A STORM BREWING

ACROSS EUROPE WIND ENERGY IS GROWING RAPIDLY, BUT NOT WITHOUT PRACTICAL PROBLEMS. **RUEDIGER KIPKE** EXAMINES THE BIGGER PICTURE

Widespread use of wind turbines really began at the start of the nineties, following on from a short wind energy boom at the beginning of the eighties in California and moderate installations in Denmark. At that time turbines in the range of 50 to 250kW with diameters between 15-30m and towers no higher then 30m were the norm. Driven by regulations in Germany, Denmark and Spain, which supported the wind turbine operators, the installation numbers rose and customers asked for bigger and more cost-effective turbines.

The second driving force for bigger turbines was the limited land space in countries like Germany, Denmark or the Netherlands. In 1994 the first 500kW turbines with diameters up to 40m came into operation, shortly followed by the 600kW class. At the end of the nineties the 1.5MW class became the norm and today planning a new wind park in Central Europe with 2MW turbines with diameters up to 82m is almost standard.

The coming offshore market requires even bigger wind generators. As the foundations and grid connection add 100% to the turbine price, everybody's aim is to install the biggest turbines possible. The GE (General Electric) Wind 3.6MW prototype was installed in May last year and the first Enercon E-112 prototype (4.5MW) was installed in August 2002. Tower heights sometimes reach 100m and more in inland Germany, to catch the higher winds there. But such growth in a short period has led to technical problems, especially as the industry has had to hire several hundred new, and sometimes inexperienced, employees each year.

Country / Region	End 2001	End 2002
Germany	8,753	10,900
Spain	3,335	4,079
Denmark	2,556	2,889
Europe total	17,500	21,319
India	1,507	1,702
USA	4,245	4,708
World	24,564	29,140

Worldwide installation of wind power in MW
[Source: *Windpower Monthly*]

GROWING TOO FAST

One of first minor problems of the 500kW class in the middle of the nineties was lightning. The high structures, frequently sited on treeless hills, were ideal receptors. Blades were broken and electronic equipment exploded. The industry found a solution in installing lightning receptors in the blades, which are connected through wires and brushes to the fixed earthing system of the tower.

The main technological problems the industry is facing today are gearboxes and blades.

Wind turbine blades, made of glass-fibre reinforced plastic (mostly epoxy) are growing in weight with slightly more then a square law relationship to blade length. A blade of a 250kW class turbine weighs about 2.5t but a 2MW turbine blade (of 80m diameter) weighs 37t. Producing blades made of dozens of layers with different directions and fibre diameters in different areas of the blade is not an easy task. Experts believe that because of the fast growing weight, the 5MW range will be the limit for modern wind turbines, although the use of carbon fibre instead of glass fibre, for instance, might lead to new solutions.

The weight of the blade influences everything from the thickness of the tower steel to the dimensions of the foundation and therefore the costs. But very light blades may sometimes have excessively flexible blade tips. In 1995 some blades touched their towers in gusty winds leading to a total breakdown of the turbine. This problem has been solved, mainly with more vibration control sensors, but even today many blades exhibit cracks or erosion on their edges.

Apart from the difficult construction, another reason for the problems with blades is the near impossibility of precalculating all the forces on the blade. With different forces (some not fully known) over the length of the blade, it is difficult to predict all the stresses. Manufacturers are talking officially of their turbines having a 20 year lifetime, but few believe that blades of turbines in the megawatt range will last that long.

The biggest technological shock in the wind industry recently has been the breakdown of hundreds of gearboxes. Manufacturers reduced the weight of the gear train (for the same reasons that they have been trying to reduce the blade weight) to the point that the equipment could not stand the very complex bending forces, torques and so on.

Retrofit programs and installation of gear oil filtering was one of the first solutions, but it is still not uncommon to find broken teeth in almost new turbines. Online condition monitoring through

detecting vibrations in bearings will probably be the next solution.

