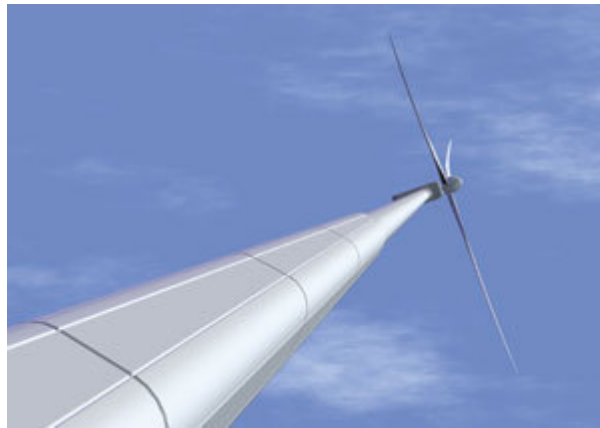


Wind innovation slows: Growth remains robust

Eize de Vries

*Although wind market growth in 2006 proved robust overall, it was slower than expected, largely due to a global shortage of key components. And as the main suppliers focus on turning out volume class 'utility type' wind turbines, the pressure for newer and larger models has cooled. **Eize de Vries** reports.*

In its annual World Market Update, BTM Consult of Denmark (see pp.50-59) reported the installation of 15,017 MW in 2006 compared with 11,407 MW in 2005, representing a 31.6% increase in annual installations. The top five countries were the United States with 2454 MW of new capacity, followed by Germany (2233 MW), India (1840 MW), Spain (1587 MW) and China (1334 MW).¹ Besides the substantial volume of 1.5 MW - 2 MW turbines that are being delivered worldwide, a new upcoming class of turbines in the 2.5 MW - 3 MW range is enjoying increasing popularity while - to the surprise of many in the wind industry - the partly renewed sub-megawatt range (750 kW -1000 kW) is again enjoying brisk demand.



An advanced concrete-steel hybrid tower being developed in the Netherlands ATS

Measured in turbine deliveries per country (in MW), Germany, with around 29% market share, overtook Denmark in 2006 (28% market share) as the number one supplier. In 2006, there were nine German-owned companies producing turbines of over 100 kW, compared with five in Spain, three in the US, three in Japan, two in Denmark and one in India (see Table 1).

Country	Manufacturer	Cumulative world market share (%) ^a
Germany	Enercon, Bard Engineering, Fuhrländer, Multibrid, Nordex, REpower, Seewind, Siemens, Vensys	29
Denmark	Norwin (former Danwin), Vestas	28
Spain	Acciona, ACSA, Ecotècnia, Gamesa, Torres	18
US	GE Energy, CTC (DeWind), Clipper Windpower	15
India	Suzlon	7
China	Goldwind	2
Belgium	Turbowinds	-
Canada	AAER (Fuhrländer licence)	-
Finland	WinWind	-
France	Vergnet	-
Italy	Leitwind	-
Japan	Mitsubishi, Harokasan, Subaru	-
Netherlands	EWT, WES, DarWinD	-

^a Cumulative totals derived from rounded figures.

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TABLE 1. Cumulative supplier market shares per country of origin in 2006 (installations of 100 kW or more). Source: WindPower Monthly, May 2007

Top 10 manufacturers

In 2006, Vestas of Denmark retained its long-running position as world market leader, supplying 4239 MW of wind turbines - 80% more than its nearest competitor Gamesa of Spain. Interestingly, and in contrast with previous years, the second, third and fourth largest manufacturers each supplied almost the same installed megawatts - Gamesa Eólica of Spain (2346 MW), followed by US giant GE Energy (2326 MW) and Enercon of Germany (2316 MW). Together, the top four suppliers delivered 75% of the world's total added installed capacity in 2006.¹ Fast-growing suppliers Suzlon of India and Siemens Wind Power of Germany maintained their fifth and sixth 2005 rankings in 2006. But at a megawatt-installed level, their performance was less than half that of fourth-ranked Enercon. Another fast-growing supplier is Nordex of Germany at number seven, with REpower in position eight. Acciona of Spain was in ninth place and, for the first time, a Chinese supplier entered the top 10 in the form of Goldwind. Finally, following Suzlon's takeover of REpower in May, the combined Suzlon-REpower world market, based on BTM's 2006 figures, ranked in fifth position.

