European Commission
Directorate-General for Energy

WIND ENERGY - THE FACTS

Volume 5

MARKET DEVELOPMENT

EXECUTIVE SUMMARY

Brief historical review

Wind energy development in Europe started in the 1970s. It has been supported by both national and EU programmes. After a slow start, the market within the EU is now the world's largest and is expanding rapidly. By the end of 1997 some 4,700 MW had been installed - compared with just 473 MW in 1990.

Present status

Over the last 5 years growth of installed capacity in various countries has ranged from 15 to 75 % per year. Germany installed more than 500 MW in 1995, and the total of new installations in Europe in 1997 is estimated to be 1,265 MW. European manufacturers are the world leaders and supplied 80% of the world market in 1997.

Wind energy targets

Previous targets set by the EWEA and by the Altener Programme's Plan of Action have been exceeded. The original target set by the EWEA was 4,000 MW by the year 2000 and Altener called for some 8,000 MW by 2005. The new EWEA targets are: 8,000 MW by the year 2000, 40,000 MW by 2010, and 100,000 MW by 2020. The figure of 40,000 MW by 2010 is supported by the Commission's White Paper "Renewable Sources of Energy" *(COM (97) 599 final)*. This document provides evidence which suggests that these targets will be achieved.

Market predictions

Predictions indicate that annual installation will increase from today's 1,000 MW per year to some 1,400 MW per year by the turn of the century. By the end of the year 2001 the resulting installed capacity will be some 9,700 MW in Europe. After 2001 the growth rate will increase significantly and a further 7,350 MW will be installed from 2001 to 2005, resulting in almost 17,000 MW by 2005.

Review of wind energy market incentives in Europe

Several ways of supporting wind energy development have been reviewed in this volume. The most common are: public funding of national R&D programmes, direct investment subsidies for the installation of wind turbines, competitive bidding processes such as the British NFFO, and fixed premium pricing of electricity delivered to the public grid. The model with fixed pricing has been shown to be the best way of creating dynamic market development, sound industries and employment within the EU.

In order to meet these targets the following characteristics are required:

- A fair price paid for wind generated electricity which reflects the environmental benefits of producing electricity without the emission of pollutants.
- A well-organised institutional framework.
- Planning regulations which favour wind energy.

Supporting such development in Europe will enable further growth of the strong European Wind Power Industry. It can then benefit from export to the rapidly expanding world market.

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1 INTRODUCTION

1.1 Brief historical review

Modern wind energy use began in the late 1970s as part of a response to the oil crises in 1973 and 1979. Many research and development programmes were started with governmental support. In addition, private sector activity in wind energy slowly emerged. Governments used several different approaches to promote wind energy. While some countries put considerable capital and effort into large R&D programs, others concentrated on creating the right market conditions for deployment of the technology.

The first significant commercial market to appear was in California which, in the period between 1980 and 1986, helped the international wind energy industry to develop. Manufacturers from Denmark, the UK, Germany, Japan and the Netherlands shared the market in California with several American companies. About 15,000 wind turbines were installed in California during the 1980s, of which almost half came from Europe, mainly from Denmark. During that period of time the size of the average wind turbine generator (WTG) increased from 55 kW to 100 kW.

WTGs of many different designs were installed and developed during this period. Significant progress was made in wind turbine technology and the international wind turbine industry matured considerably. The market in California mainly consisted of large wind farms which were installed and operated by private developers.

The years between 1986 - 1990 were difficult for the industry due to the sudden decline in the California market. The wind rush in California was by far the most significant commercial market during the 1980s and its demise caused a number of companies to become bankrupt while others were reorganised with new capital.

This period saw both the number of turbine manufacturers and the number of design concepts decrease. The standard Danish design which consisted of a 3 bladed, upwind, stall regulated machine was optimised and upscaled to 250 kW, thus making turbines more cost effective. Large pitch regulated WTGs were also designed and manufactured. These technical developments made it economically feasible to install wind power in many new markets and initiated the second period of wind power development.

The most notable new markets since 1990 have developed in Germany, India, the UK, the Netherlands, Spain and Sweden. The main issue for wind energy in developed countries is no longer the threat of another oil crisis but rather environmental concern. These issues will be addressed in later sections.

Development in India began as part of a 20 MW DANIDA [1] financed project. Joint ventures were established with local companies and the overall success showed the Indian government that wind power could help solve the shortfall in electrical generation capacity.

The German market has, for several years, been the largest in the world. The high growth in Germany is based on a premium payment for electricity produced by WTGs.

Within the last few years, Spain has become a potential market for large scale development of wind power. A common observation from all of these new markets has been that a guaranteed rate for wind energy creates more stable market conditions compared to project bidding. Similarly, guaranteed energy rates create better conditions for the establishment of a local manufacturing industry.

Over a period of six years (1990-1996) the average WTG size increased from 200 kW to over 500 kW and this trend is continuing. In 1992 the average sizes of WTG installed in Denmark and Germany were 215 kW and 185 kW respectively. These averages increased to 530 kW for both countries in 1995. In the UK the average WTG size was 560 kW in 1996. The introduction, during 1996/97, of megawatt size wind turbines will most likely accelerate this trend for some years to come.

The world market demand has grown from about 200 MW/year in 1990 to a level of 1,300 MW/year in 1995, and this trend is expected to continue to approximately 2,500 MW/year by the turn of the century.

European wind turbine manufacturers have dominated the market for the last five years. Of the 1,292 wind turbine installations recorded in 1996, more than 80% were supplied from European manufacturers. This share is expected to have grown in 1997. The demand side of the wind energy market is also dominated by European countries. In 1996 75% of the world's installations were in Europe.

The international market for wind power has experienced rapid growth since 1988 when it reached its lowest point after the market collapsed in California. There were two major markets in the 1980s which were California and Denmark. Both of these markets went into decline due to changes in investment incentives. Since then, many new markets have been developed with considerable success.

It was not until 1993 that the market exceeded its earlier peak of 420 MW in 1985. However, whereas the 1984 market was dominated by just one country (95% of the total capacity in 1985 was installed in California) the 1993 market had 90% of the installed capacity divided between eight different countries. Figure 1.1 shows the annual global installation rates since 1983 and Figure 1.2 shows the total installed capacity. The present wind farm capacity in Europe, as recorded at the end of 1996 is 3,474 MW for the EU-15 countries with another 22 MW installed in central European countries, Norway and Switzerland.

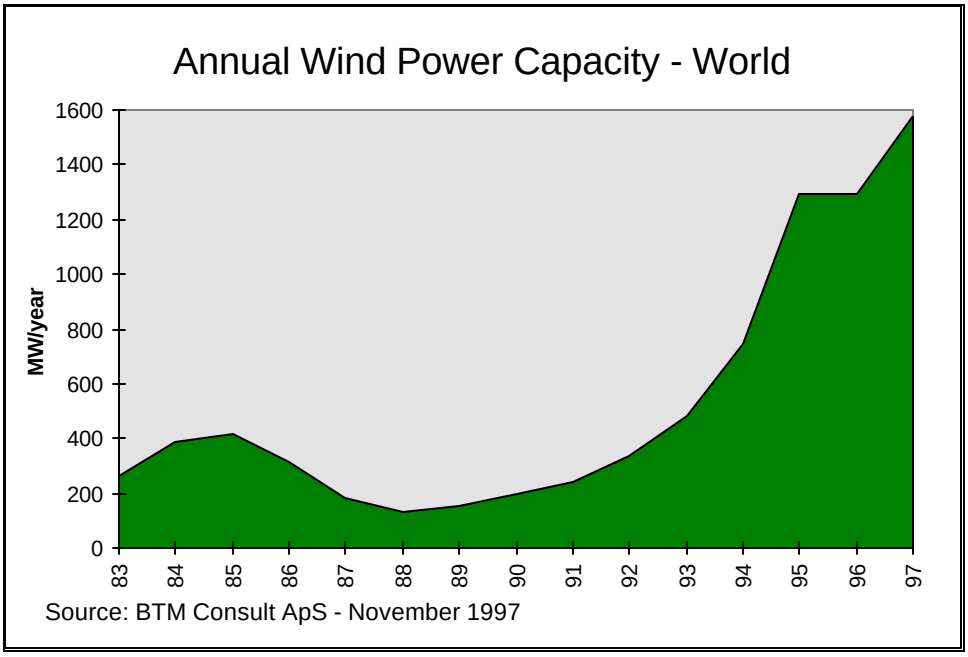

Figure 1.1: Global wind energy development rate MW/year: 1983-1997 (1997 estimate)

