



WIND ENERGY: The Global Scale

The Globalisation of Wind Energy

The Global Wind 2007 Report published by the Global Wind Energy Council (GWEC) refers prominently to ‘the globalisation of the wind industry’ as the worldwide capacity of wind energy approaches 100,000 MW. The wind energy industry is now beginning to spread significantly beyond its core locations in Europe and the USA. Wind power is growing faster than any other form of renewable energy. This is at least partly because wind is available to all countries to varying degrees, which is not the case realistically for other forms of renewable energy. At the same time the ownership and structure of the industry is changing with the involvement of much larger companies than in the past as investment opportunities become more attractive.

Fig. 1 shows how rapidly global wind power capacity has increased since 1996 when global capacity was just over 6,000 MW. In the period to 2007 it increased by a factor of fifteen to reach 94,123 MW. However, wind power still only accounts for 0.8% of the world’s electricity supply. Additional capacity has increased year-on-year over the period, with the greatest increases in the last three years. In 2007 over 20,000 MW was installed across the world, almost 5,000 MW more than the previous highest annual total in 2006.

The modern era of wind energy development started in Europe in the 1990s. Today wind energy is heavily concentrated in Europe, North America and Asia with limited capacity elsewhere (Fig. 2) although this situation will undoubtedly change in the future. Europe has achieved the highest totals for all of the five years shown but in very recent years the rate of increase has been higher in North America and Asia.

Fig. 2 shows that at present global wind energy is dominated by a relatively small number of countries. Germany is currently the world leader with 23.6% of global capacity. Germany, the USA and Spain together account for almost 58% of the world total. The UK is in ninth position with 2.5% of the world total. However, the UK has the greatest natural wind energy potential in Europe. Denmark leads the world in terms of the % of electricity produced by wind energy – almost 18%. Denmark installed the world’s first offshore wind farm in 1991.

The leading countries shown in Table 1 are all MEDCs apart from India and China which are both NICs. India and China are anxious to expand their energy options in every possible direction to satisfy rapidly increasing demand. Many energy experts see Asia, and in particular China, as central to the future of the global wind energy market. Although wind energy is very spatially concentrated it does contribute to the energy mix of more than 70 countries. The global wind market in 2007 was worth \$37 billion in new generating equipment. As this figure rises more companies will see the potential to make profits in this industry.

Fig. 1 Global cumulative installed capacity 1996-2007.

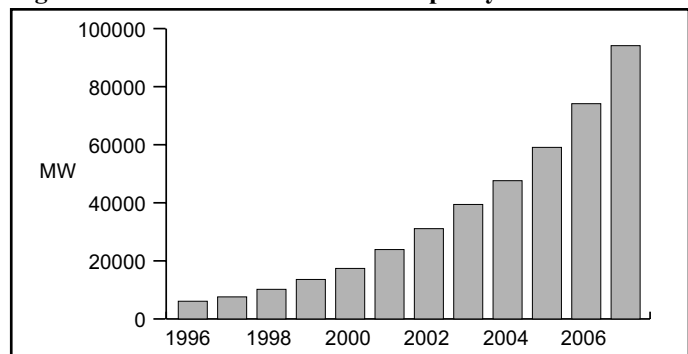


Fig. 2 Annual installed capacity by region 2003-2007.

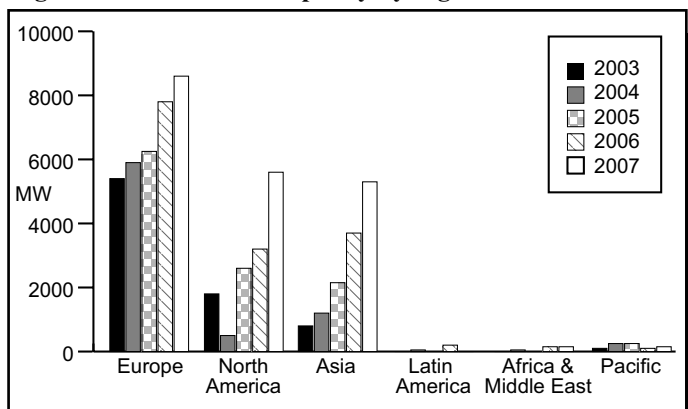


Table 1 Top ten countries – total installed capacity 2007.

