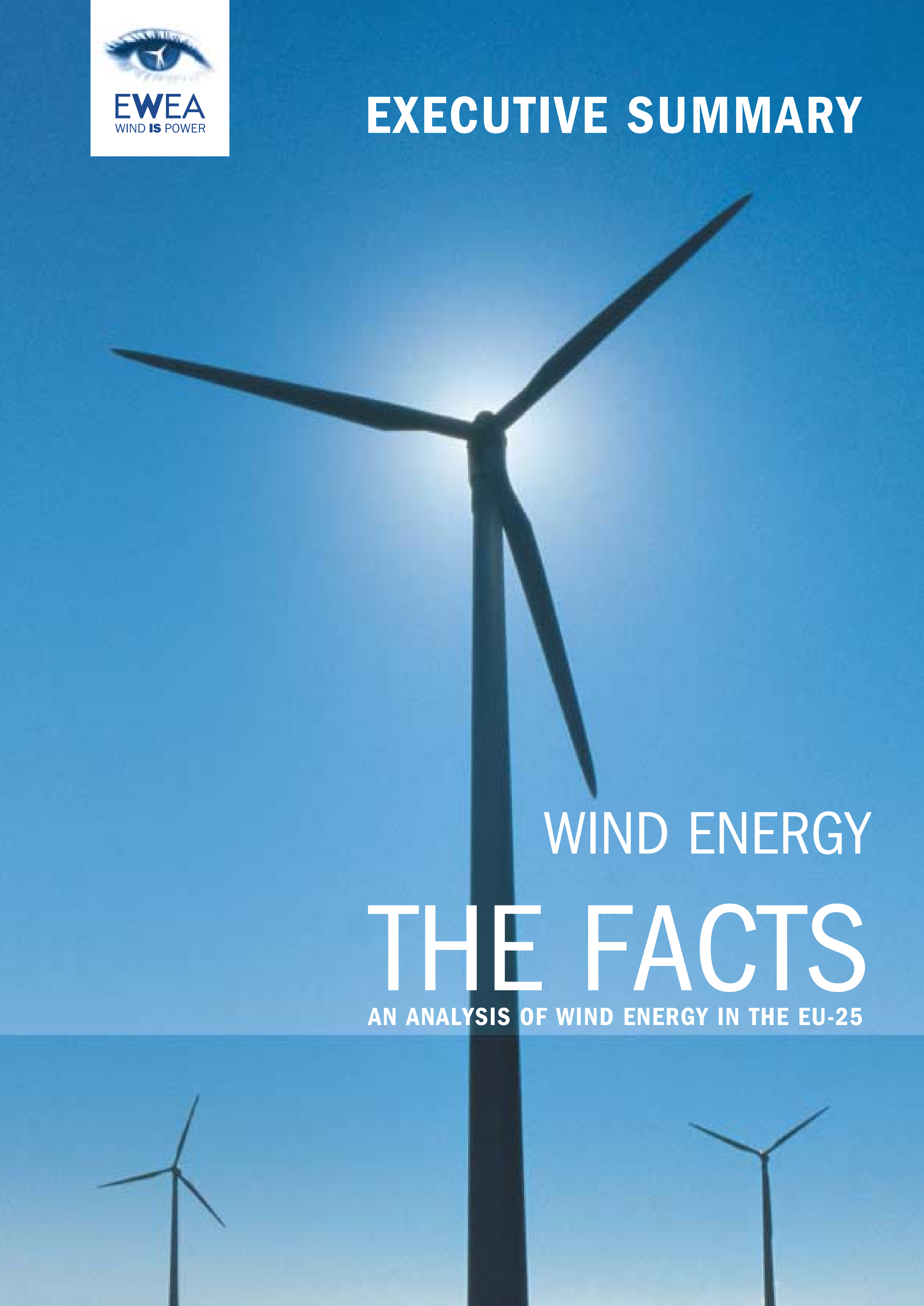

EWEA
WIND IS POWER

EXECUTIVE SUMMARY

WIND ENERGY THE FACTS

AN ANALYSIS OF WIND ENERGY IN THE EU-25

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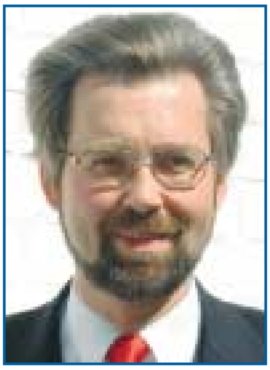
FOREWORD

by
Günther Hanreich
Director, New Energies and Demand Management,
DG TREN, European Commission

It is a pleasure for me to introduce the new edition of *Wind Energy – The Facts* produced by the European Wind Energy Association (EWEA) and supported by the European Commission in the frame of the ALTENER Programme.

The substantial progress with more efficient and bigger machines, the impressive developments in off-shore wind power generation and the enlargement of the European Union call undeniably for this valuable update.

Wind is still the fastest growing energy source and Europe is reinforcing its global leadership in wind technology. European companies have a world market share of more than 85% in wind turbine manufacturing and 75% of the installed capacity of the world is installed in Europe. Enlargement should be seen as an opportunity for the European wind industry. A wider market will open up access to a broader choice of products and a wider customer base.



EWEA has set a new target for the EU-15 of 75 GW to be installed by 2010 producing 168 TWh per year by that time, and a new target of 180 GW installed by 2020, including 70 GW off-shore. If this new target is to be achieved, half of the additional electricity production coming on stream under the Renewable Electricity Directive 2001/77/EC would come from wind energy, compared to the 40% share as foreseen previously.

More installations exploiting wind power can help to plug the growing gap in European electricity supply and at the same time dovetail with the Lisbon Strategy providing the EU with high-tech world-class technology. Furthermore this energy option will have a large impact on meeting EU Kyoto commitments and will contribute to sustainable development, economic growth and employment.

