.5 t		
Rotor (incl. hub)	48.9 t	48.9 t		
Nacelle (without rotor & hub)	77.6 t	73.0 t		
Tower	185.0 t	185.0 t		
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, transfor-mer, foundation	delivery, erection, remote data control, maintenance, transfor-mer, foundation		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) CMS			
MISCELLANEOUS				

D9.2

DeWind
Luebeck, Germany

POWER			
Rated power	2,000 kW	Cut-in wind speed	4.9 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	93.0 m	Swept area	6,792.91 m²
Number of blades	3.0	Rotor speed	16.3 rpm
Type			
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	DeWind / divers		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear, hydrodynamic WinDrive		
- Stages	2 + superimposed	- Ratio	1:29 / 1:4 variabel
- Manufacturer	divers, Voith Turbo		
Generator / Type	synchronous 4-pole synchronous/ 2.2 MVA fixed speed		
- Number	1	- Grid connection	
- Speed	1,800.0 rpm	- Grid frequency	50 Hz
- Voltage	4.6 / 13.8 kv	- Manufacturer	divers

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

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

TOWER/HUB HEIGHT	80.0 m	100.0 m		
Type / Shape	steel tubularconicalbellied contour	steel tubularconicalbellied contour		
Corrosion protection	painted	painted		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, foundation	delivery, erection, remote data control, maintenance, foundation		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor CMS			
MISCELLANEOUS				

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	5,281.02 m²
Number of blades	3.0	Rotor speed	6 - 18 (variabel) rpm
Type	E-82		
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 (variabel) 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 control, rotor 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	78.0 m	85.0 m	98.0 m	108.0/ 138.0 m
Type / Shape	steel tubularconical	steel tubularconical	concrete towerconical	concrete towerconical
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				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 2,733.0 First installation in: 2,005.0
SPECIAL FEATURES	lightning protection system upon request
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.

K82 2.0MW

KENERSYS GROUP
Münster, Germany

POWER			
Rated power	2,000 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	14.0 m/s	Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	82.0 m	Swept area	5,281.02 m^2
Number of blades	3.0	Rotor speed	17.1 rpm
Type	K82 2.0MW		
Material	glas-fibre reinforced plastic		
Manufacturer	LM WIND POWER		

NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:84
- Manufacturer	Winergy		
Generator / Type	synchronous electrically excited		
- Number	1	- Grid connection	full conversion
- Speed	1,440.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	600 V	- Manufacturer	KENERSYS

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	blade pitch control
Second brake system	blade pitch control, hydraulic disc brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bachmann
SCADA-System	CASCADA

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

TOWER/HUB HEIGHT	80.0 m	98.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 38.0 t	approx. 38.0 t		
Nacelle (without rotor & hub)	approx. 60.0 t	approx. 60.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt 3	IEC IIa/DIBt 3		
Survival wind speed	59.5 m/s	59.5 m/s		
Tested (month/year)	39.783,0	39.995,0		
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 45 (information as of Januar 2013) First installation in: 39,814.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) (CMS)			
MISCELLANEOUS				

K82 2.0 MW

Cross Section

KENERSYS
KALYANI

Vestas V80 - 2.0 MW GridStreamer

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	2,000 kW	Cut-in wind speed	4.0 m/s
Rated wind speed	14.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	80.0 m	Swept area	5,026.55 m²
Number of blades	3.0	Rotor speed	9.9 - 16.7 rpm
Type	Vestas Prepreg 39m		
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:92.5
- Manufacturer	divers		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	1,550.0 rpm	- Grid frequency	50 Hz
- Voltage	650 V	- Manufacturer	divers

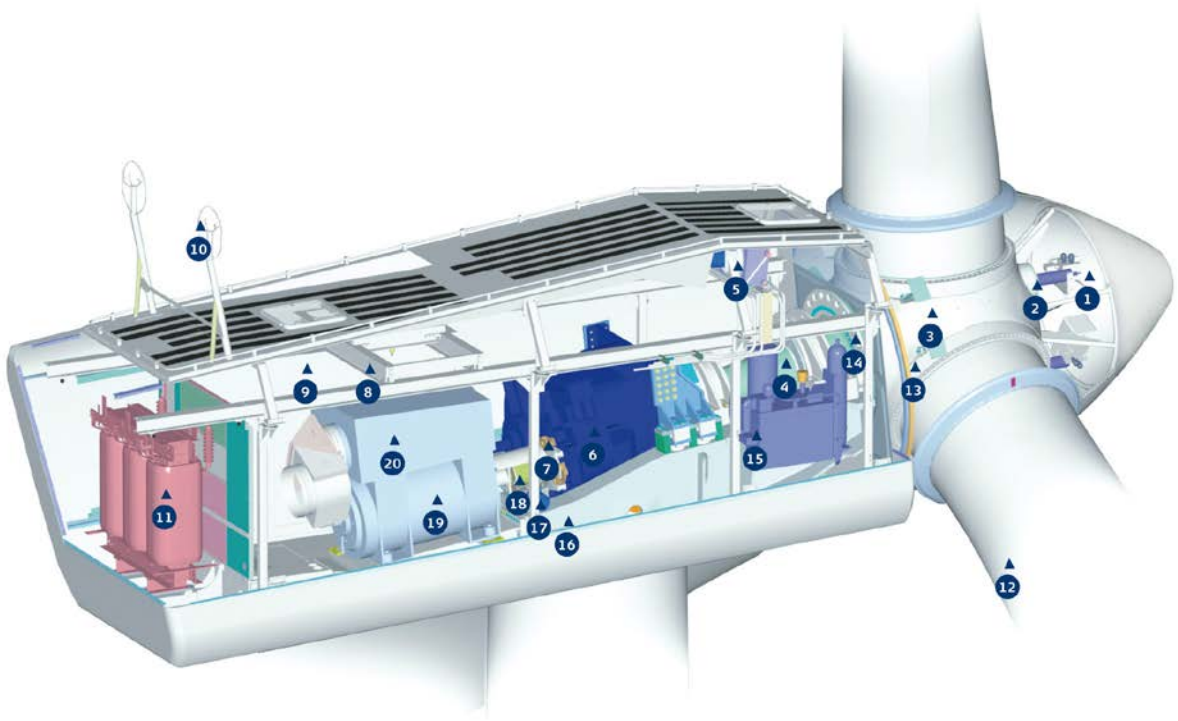
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	60.0 m	80.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	coated	coated		
WEIGHT				
Single blade	65.0 t			
Hub (incl. installed equipment)	20.6 t			
Rotor (incl. hub)				
Nacelle (without rotor & hub)	77.5 t			
Tower	850.0 t			
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 3/DIBt 3	IEC Ia/IEC Ia		
Survival wind speed	55.8 m/s			
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance	delivery, erection, remote data control, maintenance		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide 4.2 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Various options on request			
MISCELLANEOUS				

VestasV80 – 2.0 MW GridStreamer

Cross Section



1 Pitch-Controller
2 Pitch-Zylinder
3 Rotornabe
4 Hauptwelle
5 Ölkühler
6 Getriebe
7 Mechanische Rotor-Arretierung
8 Servicekran
9 VMP-Top-Controller mit Umrichter
10 Ultraschall-Sensoren
11 Hochspannungstransformator (6-33 kW)
12 Rotorblatt
13 Rotorblattlager
14 Rotor-Arretierungssystem
15 Hydraulikaggregat
16 Maschinenrahmen
17 Azimut-Antriebe
18 Kompositkupplung
19 OptiSpeed®-Generator
20 Luftkühler für Generator

Vestas®
Wind. It means the world to us.