Vestas Wind Systems

In Vestas' 2006 annual report, CEO Ditlev Engel admitted that customer satisfaction had 'nosedived' in the period 2000-2005, but he claims it had recovered in 2006.

Key volume products for Vestas remain the V80 and V90 series. By 31 December 2006, Vestas had erected a total of 1788 V80-2 MW turbines, 751 V80-1.8 MW turbines (in the North American market), 501 V90-2 MW turbines and 300 V90-3 MW turbines. The mechanical layout of the V90-2 MW is similar to the V80 series but this turbine type features the new generation 44 metre lightweight rotor blades (rotor diameter 90 metres.) developed for the V90-3 MW turbine. In fact Vestas still has little competition in the 3 MW class, although the number of contenders keeps on increasing, including suppliers such as Clipper, Ecotècnia, Fuhrländer, GE and WinWinD. Currently, the largest offshore wind farm featuring V90-3 MW turbines is the 108 MW Dutch Egmond aan Zee project, which was inaugurated in late 2006.



In 2006, Gamesa was once again the second largest wind turbine manufacturer in the world and is continuing to expand outside Spain GAMESA

For some time, however, wind industry sources have raised concerns about gearbox and other problems found in multiple V90-3 MW installations operating on land as well as offshore in the UK and the Netherlands. Different sources report that Vestas found defects in nine out of 30 turbine gearboxes at the Kentish Flats offshore wind farm in the UK.² These installations had only been operating since September 2005, and all defective gearboxes had to be replaced. According to Dutch wind industry sources, at least one gearbox in the Egmond aan Zee wind farm has been replaced recently. Many of the reported gearbox troubles seem to be failures in the third fast-speed parallel gear stage, while the planetary stages have also been pinpointed as causing problems.

With regard to new products, planned launch dates for the V100-3 MW sister product of the V90-3 MW and the V120-4.5 MW offshore turbine remain unknown.

Gamesa Eólica

Gamesa moved back into second place in 2006 (from fourth in 2005) with remarkable installation growth of 78%. This helped the company pass the 10,000 MW total installed capacity mark, of which over 25% was erected outside Spain. Among several large recent deals is a 2006 agreement with Iberdrola for the supply of 2700 MW by 2009. The year 2006 was also important for Gamesa in terms of industrial expansion, as the company opened four production centres in the US for the manufacture of blades, towers and nacelle assemblies for Gamesa G8X-2.0 MW wind turbines. In addition, a new production plant for the G5X-850 kW turbine type became operational in China, serving the vast Asian market. In the past year, 57% of all installations were Gamesa's 2 MW multi-megawatt wind turbines, with rotor diameters of 80 metres - 90 metres.

More details of the Gamesa G10X platform are gradually being released. The latest 4.5 MW G-128 prototype will be erected in late 2007 or early 2008, says Gamesa's press spokesperson Belén Míguez. Key features of the prototype include:

- *Gamesa CompactTrain™*: A concept that consists of a main shaft supported by a two-bearing arrangement integrated with a two-stage planetary type gearbox. Gamesa claims that this 'compact drive' solution reduces the number of components involved. Based on the above drive train design description it appears to have a close resemblance to the main shaft and gearbox support

solution applied in the 5 MW REpower and 5 Mand 3.6 MW Siemens SWT-3.6-107 turbines. And Gamesa, like its two competitors, seems to have traded in the three-point gearbox support system applied in the smaller 850 kW and 2 MW platforms in favour of the new drive solution.