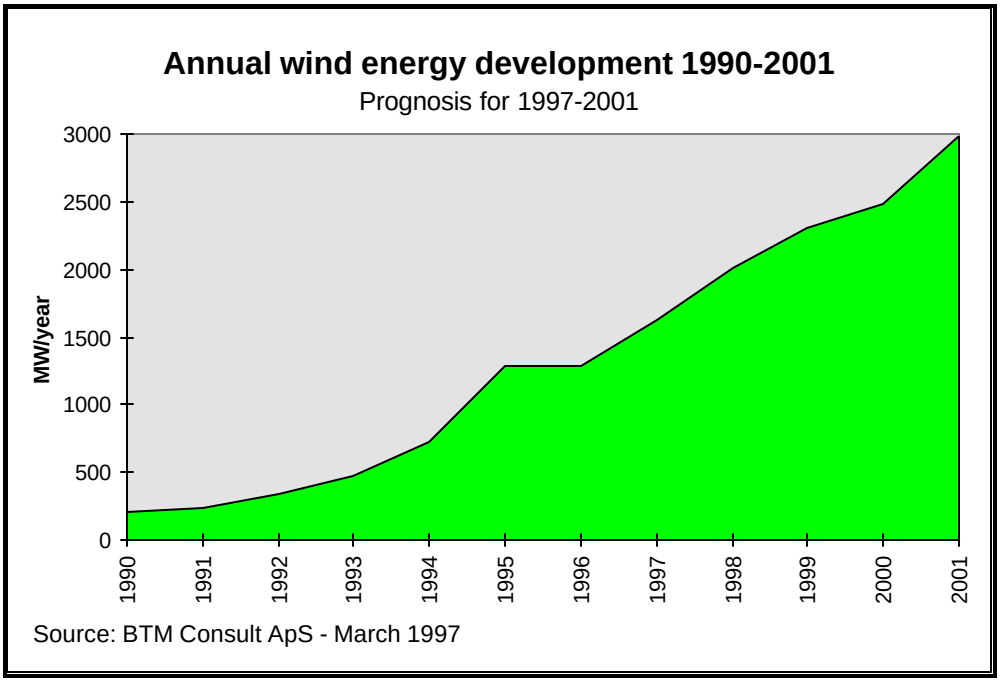

Figure 1.2: Annual global wind energy capacity

1.2 European market development

The European share of the wind energy market has been significant since the late 1970s. In addition, this market has been relatively stable and has seen the industry through times when the international market has been volatile. Table 1.2 shows that the average European market share over the past five years has been about 70%. This market share is expected to continue.

Europe has dominated both the turbine manufacturing industry and the wind farm market over the last five years. Of the 1,292 new installations throughout the world recorded in 1996, more than 80% were supplied by European manufacturers. With the demise of Kenetech in 1996, the largest non-European turbine manufacturer, this share is expected to grow in 1997.

Year	New MW World	Increase %	New MW European	Increase %	European share %
1991	240		193		80 %
1992	338	+ 41 %	218	+ 13 %	64 %
1993	480	+ 42 %	370	+ 70 %	77 %
1994	730	+ 52 %	475	+ 28 %	65 %
1995	1290	+ 77 %	836	+ 76 %	65 %
1996	1292	+0,1 %	967	+ 16 %	75 %
1997 *	1575	+ 18 %	1265	+ 24 %	80 %

Table 1.2: Annual installations and the European market share

* 1997 figures still estimates as per November 1997

2 PRESENT STATUS OF WIND POWER

2.1 Installed capacity

1995 and 1996 have been the best ever years for the wind industry. Both years have seen annual installations of approximately 1,300 MW. This value is about twice the 1994 installation rate. The first six months of 1997 suggest a similar production rate will be maintained.

Countries/regions	Capacity at end of 1995 MW	Installations during 1996 MW	Capacity at end of 1996 MW	Estimate installation during 1997	Estimate Capacity at end of 1997
Denmark	637	200	835	300	1,135
Finland	6.1	1.1	7.2	5	12.2
France	3	2.7	5.7	-	5.7
Germany	1,132	420	1,552	450	2,002
Greece	28	1	29	40	69
Italy	32	38	70	40	110
Rep. Ireland	7	3.6	10.6	40	50.6
Netherlands	249	50	299	50	349
Portugal	8.5	10.6	19.1	10	29.1
Spain	133	116	249	200	449
Sweden	69	34	103	20	123
UK	200	73	273	60	333
Other European countries *1	27	17	43	50	93

European Totals	**2,531**	**967**	**3,496**	**1,265**	**4,761**

Table 2.1: New wind energy installations for 1996 and estimate for 1997 (continues overleaf)

Countries/regions	Capacity at end of 1995 MW	Installations during 1996 MW	Capacity at end of 1996 MW	Estimate installation during 1997	Estimate Capacity at end of 1997
USA	1,591	12	1,596	50	1,646
Canada	21	0.2	21	10	31
Mexico	1.6	-	1.6	-	1.6
S & Central America	10	22	32	30	62
Total America	**1,624**	**34**	**1,651**	**90**	**1,741**
P.R. China	44	35	79	100	179
India *2	576	244	820	50	870
Rest of Asia *3	10.2	2.7	12.9	10	22.9
Asian Totals	**630**	**282**	**912**	**160**	**1,172**
Australia & New Zealand	2.8	3.5	6.3	5	11.3
Pacific Islands *7	0.3	2.7	3	20	23
North Africa *4	8.6	0.15	8.7	10	18.1
**Middle East ***5	8	2.0	10	15	25
**FSU countries ***6	17	1	18	10	28
Total other areas	**36**	**9**	**46**	**60**	**106**
Total new installations		**1,292**		**1,575**	
Global capacity.	**4,821**		**6,104**		**7,679**

Sources: BTM Consult ApS - November 1997 - 1997 figures are estimates, USA figures, source: Paul Gipe Assoc.

Table 2.1: New wind energy installations for 1996 and estimate for 1997

The following are notes on Table 2.1:

1. Other European countries: Belgium, Czech Rep, Slovak Rep, Norway, Austria, Switzerland, East European countries and others. Also includes France for 1997 estimate.

2. The installed capacity in India increased by 244 MW during 1996 although only few wind turbines were sold in India during this year. Much of this capacity was shipped to India in 1995 but not installed and connected to the grid until 1996. This is the main reason why the Danish market share seems low in India during 1996 and high in 1995. It is doubtful whether 820 MW are actually installed and operating at present although this is the official number issued by MNES (Ministry of Non-Conventional Energy Sources) in India. We have only been able to trace around 700 MW. Some sources have indicated that the 820 MW includes approved projects which have not yet been installed.

3. Rest of Asia: Korea, Japan, Malaysia, Indonesia, Thailand, Vietnam.

4. North Africa including: Egypt, Ethiopia, Libya, Tunis, Algeria, Cap Verde, Morocco.
5. Middle East including: Jordan, Syria, Israel, Saudi Arabia, Iran, Iraq (excluding Egypt).
6. FSU countries: Former Soviet Union.
7. Pacific islands: also includes rest of the world not specified under (1-6).

The 1996 installed capacity takes into account decommissioned capacity. The USA has been particularly affected by this characteristic which means that the capacity can decrease as well as increase.

Activities in India during 1996 were much more moderate than expected just a year ago. This has not adversely affected the global result since several other markets have developed more quickly than expected. The five largest markets in 1996 are shown in Table 2.1.2:

Country	**Annual installations 1996 MW**	**Estimate of annual installation 1997 MW**
China	-	100
Germany	420	450
India	244	-
Denmark	200	300
Spain	116	200
UK	73	60
Total	**1,053**	**1,110**

Table 2.1.2: The five largest markets in 1996 and estimate of 1997

Market estimate for 1997

An estimate of the sizes of the five largest markets for 1997 are shown in Table 2.1.2. The significant changes are that India has dropped out of the list, while China shows an encouraging 100 MW of growth. Also, Spain still ranks third on the list.

2.2 Growth in individual markets

Table 2.2 shows the installation of new capacity in the "Top 10" markets in the world over the past five years. Seven EU member states are involved in this list.