All these developments have been possible through the innovative efforts of industry, Member States and the European Institutions. But there is still considerable work to be done.

The Commission confirms its commitment to the development of renewable energy sources, recognising the crucial role of wind energy in the renewable electricity sector.

EWEA FOREWORD

by
Arthouros Zervos
President, European Wind Energy Association

"The end of the oil age"
(The Economist front page, October 25, 2003)

This may have been a fringe opinion some years ago, but today, such a remark is common place, and typical of the wave of interest in, and inexorable momentum towards a sustainable energy era.

Profound transformation of energy systems is upon us, driven by environmental issues, economic development, technological progress and market liberalisation.

Wind power is one of the leading technologies that can deliver solutions across these agendas, and its historical success since the pioneer days of two decades ago has helped fashion this view on the future.

Today, wind power is in the vanguard of clean energy technologies, and Europe is a world leader with European companies dominating the global market.

Nevertheless, despite such advances, the wider public's understanding of the basics of wind energy is rather primitive. How much does it cost? Is the technology reliable? What are the market prospects? What happens when the wind does not blow?

Wind energy provides electricity to the equivalent household needs of 35 million European citizens today, but very few people know this - one symptom of the widespread lack of knowledge about the technology.

The European Wind Energy Association, and the European Commission's Directorate General for Transport and Energy have collaborated on this report to provide a detailed overview of the wind energy sector to help close the gap between interest and decision making.

Wind Energy - The Facts provides a comprehensive overview of the essential issues about wind energy today: technology, costs, prices, environment, industry and employment, market development and R&D. It is a reservoir of information to assist in guiding decisions on energy matters across a new Europe of 25 nations, and worldwide.

Wind energy's rapid progress to date has been successful, yet the challenges are only just beginning: to properly exploit the potential of wind energy to meet significant goals in energy, economic and environmental agendas.

EXECUTIVE SUMMARY

*Since the previous edition of **Wind Energy - The Facts** was published five years ago, the wind energy sector has undergone rapid change and transformation. There has been an explosion in demand for and interest in a cleaner energy world from politicians, institutions, policy makers and regulators, the media, commentators and the general public. Such interest necessitates a greater depth of understanding of the wind power sector if informed choices and policy decisions are to be made.*

*The European Wind Energy Association (EWEA), and the European Commission's Directorate General for Transport and Energy have collaborated on this report to provide a detailed overview of the wind power sector. **Wind Energy - The Facts** provides a comprehensive overview of the essential issues concerning wind power today: technology, cost, prices, environment, industry and employment, market, and research and development.*

Wind energy is a relatively young but rapidly expanding industry. Over the past decade, global installed capacity has increased from 2,500 megawatts (MW) in 1992 to just over 40,000 MW at the end of 2003, at an annual growth rate of near 30%. Almost three quarters of this capacity has been installed in Europe. Penetration levels in the electricity sector have reached 20% in Denmark and about 5% in both Germany and Spain. The north German state of Schleswig-Holstein has 1,800 MW of installed wind capacity, enough to meet 30% of the region's total electricity demand, while in Navarra, in Spain, 50% of consumption is met by wind power.

If positive policy support continues to develop, EWEA has projected that wind power will achieve an installed capacity of 75,000 MW in the EU-15 by 2010. This would represent an overall contribution to electricity supply of 5.5%. By 2020, this figure is expected to increase to more than 12%, with wind power providing energy equal to the demand of 195 million European household consumers.

The Wind Resource

When considering the installation of a wind farm, the single most important characteristic is the wind speed. With a doubling of average wind speed, the power in the wind increases by a factor of 8, so even small changes in wind speed can produce large changes in the economic performance of a wind farm. By way of illustration, if the average wind speed at a given site increases from 6 metres per second (m/s) to 10 m/s, the amount of energy produced by a wind farm will increase by over 130%. Detailed and reliable information about how strongly and from which direction the wind blows, and when, is therefore vital for any prospective wind power development.

Initial assessment of the wind resource available at a given site involves the study of data from nearby weather stations and specialist computer software which is able to model the wind resource. To assist in this process, national, regional and local "wind atlases" have been produced; a review of European wind atlases is provided in this report. Although detail varies from country to country, these maps show - in broad-brush terms - the expected average wind speed in a given region. If the site is promising, more detailed measurements are carried out through the erection of an anemometry mast, bearing a number of devices – anemometers – for measuring wind speed and wind direction installed at different heights on the mast.

Resource assessments are progressively refined by analysing constraints such as local geography, economics, and alternative land use, to yield a "practical" resource.

The exploitable onshore wind resource for the EU-25 is conservatively estimated at 600 TWh and the offshore wind resource up to 3,000 TWh; the upper end of this far exceeding the EU-15's entire electricity consumption. The *European Wind Atlas* produced by the Danish national research laboratory, Forskningscenter Risø, gives a good overview of the EU potential. An offshore version is also available.

Although some countries have pushed ahead fast, most European nations still have large wind resources waiting to be exploited. There is also considerable potential in new Member States and in Russia. The appendices of the main report provide a selection of available onshore and offshore wind maps.