Vestas V90 - 2.0 MW GridStreamer

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	2,000 kW	Cut-in wind speed	4.0 m/s
Rated wind speed	13.5 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	90.0 m	Swept area	6,361.73 m²
Number of blades	3.0	Rotor speed	8.8 - 14.9 rpm
Type	Vestas Prepreg 44m		
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:104.5
- Manufacturer	divers		
Generator / Type	synchronous, permanent magnet, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	1,550.0 rpm	- Grid frequency	50 Hz
- Voltage	650 V	- Manufacturer	divers

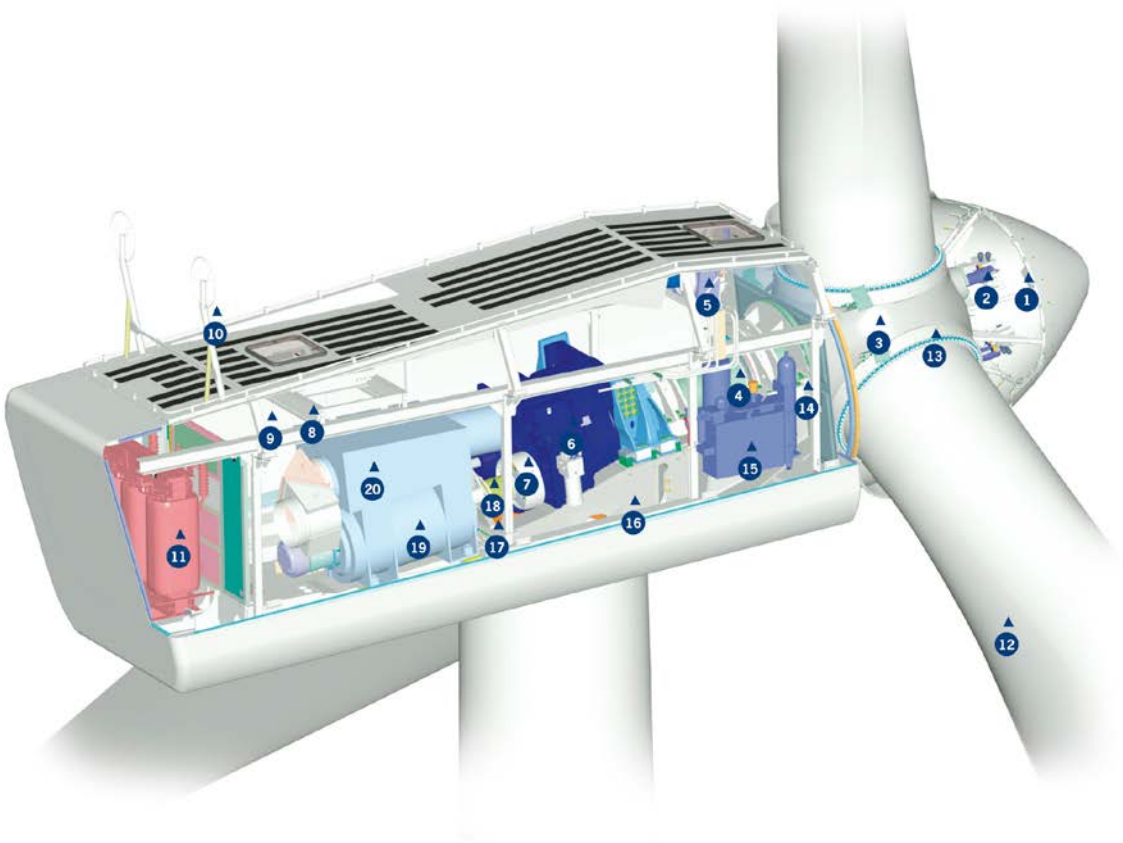
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	95.0 m	105.0 m	125.0 m	80.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
Corrosion protection	coated	coated	coated	coated
WEIGHT				
Single blade	67, 0 t			
Hub (incl. installed equipment)	20.6 t			
Rotor (incl. hub)				
Nacelle (without rotor & hub)	77.5 t			
Tower	221.0 t	208.0 t	297.0 t	
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2	DIBt 2	DIBt 2	IEC IIa
Survival wind speed	50.7 m/s	51.3 m/s	52.3 m/s	
Tested (month/year)	40.756,0	40.756,0	40.756,0	
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	delivery, erection, remote data control
WARRANTY	2 years	2 years	2 years	2 years
REFERENCES 31/12/2012	Installed turbines worldwide 5.2 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Options on request			
MISCELLANEOUS				

Vestas V90 – 2.0 MW GridStreamer

Cross Section



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18 Kompositkupplung
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20 Luftkühler für Generator

Vestas®
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e.n.o. 82

e.n.o. 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	5,332.67 m²
Number of blades	3.0	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	VEM Sachsenwerk

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	e.n.o. energy

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

TOWER/HUB HEIGHT	58.6 m	80.0 m	101.0 m	108.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
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	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 25.0 First installation in: 39,508.0			
SPECIAL FEATURES	ice sensor, condition monitoring system (CMS) shadow module			
MISCELLANEOUS				

REpower MM82

REpower Systems 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	5,281.02 m²
Number of blades	3.0	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	divers		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	900 – 1,800 (50Hz) / 720 – 1,440 (60Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	690(50) / 575(60) V	- 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	REguard

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

TOWER/HUB HEIGHT	59.0 m	69.0 m	80.0 m	100.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade	6.4	6.4 t	6.4 t	6.4 t
Hub (incl. installed equipment)	17.5 t	17.5 t	17.5 t	17.5 t
Rotor (incl. hub)	36.0	36.0 t	36.0 t	36.0 t
Nacelle (without rotor & hub)	69.0 t	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	IEC IIIa/DIBt 3
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)	4,611,421 manufacturer information		5,121,056 manufacturer information	5,475,407 manufacturer information
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	2 years

REFERENCES 31/12/2012	Installed turbines worldwide 1.9 First installation in: 37,742.0
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 REpower gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse options and service packages on request.