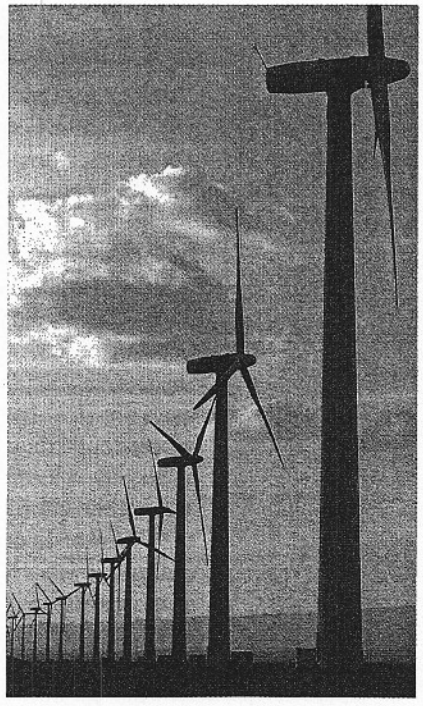
In Germany the insurance companies are threatening not to insure a turbine if the gearbox and the main shaft are not changed after five years of operation. This requirement would make most of the sites uneconomical.

NO MORE GEARS

A solution to this problem is to build gearless turbines, such as those being made by Enercon. This company is the biggest German manufacturer with about 5000 employees worldwide and dominates the worldwide market for this technology. The turbines are equipped with a ring generator, 5m in diameter, just behind the hub for the 1.5MW turbines. Of course this leads to other problems, such as the complex electronics needed to control the variable speed turbines. Enercon has the highest vertical integration of all wind turbine manufacturers, producing its own generator, blades and in joint-ventures even towers. Production cannot cope with the demand, even with blades being shipped from Enercon factories in Brazil, India or Turkey.

The world's biggest manufacturer is Vestas, based on the Western coast of Denmark, also with around 5000 employees, but far less vertical integration than Enercon. Having started earlier, as the Danish market started earlier than the German, the company is well positioned internationally. Its flagship, the 2MW turbine V80, is being used in the world's biggest offshore wind farm, Horns Rev (160MW), off the Danish West coast (see p22).

A wind farm in Morocco



COPING WITH THE GRID

Wind power already contributes 25% of Danish electricity consumption and the official aim of the last government was 50% by the year 2030. This country can more easily live with the fluctuating output of the generators than most because of its link to Norwegian hydropower. But utility officials have already announced that wind farms may have to be closed down temporarily if the grid requires it.

The Spanish wind power developers, on the other hand, are currently facing huge grid bottlenecks. Grid extension and the construction of dozens of substations is the problem here, slowing down the very high growth rate of the last years. In Germany, as a very densely populated and electrified country, many developers have connected their wind farms to the 110 or 380/400kV network. But with the huge offshore plans in the North and Baltic Sea a solution has to be found for delivering the gigawatthours to the consumption areas in West and South Germany. 6,000 – 10,000MW are in the approval process, sometimes as far as 70km from the coast. The actual share of wind power in the electricity market is around 4%. Experts believe that it will top hydropower, with its 6% share, at the beginning of next year.

TO WHAT COST?

Wind power's tremendous growth rate has been driven by a series of market incentives and fixed prices. So ironically Germany, the country with the highest installation, with 10,900MW at the end of 2002, is one of the less windy countries in the world. A feed-in law, which came into force in 1991 and changed in 2000, sets up a price of 9€-cents per kWh, reducing to 6€-cents after at least five years, dependent on the wind conditions. Utilities have to connect all wind farm installations and have to bear the extension of the grid. But it should not be forgotten that wind farms are usually located in remote areas, thus reducing the losses the utilities otherwise would have, transporting electricity from the big units to those areas.

The reason for Germany's high feed-in tariff is that wind speeds reach barely 7m/s – always counted at hub height – in coastal Germany. In the UK, Ireland or Greece, 8-9m/s is quite normal. Even stronger breezes can be found in countries like Costa Rica or Egypt with a maximum around 13m/s. Reaching 3€-cents per kWh is not a difficult task in those areas, especially with wind farms above 50MW. And the prices are continuously decreasing, according to the International Energy Agency. Some utilities in the United States currently argue that wind is cheaper then gas and are building up gigantic wind farms. The world's biggest site so far is the 278MW Kind Mountain wind farm in the oil state of Texas.

As technology advances, wind power can only become more competitive.