Country	Capacity MW 1991	Annual installations - MW/year 1992	1993	1994	1995	1996	Total installations MW 1992-96	Average growth of Capacity % year 1992-96
Germany	110	65	150	307	500	**420**	**1,442**	**70**
India	33	5	22	141	375	**244**	**787**	**90**
USA [1]	1,450	20	80	100	53	**12**	**265**	**3**
Denmark	409	45	29	54	98	**200**	**426**	**15**
Netherlands	83	23	26	22	95	**50**	**216**	**29**
UK	81	38	80	30	40	**73**	**261**	**35**
Spain	15	7	30	23	58	**116**	**234**	**75**
Sweden [2]	9	5	16	10	29	**34**	**94**	**-**
China [2]	3	3	6	18	14	**35**	**76**	**-**
Italy [2]	22	-	-	-	10	**38**	**48**	**-**
Top 10 Totals	**2,215**	**211**	**439**	**704**	**1,273**	**1,222**	**3,780**	
World Totals [1]	**2,223**	**338**	**480**	**730**	**1,290**	**1,292**	**4,130**	**22 %**

Table 2.2: The "Top 10" markets over the past five years (1992-1996)

Notes:

1. The figures for the US are “New installed capacity” which does not take into account the more than 200 MW of older turbines which have been removed.
2. Sweden, China and Italy have not been included in the growth rate column because of their very low 1991 base level.
3. Table 2.1 with 1997 estimates indicate that the growth of installed capacity in 1997 will be some 25%.

Table 2.2 shows that Germany is by far the largest market in Europe. Healthy growth rates are occurring in Spain, the UK and the Netherlands. It is likely that Spain will have a significant increase in installed capacity over the next two years. Italy is expected to become an important market as well.

The total installed wind power capacity in Europe has increased by a factor of three in the period between 1990 and 1996. Figure 2.2 clearly shows that Europe and Asia have become major markets during this period while America (mainly USA) has decreased dramatically.
The market growth in Germany and India have been the two most important elements in this change. Denmark, the UK and the Netherlands have also played an important part in this growth.

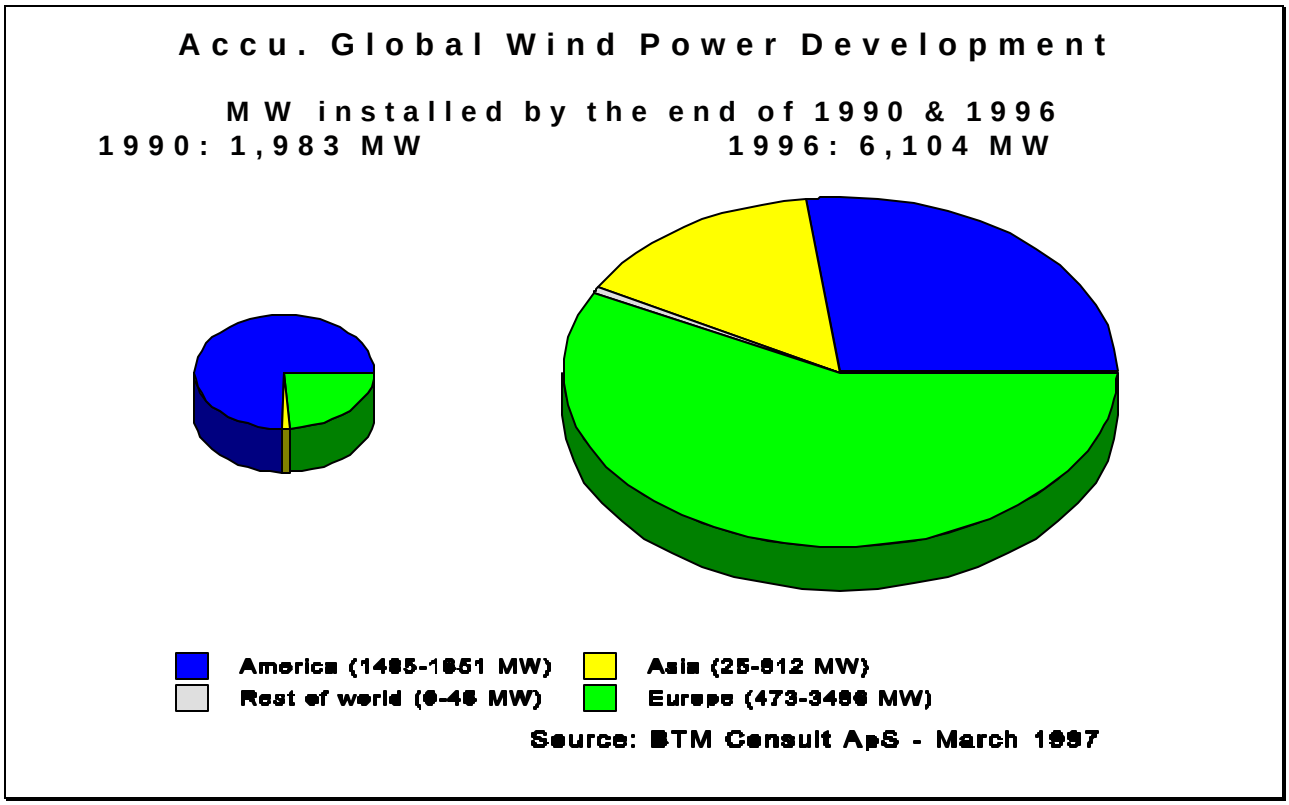

Figure 2.2: Regional breakdown of installed wind power capacity

2.3 Growth in the leading markets

Appendix A shows the pattern of market growth in the main wind farm markets. The countries included have a significant amount of installed capacity and all have been in the emerging and/or mature phase for at least five years. Eight countries are presented which include six from Europe: Germany, Denmark, UK, Spain, the Netherlands and Sweden.

The six European countries accounted for 69% of all new installations in 1996, and their total installed capacity at the end of 1996 was 54% of the world's total. Their share of Europe's installed capacity as of December 1996 was 94%.

3 WIND ENERGY MARKET DESCRIPTION

3.1 Environmental & Energy driven markets

Table 3.1 divides the world wind energy market into two main categories.

These categories are: *'Energy Driven Markets'* (mainly Africa, Asia & Latin America) and *'Environment Driven Markets'* (mainly OECD countries). With the exception of India, Energy Driven Markets are presently small but will become more important.

The Environment Driven Markets are expected to create the main demand in the period 1997-2001. Local manufacturing of wind turbines via joint ventures and the ability and willingness to assist in technology transfer will also become essential factors in both of these markets.

Environment Driven Markets Mainly OECD countries	**Energy Driven Markets** Mainly Africa, Asia and Latin America
Market characteristic No need for additional capacity. Financially able to invest. Wind energy only contributes a very small part of the total energy supply. Political interest and international obligation to reduce CO_2-emission. Wind energy development is <u>not very sensitive</u> to variations in international fuel prices.	**Market characteristic** Immediate need for additional energy, especially electricity. Capacity shortfall. Dependent on importation of fossil fuels. In best case self sufficient. Shortage of foreign currency. Moderate to high economic growth (South and East Asia). Higher average increase in population, economic growth and energy consumption than OECD-countries. Need for technology transfer and local production. Very sensitive to variations in international fuel prices.
EU countries: Germany, UK, the Netherlands, Denmark, Italy, Ireland, Greece, Spain , Portugal, Finland, Sweden, Austria, (Norway) **America:** USA, Canada, Caribbean Islands **Pacific area:** Australia, New Zealand Some islands in the Pacific Ocean **Asia:** Japan, Taiwan, Malaysia	**Africa:** Egypt, Cape Verde, Morocco, Libya **Asia:** India, China, North Korea, Indonesia, Thailand, Vietnam **South America:** Argentina, Brazil, Chile, Bolivia **Central America:** Costa Rica, Mexico, Nicaragua
These markets are expected to increase by 6,180 MW of installed wind power capacity between the year 1998-2001. Status at end of 1997 6,449 MW	These markets are expected to increase by 2,905 MW of installed wind power capacity between the year 1998-2001. Status at end of 1997: 1,230 MW
Other markets: Between 1998 and 2001 an additional 705 MW is expected to be installed throughout the world. This will mainly be in the Middle East and the FSU countries which are very uncertain markets. Since the FSU countries changed to a market economy, they have experienced a decrease in the energy consumption and they possess large reserves of fossil fuels. The Middle East countries have neither an acute need for additional energy nor national environmental goals. The installation in other markets by the end of 1997 is expected to be approx. 100 MW (estimate).	

Table 3.1: Current and emerging markets for wind energy

These market segments are further described in Table 3.2 where examples are presented. It is expected that new markets will follow development patterns similar to those which have occurred in other countries.