Country	MW	%
Germany	22,247	23.6
USA	16,818	17.9
Spain	15,145	16.1
India	8,000	8.5
China	6,050	6.4
Denmark	3,125	3.3
Italy	2,726	2.9
France	2,454	2.6
UK	2,389	2.5
Portugal	2,150	2.3
Rest of world	13,019	13.8
Total top 10	81,104	86.2

Global annual capacity will continue to increase significantly in the near future (Figs 3 and 4), reaching 240.3 GW in 2012. The GWEC and the environmental organisation Greenpeace say that wind power could generate almost 30% of the world's electricity by 2030. However, other organisations are far more cautious. The International Energy Agency forecasts that wind will account for only 3.5% of global electricity by 2030. Much will depend on the costs of conventional energy sources and the other 'new' renewable forms of energy as well as government incentives to develop wind energy.

Wind energy is not only undergoing a significant change in location but also in scale. Individual wind farms are now being built with a capacity up to several hundred MW, whereas ten years ago 50 MW would have been considered sizeable. Offshore wind farms of 1,000 MW are now under construction. One thousand megawatts is the capacity of a large thermal power station. Modern turbines have rotors up to 100 meters in diameter. They can generate 180 times more electricity for half the cost of turbines built 20 years ago. One modern turbine can produce electricity equivalent to the needs of over 1000 households.

Fig. 3 Forecast annual installed capacity 2008-2012.

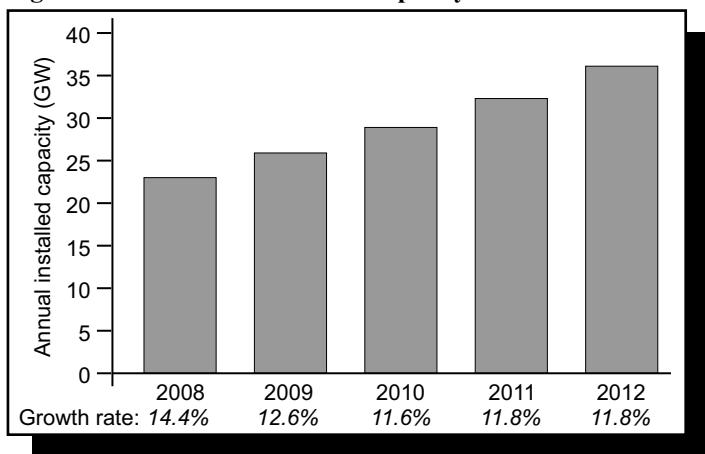
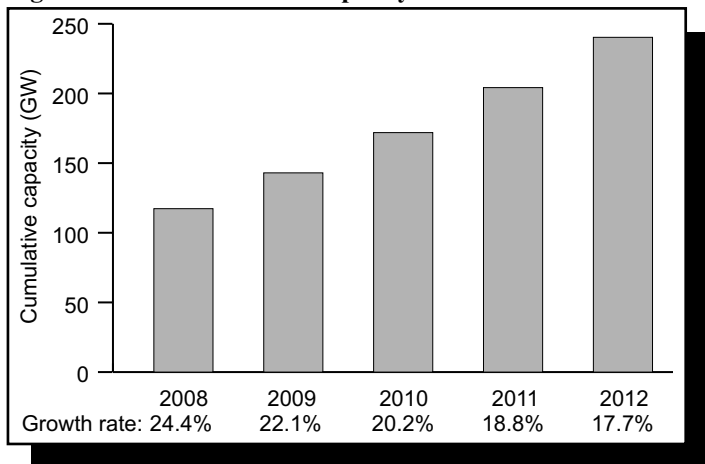


Fig. 4 Forecast cumulative capacity 2008-2012.



The Role of Government

Some governments have played an important role in the expansion of wind energy by placing an obligation on energy producers to source an increasing percentage of their electricity from renewable energy. In the UK this is done through the Renewables Obligation and in the USA by the state by state Renewable Portfolio Standards. By far the most important government decision has been taken by the European Union. The EU has introduced a legally binding target of 20% of total energy from renewable sources by 2020. For many member countries wind energy is seen as the most viable way of meeting the majority of this target. In Spain the government has used a national premium tariff to increase the contribution of wind power,

By ensuring guaranteed markets and setting favourable tariffs over a set period of time, governments can provide renewable suppliers with a secure market in which to plan investment.