Exploiting the Wind Resource

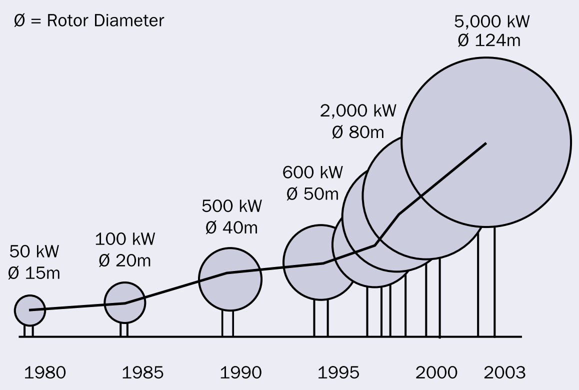
Once the wind resource is established, the engineering challenge is to harness the energy and convert it into electricity. In contrast to the windmills common in the nineteenth century, a modern power generating wind turbine is designed to generate high quality, network frequency electricity, and to operate continuously, unattended and with low maintenance, for more than 20 years or some 120,000 hours of operation. In comparison a car engine typically has a design lifetime of 4,000 to 6,000 hours.

The rotors of modern wind turbines generally consist of three blades, and their speed and power are controlled by either stall or pitch regulation. The rotor may be attached to its generator via a gearbox and drive train, or the generator may be coupled directly to the rotor in an arrangement known as “direct drive”. Turbines able to operate at varying speeds are becoming increasingly common, and this chacteristic improves compatibility with the electricity grid. Rotor blades are typically manufactured from glass polyester or glass epoxy, sometimes in combination with wood and carbon. The tubular towers supporting the nacelle and rotor are made of steel and taper from their base to the nacelle at the top.

Commercial wind turbines started in earnest in the 1980s, and in the last twenty years turbine power has increased by a factor of 100. In the same period wind power generation costs have declined by some 80 percent. From units of 20-60 kW in the early 1980s, with rotor diameters of around 20 m, generators of single wind turbines have increased to 5,000 kW, at the time of writing, with rotor diameters of over 100 m (see Figure 1). Some prototype designs for offshore turbines have even larger generators and rotors.

The dramatic increase in size and technological know-how, coupled with economy of scale from fast growing production volumes have greatly reduced the cost of wind power to the point where some high yield onshore wind farms are approaching price competitiveness with the cheapest alternative – combined cycle gas power plants.

Figure 1: Growth in Size of Commercial Wind Turbine Designs



Mechanical noise has been practically eliminated and aerodynamic noise vastly reduced. Wind turbines are highly reliable, with operating availabilities of about 98%: they are able to run during 98% of the hours in a year. No other electricity generating technology has a higher availability.

A growing market for offshore wind power is now the main driver for the development of large turbines. Wind farms are operating off the coasts of Denmark, Sweden, Ireland, the Netherlands and the United Kingdom. Although there are still many challenges, including costs for both grid connection and foundations, there are major advantages in the higher mean wind speeds, low turbulence (i.e. longer turbine lifetime) and reduced constraints to be found offshore, and a resource large enough to supply all of Europe’s electricity.

Wind Farm Development

A number of constraints affect the siting of a cluster of wind turbines, usually described as a wind farm. These include land ownership, positioning in relation to roads or overhead lines, the location of inhabited buildings such as schools and homes and avoidance of sites of special environmental importance. Once these constraints have been determined, the layout of the wind turbines themselves can be planned. The overall aim is to maximise electricity production whilst minimising infrastructure, operation and maintenance (O&M) costs, and socioenvironmental impacts. Specialist software has been developed to produce visualisations of how the turbines will appear in the landscape, enabling developers and planners to choose the best visual impact solutions before the project is constructed.

Aside from the turbines, the other principal components of a wind farm are: the foundations to support the turbine towers; access roads, and the electrical infrastructure to enable transport of the electrical output to the grid network.

A 10 MW wind farm can easily be constructed within two months, producing enough power to meet the consumption of over 4,000 average European households.

Once operating, a wind farm can be monitored and controlled remotely. A mobile team carries out maintenance work, with roughly two personnel for every 20 to 30 turbines. Maintenance is usually carried out every six months. Typical maintenance time for a modern wind turbine is 40 hours per year.

Transmission and Distribution of Wind Electricity

A key strategic element in the successful penetration of wind power is its efficient integration into the European electricity transmission and distribution grid network. Technical, economic and regulatory considerations must be borne in mind when approaching this area. The three main issues are connection to the grid network, operating and upgrading of the network and planning for new generation capacity.

The rapid increase in penetration of wind power production into the grid raises a number of issues. Most are matters of utility attitude rather than engineering imperative.

- The output from a wind farm fluctuates to a certain degree according to the weather.
- Wind farms are often located at the end of the distribution networks. Most European grids have been designed for large-scale electricity generation from a relatively small number of large plants, sending power outwards towards the periphery, rather than in the opposite direction.
- The technical characteristics of wind generation are different to those of conventional power stations, around which the existing systems have evolved.

The requirement for grid network operators to handle an increasing proportion of such "distributed generation" is coming not only from wind energy. Environmental considerations and the liberalisation of the electricity market have increased interest in smaller scale commercial generation; a shift in both the attitude of utilities, and grid operation, is required to accommodate this development.

Intermittency issues require an understanding of *variability* and *predictability*. The variability of power output of a single turbine is small in the time scale of a few minutes and, for wind farms across a large area, is small in a timescale of hours. High-level data allows systems operators to determine the level of reserve to maintain. Wind prediction techniques are at present still at an early stage of development, and improvement here can help firm up wind power for systems operators by reducing and specifying forecast error.

It has been suggested that grid stability issues might arise with the penetration of wind power above a certain level. Such concerns need to be weighed against the potential benefits, including local reinforcement of grids and the ability of variable speed turbines to contribute to grid stability. In balancing a system to accommodate the fluctuating input from wind power, a range of techniques are available to the grid operator. In a situation where much wind is available, for example, the operator may maintain other types of generation plant at low output. Other solutions are likely to become increasingly significant as wind energy's penetration expands. These include forecasting, interconnectors and electricity storage, as described below. Using such techniques, as well as reinforcement of the grid network itself, and increased geographical dispersion of wind power, it is feasible to have a very high level of wind penetration in the European electricity systems without affecting the quality of supply.