Description of different market segments	**Customers**	**Existing markets and potential newcomers**
Privately owned WTGs - 150 kW to 1.5 MW Smaller projects with 1-5 units. Often owned by a group of investors.	Small Cooperatives Farmers Industrial factories	Denmark, the Netherlands Sweden Germany lately also in the USA
Small Commercial wind farms < 5 MW Clusters or small wind farms with 10-20 WTGs, owned by several investors.	Larger Cooperatives Industrial factories Investment groups	Denmark, Germany India, UK
Large Commercial wind farms < 100 MW Large projects established by specialised developers, which build and operate the project.	Independent Power Producers (IPP) Electricity utilities	USA UK Spain Beginning in Germany
Utility owned wind farms in the size 5-100 MW Normally larger projects where the electricity from wind power is part of the generation mix.	Utilities often buy the WTGs directly or via a bidding process. Sometimes as a turn-key project. The market is still rather small globally.	Denmark USA UK China The Netherlands
Joint venture, Type I Sales, assembling and service. Limited technology transfer. Could be the first step to Type II depending on present conditions.	Private companies/factories Industrial entities	Spain India Egypt China
Joint venture, Type II Similar to Type I but also includes local manufacturing and more technology transfer.	Private companies/factories Industrial entities	India Spain USA (still only small scale) China, Egypt
Niche markets Rural areas with only little or no infrastructure.	Development aid and often tailor made assignments. Customers are often international aid organisations.	Developing countries Arctic areas Middle East
Offshore projects Still mainly pilot projects.	R&D with utilities who are expected to become main customers in the future.	Denmark The Netherlands Germany, UK

Table 3.2: Market Segments by customers and size of plants

3.2 Future markets

Different market segments for wind power have evolved over the last 20 years. These segments can be sub-divided in terms of size, customer type and potential for future development. The main categories are listed below:

- Individually owned WTGs in the size between 150 kW to 1.5 MW
- Commercial owned (Cooperatives) wind farms up to 5 MW
- Private developers, wind farms up to 100 MW
- Utility owned wind farms in the size 5-100 MW
- Joint ventures - Type 1: sales, assembling and service of WTGs
- Joint ventures - Type 2: as per Type 1 plus local manufacturing of WTGs
- Niche markets: Stand alone, wind-diesel, fresh water production, telecommunication, ice production and hybrid utilisation
- Offshore projects (emerging market in northern Europe).

Offshore projects

Offshore development has been limited. Recently the Danish Government released a new national energy plan, Energy 21, with a long term (2030) wind target which includes 4,000 MW of offshore wind farms. In July 1997 Danish utilities and the Danish Energy Agency released an assessment of offshore development in Denmark. This assessment predicts that 700 - 800 MW of offshore wind farms will be installed before 2006. In October 1997 the Danish utilities committed themselves to build the first 750 MW for demonstration of Danish offshore wind power. The Dutch authorities have significant plans for utilising their huge offshore potential and there are commercial plans for both Germany and the UK. In the UK a power purchase contract has been let for a 30 MW development in the Thames estuary.

Table 3.3 shows an assessment of the size of the different market segments, based on global wind power development in 1994, 1995 and 1996.

Market segments	% of world market in 1994	% of world market in 1995	% of world market in 1996
Privately owned WTG 150 kW to 1.5 MW	35	52	49
Small commercial wind farms < 5 MW	32	23	21
Large commercial wind farms < 100 MW	22	14	18
Utility owned wind farms < 100 MW	10	10	10
Niche markets	1	1	1

Table 3.3: Market segments in 1994-1996

The future market for global wind power development can be divided into the two different major categories shown in Table 3.1.

Table 3.4 quantifies the market potential for wind power for each of the market segments in these two categories in the year 2001.

Environment Driven Markets	**% of Environment Driven Market**
1. Privately owned WTG: 150 kW to 1.5 MW	7
2. Small Commercial wind farms: < 5 MW	17
3. Large Commercial wind farms: < 100 MW	34
4. Utility owned wind farms: 5-100 MW	34
5. Offshore projects	6
6. Niche markets	2
Total market share (60% of the global market)	100
7. Joint ventures (Type I & II) contributes with:	20

Energy Driven Markets	**% of Energy Driven Market**
1. Privately owned WTG: 150 kW to 1.5 MW	20
2. Small Commercial wind farms: < 5 MW	40
3. Large Commercial wind farms: < 100 MW	17
4. Utility owned wind farms: 5-100 MW	20
5. Offshore projects	0
6. Niche markets	3
Total market share (40% of the global market)	100
7. Joint ventures (Type I & II) contributes with:	80

Table 3.4: Predicted market segment potential in 2001

The global potential for wind energy is estimated to be 7,600 MW of new installed capacity for the four year period 1997-2000. Of this growth 60% (4,600 MW) will be in the Environmental Driven Markets and 40% (3,000 MW) in the Energy Driven Markets.

Activity in the Former Soviet Union and Middle East countries is not included in these figures and is expected to be only about 1% (60-100 MW) of the total.

It is predicted that nearly 50% of the total market between 1997-2000 will be sold via joint venture projects. This segment will be approximately 80% of the Energy Driven Markets and 20% of the Environment Driven Markets.

The latest development during 1996 and 1997 have not - so far - confirmed the forecast of the split between Energy Driven Markets and Environmental Driven Markets. However, we still believe that this will be achieved in the long run. That is based on the resources and the general energy situation in Asia characterised by lack of electricity and rapid economic growth.

4 WIND ENERGY TARGETS

4.1 Background for wind energy development in the EU

Almost 25 years after the first oil crisis, the EU and a number of European countries are still the only governments to have created lasting incentives for renewable energy. These incentives have been instrumental in establishing commercial wind turbine manufacturers and large wind energy utilisation.

The introduction of the European free market (EU-12) in 1988 excluded electricity and gas. Since 1988 the EU has been moving towards a free and transparent market for the electricity sector. In 1996 a free market model was developed for electricity and, according to an EU Directive, must be implemented by all member states before January 1999 and thus increases access to outside suppliers. The level of access increases from 23% in 1999 to 33% in 2003.

The EU free market model does not give any priority to renewable energy. However, individual member states may give priority to renewables and to national issues of strategic importance through the EU's Public Service Obligation (PSO). Extra costs incurred due to any PSO will be shared by all electricity consumers in the country.

The EU-15 presently import 55% of their energy requirements. This dependency is expected to increase to 70 % by 2010. Strategic concerns over energy supply may become an important driver for the exploitation of all indigenous energy sources.

In spite of the lack of firm political goals, there is considerable activity within the European Union initiated by the European Commission, the European Parliament, the Council of Ministers as well as some EU member national governments.

4.2 European wind energy targets

Since the first oil crisis in 1973, many programs to support renewable energy technologies have been established. Most have focused on R&D activities and also on demonstration projects. These activities have taken place on both a national and a European level, by the member countries and by the European Commission. On both levels, targets for renewables, including wind energy, have been set. The most important wind energy targets to date are as follows:

4.2.1 The European Commission's ALTENER program

In 1992 the Commission launched the ALTENER program which was designed to increase the use of renewable energy in the Union.

This program has a renewable energy target of 8% of the total energy use. For reference, at present, renewable energy, mainly hydro, provides 6% of EU member countries energy. The main contributors to the ALTENER 8% target are expected to be wind, biomass and small hydro.

An ALTENER sub-target (3) is 8,000 MW for wind energy which is to be reached by or before 2005. It is likely that wind energy will reach the 8,000 MW goal by 2001, five years earlier than expected.

4.2.2 The EU White Paper on Renewable Energy (1997)

This paper, based on a previous report from the EU Commission: European Energy to 2020 - A scenario approach, EU Commission 1996, and on the TERES 2 report, predicts that 12% of the total primary energy used in Europe can be supplied by renewable energy by 2010. The predictions in these reports [2] suggest that the wind energy installed capacity will be about 50,000 MW by 2020 or 6 to 7% of Europe's total generation capacity.

The preparatory Green Paper was in a hearing process during 1997. It was approved by the Commission on November 26 and became a White Paper "Renewable Sources of Energy" *(COM (97) 599 final)*. In the White Paper the specific target for wind power is set at 40,000 MW installed capacity by 2010.

Opinion in the wind industry on this EU White Paper is generally favourable. However, while the paper correctly identifies the market barriers to wind, its predictions for wind energy (based on TERES 2) are thought to be too conservative.

According to the EWEA targets, 100,000 MW installed by 2020, wind energy will provide 220 TWh per year. That capacity will produce 18,9 Mtoe equal to 12 % of the total new renewables in 2020. The TERES 2 report expects a contribution from wind energy which is just half of that covered by the EWEA Target 2020.

It is the opinion of the EWEA that wind energy can contribute at least 15-20 % of the total new renewable energy by 2030. This will require the installation of more than 200,000 MW of capacity according to the total mix of renewables in the TERES 2 report.

4.2.3 The Madrid Declaration (1994)

At a conference held in Madrid in March 1994, a broad group of people from the renewable energy community in Europe, along with representatives from the Commission (DG 12 and DG 17) and members of the European Parliament created a "Plan of Action" to promote the development of renewable energy up to the year 2010. This conference produced the Madrid Declaration, which called for a 15% contribution from renewables by 2010.