REpower MM92

REpower Systems SE
Hamburg, Germany

POWER			
Rated power	2,050 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.5 m/s	Cut-out wind speed	24.0 m/s
ROTOR			
Diameter	92.5 m	Swept area	6,720.06 m²
Number of blades	3.0	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	divers		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	900 – 1,800 (50Hz) / 720 – 1,440 (60Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	690(50) / 575 (60) V	- 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	REguard

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

TOWER/HUB HEIGHT	68.5 m	80.0 m	100.0 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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 IIaDIBt 3	IEC IIaDIBt 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 1.9 First installation in: 38,565.0			
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 REpower gear box guideline. Power limitation: by individual electrical blade pitch control (fail safe design). Diverse Options and service packages on request.			

e.n.o. 92

e.n.o. 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	6,763.72 m²
Number of blades	3.0	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	VEM Sachsenwerk

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	yes

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

TOWER/HUB HEIGHT	103.0 m	123.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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	406.0 t		
TYPE APPROVAL				
Guideline, Class	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, foundation	delivery, erection, remote data control, maintenance, transformer, foundation		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012	Installed turbines worldwide 14.0 First installation in: 40,330.0			
SPECIAL FEATURES	ice sensor, condition monitoring system (CMS) shadow module			
MISCELLANEOUS				

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	7,948.51 m²
Number of blades	3.0	Rotor speed	14.3 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	via converter
- Speed	14.3 rpm	- Grid frequency	50 / 60 Hz, Converter (AC-DC-AC)
- Voltage	690 V	- Manufacturer	GDS

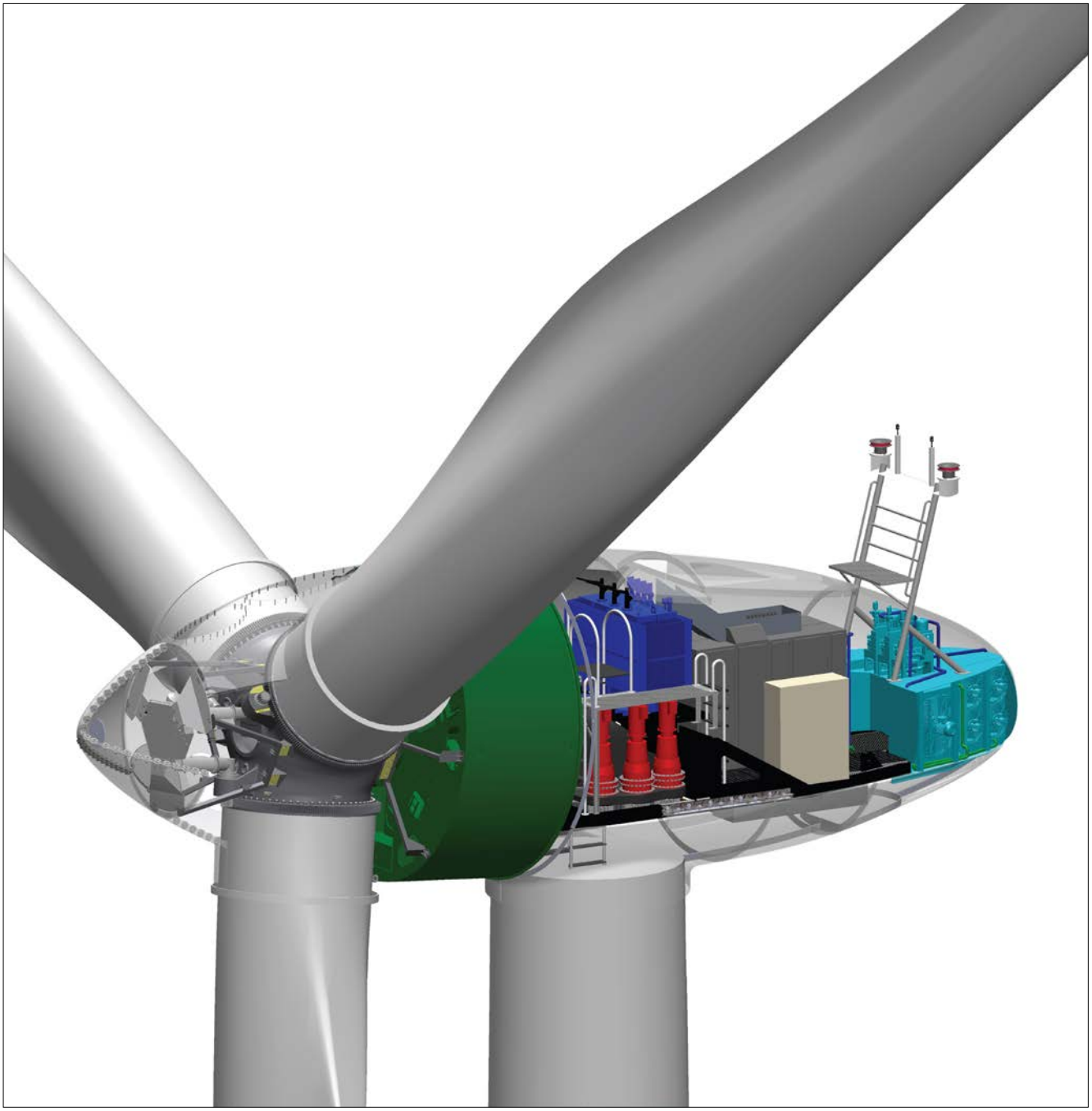
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	individual blade pitch control
Second brake system	hydraulic fail-safe disk brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Beckhoff
SCADA-System	SCADA international

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

TOWER/HUB HEIGHT	99.0 m			
Type / Shape	steel tubularconical			
Corrosion protection	coated			
WEIGHT				
Single blade	10.5 t			
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	75.0			
Tower	289.0 t			
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIIa			
Survival wind speed	52.5 m/s			
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

AV 1010 – 2.3 MW

Cross Section



AVANTIS Energy

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	3,959.19 m²
Number of blades	3.0	Rotor speed	6 - 21.5 (variabel) 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 (variabel) 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 control
Yaw control system	6 electric gear motor(s)
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	57.0 m	64.0 m	98,0 / 113,0 m	
Type / Shape	steel tubularconical	steel tubularconical	concrete towerconical	
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				
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 3,752.0 First installation in: 2,003.0
SPECIAL FEATURES	lightning protection system upon request
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.

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	5,281.02 m²
Number of blades	3.0	Rotor speed	6 - 18 (variable) rpm
Type	E-82		
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 control, rotor 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	

TOWER/HUB HEIGHT	78.0 m	85.0 m	98.0 m	108.0 / 138.0 m
Type / Shape	steel tubularconical	steel tubular, or concrete towerconical	concrete towerconical	concrete towerconical
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)				
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 849.0 First installation in:			
SPECIAL FEATURES	lightning protection system			
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.			