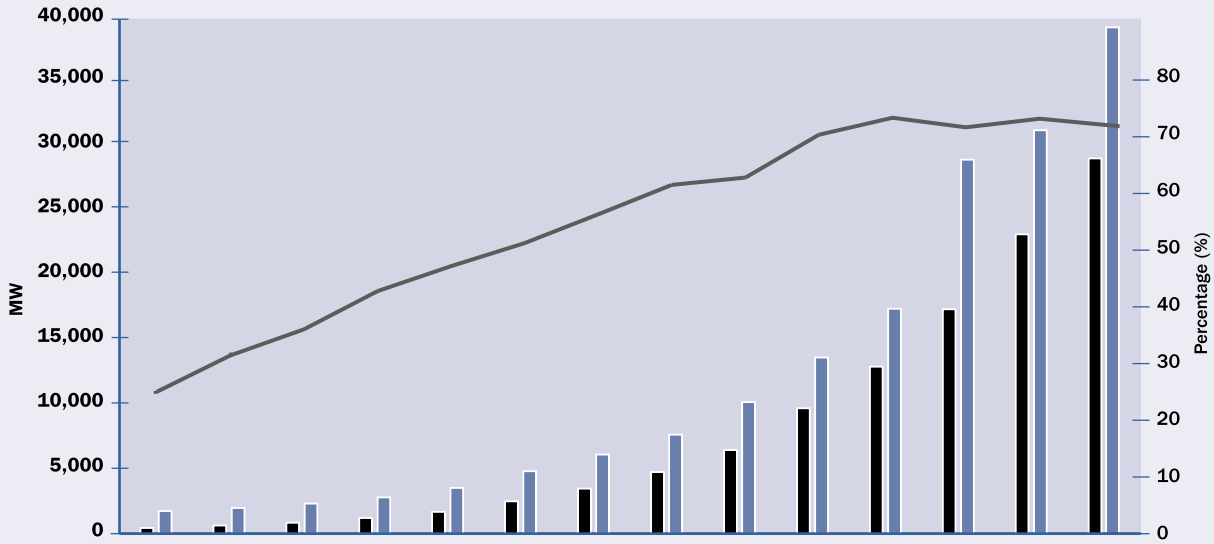
ENERGY PREDICTION

Progress has been made in recent years in predicting the energy output from wind farms. It has generally been found that even with relatively short measurement periods on a site, it is possible to predict output very accurately using a correlation with measured meteorological data from nearby weather stations.

INTERCONNECTORS

An essential element in establishing wind energy is to ensure that the electricity generated can feed into the grid system, and reach electricity consumers. Experience has shown that combining a diverse mix of creative demand and supply solutions allows large wind power penetration in an electricity grid without adverse effect. In the Eltra system in West Denmark, for example, use of interconnectors to the large hydropower generators in Norway to the north and Germany in the south has allowed 30% wind energy penetration.

Figure 2: EU-15 and Global Cumulative Installed Wind Capacities, 1990 - 2003



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
EU-15	439	629	844	1,211	1,683	2,497	3,476	4,753	6,453	9,678	12,887	17,315	23,098	28,440
WORLD	1,743	1,983	2,321	2,801	3,531	4,821	6,104	7,636	10,153	13,594	17,357	28,857	31,128	39,500
EU % of world	25	32	36	43	48	52	57	62	64	71	74	73	74	72

Wind Industry Status

The industry has changed significantly in the last five years. Five years ago, a wind farm of 20 MW would be considered large - today the largest single wind farm is 278.2 MW, and a single financing of wind farms in Spain covered 1,200 MW. The growing scale of wind power projects and a larger market have brought new players into the market, including industrial conglomerates such as General Electric and Shell as well as conventional power companies such as Siemens and ABB.

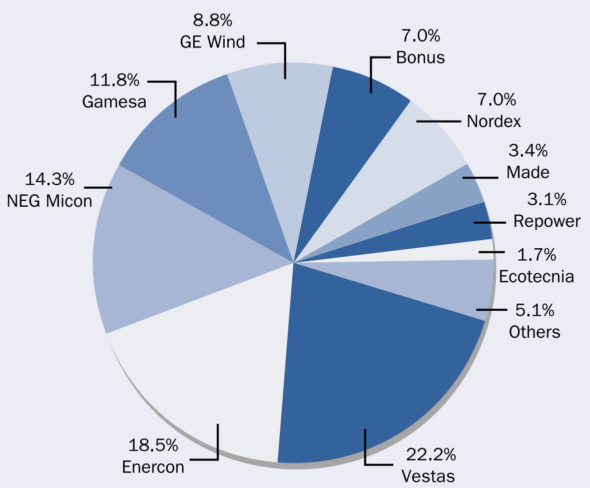
The progress of wind power around the world in recent years has been impressive, with Europe leading the global market. By the end of 2003 approximately 40,000 MW of wind turbine capacity were operating in 50 countries around the world (see Figure 2). Of these, more than 28,000 MW (70%) were installed in the EU. The average annual market growth in Europe over the last decade has been in the region of 30%.

A new market segment is emerging offshore. Some 500 MW of offshore wind power capacity has been installed in the seas off the Netherlands, Denmark, Sweden, Ireland and the UK. According to the Douglas Westwood *World Offshore Wind Database*, a further 9,000 MW is scheduled for construction in northern Europe by 2006. Some of the largest installations are planned off the Baltic and North Sea coasts of Germany and the UK.

Nine of the world's ten largest wind turbine manufacturers are based in Europe, and European companies supplied some 90% of the wind power capacity sold worldwide in 2002 (see Figure 3).