- *Gamesa MultiSmart™*: A multivariable control system that minimizes blade vibration and reduces blade loads by up to 30% by incorporating the latest cost-reduction and efficiency optimization technologies.
- *Gamesa InnoBlade™*: A sectional blade design that permits similar accessibility and use of the same transport equipment as for the 2 MW turbine. Substantial international research efforts have been dedicated to sectional rotor blades. Among some of the past difficulties reported was an interruption in blade stiffness properties at the point where two sections are joined together. More details on Gamesa's sectional blade technology and, especially, how it tackled the blade section joining challenge are not available.
- *Gamesa ConcreTower™*: A hybrid tower concept that guarantees the lowest costs at large hub heights.
- *Gamesa FlexiFit™*: An 'attached' crane system that reduces the need for large external cranes, thereby simplifying field assembly and disassembly of components.
- *Gamesa GridMate™*: A full converter technology that allows for compliance with the most demanding grid connection codes. The latter implies that Gamesa has now opted for a different type of (synchronous) generator instead of the doubly-fed induction generator applied in its 850 kW and 2 MW models.

GE Energy

US giant GE Energy was once again solely dependent on its successful GE 1.5 MW series in 2006. Last May, at the international 2006 Hamburg wind industry fair, GE Energy introduced three upgraded megawatt series wind turbine models, one with 2.5 MW capacity and two 3 MW models, each fitted with a corresponding rotor size. After many design validations and extensive market research, GE has recently decided to skip two of these versions, moving instead to series manufacture with the 2.5 MW 2.5xl. This pitch-controlled variable-speed wind turbine type features a 100 metre rotor and a permanent magnet type (PM) generator (Table 2). The new product will become available worldwide in 50 Hz as well as 60 Hz versions from 2008, explained GE Wind Energy Europe Managing Director Rainer Bröring earlier this year: 'During the second half of 2007, we plan to erect two 50 Hz prototypes in either Germany, the Netherlands or Spain, depending on local building permission progress, as keeping momentum is crucial for GE. Installation of a 60 Hz prototype in the US is planned for 2008, and next year we will also ramp up production of the 50 Hz turbine version to a couple of hundred units with an initial key focus on European markets.' Both 50 Hz and 60 Hz versions will become available for IEC II and IEC III class wind locations, and the 2.5xl already contains the necessary features for cold weather operation in arctic regions. Bröring continues: 'GE considers the 2.5xl as its "next generation" volume turbine type that is to succeed our proven 1.5 MW series.' The continuously upgraded 1.5 MW platform, which currently has over 6,000 units in operation, is now available with rotor diameters of between 70.5 metres and 82.5 metres.

Capacity	2.5 MW
Rotor diameter	100 metres
Cut-in wind speed	3.5 m/s
Cut-out wind speed	25 m/s
Rated wind speed	12.5 m/s
Power control	Active blade pitching
Gearbox	Multi-stage planetary spur gear system
Generator	PM type with full converter
Safety	Independent electromechanical blade pitch (three self-contained systems) Hydraulic parking brake
Hoisting system	Nacelle crane with 1000 kg lifting capacity
Masses:	
Nacelle	82,000 kg – 85,000 kg
Rotor	~40,000 kg
Top head mass	122,000 kg – 125,000 kg*
Hub height	100 metres

* Depends on specifications of outsourced key components.

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TABLE 2. Main specifications of GE 2.5xl Source: GE Energy – February 2007

The upgraded 3.6 MW GE 3.6sl with enlarged 111-metre rotor (previously 104 metres) has been shelved for the moment, explains Bröring: ‘GE’s initial plan to install a prototype this year will therefore not materialise yet. But we have already gained a lot of operational experience with the seven 3.6 MW offshore turbines at the Arklow Bank project. The product itself is matured and ready for use for any feasible upcoming project. Among potentially promising US offshore projects for GE in the pipeline are Long Island and Cape Wind.’

