A PLAN FOR ACTION IN EUROPE

WIND ENERGY - The facts

European Commission
Directorate-General for Energy

WIND ENERGY - THE FACTS

Vol. 1:Technology

Vol. 2: Costs, prices and values

Vol. 3: Industry and employment

Vol. 4: The environment

Vol. 5: Market development

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This document will form the basis for a publication on wind energy aimed at the general public and for an EWEA strategy for implementation.

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PREFACE

The European Wind Energy Association published a Strategy Document in 1991. Since then, the amount of wind energy installed in Europe has risen dramatically. This Document was produced to reflect the changes that have been happening in the industry at the European level. Five main areas were addressed: Technology; Industry and employment; Environment; Costs, prices and values, and Market Development.

A Project Chairman was appointed, a Steering Committee was set up, lead authors appointed to produce the main chapters and a network of energy experts was formed to contribute to the project and to peer review the draft documents.

The Lead authors were as follows:

- Mr David Milborrow (UK) produced the volume on the costs, prices and values;
- The companies Garrad Hassan & Partners (UK) and BTM Consult AS (DK) produced jointly the chapters on the Industry, the Technology, the Environment and the Market Development.

EXECUTIVE SUMMARY

"Coal, gas and oil will not be the three kings of the energy world for ever. It is no longer folly to look up to the sun and wind, down into the sea's waves"[1]

The work reported on in this book results from a unique project which has sought to summarise the state of the developments in the fast changing wind energy industry with realistic prospects for the economic, technical, technological, environmental and market development.

European wind technology is a great success story. In the space of fifteen years it has evolved from an industry making small, simple machines into a technology which can compete with the well established forms of power generation.

In its first Strategy document published in 1991 EWEA set goals for the deployment of wind energy in Europe. These were as shown in the table below.

"OLD" EWEA TARGETS (1991)	
Year	***Installed Capacity***
2000	*4,000 MW*
2005	*11,500 MW*
2010	*25,000 MW*
2030	*100,000 MW*

These goals were set in order that 100,000 MW of wind energy could supply about 10 per cent of the Community's electricity requirement by 2030. At the time, even the goal set for the year 2000 was considered by many to be wildly unrealistic. It was pointed out that if all the turbines required for the 2030 target were built into one wind farm, only an area of land about the size of Crete would be required.

In making the projections for the 1991 strategy document, EWEA based its calculations on a 25% to 30% annual growth rate. From 1991 to 1997, the installed wind energy capacity in Europe has increased by about 40% per year to 4,500 MW.

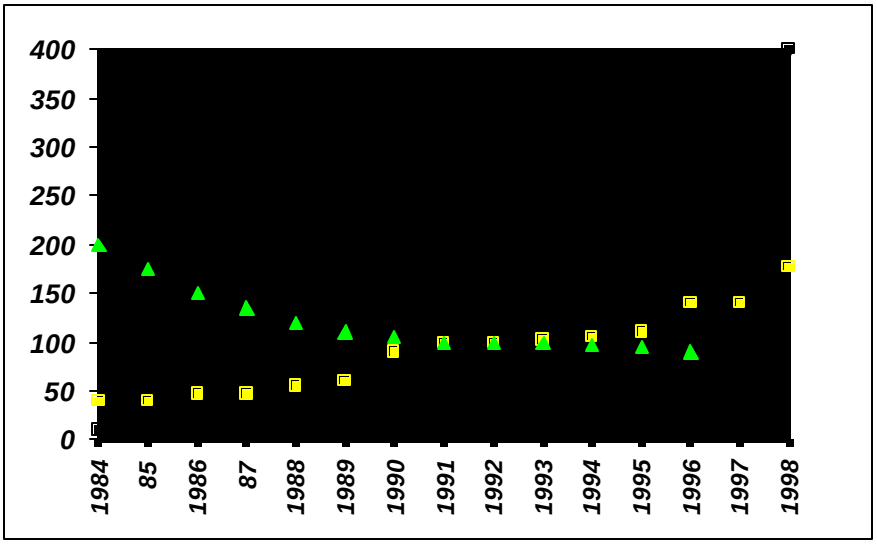
The target for the year 2000 being already met, EWEA has had to revise its set of targets to take into account the continued increased growth rate. The target for the year 2000 has been doubled to 8,000 MW, and we believe that the earlier target of 100,000 MW by 2030 can be met by 2020.

[1] The Economist (7 October 1995)

The new EWEA targets are shown below.

"NEW" EWEA TARGETS (1997)	
Year	**Installed Capacity**
2000	**8,000 MW**
2010	**40,000 MW**
2020	**100,000 MW**

The wind energy industry has volume production of medium size machines in the 600 kW range and some 10 designs in the megawatt range with commercial prospects. The increase in available rated capacity (by about a factor of 3 from 500 or 600 kW to 1.5 MW) is striking and has been a very rapid development since 1990. The arrival of the largest units is timely as the industry prepares for major offshore developments. This evolution is shown schematically in the Figure below.