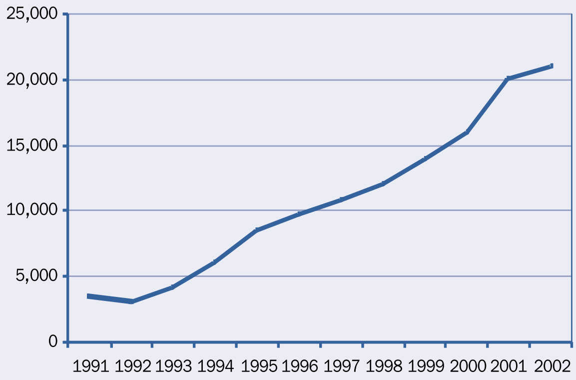
Development of wind energy in Europe has been supported by market incentives backed by targets set to promote the production of electricity from cleaner sources, and to develop the technology to secure a clean energy alternative in the future on a large scale and to combat the climate changing effects of greenhouse gas emissions. Other markets, in India for example, are driven by a shortage of energy, where the quick build time of wind power gives the technology a competitive edge.

Figure 3: Top 10 Companies Supplying MW-Scale Wind Turbines in 2002



Source: BTM Consult, World Market Update, March 2003

Figure 4: Growth in Employment in Danish Wind Turbine Manufacturing, 1991 - 2002



Source: Danish Wind Industry Association (2002).

Employment

Employment in the European wind energy sector has been growing rapidly. Including both direct and indirect employment in manufacturing, installation and maintenance, the number of people employed in the European industry has increased to more than 72,000, compared to 25,000 in 1998. This figure relates only to employment through manufacture, installation and O&M of wind turbines in EU countries. Employment in the EU and elsewhere associated with exports of turbines outside the EU is not included.

Although jobs related to wind turbine manufacturing are presently concentrated in three countries – Germany, Spain and Denmark – this will change as the industry expands in and into other states. In Denmark, employment in the wind industry has increased from 2,900 people in 1991 to 21,000 in 2002 - much faster than any other manufacturing sector (see Figure 4).

Looking forward, following the projections from the EWEA scenario, *Wind Force 12*, employment in Europe could reach almost 200,000 by 2020. This figure is projected to be twice as high for the rest of the world, and European companies will capture a proportion of these jobs depending on their export ability.

Economics and Costs

Three major trends have dominated the economics of grid-connected wind turbines in recent years:

- The turbines have grown larger and taller. The average capacity of all the turbines installed in Germany and Denmark increased from roughly 200 kW in 1990 to almost 1.5 MW during 2002.
- Turbine efficiency has increased. A mixture of taller turbines, improved components and better siting has resulted in an overall efficiency increase of 2% - 3% annually over the last 15 years.
- Investment costs have decreased. Today the average cost per kW of installed wind power capacity varies from 900 €/kW to 1,100 €/kW. The turbine comprises about 80% of this total cost.

The other principal cost element is operation and maintenance (O&M). O&M costs, including repairs and insurance, can account for 20% - 25% of total production costs per kilowatt hour (kWh), at some 1.2 c€/kWh over the lifetime of the turbine. Manufacturers aim to shrink these costs significantly through development of new turbine designs requiring fewer regular service visits and, consequently, reduced downtime. Furthermore, the trend towards larger wind turbines reduces O&M costs per kWh produced.

Overall Cost of Wind Power

When all cost elements are considered together, the cost of wind power ranges from approximately 4 - 5 c€/kWh at sites with very good wind speeds to 6 - 8 c€/kWh at sites with low wind speeds (2003). This calculation assumes a medium-sized turbine of 850 - 1,500 kW capacity, investment costs ranging from 900 to 1,100 €/kW, O&M costs averaging 1.2 c€/kWh over a lifetime of 20 years, and a discount rate of 7.5% per annum.

The cost of capital (discount or interest rate) is a particularly important factor. Like hydropower, wind power is a very capital intensive technology with about 75% of total costs as capital up front (for a natural gas plant the share is typically 40 - 60%). Therefore, the economic performance of a wind power project is highly dependent on the level of interest rates.

Future Development Costs

Power production costs of wind-generated electricity have fallen steadily as the technology has developed. The average cost for a coastal turbine has decreased from approximately 8.8 c€/kWh (for a 95 kW turbine installed in the mid-1980s) to 4.1 c€/kWh for a recent 1,000 kW machine, an improvement of more than 50% over 15 years.

Looking forward, using the "experience curve" method, it is anticipated that power production costs will continue to decrease: with a doubling of total installed capacity, the cost of production per kWh on new wind turbines will fall by between 9% and 17%. Assuming that this doubling occurs over a five year period, as projected by EWEA, the cost of production from a coastal turbine could be as low as 3.1 c€/kWh by 2010.

These calculations take no account of the environmental benefits to society of wind power or the "external costs" (the environmental and social costs which are not reflected in the market price) of conventional electricity generation, see below.

Power, People, Pollution

Environmental pollution and emission of CO_2 from the use of fossil fuels constitute a threat to health, the environment and sustainable development. Wind turbines cause virtually no emissions during their operation and very little during their manufacture, installation, maintenance and removal. Other major pollutants from conventional electricity, which are avoided through wind power, include SO_2, No_x, and PM10.

External Costs

If the entire fuel cycle is assessed, from fuel extraction, through processing, transformation, and construction, to operation and waste disposal, it becomes very clear that the economic damage attributable to conventional fuels towers over that of wind. The most detailed analysis of externalities to date is the European Commission's ExternE project. This was conducted over a period of more than ten years and still continues. It values the external costs of wind energy at less than 0.26 c€/kWh whilst those for coal-fired generation range from 2 to 15 c€/kWh.