Enercon

At the April 2007 Hanover international trade fair, Enercon focused on the medium-sized 800 kW E-48 as well as the more recent additions to its range, the 800 kW E-53 and the strong-wind-speed 900 kW E-44 turbines. As of 31 May 2007, the combined installation of these three sister models was nearly 1,500 units. Enercon expects that the latest 2 MW E-82, fitted with a substantially larger 82 metre rotor, may gradually replace the E-70 E-4 as the company’s key volume model over the next few years. A 3 MW version of the E-82 with a new type generator is currently being tested near Aurich and will become commercially available in late 2008 or early 2009.

The German market leader commenced prototype testing of the 100 kW E-20 turbine in September 2006. In common with the E-82, the outer shell of the compact 1.7 metre high nacelle of the E-20 is made of 3D curved aluminium sheets. This small-wind class IEC 1A variable-speed concept distinguishes itself from the larger pitch-controlled Enercon models through the application of steel rotor blades that are fitted to the hub at a fixed angle (classic stall principle). Steel rotor blades are not new for the wind industry as they have in the past been used, for example, by former NedWind of the Netherlands on a 500 kW turbine model. However, combining variable-speed operation and stall-power limitation is still unusual for turbine types of about 25 kW and up. Jeumont Industrie of France previously developed a variable-speed stall type turbine in the 750 kW class, but production of this unsuccessful J48 direct-drive concept ceased after manufacturing only around 50 units.



*The offshore environment is challenging, with some reports indicating that gearbox failure may be a serious issue for some manufacturers
ELSAM/DONG ENERGY*

The once highly popular 'Danish design' fixed-speed stall-type turbines with a non-integrated geared drive train up to about 1500 kW were directly connected to the grid but now have great difficulty meeting today's stringent grid rules and are therefore gradually being phased out. Enercon's preference for the E-20 stall-power limitation option is explained by its simplified construction and reduced need for maintenance. A sophisticated control system is claimed to minimise power output deviations in the rated power range.

The long-awaited E-126 prototype has now been announced for the autumn of this year. It is the successor to the 4.5 MW - 6 MW E-112 series, of which nine units have become operational since August 2002. The E-126 will be fitted with either a 126 metre or 127 metre rotor, and the power rating 'will be at least' 6 MW capacity. According to company sources, first commercial deliveries could take place at the end of 2008.

Suzlon Energy

Sales by India's sole large turbine manufacturer Suzlon Energy jumped to 1157 MW in 2006 from 700 MW in 2005, with the company focusing on the commercial introduction of its new 2.1 MW S.88 model. Vertically integrated Suzlon is becoming a key player in several wind markets, including the US. A recent order from California-based Edison Mission Group (EMG) involves the purchase of 300 S.88 turbines (630 MW) for delivery in 2008 and 2009 (see also separate feature on Suzlon on pp197-199).

Siemens Wind Power

Last year Siemens Wind Power (SWP) boosted wind turbine deliveries to 1103 MW from 629 MW in 2005, with offshore wind energy becoming a key focus for the company. In a recent interview, CEO Andreas Nauen said that in a couple of years' time, 20%-25% of SWP's total wind turbine supply will be dedicated to offshore projects: 'Also at the moment, Siemens is well positioned in the offshore wind market with contracts for two major projects this year and one project for 2008 and 2009 each. Very likely there will be more.'

milestone for SWP is the erection this year of 25 3.6 MW SWT-3.6-107 turbines at the Burbo Banks offshore project in the UK following the successful prototype trial in Denmark launched in September 2004. Another 54 of these giant turbines will be erected next year in the UK at Lynn and Inner Dowsing and, in 2009, 25 3.6 MW units will be installed at Gunfleet Sands.