The Wind Industry

Wind power is not just an increasingly important source of energy, it an industry in itself which is expanding at a rapid rate. In some countries it is beginning to make a significant contribution to employment, GDP and exports.

In the early years of wind power manufacturing, the industry was dominated by small independent companies. However, as the market has increased in size and profitability, larger companies have moved into this sector in a big way. Such companies include General Electric and Siemens. At the beginning of 2008 General Electric stated that it would increase its investment in renewable energy to \$6 billion by 2010, with the majority of this sum invested in wind power. This represents about 25% of the company's total investment in the energy and water sector.

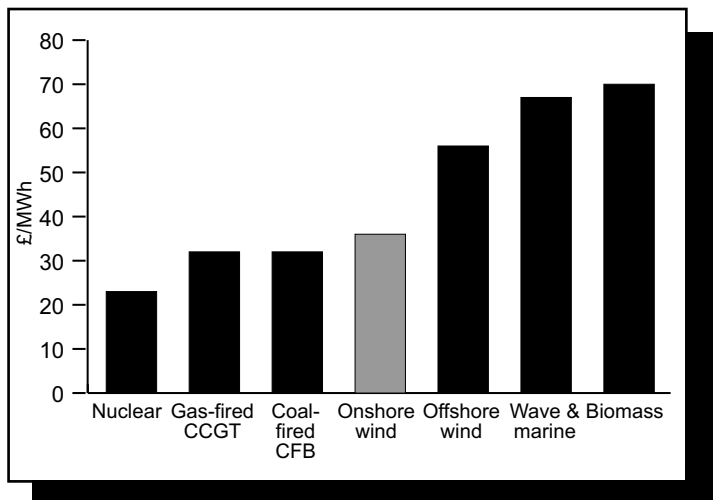
A similar trend is also apparent in the ownership of wind farms with, for example, Shell and BP increasing their stakes in wind energy. Major utility (supply) companies and IPPs (independent power producers) have also moved into wind power ownership in a significant manner. A report published by the market analyst Emerging Energy Research noted that seven of the top ten global owners in wind energy are now either European utilities or IPPs. The involvement of larger companies in each key stage of the industry is an important factor in the increasing globalisation of the industry.

The Cost of Wind Power

Costs of generating electricity from wind today are only about 10% of what they were 20 years ago due mainly to advances in turbine technology. Thus, at well chosen locations wind power can now compete with conventional sources of energy. Wind energy operators argue that costs should fall further due to [a] further technological advances and [b] increasing economies of scale. One large turbine manufacturer has stated that it expects turbine costs to be reduced by 3.5% a year for the foreseeable future.

Comparing costs between different forms of energy is not always straightforward. As such, different sources can produce somewhat varying scenarios. For example, the costs of coal, gas and oil used in fossil fuel power plants can change considerably even within a year. Fig. 5 shows a recent comparison from the Royal Academy of Engineering. Here, on-shore wind is only slightly higher in cost compared to gas and coal-fired power stations.

Fig. 5 The cost of generating electricity.



Source: Royal Academy of Engineering.

Table 2 Wind Farm Locations.

Location	Characteristics
Onshore	Mainly in hilly or mountainous locations 3km or more inland. Ridgelines favoured to exploit topographic acceleration as the wind accelerates over a ridge. Often very scenic locations.
Near-shore	On land within 3km of the coast or on water within 10km of the coast. Such locations benefit from land and sea breezes.
Offshore	Ten kilometres or more from the coast. Because water has less surface roughness than land, particularly deep water, the average wind speed is usually considerably higher over open water. Power transmission from offshore turbines is through undersea cable. Offshore wind operations are considerably more expensive than land-based schemes, but much less visually obtrusive.

Locating Wind Farms

An average wind speed of 4.5 meters a second (m/sec) at a height of 15 meters above ground level is generally seen as the minimum for the exploitation of wind energy today.

Offshore wind farms have the potential to produce more electricity than onshore facilities. Winds are stronger and more constant offshore. At the height of a wind turbine offshore wind is on average 90% stronger as hills, trees and building don't get in the way of winds blowing over the seas and oceans. However, offshore costs are considerably higher than those onshore (Table 2).