K120 2.3MW

KENERSYS GROUP
Münster, Germany

POWER			
Rated power	2,300 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	11.0 m/s	Cut-out wind speed	20.0 m/s

ROTOR			
Diameter	120.0 m	Swept area	11,309.73 m²
Number of blades	3.0	Rotor speed	11.9 rpm
Type	K120 2.3MW		
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	LM WIND POWER		

NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:138
- Manufacturer	Winergy		
Generator / Type	synchronous synchronous, electrically excited		
- Number	1	- Grid connection	via converter
- Speed	1,650.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	600 V	- Manufacturer	KENERSYS

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	blade tip control
Second brake system	blade pitch control, active blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bachmann
SCADA-System	CASADA

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

TOWER/HUB HEIGHT 90.0 m				
Type / Shape	steel tubularconical			
Corrosion protection	multi-coated			

WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)	69.0 t			
Nacelle (without rotor & hub)	94.0 t			
Tower				
Total weight				

TYPE APPROVAL				
Guideline, Class	DIBt 2			
Survival wind speed	42.5 m/s			
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide First installation in: 2,013.0
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
MISCELLANEOUS	

Siemens SWT-2.3-101

Siemens Wind Power
Hamburg

POWER			
Rated power	2,300 kW	Cut-in wind speed	3 -4 m/s
Rated wind speed	12-13 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	101.0 m	Swept area	8,011.85 m²
Number of blades	3.0	Rotor speed	6-16 rpm
Type	B49		
Material	Fiberglass reinforced epoxy		
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:91
- Manufacturer	Winergy / Hansen		
Generator / Type	asynchronous		
- Number	1	- Grid connection	via converter
- Speed	600 – 1,600 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	80.0 m	90.0 m	99.5 m	73.5 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
Corrosion protection	multi-coated	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	82.0 t
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIB	IEC IIB	DiBt WZ 2 (B) 2004	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	delivery, erection, remote data control, maintenance
WARRANTY	5 years	5 years	5 years	5 years
REFERENCES 31/12/2012	Installed turbines worldwide 1,549.0 First installation in: 2,009.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

K110 2.4MW

KENERSYS GROUP
Münster, Germany

POWER			
Rated power	2,400 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	ca. 12 m/s	Cut-out wind speed	20.0 m/s

ROTOR			
Diameter	109.0 m	Swept area	9,331.32 m^2
Number of blades	3.0	Rotor speed	12.8 rpm
Type	K110 2.4MW		
Material	glas-fibre reinforced plastic		
Manufacturer	LM WIND POWER		

NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:117
- Manufacturer	Winergy		
Generator / Type	synchronous electrically excited		
- Number		- Grid connection	full conversion
- Speed	1,500.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	600 V	- Manufacturer	KENERSYS

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	blade pitch control
Second brake system	blade pitch control, hydraulic disc brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bachmann
SCADA-System	CASCADA

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

TOWER/HUB HEIGHT	95.0 m	145.0 m		
Type / Shape	steel tubularconical	concrete tower, hybrid concrete/ steelconical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 62.0 t	approx. 62.0 t		
Nacelle (without rotor & hub)	approx. 90.0 t	approx. 90.0 t		
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC II/III	DIBt 2/IEC III		
Survival wind speed	59.5 m/s	52.5 m/s		
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 9 (information as of January 2013) First installation in: 41,030.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

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	10,714.59 m²
Number of blades	3.0	Rotor speed	7.5 - 13.2 . rpm
Type	NR 58.5		
Material	Glasfibre and carbon reinforced plastic with integrated lightning protection.		
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	740-1,300 (50Hz) / 890-1,560 (60Hz) rpm	- Grid frequency	50 / 60 Hz
- Voltage	660V± 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	91.0 m	120.0 m	141.0 m	
Type / Shape	steel tubularcylindrical, cylindrical, top segment conical	steel tubularcylindrical, cylindrical, top segment conical	concrete tower, Hybrid tower, combined concrete / tubular steel towerconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	On Request On Request	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	IEC IIIa	IEC IIIa	
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	9 years	9 years	9 years	
REFERENCES 31/12/2012	Installed turbines worldwide 36.0 First installation in: 40,878.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Condition monitoring system (CMS); Ice detection; Nordex Anti Icing System; Fire detection- and extinguishing system; Burglar Alarm; Bat-Friendly System operation; Shadow flicker module; Radar friendly system operation; customer specific markings on blade			
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	6,822.16 m²
Number of blades	3.0	Rotor speed	16.0 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	via converter
- Speed	16.0 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	80.0 m	99.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	coated	coated		
WEIGHT				
Single blade	9.8 t	9.8 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	59.5 m/s	59.5 m/s		
Tested (month/year)	2.012,0	2.012,0		
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 20.0 First installation in: 39,934.0			
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.			

E-115

ENERCON GmbH
Aurich, Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	
Rated wind speed		Cut-out wind speed	

ROTOR			
Diameter	115.0 m	Swept area	10,386.89 m²
Number of blades	3.0	Rotor speed	variabel. 3 - 12.8 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	variabel. 3 - 12.8 rpm	- Grid frequency	50 / 60 Hz
- Voltage	400 V	- Manufacturer	ENERCON

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	individual blade pitch control
Second brake system	individual blade pitch control, rotor 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 92,5 - 149 m				
Type / Shape	concrete towerconical			
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)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide First installation in:
SPECIAL FEATURES	lightning protection system
MISCELLANEOUS	Service concept: ENERCON PartnerKonzept (EPK).

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	7,853.98 m^2
Number of blades	3.0	Rotor speed	14.1 (Nennleistung) 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	1:117
- 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	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
on request	on request	on request

TOWER/HUB HEIGHT	75.0 m	85.0 m	98.3 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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 IIbDIBt	IEC IIIaDIBt	
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)			36,192 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: 38,930.0
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 2.5-103

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	103.0 m	Swept area	8,332.29 m²
Number of blades	3.0	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	1:117
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed	1,500.0 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	GE WindSCADA			
POWER CURVE		**SOUND POWER LEVEL**		**ELECTRICAL CHARACTERISTICS**
on request		on request		on request
TOWER/HUB HEIGHT	**85.0 m**	**98.3 m**		
Type / Shape	steel tubularconical	steel tubularconical		
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	Installed turbines worldwide First installation in: 2,009.0			
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			

K100 2.5MW

KENERSYS GROUP
Münster, Germany

POWER			
Rated power	2,500 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	ca. 13 m/s	Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	100.0 m	Swept area	7,853.98 m^2
Number of blades	3.0	Rotor speed	14.1 rpm
Type	K100 2.5MW		
Material	glas-fibre reinforced plastic		
Manufacturer	LM WIND POWER		

NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:117
- Manufacturer	Bosch Rexroth/Winergy		
Generator / Type	synchronous electrically excited		
- Number	1	- Grid connection	full conversion
- Speed	1,650.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	600 V	- Manufacturer	KENERSYS

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	active blade pitch control
Main break	blade pitch control
Second brake system	blade pitch control, hydraulic disc brake
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	Bachmann
SCADA-System	CASCADA