The REpower 5M turbine installed offshore in Scotland ALASDAIR CAMERON

Special projects manager Henrik Stiesdal says that in the past, turbine capacity roughly doubled every four years, but this trend is no longer apparent: 'Our 2.3 MW series was introduced in 2003 and has ever since remained our bestseller as it fits broadly into the market. With the current 2.3 MW volume product that is available with rotor diameters up to 93 metres we may in fact have hit a ceiling with regard to size for the bulk market. Also, for the much larger 3.6 MW turbine, there is a huge demand, and we could sell many more if we had the capacity. At some time in the future, this turbine type may have a bigger rotor to further optimise the price-performance ratio.' Other news is that the Norwegian energy company Hydro and Siemens Power generation (PG) have entered into an agreement to co-operate on technology to develop floating wind turbines based on Hydro's Hywind concept. Siemens will deliver the first wind turbine for the demonstration unit that will be positioned off the coast of Norway.

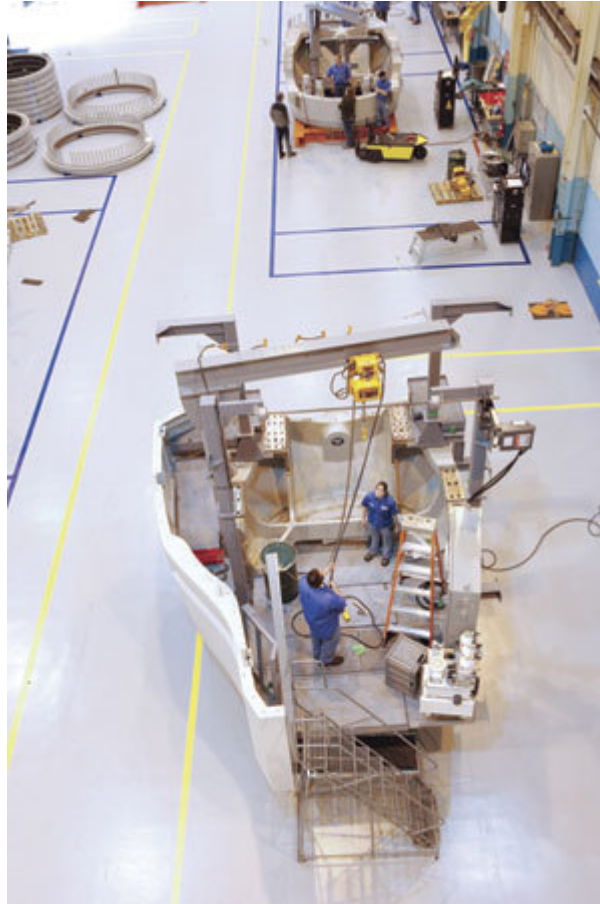
Nordex

This year, Nordex plans to erect between 630-750 MW, says press spokesperson Felix Losada. The bulk of Nordex turnover now comes from the variable-speed 2.3-2.5 MW N80/N90 series with more than 400 units in operation worldwide. Current volume product is the 2.5 MW N90/2500 series (rotor diameter 90 metres), which is available in both low speed (LS) and high speed (HS) versions. Nordex is also working on a bigger turbine model, but Losada did not wish to go into further details. Early June saw the first N90/2500 HS turbine connected to the North American grid in Hewitt, Minnesota. An additional 21 turbines are planned for this wind farm by 2009.

The 60Hz N90/2500 US version is equipped with a new control technique named Nordex AP. Two automatic controls - the torque control and the pitch control - are coupled to improve overall control dynamics, optimize hysteresis behaviour and to provide particular 'power optimized operational conditions'. Nordex has applied for several worldwide patents for these new technologies. A factor of key importance, says Losada, since it enabled Nordex to re-enter the US market, is that the new control system does not infringe GE's variable-speed patent. A condition monitoring system provides early warning against unforeseen component wear, while icing sensors and an automatic fire-extinguishing system complete the turbine's safety package.