Repowering

Apart from establishing new wind energy sites, **repowering** is also beginning to play an important role. This means replacing first generation wind turbines with modern multi-megawatt turbines which give a much better performance. The advantages are:

- More wind power from the same area of land
- Fewer wind turbines
- Higher efficiency, lower costs
- Enhanced appearance as modern turbines rotate at a lower speed and as usually more visually pleasing due to enhanced design
- Better grid integration as modern turbines use a connection method similar to conventional power plants.

Case Study 1: Germany

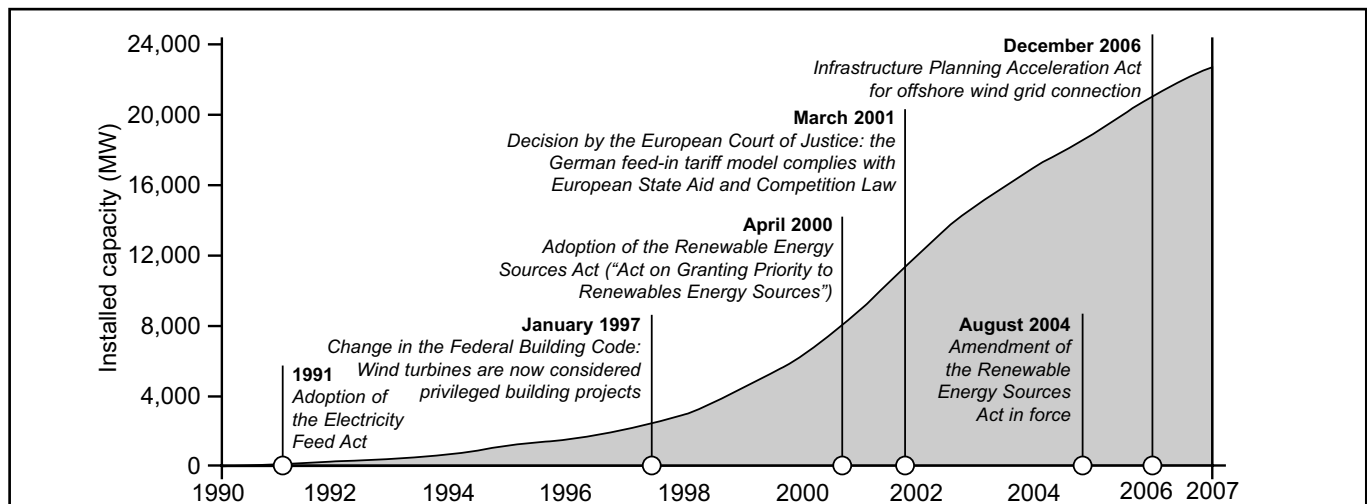
By the end of 2007 there were 19,460 wind turbines in Germany with a total capacity of 22, 247 MW. These wind turbines accounted for 7% of Germany's electricity consumption. Germany is now looking to build offshore windfarms to accompany its land-based turbines. The German government has legislated to promote wind energy since 1991 with the most important impetus coming from the Renewable Energy Sources Act of 2000 and its amendment in 2004 (Fig. 6). The central element is a minimum price, guaranteed for more than 20 years, which will be paid for electricity fed into the grid that has been generated from renewable energy sources. Power companies have to take this electricity by law. The renewable energy industry also benefits from favourable tax concessions designed to encourage the expansion of the industry.

It has been estimated that there is the potential for new turbine capacity of up to 10,000 MW on already commissioned sites onshore. Additional onshore capacity can be produced by repowering which could double the amount of wind capacity onshore with considerably fewer turbines.

Germany could have an onshore capacity of 45,000 MW by 2020 with an additional 10,000 MW from offshore wind farms in the North and Baltic Seas. If these figures are reached wind power could contribute 25% of Germany's electricity consumption. The German manufacturer, Multibruid, is developing a 5 MW turbine designed for operating at sea.

German wind turbine and components manufacturers hold first position in the world with a global market share of 37%. The industry in Germany employs more than 100,000 people. In 2007 the wind turbine industry contributed 6 billion euros in export earnings to the German economy. Total revenue from the industry amounted to 11.7 billion euros in 2007. The industry has developed from Germany's long tradition of mechanical and electronic engineering. The wind industry in Germany has reached such a size that it is now benefiting from significant economies of scale. Considerable investment in research and development is occurring.

Fig. 6 The development of wind energy in Germany.