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

TOWER/HUB HEIGHT	85.0 m	100.0 m	135.0 m	
Type / Shape	steel tubularconical	steel tubularconical	concrete tower, hybrid concrete/ steelconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 55.0 t	approx. 55.0 t	approx. 55.0 t	
Nacelle (without rotor & hub)	approx. 90.0 t	approx. 90.0 t	approx. 90.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt 3	IEC IIIa/DIBt 2	IEC IIIa/DIBt 2	
Survival wind speed	59.5 m/s	52.5 m/s	52.5 m/s	
Tested (month/year)		39.783,0	40.210,0	
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 20 (information as of January 2013) First installation in: 39,814.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) lightning protection, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

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	7,822.60 m²
Number of blades	3.0	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 (50) / 1:92.9 (60)
- Manufacturer	Several		
Generator / Type	asynchronous, double fed induction, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	740 – 1,300 (50) / 890 – 1,560 (60) 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	100.0 m	80.0 m	75.0 m	
Type / Shape	steel tubularcylindrical, Top segment conical	steel tubularcylindrical, Top segment conical	steel tubularcylindrical, Top segment conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	On Request On Request	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)	40.634,0	40.969,0	40.969,0	
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	9 years	9 years	9 years	
REFERENCES 31/12/2012	Installed turbines worldwide 406N100/2500 First installation in: 39,508.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Condition monitoring system (CMS); Ice detection; Nordex Anti Icing System; Fire detection- and extinguishing system; Burglar Alarm; Bat-Friendly System operation; Shadow flicker module; Radar friendly system operation; customer specific markings on blade			
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	6,361.73 m²
Number of blades	3.0	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 (50) / 1:86.3 (60)
- 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	65.0 m	80.0 m	70.0 m	
Type / Shape	steel tubularcylindrical, Top segment conical	steel tubularcylindrical, Top segment conical	steel tubularcylindrical, Top segment conical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	On Request On Request	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	Auf Anfrage	
Total weight	On Request	On Request	On Request	
TYPE APPROVAL				
Guideline, Class	IEC Ia	IEC Ia	IEC Ia	
Survival wind speed				
Tested (month/year)	40.940,0	40.878,0	41.365,0	
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	9 years	9 years	9 years	
REFERENCES 31/12/2012	Installed turbines worldwide 911 N90/2500 First installation in: 38,749.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Condition monitoring system (CMS); Ice detection; Nordex Anti Icing System; Fire detection- and extinguishing system; Burglar Alarm; Bat-Friendly System operation; Shadow flicker module; Radar friendly system operation; customer specific markings on blade			
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	7,822.60 m^2
Number of blades	3.0	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 100.0 m				
Type / Shape	steel tubularconical			
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 1.0 First installation in: 2,009.0			
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	108.9 m	Swept area	9,331.32 m²
Number of blades	3.0	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				
Type / Shape	steel tubularconical			
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	Installed turbines worldwide First installation in:			
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	11 – 11.5 m/s	Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	112.5 m	Swept area	9,940.20 m²
Number of blades	3.0	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	V	- 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				
Type / Shape	steel tubularHybridconical			
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	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	ice sensor			
MISCELLANEOUS				

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	7,853.98 m^2
Number of blades	3.0	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	1:117
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed		- 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	GE WindSCADA

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

TOWER/HUB HEIGHT	75.0 m	85.0 m	98.3 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
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	Installed turbines worldwide First installation in:			
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	8,332.29 m²
Number of blades	3.0	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	1:117
- Manufacturer			
Generator / Type	asynchronous, double fed induction		
- Number		- Grid connection	via converter
- Speed		- 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	GE WindSCADA

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

TOWER/HUB HEIGHT	85.0 m	98.0 m	123.5 m	
Type / Shape	steel tubularconical	steel tubularconical	concrete tower, hybrid 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	Installed turbines worldwide First installation in:			
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 Can be operating with 2.75MW rated power.			

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	5,281.02 m²
Number of blades	3.0	Rotor speed	6 - 18.5 (variabel) rpm
Type			
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 - 18.5 (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 control, rotor 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	

TOWER/HUB HEIGHT	78.0 m	85.0 m	98.0 m	108.0 / 138.0 m
Type / Shape	steel tubularconical	steel tubular, or concrete towerconical	concrete towerconical	concrete towerconical
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)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 132.0 First installation in: 2,010.0
SPECIAL FEATURES	lightning protection system
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.

LEITWIND LTW101

LEITWIND AG
Sterzing, Italy

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed		Cut-out wind speed	25.0 m/s

ROTOR			
Diameter	100.9 m	Swept area	7,995.99 m^2
Number of blades	3.0	Rotor speed	6 - 14.4 (variabel) rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer			

NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	1:1
- Manufacturer	LEITWIND		
Generator / Type	synchronous, permanent magnet		
- Number	1	- Grid connection	via converter
- Speed	6 - 14.4 (variable) rpm	- Grid frequency	50 / 60 Hz
- Voltage	690 V	- Manufacturer	LEITWIND

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, individual blade pitch control
Yaw control system	4 electric gear motor(s)
Manufacturer of control system	LEITWIND
SCADA-System	LEITWIND SCADA

POWER CURVE	SOUND POWER LEVEL	ELECTRICAL CHARACTERISTICS
yes	yes	yes

TOWER/HUB HEIGHT	95.0 m	143.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
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 IIa	IEC IIa		
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide Prototype First installation in: In Progress
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
MISCELLANEOUS	

REpower 3.0M122

REpower Systems 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	11,689.87 m²
Number of blades	3.0	Rotor speed	11.3 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 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	

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

TOWER/HUB HEIGHT 139.0 m				
Type / Shape	concrete towerhybrid towerconi-cal, steel/concrete			
Corrosion protection	multi-coated			
WEIGHT				
Single blade	ca. 15 t			
Hub (incl. installed equipment)				
Rotor (incl. hub)	ca. 68 t			
Nacelle (without rotor & hub)	approx. 104 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	Installed turbines worldwide First installation in: 2013 (Prototyp)
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 REpower 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	8,011.85 m²
Number of blades	3.0	Rotor speed	6-16 rpm
Type	B49		
Material	Fiberglass reinforced epoxy		
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	79.5 m	89.5 m	99.5 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	78.0 t	78.0 t	78.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ia/DIBt WZ 3 (2004)	IEC IIa/IEC IA and IIA pending	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	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	5 years
REFERENCES 31/12/2012	Installed turbines worldwide 64.0 First installation in: 2,009.0			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

Wind Turbines 3,000 kW

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	10,028.75 m²
Number of blades	3.0	Rotor speed	6-15.5 rpm
Type	B55		
Material	Fiberglass reinforced epoxy		
Manufacturer	Siemens Wind Power A/S		
NACELLE			
Design	integrated		
Gear box / Type	gearless		
- Stages		- Ratio	N/A (getriebelos)
- 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	
SCADA-System	WPS