Economic savings through implementation of wind power may be calculated by comparing its external costs with those of fossil fuel technologies, as above, and relating these costs to the proportion of fossil fuel generation capacity displaced by penetration of wind technology. Total avoided external costs through the use of wind power amounted to nearly €1.8 billion in 2000. Taking EWEA projections for wind energy in 2020 to generate 425 TWh/a, the level of avoided external costs would rise to €25 billion in that year alone. For CO_2, the main greenhouse gas contributing to climate change, calculations show that, in 2000, a total of approximately 15 million tonnes of CO_2 production was avoided across 28 European countries, through wind energy generation.

Public Acceptance

A summary of public opinion surveys carried out in a number of countries, including Spain, the UK, Denmark, Germany and Sweden, shows substantial majorities in favour of wind energy, especially when compared with existing fuel sources. In Germany, for instance, a 2002 poll showed 86% in favour of increasing wind's contribution to the energy mix. The surveys also show that local approval rises once a wind farm starts operating, and is increased with local involvement and good planning guidelines and integration into the landscape.

In some countries, direct involvement of the general public in wind energy projects has helped to encourage public acceptance. In Denmark, about 150,000 families own wind turbines or shares in wind turbine co-operatives.

Wind turbines are a relatively new feature in the European countryside, and will become more visible as more wind farms are built. Consultation with, and acceptance by, local communities is essential, especially in rural areas where particularly high value is placed on the landscape amenity. Acceptance is more likely where there has been a clear assessment of the impacts of a proposed wind farm, and the mitigation measures have been properly explained. Once sited, however, existing activities such as agriculture can continue operating alongside wind farms.

Wind energy is a clean technology but it also has impacts: visual, noise, land use; to bird life; and in terms of electromagnetic interference and life cycle energy consumption.

Bird impacts are very site specific and are either by collision or migration interruption, rather than habitat or ecosystem impacts and disturbance. Research cited in this report shows that the risk of bird deaths through collision with wind turbines is low. For example, it is estimated that 33,000 birds are killed annually by wind turbines operating in the US, an average of 2.2 fatalities for each of the 15,000 turbines. In Spain, a study showed 0.13 dead birds per year per turbine. By comparison in the US, between 100 million and 1,000 million birds are estimated to die each year from colliding with vehicles, buildings, power lines and other structures, with wind power responsible for 1 out of every 5,000 - 10,000 avian fatalities. Worldwide, 99% of the threat to bird life is related to human activities, the most serious habitat loss.

Wind farms from 15 - 20 years ago that were poorly sited caused a greater number of bird deaths than today, but there is still a need to continue research on modern turbines. Careful turbine siting, away from migration routes for example, can virtually prevent fatalities altogether.

Market Incentives and Support Mechanisms

Until external costs are fully integrated into conventional energy economics, some form of market incentive or support is required to develop the technology. Meanwhile it should not been forgotten that conventional power production technologies, such as coal and nuclear, continue to benefit from state aid which increases the cost to society of introducing new cleaner technologies into the market. An effective way of internalising external cost is through harmonised energy taxes that reflect the actual environmental impact of each technology. In the absence of full internalisation of external costs, a more equitable electricity market can be encouraged by market incentives for electricity generated from renewable energy sources. There are two main types of incentive: fixed price systems and fixed quantity systems.

Support for such incentives is provided by the 2001 EU Directive on the promotion of electricity from renewable energy sources, which sets indicative targets for the level of electricity to be achieved from renewables in each member state by 2010. The overall Community target is to increase renewables' share of electricity from 14% in 1997 to 22% in 2010.

Together with good planning procedures and fair conditions for accessing the electricity grid, the financial framework for wind power investments is one of the main ingredients of successful market development.

VOLUNTARY SYSTEMS

Although good in theory, in practice it has been found that marketing programmes which depend on the willingness of customers to pay extra for “green” electricity have had little impact on uptake.

FIXED PRICE SYSTEMS

Operators are paid a fixed price for every unit of output, with the extra cost borne by taxpayers or all electricity consumers. In Germany, for example, the additional cost of the “feed-in tariff” is approximately €1 per month on the average household electricity bill.

Fixed price systems have been highly effective at attracting wind energy investment in Denmark, Spain and Germany. Other countries with such systems in place are Austria, France, Greece, Luxembourg, the Netherlands and Portugal.

FIXED QUANTITY SYSTEMS

Also known as “renewable quota” systems, fixed quantity systems involve a decision on behalf of national governments on the level of renewable electricity to be achieved during a certain period, while market forces are left to establish the price.

Under tendering versions of this system, as in Ireland, competitive bidding occurs for a limited number of power purchase contracts. Under the green certificate model, tradable certificates are issued to reflect the additional cost of renewable electricity produced to meet the agreed quota. Tradable green certificate systems are under development in the UK, Sweden, Belgium and Italy. These are all in an early stage of development. Using these systems to provide financeable long term Power Purchase Contacts remains a challenge.

TARGETS FOR WIND ENERGY

EWEA predicts that if there is continued positive policy support, 75,000 MW of wind power could be installed in the EU-15 by the end of the decade, of which 10,000 MW would be installed offshore (see Figure 5). Also by 2010, the latest projections from the European Commission suggest that wind power in Europe may reach a total of 69,900 MW. EWEA predicts a total of 180,000 MW will be reached by 2020, of which 70,000 MW would be offshore.

In 1997, EWEA adopted the target set out in the European Commission’s White Paper on renewable sources of energy of 40,000 MW by 2010. Three years later, EWEA revised its target to 60,000 MW by 2010 (including 5,000 MW offshore) and 150,000 MW by 2020 (including 50,000 MW offshore). These forecasts were then revised to those above in 2003. On each occasion, targets set by EWEA have been conservative, and were outstripped by higher growth in reality.