REpower

REpower's volume products are the 2 MW MM series with rotor diameters from 70 metres to 92.5 metres. Prior to the company's takeover by Suzlon in early May 2007, a joint venture for in-house rotor blade production with the German rotor blade supplier Abeking & Rasmussen (A&R) had been announced, with REpower having a 51% controlling stake. The joint venture aims to produce sophisticated rotor blades developed by REpower. The location of the approximately 16,000 m² blade factory is to be in Bremerhaven, close to the planned production hall for REpower's 5 MW offshore wind turbines. Independent from rotor blade production in Bremerhaven, a rotor blade production facility in Portugal was already planned.



Although Vestas currently has relatively little competition in the 3 MW class, there is a range of companies large and small looking to challenge its dominance CLIPPER WINDPOWER

On 23 May 2007, REpower signed a contract with Belgian company C-Power to erect six of its 5 MW wind energy turbines at Thornton Bank, the first offshore wind farm in Belgium. After the first phase involving 30 MW, another 270 MW will be added in phases two and three over the next few years. The offshore wind farm is to be established in a water depth of 25 metres about 30 km off the Belgian coast. For the first time at such a water depth a gravity-based foundation (ballast concrete structure) will be used for the 5 MW turbines. Assembly of the turbines is scheduled from the beginning of next year in the new 5 MW production facility in Bremerhaven, while North Sea erection and commissioning has to be completed by end of September 2008.

Acciona Energia

Formerly EHN, Acciona Energia is wholly owned by Acciona S.A., a group based in Spain dedicated to infrastructures and services aimed at sustainable development and social welfare. Acciona Energia is a leader in the development, construction, operation and ownership of renewable energy projects. Through its subsidiary Acciona Windpower it manufactures a 1500 kW AW type wind turbine series using in-house technology. The turbines are available with rotor diameters of 70 metres, 77 metres and 82 metres.

Goldwind

China's leading wind turbine manufacturer produces turbines in the 600-750 kW power range under a licence agreement with REpower of Germany. It holds a second licence agreement with Vensys of Germany for the 1.5 MW Vensys 70/77 series. These novel direct-drive turbines are an up-scaling of the 1.2 MW Vensys 62 (rotor diameter 62 metres). In April, Goldwind erected three 1.5 MW prototypes, which it plans to enter series production at a later stage.

Globalizing the wind industry

The entry of US giant General Electric into the wind sector in 2002 through the purchase of Enron Wind marked the start of a new phase for the maturing global wind industry. Its German rival Siemens Power Generation bought Bonus Energy of Denmark in late 2004, since when its turnover has tripled. In 2005, another Siemens division acquired Flender Holding GmbH, Bocholt, one of the world's leading suppliers of electrical and mechanical drive systems, including gearboxes, generators and frequency converters.

During the next few years, it is likely that mergers and takeovers will continue and that some international contenders will prove more successful than others. This in turn will cause shifts in the top 10 ranking order, as happened last year when Mitsubishi of Japan and Ecotènia of Spain disappeared from the list while Acciona and Goldwind entered. And as a genuine globalizing move last May, Suzlon Energy of India took an 87.1% stake in Germany's REpower, a highly respected pioneer in the development of 5 MW offshore wind technology. In 2006, Suzlon had already acquired the renowned Belgian gearbox maker Hansen Transmissions International, so giving itself access to the latest drive technology. The move heralds an expected trend for ambitious newcomers, especially from Asia, to enter the world market. The trend will be reinforced by a major global wind technology transfer process. A number of specialised engineering consultancy firms are currently involved in the design of new wind turbines of 1.5 MW and higher for Asian clients based on European technology. As the race accelerates for access to state-of-the-art wind technology, manufacturing capacity, skills and market share, the stakes will be raised even higher for established parties as well as newcomers. Considering the world's huge and growing need for energy, wind power is one of the most sustainable and certainly most cost-effective options available. Globalization of the wind industry, the spreading of manufacturing capacity and a diffusion of know-how and skills provide opportunities to strengthen and diversify the wind energy market.

Eize de Vries is Wind Technology Correspondent, Renewable Energy World
e-mail: rew@pennwell.com

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