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

TOWER/HUB HEIGHT	92.5 m	99.5 m	122.5 m	142.5 m
Type / Shape	steel tubularconical	steel tubular, Steel shell tower-conical	, Steel shell towerconical	, Steel shell towerconical
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)	78.0 t	78.0 t	78.0 t	78.0 t
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt WZ 3 (2012) planned, IEC IIA	IEC IIA pending	DIBt WZ 3 (2012) planned and IEC IIA	DIBt WZ 2 (2012) planned, IEC IIA
Survival wind speed				
Tested (month/year)	pending			
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 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

Vestas V90 - 3.0 MW

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	15.0 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	90.0 m	Swept area	6,361.73 m^2
Number of blades	3.0	Rotor speed	8.6 - 18.4 rpm
Type	RISÖP + FFA-W3		
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		
NACELLE			
Design	integrated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:104.5
- Manufacturer	divers		
Generator / Type	asynchronous, double fed induction		
- Number	1	- Grid connection	via converter
- Speed	1,680 (rated speed) rpm	- Grid frequency	50 / 60 Hz
- Voltage	1,000 V	- Manufacturer	divers

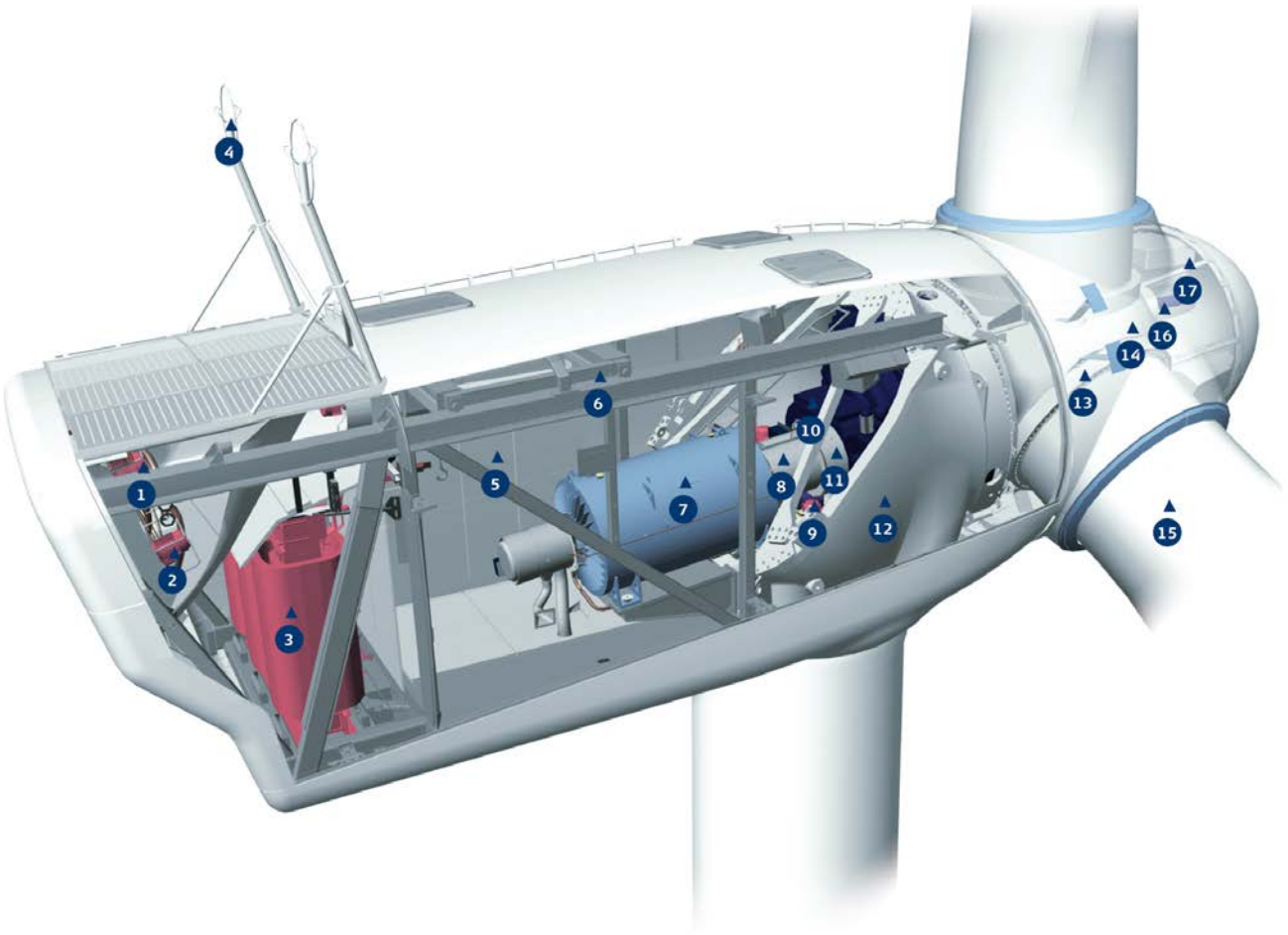
CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	disk brake
Yaw control system	6 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	80.0 m	90.0 m	105.0 m	
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	
Corrosion protection	coated	coated	coated	
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 3/	IEC Ia/	IEC IIa/	
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	2 years	2 years	2 years	
REFERENCES 31/12/2012	Installed turbines worldwide 4.5 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Opntions on request			
MISCELLANEOUS				

Vestas V90 – 3.0 MW

Cross Section



1 Ölkühler
2 Wasserkühler für Generator
3 Hochspannungstransformator
4 Ultraschall-Windsensoren
5 VMP-Top-Controller mit Umrichter
6 Servicekran
7 OptiSpeed®-Generator
8 Kompositkoppling
9 Azimut-Antriebe
10 Getriebe
11 Scheibenbremse
12 Maschinenrahmen
13 Rotorblattlager
14 Rotornabe
15 Rotorblatt
16 Pitch-Zylinder
17 Pitch-Controller

Vestas®
Wind. It means the world to us.

Vestas V112 - 3.0 MW

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	3,000 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	112.0 m	Swept area	9,852.03 m^2
Number of blades	3.0	Rotor speed	4.4 - 17.7 rpm
Type			
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		
NACELLE			
Design	integrated		
Gear box / Type	combined spur / planetary gear		
- Stages	4	- Ratio	1:113.2 (onshore). 1:105.2 (offshore)
- Manufacturer	divers		
Generator / Type	synchronous, permanent magnet, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed	1,540.0 rpm	- Grid frequency	50 / 60 Hz
- Voltage	650 V	- Manufacturer	divers

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	blade pitch control, individual blade pitch controlThe mechanical brake is only used as a parking brake and when activating the emergency stop push buttons.
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	84.0 m	94.0 m	119.0 m	140.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	steel tubularconical
Corrosion protection	coated	coated	coated	coated
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa	IEC IIa	IEC IIIa	DIBt 2
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 First installation in:			
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Options on request			
MISCELLANEOUS				

Vestas V112 – 3.0 MW

Cross Section

Vestas®
Wind. It means the world to us.