In terms of Europe’s electricity consumption, the EWEA projection would see wind energy contributing 5.5% in 2010 and 12.1% in 2020. This is equivalent to the electricity needs of more than 195 million people. Wind energy would also account for 50% of the net increase in European generating capacity during the period 2001 - 2010 and just over 70% in the period 2011 - 2020.

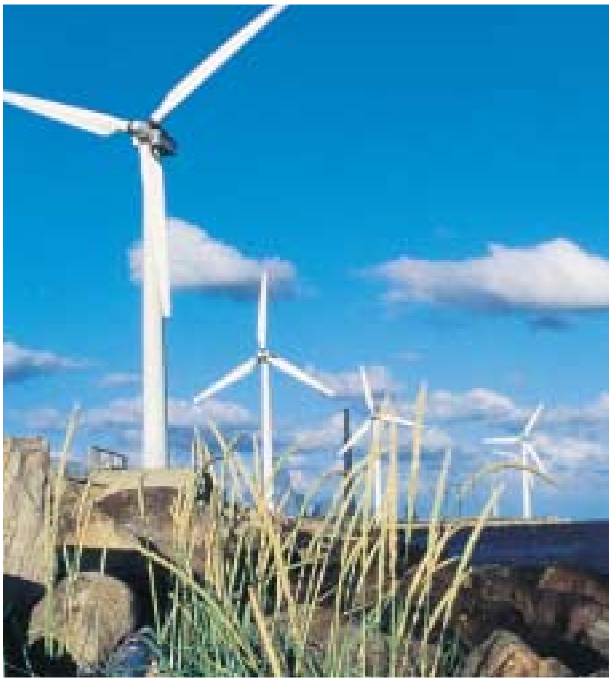
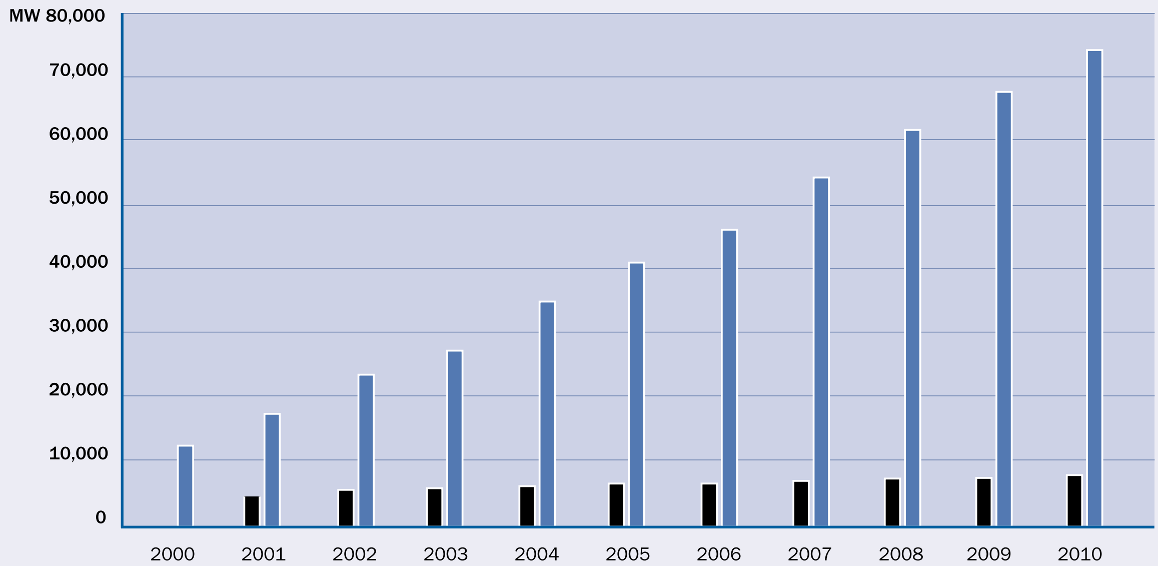
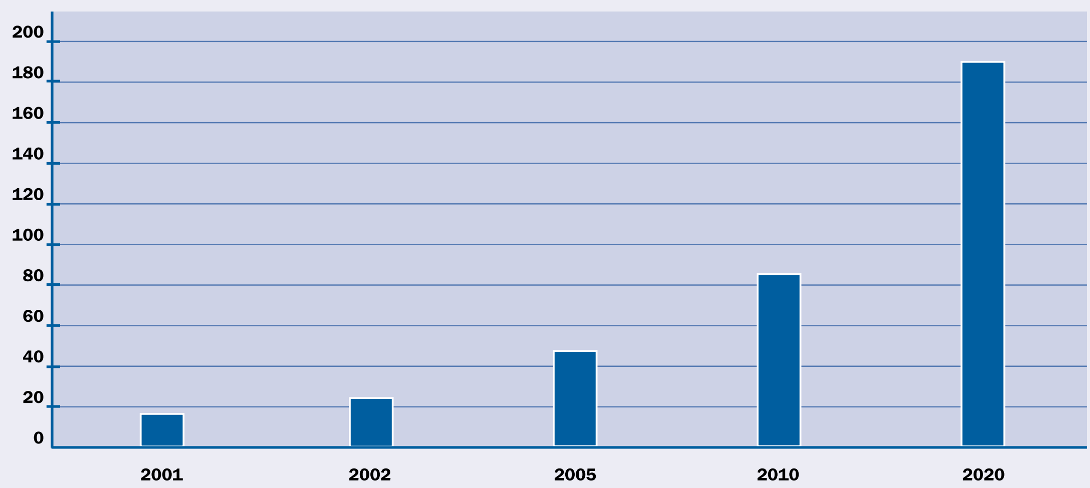