The declaration did not give specific figures for the contribution from wind, but the intention was that PV, mini-hydro and wind energy collectively should reach 55,000 MW of installed capacity by 2010.

4.2.4 European Parliament (1997)

In 1997 the European Parliament adopted a new goal for contribution of renewables of 15% which was based on the Mombaur Report. The European Parliament thus has a more ambitious target than the predictions for wind made in the European Commission's White Paper on renewable energy.

4.3 EU member states wind energy targets

Some of the EU member states have national goals for the development of wind energy. The effectiveness of these goals has been varied from country to country. Some countries have experienced problems in fulfilling their goals due to lack of an appropriate institutional framework such as effective planning guidelines. Other countries with very modest goals have large wind markets. Table 4.3 lists wind energy targets for the EU-15 countries.

Country	Wind capacity by	Targets	Comments

	end 1997 - MW (Estimate) *	MW	
Austria	17	No targets	Some activity, but electricity prices are too low.
Belgium	7	No specific targets for wind energy	National CO2 plan of 700 MW decentralised capacity by 2005
Denmark	1135	1,500 MW by 2005	Long term target for offshore of 4,000 MW by 2030, of which 540 MW now under negotiation by 2004.
Finland	12	No targets	100 MW by 2000 has been estimated.
France	6	250-500 MW by 2005	Being administrated by EdF
Germany	2,002	2,200 MW by 2000	Targets are set by each Bundesländer. Highest contributions by Schleswig-Holstein and Lower Saxony.
Greece	69	245 MW by 2000 350 MW by 2005	Almost no new installations since 1994, in spite of legislative support for private investment in 1994.
Italy	110	300-600 MW by 2000	Will be exceeded. More than 750 MW has been approved to date.
Rep Ireland	50	170 MW by 1999 470 MW by 2010	After completion of AER-1 a market of 30 MW per year will be stimulated.
Luxembourg	2	No targets	Land resources are limited.
Netherlands	349	1,000 MW by 2000 2,000 MW by 2007 2,800 MW by 2020	The targets after year 2000 will be on offshore locations
Portugal	29	70 MW by 2000	
Spain	449	Targets are set by individual Provinces Galicia, Andalucia and Catalonia possess the majority of the potential	1,200 MW expected by 2000. Potential of more than 6,000 MW has been identified within 5 Provinces
Sweden	123	No targets	Funds available in 1997 to support a further 250 MW
UK	333	No specific target for wind	1,500 MW dnc of all renewables by year 2000

* Note : The figures are rough estimates - November 1997, BTM Consult ApS.

Table 4.3: Targets for wind power development in Europe (EU-15)

Although the targets in Table 4.3 refer to different periods, a summation of the targets and the estimates for those countries without targets, indicate that a total installed capacity of 9,000-12,000 MW will be reached during the period 2000 to 2005.

4.4 EWEA wind energy targets

The European Wind Energy Association (EWEA) introduced its first Strategy Document, "Wind Energy in Europe - Time for Action"[2] in 1991. The goals established in that document were replaced by a new set on the release of the new EWEA Strategy Document 1997. The EWEA goals, together with historical capacity levels for reference, are shown in the table below.

Year	1991 EWEA Targets Installed Capacity MW	1997 EWEA Targets Installed Capacity MW	Annual growth rates (1997 Targets) %/year	Average production rate MW/year
1990	500			
1996		3,500	38	500
1997 estimate		4,761	36	1,265
2000	4,000	8,000	17,5	3,200
2005	11,500		17,5	3,200
2010	25,000	40,000	10	6,000
2020	-	100,000	5	7,500
2030	100,000	-	5	7,500

Table 4.4: Predicted growth in capacity and annual production to 2040

The goals above call for a doubling of the capacity every five years until 2010 and, thereafter, almost a doubling every ten years. The period from 1996 to 2000 represents a doubling in about four years. In comparison during the period 1990-1996 the capacity increased from approximately 500MW to 3,500MW - approximately a doubling every two years.

4.4.1 Are these targets achievable?

The factors that will determine the wind energy market growth in Europe include resources, costs, grid issues, industry limitations and, most importantly, politics. While the first four factors are readily assessed, the political factor is not. Political will is very important for the implementation of wind energy and politics will continue to be a key consideration for the wind energy industry.

4.4.2 Wind Resources in Europe

One European wind resource assessment [3] has judged the land based technical potential [4] for wind energy to be approximately 550 TWh/year for the EU-15. The Norwegian potential increases this figure

to 630 TWh/year. Another study carried out for the European Commission by Germanischer Lloyd and Garrad Hassan has assessed the European offshore potential to be large enough to supply all electricity consumption in Europe. The exploitation of this resource will depend strongly on costs. There is strong interest in this area and costs look set to fall sharply. The potential of wind energy in Europe are described in more detail in Volume 1: Technology.

An ultimate goal for Europe of a 20% wind energy contribution or some 400 TWh/year, can be supplied by 200,000 MW with a capacity factor of 23% (based on today's consumption in EU-15 = 2100 TWh/year). This is far less than the European land-based technical potential. The offshore potential add substantial capacity to that on land - see Volume 1: Technology.

It can be concluded that the resource will not be a limitation on the use of wind energy in Europe to the extent of the targets set by the EWEA.

4.4.3 Cost of energy

The cost of a kWh of electricity produced by wind turbines has decreased by a factor of 2.5-3 since 1980. Commercial wind farms with present technology produce electricity in the range of 4-7 cECU/kWh. The cost is mainly dependent on the wind resource. It has been predicted that a reduction potential of at least 50% is achievable over the next 20-30 years. More detailed assessment of the economics of wind energy has been carried out in Volume 2:Costs, Prices and Values.

In general, an increase in manufacturing output results in lower production costs. This cost decrease has been quantified at 15-20 % for each [5] doubling of the installed capacity. Wind turbines consist of many parts and the market supply is a mix of many models and sizes, making such calculations rather complicated. However, applying the production/cost decrease rate as stated above for the period from 1996 - 2010 during which the production rate is likely to double about three times, suggests a cost decrease of 45-60%. The cost reduction potential for wind energy has been assessed by US-DOE (1990) and Risø (1996) and both studies support the values suggested in this report.

The cost reductions of wind energy have been dramatic over the last decade and will continue. The cash cost of wind energy is still higher in markets where gas fired thermal plant dominate. Energy from modern thermal plant using cheap natural gas with no environmental cost component is still much less costly than wind energy because it fail to recognise the environmental benefits of using wind.

4.4.4 Interaction with the grid and present consumption of electricity

It is accepted that a modern electrical grid system will be able to accommodate a penetration of 10-20% by wind power. Forecasts expect the total European consumption to be +3,000 TWh after year 2020. Wind Energy will then contribute with some 20% off all electricity consumption in Europe (EU-15).

Wind energy is unequally distributed over Europe. While some countries will reach the "20% penetration limit" others will not be able to achieve this level due to lack of resources. Assuming no exchange of

electricity and present consumption levels, the technical potential (on land) will be reduced from approximately 550 TWh to 340 TWh. This will require about 170,000 MW of wind farm capacity.

However, the liberalisation of the European electricity market is expected to increase the transmission capacity, increase cross-border trading of electricity and bring closer co-operation between countries possessing "comparative advantages" such as wind and hydro-power, particularly from Scandinavia. Therefore, a penetration of 16 -17 % is not unrealistic.

4.4.5 Capacity of the industry

The future installed capacity as projected by EWEA is shown in Table 4.4 together with the required wind turbine production rates. The European wind industry supplied almost 1,000 MW during 1996. The manufacturing capacity at present is over 2,300 MW/year (See Volume 3: Industry and Employment). The production increase shown in Table 4.4 is not an unusual growth rate for an emerging industry. It may, therefore, be concluded that the required expansion of the industry will not be the limiting factor for achieving the goals set by EWEA.

4.4.6 Conclusions on targets

While the EU, national governments and industry associations have set implementation targets for wind energy and the European Commission has heavily supported the R&D and demonstration of wind energy technologies, the lack of effective market regulation will continue to marginalise wind energy. To compete equitably with traditional energy sources, it is necessary to internalise the social and environmental costs of all energy use. This will help establish a fair means of cost comparison between different sources of energy.

The necessary action can include regulatory, financial and taxation instruments. However, until such actions are taken, wind energy will not be exploited throughout Europe to its full potential.

5 MARKET PREDICTIONS

5.1 Prediction methods and data sources

Methods

The predictions made in this report are based on an analysis of the wind energy market over previous years. Recent experience has shown that even when individual markets fail to live up to expectations, market diversity is now so broad that the global market remains stable.