The development of commercial machines (1992 = 100% for all parameters)

Progress on standards and certification must be maintained to promote and keep investor confidence. This important area of work has been responsible for a steady improvement of both design and manufacturing quality and has helped the industry move from its early pioneering stage to a competitive industry which can compete on a world wide market. Continued efforts on this front are vital.

Design consolidation has taken place with three bladed designs predominating to an even greater extent than previously. There is increasing use of variable speed systems. A major recent innovation has been the introduction of direct drive generator technology.

The full exploitation of wind energy potential will require properly optimised machines for different types of site:

- high and low wind speed
- onshore and offshore
- remote and grid connected
- large and small applications

Cost trends show the latest megawatt machines as competitive. It is now pressing to assess the limits of up-scaling and the need for new concepts for large offshore units. Major offshore developments are certain in the early part of the next century. This will be the next major step for the technology and will result in a dramatic increase in potential, particularly in the northern European waters.

Careful consideration of the interaction between wind turbines and the grid is now, and will continue to be, an important area of both technical design and political action. This matter will come to the fore over the next decade as the substantial goals established for the industry are realised. It will require a imaginative approach to the way grid management is organised on a Europe wide basis.

The increasing reliability of wind turbines and growing penetration of world wide markets, mean the future for the technology is bright. The real benefits of the substantial investment of the European Commission and the EU member states have made in research to improve the understanding of wind turbine behaviour, through careful modelling and measurement, is just starting to bear fruit. It must be carefully sustained and is set to play a major role in future technology development.

From an economic point of view, it must be emphasised that no single value can be assigned to the price of wind energy. The same is true of energy prices for thermal plant. It is also important to distinguish between the cost of plant (such as wind turbines and wind farms) and the price of

the electrical energy which they produce. Capital costs speaking, are primarily a function of the size of the installation (due to economies of scale).

Energy prices, however, depend on wind speeds and on institutional factors, and have two principal components:-

- Capital repayments, including interest charges
- Operating costs

The calculation of wind energy generation prices follows procedures which are reasonably standardised across the power industry. "Real", i.e. net of inflation, interest rates - more accurately, test discount rates - are used to calculate levelised costs. National interest rates and repayment periods vary widely across the EU, but reference energy prices may be derived provided the actual levels are quoted.

Institutional factors arguably account for most of the apparent variations in quoted wind energy prices. In Denmark, for example, the costs of grid connection of wind installations have not always been charged to the developer.

The cost of wind energy plant has fallen substantially during the last fifteen years, and this trend is continuing. Energy prices have fallen even faster, due to lower wind turbine prices, higher efficiency and availability, and lower operation and maintenance costs. Wind turbines prices fell by a factor of at least three from 1981 to 1991, and energy prices have halved in the last 9-10 years.

The price of modern turbines around the 45 m diameter mark is around 700 ECU/kW. It may be noted that the "most economic size" has changed over the years and is still moving upwards. The larger the machines, the fewer are required for a given capacity. This brings savings in site costs and in operation and maintenance costs. For example, site costs can be reduced by around 25% by moving from machines of the 300 kW size range to 1 MW size machines.

Overall, balance of plant costs adds between 15 and 40% to wind turbine costs, depending on the number and size of machines in the wind farm, and the location. The windiest sites - on hilltop sites, often remote from a grid connection, or coastal locations where deep piling into silt is needed, tend to incur costs above average. Operational costs vary between countries and between wind farm sites; they range from around 25 ECU/kW/yr for 200 kW machines, falling to around 15 ECU/kW year for 500 kW machines. Current energy prices corresponding to a mid-range wind farm cost of 850 ECU/kW are 9.6 cECU/kWh at 5 m/s, declining to 3.4 cECU/kWh at 10 m/s. (All wind speeds refer to hub height). These assume a 7.5% test discount rate and depreciation over 20 years.

National institutional frameworks influence discount rates and depreciation periods, and vary across the EU. Local wind speeds also vary widely across the European Union. The best resources are in the upland regions of Ireland, Britain and Greece, parts of Spain and the Canary Islands, where average wind speeds (at hub height) may be around 8-10 m/s. In Western Denmark, and the coastal regions of north Germany, wind speeds range up to about 7.5 m/s, and elsewhere winds are lower, with speeds decreasing further inland.

Offshore wind has the potential to deliver substantial quantities of energy - at a price which is cheaper than most of the other renewable energies. Wind speeds are generally higher offshore than on land, although the upland regions of the British Isles, Italy and Greece, do yield higher speeds.

The electricity generation costs from thermal plant in the EU vary widely. Government support for the nuclear and coal industries may mean that the real generation costs are higher than is apparent. Direct comparisons between the price of wind energy and that of electricity from the thermal sources ignore the fact that, in many instances, renewable electricity-generating technologies deliver energy closer to consumer demand than centralised generation.

Electricity prices for thermal plant, moreover do not include the so-called "external costs" of electricity generation - those associated with damage to health and the environment.