Vestas V126 - 3.0 MW GridStreamer

Vestas Deutschland GmbH
Husum, Germany

POWER			
Rated power	3,000 kW	Cut-in wind speed	3.0 m/s
Rated wind speed	12.0 m/s	Cut-out wind speed	22.5 m/s

ROTOR			
Diameter	126.0 m	Swept area	12,468.98 m²
Number of blades	3.0	Rotor speed	
Type			
Material	glas-fibre reinforced plastic		
Manufacturer	Vestas		

NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages		- Ratio	
- Manufacturer	divers		
Generator / Type	synchronous, permanent magnet, liquid-cooled		
- Number	1	- Grid connection	via converter
- Speed		- Grid frequency	50 / 60 Hz
- Voltage		- Manufacturer	Vestas

CONTROL- AND PROTECTION SYSTEM	
Power limitation	pitch
Speed control	variable via microprocessor, active blade pitch control
Main break	blade pitch control
Second brake system	disk brake
Yaw control system	8 electric gear motor(s)
Manufacturer of control system	Vestas
SCADA-System	VestasOnline® Business or VestasOnline® Compact

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

TOWER/HUB HEIGHT	117.0 m	137.0 m		
Type / Shape	steel tubularconical	steel tubularconical		
Corrosion protection	coated	coated		
WEIGHT				
Single blade				
Hub (incl. installed equipment)				
Rotor (incl. hub)				
Nacelle (without rotor & hub)				
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/DIBt 2	DIBt 2/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		
WARRANTY	2 years	2 years		
REFERENCES 31/12/2012				
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS) Options on request			
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	8,011.85 m^2
Number of blades	3.0	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 (variabel)	- 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 control, rotor 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	99.0 m	135.0 m	149.0 m	
Type / Shape	concrete towerconical	concrete towerconical	concrete towerconical	
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				
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				
REFERENCES 31/12/2012	Installed turbines worldwide 12.0 First installation in: 2,010.0			
SPECIAL FEATURES	lightning protection system			
MISCELLANEOUS				

REpower 3.2M114

REpower Systems 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	10,207.03 m²
Number of blades	3.0	Rotor speed	ca. 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	REguard

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

TOWER/HUB HEIGHT	90.0 - 93.0 m	120.0 - 123.0 m	140.0 - 143.0 m	
Type / Shape	steel tubularconical	concrete tower, Hybridtower Concrete-Steelconical	concrete tower, Hybridtower Concrete-Steelconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	ca. 15 t	ca. 15 t	ca. 15 t	
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx. 68 t	approx. 68 t	approx. 68 t	
Nacelle (without rotor & hub)	approx. 104 t	approx. 104 t	approx. 104 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC IIa/DIBt WZ3	IEC IIa/DIBt WZ3	IEC IIa/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: 40,878.0			
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 REpower 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.			

REpower 3.4M104

REpower Systems 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	8,494.87 m²
Number of blades	3.0	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	REguard

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

TOWER/HUB HEIGHT	78.0 - 80.0 m	93.0 m	96.5 - 100.0 m	12.0 - 128.0 m
Type / Shape	steel tubularconical	steel tubularconical	steel tubularconical	concrete tower, hybrid towerconical, steel/concrete
Corrosion protection	multi-coated	multi-coated	multi-coated	multi-coated
WEIGHT				
Single blade	ca. 11 t	ca. 11 t	ca. 11 t	ca. 11 t
Hub (incl. installed equipment)				
Rotor (incl. hub)	approx.56 t	approx.56 t	approx.56	approx.56 t
Nacelle (without rotor & hub)	approx. 104 t	approx. 104 t	approx. 104 t	approx. 104 t
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	IEC Ib/DIBt 4	IEC Ib/	IEC IIa/DIBt 4	IEC IIIa/DIBt 3
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY	2 years	2 years	2 years	2 years

REFERENCES 31/12/2012	**Installed turbines worldwide** 48.0 **First installation in:** 39,814.0
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 REpower 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.

e.n.o. 114

e.n.o. 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	10,368.83 m²
Number of blades	3.0	Rotor speed	4 - 11.8 rpm
Type	e.n.o. energy		
Material	glas-fibre reinforced plastic		
Manufacturer	e.n.o. energy		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear or differential gear box		
- Stages	3	- Ratio	1:119
- Manufacturer	Winergy		
Generator / Type	synchronous		
- Number	1	- Grid connection	full conversion
- Speed	480 – 1,410 rpm	- Grid frequency	50 Hz
- Voltage	600 V	- Manufacturer	VEM Sachsenwerk

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

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

TOWER/HUB HEIGHT	127.5 m	142.0 m		
Type / Shape	customised, steel tubularconical	customised, hybrid concrete/ steelconical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	14.7 t	14.7 t		
Hub (incl. installed equipment)	33.0 t	33.0 t		
Rotor (incl. hub)	77.1 t	77.1 t		
Nacelle (without rotor & hub)	67.0 t	67.0 t		
Tower		425.0		
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 3/IEC II s	DIBt 3/IEC II s		
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 First installation in:			
SPECIAL FEATURES	ice sensor, condition monitoring system (CMS)			
MISCELLANEOUS				

e.n.o. 126

e.n.o. energy systems GmbH
Rostock, Deutschland

POWER			
Rated power	3,500 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	126.0 m	Swept area	12,468.98 m²
Number of blades	3.0	Rotor speed	4-11.4 rpm
Type			
Material	glas-fibre reinforced plastic, carbon fibre reinforced plastic		
Manufacturer	e.n.o. energy systems GmbH		
NACELLE			
Design	separated		
Gear box / Type	combined spur / planetary gear		
- Stages	3	- Ratio	1:119
- Manufacturer	Winergy		
Generator / Type	synchronous		
- Number	1	- Grid connection	full conversion
- Speed	470 - 1,360 rpm	- Grid frequency	0 Hz
- Voltage	800 V	- Manufacturer	VEM Sachsenwerk

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	Bonfiglioli
SCADA-System	e.n.o. energy