Predictions based on at least five years of market data dampen yearly fluctuations and provide improved accuracy. Recent and expected government policies, which are designed to promote renewable energy uptake, are taken into account.

The predictions are based on individual markets which include countries with:

- National energy plans and governmental support for renewable energy
- Wind energy market growth
- Good wind resources.

The historical development of the leading wind energy markets is shown in Appendix A.

Sources

Data for predictions come from information about installed wind farms and from wind turbine manufacturers from around the world. Important sources include wind power magazines such as Windpower Monthly, Wind Direction, Wind Energie Aktuel, Windkraft Journal, Wind Energy Weekly, DEWI, SERO Journalen. Another important source is the statistical data from The Danish Wind Turbine Manufacturers Association (Vind-Note). BTM Consult ApS also obtain information from a world wide network of consultants, along with government and energy industry contacts.

5.2 Leading markets (1997-2001)

Table 5.2 shows the markets that are predicted to be in the "Top 10" to the year 2001. The countries are ranked in terms of predicted annual installation rates.

Country	1996*	1997 **	1998	1999	2000	2001	Total
India	244	50	300	500	500	500	**1,850**
Germany	420	450	300	300	300	300	**1,650**
Spain	116	200	250	250	250	250	**1,200**
USA	12	50	150	150	200	400	**950**
China	35	100	150	150	150	200	**750**
Denmark	200	300	125	125	150	150	**850**
UK	73	60	100	150	100	100	**510**
Sweden	34	20	50	50	100	100	**320**
Netherlands	50	50	50	50	50	100	**300**
Canada	0,2	10	30	50	100	100	**290**
Total	**1,184**	**1,290**	**1,505**	**1,775**	**1,900**	**2,200**	**8,670**

Table 5.2: Leading markets for the years 1997-2001 Annual installation rates - MW

* 1996 data are actual values ** 1997 figures based on estimate of November 1997

Table 5.2 shows that the "Top 10" countries for the next five years are expected to be the same as for the past five years although rankings have changed. Presently, there are some countries which are not growing as predicted for 1997. However, in the longer term, and more importantly, on a global scale, the market appears to be close to expectations. Countries such as Italy, Greece and Ireland can develop to leading markets within a few years.

5.3 Individual markets

The following comments about some of the individual markets will help to interpret the values in Table 5.2.

- A change of government in **India** in March 1995 was followed by higher interest rates and changes in tax subsidies. This led to a dramatic decline in the Indian wind energy market. The predicted market values for India assume a recovery of the market and then slow but sustained growth. The busiest period for investment in India, due to tax regulations, is the first quarter of the year. 1997 seems to be very disappointing.
- The present market situation in **Germany** is uncertain, as the future of EFL payments is under review. If the present payment of 17.2 pf/kWh is reduced to 12-14 pf/kWh as proposed, the market will decline. In addition, the high wind speed areas are being used up leaving less economic areas to exploit. This will reduce the level of activity. Alternatively, if the current EFL debate ends soon in favour of wind power, the market will continue to grow.

- Annual development in the **USA** is difficult to predict due to the few large projects now at the planning stage. The market prediction is sensitive for the next few years and will be highly affected if just one or two projects are postponed. Several of these large proposed projects which are located in California, Iowa, Minnesota, Texas, Wyoming and the North Western states were planned to be installed in 1995/96 but have been postponed until 1997/99. The USA has an enormous potential for wind power development if the right conditions are established. The market could therefore be much bigger than estimated. Recent press releases from Enron-Zond, the leading manufacturer in the US, details firm orders for more than 300 MW of capacity (NSP Phase 2 and 3 and in Iowa). These orders suggest a renewal of the wind energy market in the US.
- The development pattern in **Spain** has adopted large projects similar to wind farm projects in the USA, although at a more sustained level. Spain has a vast wind energy potential. Combined with a fairly high fixed payment for electricity [6], the market is very promising. It is still uncertain, as a result of lengthy grid connection discussion, when the development in Galicia will start in earnest, but when it does the conditions should result in very significant growth.
- Development in **Denmark** during 1996 was the highest on record and most recent information indicates that 1997 will probably be as good. The large growth was mainly due to private investors buying into wind turbine projects outside of their area during 1995. This investment opportunity was stopped in 1996 but all projects approved in 1995 will be allowed to proceed. The majority of installed capacity in 1996 and 1997 is based on the 1995 conditions. The future for private development after 1997 is uncertain. As a result, it is expected that the majority of new installations will be by the Danish utilities who have been mandated to install 200 MW (ELSAM: 120 MW, ELKRAFT: 80 MW) between 1996 and the end of 1999. Only a very small part of this goal has already been installed. Previous experience has shown, however, that utility projects are often delayed by 1-2 years.
- The current debate in **Sweden** on decommissioning their nuclear power plants is very likely to benefit wind power development as wind is one of the only options which will not increase CO_2 emissions. It is difficult to estimate how soon this will start to take effect and the current situation for 1997 is not promising. The 30% investment incentive for wind farms was abandoned in 1996 and the payment for wind electricity is not high enough to establish a big market. Recently a new investment subsidy of 15% was launched. The Swedish government is presently working on a new scheme of supporting other technologies to replace the first decommissioned nuclear plant (Barsebäck) which will leave Sweden with a loss of 8-9 TWh/year. It is most likely that wind power will benefit from this new scheme.
- **China** will see a breakthrough this year. For the first time ever a single years installation of new capacity will exceed 100 MW. China is a market where almost all leading manufacturers have installed wind turbines. China have the greatest potential for wind energy in Asia. The national goal for the year 2000 is 600 - 800 MW.
- The **UK** possesses the greatest potential for wind energy in Europe. The NFFO scheme initiated in 1991 has proved to be a successful model for achieving lower prices by the use of a bidding process. Interest has been great, but many applicants have been unsuccessful with their projects due to fierce competition. After the latest NFFO round projects accounting for some 790 MW were awarded.

Past experience has shown that many projects do not obtain planning approval. Therefore, it is

estimated that about half of the awarded projects will be realised in the future. One more NFFO round will be launched before the year 2000. Wind energy has shown to be very competitive compared to other renewables within the NFFO scheme. Also the similar bidding rounds in Scotland and Northern Ireland have been successful. No markets for small individual wind power plants has emerged yet.

5.4 Predicted world wind energy market up to 2001

In this section the data and arguments presented in the foregoing sections are summarised into a single table in which the global market is estimated.

Country (area)	**Total capacity MW**	**New capacity MW**	**Predicted growth 1997-2001**					**New capacity MW**	**Total capacity MW**
	1996	1996	1997	1998	1999	2000	2001	1997-2001	2001
USA	1,596	12	50	150	150	200	400	950	2,546
Canada	21	0	10	30	50	100	100	290	311
Latin America	34	22	30	50	50	100	120	350	384
Total America	**1,651**	**34**	**90**	**230**	**250**	**400**	**620**	**1,590**	**3,241**
Denmark	835	200	300	125	125	150	150	850	1,685
Finland	7	1	5	10	10	10	20	55	62
Germany	1,552	420	450	300	300	300	300	1,650	3,202
Greece	29	1	40	50	50	50	50	240	269
Italy	71	38	40	40	40	40	50	210	281
Rep. Ireland	11	4	40	30	30	30	50	180	191
Netherlands	299	50	50	50	50	50	100	300	599
Portugal	19	11	10	10	10	10	20	60	79
Spain	249	116	200	250	250	250	250	1,200	1,449
Sweden	103	34	20	50	50	100	100	320	423
UK	273	73	60	100	150	100	100	510	783
Other European countries: *1	49	20	50	100	125	125	200	600	649
Total Europe	**3,496**	**967**	**1,265**	**1,115**	**1,190**	**1,215**	**1,390**	**6,175**	**9,671**

Table 5.4: Predicted world wind energy markets to 2001 *continued overleaf*

Country (area)	Total capacity MW	New capacity MW	Predicted growth 1997-2001					New capacity MW	Total capacity MW
	1996	1996	1997	1998	1999	2000	2001	1997-2001	2001
P.R. China	79	35	100	150	150	150	200	750	829
India	820	244	50	300	500	500	500	1,850	2,670
Other Asian countries: *2	13	3	10	50	50	50	75	235	248
Total Asia	**912**	**282**	**160**	**500**	**700**	**700**	**775**	**2,835**	**3,747**
Australia & New Zealand	6	4	5	20	20	20	30	95	101
North Africa *3	9	0	10	100	75	75	75	335	344
Middle East *4	10	2	15	20	30	30	30	125	135
FSU countries *5	18	1	10	10	20	20	50	110	128
Rest of the world	3	3	20	20	20	20	20	100	103
Total other areas	**46**	**9**	**60**	**170**	**165**	**165**	**205**	**765**	**811**
Total new capacity MW/year		**1,292**	1,575	2,015	2,305	2,480	2,990	**11,365**	**17,469**

Installed capacity (MW)	**6,104**		**7,679**	**9,694**	**11,999**	**14,479**	**17,469**

Source: BTM Consult ApS - March 1997, *) 1997 estimate corrected in November 1997

Table 5.4: Predicted world wind energy markets to 2001

1. Other European countries: Belgium, Czech Rep, Slovak Rep, France, Norway, Austria, Switzerland, other East European countries.
2. Other Asian countries: Korea, Japan, Malaysia, Indonesia, Thailand, Vietnam, etc.
3. North Africa including: Egypt, Ethiopia, Libya, Tunis, Algeria, Morocco
4. Middle East - including : Jordan, Syria, Israel, Saudi Arabia, Iran, Iraq excluding. Egypt
5. FSU countries: Former Soviet Union

The market projections in Table 5.4 are also shown in Figure 5.4.