There are a number of factors which are causing a steady fall in the cost of wind energy systems:-

- The trend towards larger wind turbines
- Falling infrastructure costs
- Possible reductions in the cost of raw materials

Data from The European Renewable Energy Study (TERES II) (DG XVII), indicate that wind may become one of the cheapest renewable energy sources, with prices within the range of those of the thermal sources. Energy prices from the thermal sources are, however, subject to uncertainty.

The wind energy industry is now a mature industry that employs many thousands Europeans. One Megawatt of wind power installed capacity creates jobs for 15-19 people under present European market conditions. In more labour intensive parts of the world this figure may double.

Jobs created by the wind industry

Year	Installed Capacity (MW) EWEA-goal	Jobs created Man Years
1996	3,500	72,000

2000	8,000	512,000
2010	40,000	960,000
2020	100,000	2,400,000

The development in the wind energy sector has given birth to new major factories throughout the whole world and the new technological arena stimulates production of components for the new wind turbine generator makers in factories which traditionally supplied the 'old technology' electricity producers.

The development of offshore wind energy gives the industry further opportunities. As the technology matures, the cost reduces and the market expands, the industry is being recognised as an exciting and vibrant entity, and major players who have hitherto been reticent about identifying themselves with renewable energy, are now keen to join in.

This move is to be welcomed and is a clear sign that in commercial terms wind is just one of the sources on the energy portfolio along with coal, oil and gas.

Wind energy is a clean, renewable and sustainable means of electricity generation. It is one of the most cost-effective energy options for reducing global warming. Wind energy already avoids over 6,300,000 tons of CO_2, 21,000 tons of SO_2 and 17,500 tons of NO_x emissions per year in the EU alone. It will avoid over 28,000,000 tons of CO_2, 94,000 tons of SO_2 and 78,000 tons of NO_x emissions per year outside the EU by 2005. Wind energy could reduce EU power sector CO_2 emissions by over 11% by 2040. Furthermore, wind energy does not create any dangerous waste products. It is indigenous, secure and freely available.

About 99% of the land area within a typical wind farm site is available for agricultural or other use. 80% of people polled are infavour of wind energy.

In 3 to 4 months a modern wind turbine on an average site will generate as much energy as that used to manufacture it. Wind farms can be decommissioned, and sites fully restored, very easily. The recyclable content of wind turbines is increasing and more energy can be recovered from, than is used in, scrapping machines.

Wind farm development abides by planning requirements throughout the EU and the industry has adopted European "Best practice Guidelines for responsible development of wind farms".

Wind Energy development in Europe has taken place since end of the 70's. This development has been supported by national programmes within EU-member countries and by the EU-programmes : JOULE and THERMIE. After a slow start, the EU is now the region with the greatest expansion of wind energy utilisation in the world. By end of 1997 some 4,700 MW will have been installed - a development from just 473 MW in 1990.

Four European countries, Germany, Denmark, Spain and UK are among the world's leading nations in the field of wind energy. During the last five years the growth rate of installed capacity in individual countries has been between 15 and 75 % per year. Germany installed more than 500 MW in one year (1995), and the total new installation in Europe in 1997 is estimated to be 1,265 MW. European manufacturers are world leaders covering some 80% of the world market in 1997.

As recalled earlier, previous targets set by EWEA and by the Plan of Action for the Altener programme have been exceeded. The original EWEA target by was 4,000 MW by year 2000 and Altener estimated some 8,000 MW by 2005. The new EWEA targets are: 8,000 MW by 2000, 40,000 MW by 2010, 100,000 MW by 2020. The 40,000 MW by 2010 is supported by the Commission's "White Paper for Renewables Sources of Energy in the EU" (COM (97) 599 final). The assessment carried out in this paper supports the likelihood of these targets being met.

Market forecasts indicates that annual installations will grow from today's 1,000 MW per year to some 1,400 MW per by turn of the century. The resulting installation by end of year 2001 is some 9,700 MW operational in Europe. Post 2001 the growth rate will increase significantly and further 7,350 MW will be installed from 2001 to 2005, ending up with almost 17,000 MW by 2005.

Different ways of supporting wind energy development exist. Among these the most common are:

- General public funding of national R&D programmes,
- Direct investment subsidies to installation of wind turbines,
- Bidding processes like the British NFFO,
- Fixed premium price of electricity delivered to the public grid.

The model with fixed prices has shown to be the most successful way to create a dynamic market development and creating sound industries and employment, within the EU. The use of fixed prices has shown to be very successful in Germany and Denmark.

In conclusion, a general fair price paid to the wind generators, reflecting the environmental benefits of producing electricity without emission of pollutants, taking place in a well organised institutional framework, in countries with planning regulations for wind energy in place are key elements for Europe, if the targets are to be achieved.

Supporting such a development in Europe, will enable a further growth of a strong European wind power industry, which in turn, can benefit from export to a world market expected to be at least twice that of Europe, in terms of predicted installed megawatts over the next two decades.

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