Case Study 2: The USA

In the USA wind energy is the second biggest source of new energy after natural gas. Investment in wind power in the USA is increasing rapidly due to:

- Attractive federal and state government incentives
- The rising cost of conventional energy sources
- The American perception of space – the feeling that there is much more room for large wind farms in the USA than in more densely populated Europe.

New installed wind power capacity reached a record 5,244 MW in 2007. It has been estimated that wind farms will supply 1% of the USA's electricity in 2008. This is enough to supply the needs of 4.5 million homes.

34 of the 50 states in the USA were producing electricity from wind power in 2007. The leading states are Texas, California, Minnesota, Iowa and Washington.

21 states have renewable energy standards requiring a certain proportion of power sold to come from renewable energy suppliers. The Global Wind Energy Council expects the USA to take over from Germany as the world leader in wind energy by the end of 2009.

At present, all of the USA's wind turbines are sited on land. However, the National Renewable Energy Laboratory located in Golden, Colorado estimates that offshore areas within about 90 km of the coast have winds strong enough to produce about 90% of the country's current electricity capacity.

A report published by the US Department of Energy in 2008 stated that wind power is capable of reaching as much as 20% of US electricity supply by 2030. The report contrasted this scenario with no new wind power capacity. Under the 20% scenario, installation of new capacity would increase to more than 16,000 MW a year to 2018, and continue at that rate through 2030. The report stated that this level of wind power is the equivalent of taking 140 million cars off the roads.

Case Study 3: China

China is looking to both considerably increase its production of electricity from wind power and to develop a major wind power industry of its own. The country is the world's fastest growing wind energy market. At present, more than 40 Chinese companies are involved in turbine manufacture, accounting for more than half of recently installed wind power capacity in China. The Chinese government has passed a law stating that 70% of the equipment used in a commercial wind farm must be sourced from domestic manufacturers. Total domestic manufacturing capacity is now close to 5,000 MW, with the objective of a capacity up to 12,000 by 2010.

The first Chinese wind farm, which was a demonstration project, went online in 1986. By the end of 2007 China had 6,000 MW of installed capacity. The Chinese Renewable Energy Industry Association forecasts an increase in capacity to about 50,000 MW by 2015. The regions with the best wind power potential are along the South-East coast and Inner Mongolia, Xinjiang, Gansu Province's Hexi Corridor and in some parts of North-East China, North-West China, Northern China and the Qinghai-Tibetan Plateau.

The government has noted the economic benefits to areas where wind farms are located. These are frequently remote and poor rural areas which benefit from:

- The annual income tax paid to county governments
- Employment in wind farm construction and maintenance
- Grid extension for rural electrification

In the UK the Campaign to Protect Rural England has expressed concern over the large number of planning applications for wind farms, where as other environmental NGOs, such as Friends of the Earth, have been strongly in favour.

Turbine Shortages

The recent rapid increase in demand for turbines has resulted in a shortage of supply. New projects now have to make orders for turbines in large blocks up to several years in advance to ensure firm delivery dates from manufacturers. Likewise investment from manufacturers is having to rise significantly to keep pace with such buoyant demand.

New Developments

- In 2008 a Dutch company installed the world's first floating wind turbine off the southern coast of Italy in water 110m deep. The technology is known as the Submerged Deepwater Platform System.
- The Swedish company Nordic has recently brought a two-bladed turbine onto the market.

Conclusion

Wind energy has reached the 'take-off' stage both as a source of energy and a manufacturing industry. As the cost of wind energy improves further against conventional energy sources, more and more countries will expand into this sector. However, projections regarding the industry still vary considerably because of the number of variables which will impact on its future.

Useful Websites

www.gwec.net – Global Wind Energy Council

www.windpower-monthly.com – Windpower Monthly

Issues Relating to Wind Power

As wind turbines have been erected in more areas of more countries, the opposition to this form of renewable energy has increased.

- People are concerned that huge turbines located nearby could blight their homes and have a significant impact on property values
- Concerns about the hum of turbines disturbing both people and wildlife
- Skylines in scenically beautiful areas might be spoiled forever
- Turbines can kill birds. Migratory flocks tend to follow strong winds but wind companies argue they steer clear of migratory routes
- Suitable areas for wind farms are often near the coast where land is expensive
- Turbines can affect TV reception nearby
- The opportunity cost of heavy investment in wind compared to the alternatives

Acknowledgements

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