The market trend experienced from 1990 to 1995 is not expected to continue. This period saw an increase in the annual growth rate from about 15% in 1990 to 34% in 1995. In 1996 it slowed to 26%. Predictions show an annual growth rate of 26% for 1997 which decreases steadily to 21% in 2001.

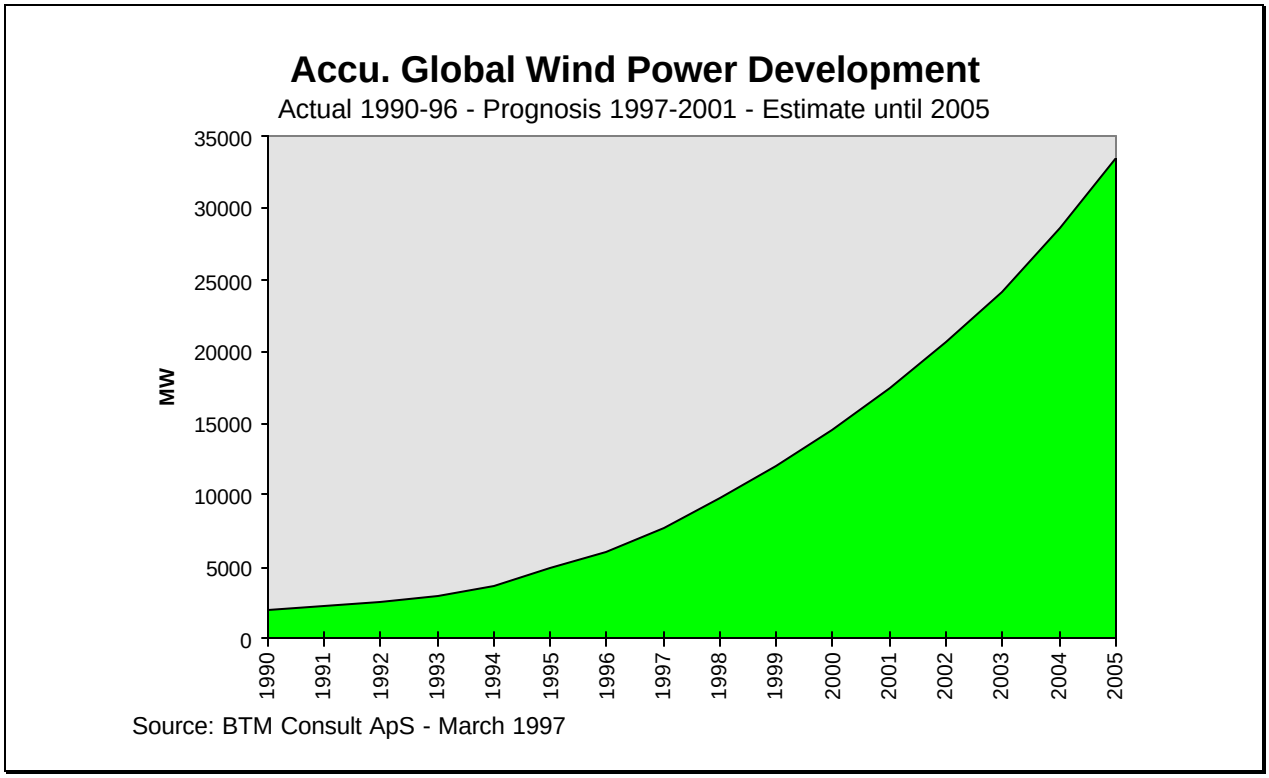

Figure 5.4: Actual and predicted market growth : 1990 - 2000, MW/year

Figure 5.4.1 shows the way in which the global market is expected to be distributed in the year 2001 together with the same information for l996.

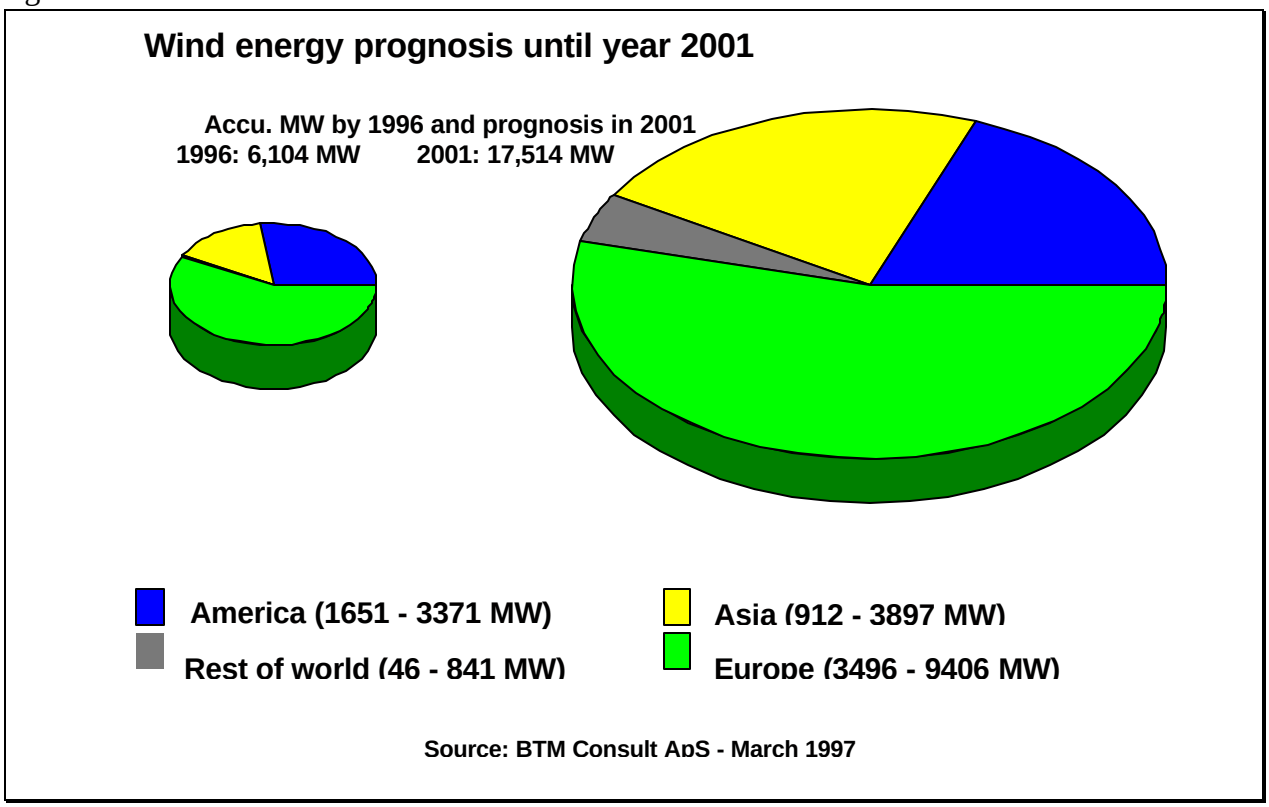

Figure 5.4.1: Regional breakdown of installed capacity in 1996 and predicted for 2001

5.5 Predicted market for the period 2001 - 2005

Table 5.5 shows predictions for the wind energy market for the period of 2001 to 2005. The uncertainty is greater than for the period to 2000 but the figures are nevertheless considered useful.