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

TOWER/HUB HEIGHT	117.0 m	137.0 m	165.0 m	
Type / Shape	steel tubularconical	customised, hybridconical	customisedhybridconical	
Corrosion protection	multi-coated	multi-coated	multi-coated	
WEIGHT				
Single blade	14.0 t	14.0 t	14.0 t	
Hub (incl. installed equipment)	33.0 t	33.0 t	33.0 t	
Rotor (incl. hub)	75.0 t	75.0 t	75.0 t	
Nacelle (without rotor & hub)	115.0 t	115.0 t	115.0 t	
Tower				
Total weight				
TYPE APPROVAL				
Guideline, Class	DIBt 2/IEC III s	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	delivery, erection, remote data control, maintenance, transformer	
WARRANTY	2 years	2 years	2 years	
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:			
SPECIAL FEATURES	ice sensor, condition monitoring system (CMS) Schattenwurfmodul			
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	11,309.73 m²
Number of blades	3.0	Rotor speed	5-14 rpm
Type	B58		
Material	Fiberglass reinforced epoxy		
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	600 – 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	89.5 m (Onshore)			
Type / Shape	steel tubularconical			
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 and DIBt III (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 528.0 First installation in: 2,009.0			
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	3-5 m/s
Rated wind speed	11-12 m/s	Cut-out wind speed	25.0 m/s
ROTOR			
Diameter	130.0 m	Swept area	13,273.23 m²
Number of blades	3.0	Rotor speed	5-14 rpm
Type	B 63		
Material	Fiberglass reinforced epoxy		
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 – 1,550 rpm	- Grid frequency	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	6 electric gear motor(s)
Manufacturer of control system	KK-electronic A/S
SCADA-System	Siemens Wind Power A/S

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

TOWER/HUB HEIGHT	on request
Type / Shape	steel tubularconical
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/IEC Ib pending
Survival wind speed	
Tested (month/year)	
REFERENCE ENERGY YIELD (kWh/a)	
SCOPE OF SUPPLY	delivery, erection, remote data control, maintenance, foundation
WARRANTY	5 years
REFERENCES 31/12/2012	Installed turbines worldwide First installation in:
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	10,568.32 m²
Number of blades	3.0	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	via converter
- 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	90.0 m			
Type / Shape	steel tubularconical			
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)	expected for 2/2010			
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 10.0 First installation in: 38,322.0
SPECIAL FEATURES	lightning protection system, condition monitoring system (CMS) (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	18,626.50 m²
Number of blades	3.0	Rotor speed	5-11 rpm
Type	B75		
Material	Fiberglass reinforced epoxy		
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	rpm	- Grid frequency	0 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	120.0 m (Onshore)			
Type / Shape	steel tubularconical			
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/IEC Ia pending			
Survival wind speed				
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 2.0 First installation in: 2,011.0
SPECIAL FEATURES	lightning protection system, ice sensor, condition monitoring system (CMS)
MISCELLANEOUS	

REpower 6M

REpower Systems SE
Hamburg, Germany

POWER			
Rated power	6,150 kW	Cut-in wind speed	3.5 m/s
Rated wind speed	14.5 (Onshore) / 14.0 (Offshore) m/s	Cut-out wind speed	25.0 (Onshore) / 30.0 (Offshore) m/s
ROTOR			
Diameter	126.0 m	Swept area	12,468.98 m²
Number of blades	3.0	Rotor speed	12.1 rpm (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	1:96
- 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	REguard Control B

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

TOWER/HUB HEIGHT	**85.0 – 95.0 m (Offshore)**	**100.0 - 117.0 (Onshore) m**		
Type / Shape	steel tubularcylindrical	steel tubularcylindrical		
Corrosion protection	multi-coated	multi-coated		
WEIGHT				
Single blade	20 - 23 t	20 - 23 t		
Hub (incl. installed equipment)	71.0 t	71.0 t		
Rotor (incl. hub)	130 - 135 t	130 - 135 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	/IIA, S-Class (IB)		
Survival wind speed	70.0 m/s	60.0 m/s		
Tested (month/year)				
REFERENCE ENERGY YIELD (kWh/a)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 3.0 First installation in: 39,873.0
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. Cut-out wind speed onshore = 25.0 m/s.

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	12,667.69 m²
Number of blades	3.0	Rotor speed	5 – 11.7 rpm (variabel)
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		- Grid connection	via converter
- Speed	5 – 11.7 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	3 independent pitch control systems with emergency power supply
Second brake system	Rotor brake
Yaw control system	, 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				
Type / Shape	concrete towerconical			
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)				
SCOPE OF SUPPLY				
WARRANTY				

REFERENCES 31/12/2012	Installed turbines worldwide 22 (E-126/6MW) / 9 (E-126/7.5 MW) First installation in: 2,007.0
SPECIAL FEATURES	lightning protection system
MISCELLANEOUS	Maintenance concept and ENERCON PartnerKonzept (EPK) on request.

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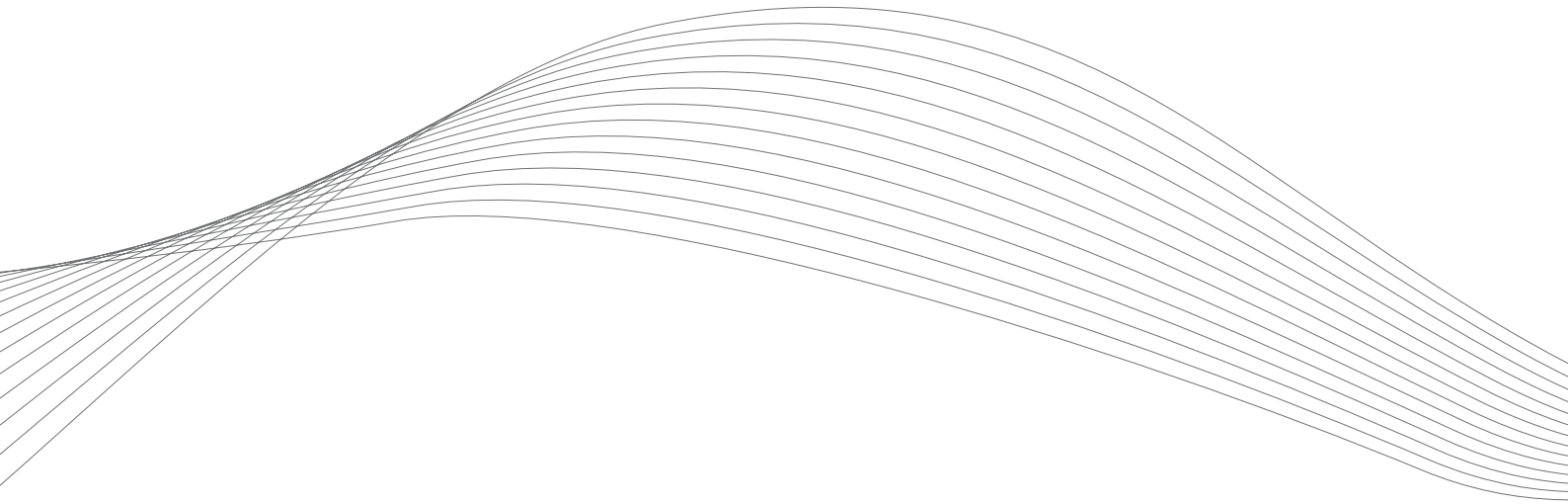

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