Figure 5: Wind Power Targets in the EU-15 (MW)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
New Capacity (MW)		4,500	5,700	5,900	6,100	6,300	6,450	6,600	6,750	6,900	7,000
Cumultative Capacity (MW)	12,800	17,300	23,000	28,900	35,000	41,300	47,750	54,350	61,100	68,000	75,000
Annual Growth of New Capacity			26.7%	3.5%	3.4%	3.3%	2.4%	2.3%	2.3%	2.2%	1.4%
Annual Growth of Cumulative Capacity		35.2%	32.9%	25.7%	21.1%	18%	15.6%	13.8%	12.4%	11.3%	10.3%

Figure 6: EWEA Targets to 2020 Equivalent Household Electricity Needs Met by Wind Power (per person)



	2001	2002	2005	2010	2020
European People (millions)	18.91	25.72	47.44	85.66	194.86
Wind Power Production (TWh)	32.4	44.8	86.5	167.4	425

World Market Forecasts 2007 - 2012

Future market assessments are essentially scenarios that are shaped by the variety of assumptions and data used. This report presents two market scenarios; a *conventional* and an *advanced* scenario to the years 2007 and 2012. The *conventional* scenario could be classified as "favourable business-as-usual" where the current strong development of the wind power market to date continues as long as commitment to the sector by a number of governments continues to strengthen, and that such support is converted into actual deployment. But there is no potent policy intervention on the scale of that envisaged in the *advanced* scenario in Wind Force 12, which is a scenario for a greatly increased market due to higher political and policy support than is experienced today.

A market assessment with a five year horizon is generally regarded as being a more accurate forecast. Beyond that, the predictive ability is greatly reduced because the defining factors are difficult to foresee with accuracy.

- Under the *conventional* scenario, the average annual growth rate for cumulative capacity is 20.6% in the period 2003 - 07 to reach MW 80,050 MW installed worldwide, and 15% in the period 2008 - 12 to reach 160,900 MW.
- In the *advanced* scenario the average annual growth rate for cumulative capacity is 27% in the period 2003 - 07 to reach 106,000 MW installed worldwide, and 24% in the period 2008 - 12 to reach 311,000 MW.

Under the *conventional* scenario, European markets will continue to dominate. The leading markets will remain Germany and Spain, although important markets in France, the UK, The Netherlands, Italy and Sweden will emerge. The market forecast indicates a slight slowing down of the onshore European market, but an increase in activity in countries which have not played a major role to date. There will be a time lag before the offshore market takes off to replace it. There will be significant growth in the US. New markets are starting to develop in Australia, Japan, Canada and South America. There is relatively little installed capacity in these countries and, hence, the potential for future growth is large. Other countries that are considering serious investment include Canada, Brazil, Tunisia, China, Egypt, Morocco, the Philippines, Turkey and Vietnam.

The considerable difference between the two scenarios for 2012 highlights the fact that market development for the global wind sector is constrained by policy decisions. This constraint reduces the potential global market in 2012 by 50% (see Figure 7).

Figure 7: Summary of Conventional and Advanced Market Scenarios (Cumulative Installed MW)

Year	2007	2012
ADVANCED scenario - Europe	59,000	112,000
Average annual growth rate	20%	14%
ADVANCED scenario - world	106,000	311,000
Average annual growth rate	27%	24%
CONVENTIONAL scenario - Europe	55,941	-
CONVENTIONAL scenario - world	80,050	160,900
Average annual growth rate	20.6%	15%

Note: The average annual growth rates are for the periods 2003 - 2007, and 2008 - 2012.

Research and Development

EU-funded research and development programmes such as those under the Fifth Framework Programme have given great impetus to the wind power industry over the last 15 years. The results of such programmes include the development of large MW-scale turbines, the first European wind atlas, and support for demonstration projects such as the first offshore wind farm.

EWEA has published the first report of its strategic plan for R&D: *Creating the knowledge foundation for a clean energy era.*

The great advances made in wind power technology have at their root enormous effort on the part of both private industry and research institutions. Further research across the wind industry is essential to ensure wind power reaches a position where it is fully competitive with the cheapest alternatives.

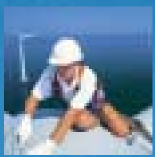
A principal objective of future R&D is to meet the levels of wind penetration described in Wind Force 12. To achieve this, the industry needs to:

- Continue reducing costs
- Enable increased penetration of wind power
- Minimise environmental and social impacts

Key research areas include: economic, policy and market issues; environmental and social impacts; turbine and component design issues; grid integration; energy systems and resource prediction; O&M; new potential sites; offshore technology; and multi-megawatt turbines.

Wind Force 12 – A Global Blueprint

The EWEA *Wind Force 12* scenario demonstrates that wind power is capable of supplying 12% of the world's electricity within two decades, even if overall demand increases over that period by two-thirds. This scenario, requiring increased political support for wind power, sees in 2020 an installed capacity of over 1,200 GW generating 3,000 TWh of electricity. This would involve cumulative savings of approximately 11,000 million tonnes of CO_2 - savings made possible by a wind industry worth € 75 billion annually.

About EWEA

EWEA is the voice of the wind industry - actively promoting the utilisation of wind power in Europe and worldwide.

EWEA members from over 40 countries include 200 companies, organisations, and research institutions. EWEA members include manufacturers covering 98% of the world wind power market, component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants. This combined strength makes EWEA the world's largest renewable energy association.

The EWEA Secretariat is located in Brussels at the Renewable Energy House. The Secretariat co-ordinates international policy, communications, research, and analysis. It manages various European projects, hosts events and supports the needs of its members.

EWEA is a founding member of the European Renewable Energy Council (EREC) which groups the 6 key renewables industries and research associations under one roof.

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