County (area)	Total capacity (MW)	Predicted growth 2001 - 2005					New capacity	Total capacity (MW)
	1996	2001	2002	2003	2004	2005	2001-2005	2005
North America	1617	2967	500	500	700	700	2400	5367
Latin America	34	404	120	200	250	300	870	1274
Total America:	**1651**	**3371**	**620**	**700**	**950**	**1000**	**3270**	**6641**
Denmark	835	1535	150	150	150	150	600	2135
Germany	1552	3052	300	300	400	500	1500	4552
Netherlands	299	599	200	200	250	250	900	1499
Spain	249	1449	200	200	300	300	1000	2449
Sweden	103	433	100	150	250	300	800	1233
UK	273	823	250	250	300	300	1100	1923
Other EU-countries	136	866	150	200	200	300	850	1716
Central Europe + Russia	66	776	100	150	150	200	600	1376
Total Europe	**3514**	**9534**	**1450**	**1600**	**2000**	**2300**	**7350**	**16884**
India	820	2820	500	500	500	500	2000	4820
P. R. China	79	829	300	400	500	500	1700	529
Other Asian	13	248	100	150	150	200	600	848
Total Asia	**912**	**3897**	**900**	**1050**	**1150**	**1200**	**4300**	**8197**
Australia & New Zealand	6	106	30	50	100	100	280	386
Middle East & Africa	19	504	100	150	200	250	700	1204
Rest of the world	3	103	10	15	15	5	55	158
Total others	**28**	**713**	**140**	**215**	**315**	**365**	**1035**	**1748**
World per year			3,110	3,565	4,415	4,865	**15,955**	
Total installed MW	6104	17,514	20,624	24,189	28,604	**33,469**		
Growth rates of total installed capacity			18%	17%	18%	17%		

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Table 5.5: Predicted global wind power development for the period 2001 - 2005

The predictions shown in Table 5.5 are based on a conservative scenario. It is predicted that the annual growth rate will decrease from the 1997 value of 27% until 2002 when it will be about 18% per annum, after which it remains constant.

Based on the predictions presented above the European wind farm installed capacity will develop as follows:

Year	Power
1996	3,500 MW
2001	9,500 MW
2005	17,000 MW

The figures include Central Europe and Former Soviet Union States.

5.5.1 Offshore

It is difficult at present to estimate the offshore share of the installation. However, based on the projects currently under planning and the offshore scheme announced by the Danish Ministry of Energy - 750 MW before 2006, a qualified guess is that some 2-2,500 MW will be offshore installations in year 2005 which accounts for 10-15 % of all wind capacity by 2005.

6 REVIEW OF WIND ENERGY MARKET INCENTIVES IN EUROPE

Turbines have had to compete with mature technologies built on a large scale which have more than 50 years experience and benefit from continuous cost improvements. Cost comparisons on a commercial and equitable basis are therefore difficult.

In the early 1980s, incentives were essential to initiate wind farm development. More recently, the cost of wind turbines has fallen and as a result incentives have been reduced. In some places which have good wind regimes, wind turbines can compete with conventional forms of generation. However, even with cost effective turbines, it is sometimes difficult to compete with public utility systems because of their favourable financing sources - often financed by billing the consumers in advance of the installation of a power plant. Private wind turbine owners and commercial wind farm development companies must borrow money on commercial terms. Often it is difficult to negotiate a loan period which matches the lifetime of the wind turbine. This difficulty is the main reason for the importance of economic incentives for wind farm development and the establishment of the industry.

This problem is not peculiar to wind turbines. It is a common problem in the commercialisation of new technology. The following section reviews some of the most significant models used within the EU and the lessons learned from them.

6.1 Brief characteristics of different schemes and models used within the EU

The development and demonstration of wind energy technology and assistance with market penetration have been supported by national governments and the European Commission since the mid 1970s. The first Joule and Thermie programs were started in 1978 and have continued in the form of 5 year framework programs.

National support programs have been launched in many of the EU member countries. Many different models have been used and the level and continuing flow of support have differed considerably from country to country and over time. The most common models for market stimulation follow:

1. Public funds for R&D programs
2. Public funds for demonstration projects
3. Direct support of investment cost (% of total cost or an amount per kW installed)
4. Support through the use of premium price of electricity from wind turbines (an amount per kWh delivered)
5. Financial incentives - special loans, favourable interest rates, etc.
6. Tax incentives i.e. favourable depreciation
7. Other incentives.

Public funds for R&D and the demonstration of innovative wind technologies have been the most widespread means of stimulation within the EU. They have been used for years at a national level and by the Commission to encourage the development of wind energy within the European Union. EU support for the development of the next generation of MW turbines from the Joule-Thermie Program is a typical example. This development started 7 years ago and the result is that several MW scale machines are available in the market. Substantial national programs have been undertaken in Germany, the UK, the Netherlands and Sweden over the last two decades.

Direct support for private investments has been used to create markets for wind energy and thus to establish a new industry. Direct support for investment costs was used for the first time in Denmark in 1979. The program offered 30 % direct support of the total investment cost, it lasted for 10 years at a declining rate. In 1989, when the subsidy reached 10 %, the program was ended. Since then a similar model has been used in the Netherlands, Sweden and Germany at Länder level, with different rates in each Länder. The Dutch model was based on an amount per kW of installed capacity - adopted from the US market in the mid-eighties - and with some other technical constraints based on the ratio of swept area to installed capacity.

In other cases premium prices for electricity from wind turbines have been used for the stimulation of markets. The most significant use of this model has been in Germany. A law put in force *(Strohmeinspeissegerichte)* in January 1991 required the utilities to pay 90% of the retail consumer price which, at the time, was 0.167 DM. In parallel to this approach, Germany also initiated its “250 MW program”, which gave R&D support to selected turbines in the form of a kWh payment. Initially it was set at 0.08 DM/kWh and later reduced to 0.06 DM/kWh.

These subsidies were limited to 10 years and the recipients were obliged to report the performance of the turbines. This model has been very successful. Other countries which have used the same model are the Netherlands, Sweden and Spain. In Italy, a model using a premium price, based on a license, has been adopted. The UK model, called the Non-Fossil Fuel Obligation, is also based on a premium price, but the projects are selected as a result of a bidding process. This means that there has been competition to obtain contracts, which are valid for 15 years.

Financial incentives in the form of loans have also been used. Again the best example of this incentive is found in Germany, where wind turbine owners have had access to low interest loans, similar to those used for financing agricultural equipment. In Denmark, in the first half of the 1980s, it was possible to get real estate loans for wind turbines and this approach allowed the construction of many of the first turbines. The loan for the wind turbine was an integrated part of the whole loan package for the real estate, including the wind power plant.

A mixture of incentives has often been used to support wind energy development. In Denmark, for example, the incentive package included: a premium price for electricity, a grant towards investment cost and some tax allowances (in particular for co-operatives). Also, a mixture of incentives has been used in Germany and Sweden.

Economic incentives can not stand alone. The general institutional framework must also be in place to secure a successful development of wind energy. This issue will be discussed in Section 6.2. Elements which create a favourable institutional framework are:

- National bodies working on technical approval and certification of wind turbines.
- Careful planning of the implementation of wind turbines, without creating objections from people in the surrounding area.
- Availability of specialist services to the industry has also been shown to be important - as long as they do not possess a monopoly status.

6.2 Lessons learned

The use of market incentives has differed from country to country and from time to time depending on specific needs. The first programs were started some 18 years ago and new ones are still to be launched. It is thus very difficult to make direct comparisons between countries. However, some conclusions can be drawn about the use of incentives to create markets:

- No country can develop a sound industry without having access to results from basic R&D and must have its own R&D institutions.
- National R&D alone does not create markets.
- The use of direct market stimulation through grants and/or through premium prices paid per kWh have both proved effective within the EU.
- The right mixture of incentives reflecting actual and future needs has been crucial for achieving market development.
- Access to the public grid under fair commercial conditions has also been an important issue.

- The key element still missing, on a general European level, is direct payment to reflect the environmental benefit of producing electricity by use of wind energy. This has, to some extent, been included in some national programs.

The use of direct grants to cover a proportion of installation costs has been quite a successful way of supporting development, particularly at the early stages, when it was difficult to obtain sufficient loans for investment in wind turbines. In a typical approach model a National Government allocates funds for this purpose one or two years in advance.

When such a stimulation is successful, it is often followed by a “stop and go” effect because the money is used several months before the end of the year and thereby creates a discontinuity in the market development and creates severe problems for the supply side of the market. The use of direct grants should be carefully considered as part of a general framework which should be in place before the launch of such a program. The “stop and go” effect has been experienced in Sweden and Denmark.

Use of premium prices paid per kWh has been shown to be the most effective tool in stimulating markets. Experiences in both Denmark and Germany demonstrate the efficacy of this approach.

The bidding process, as carried out under the British NFFO scheme, has been shown to be an effective tool for reducing the price of electricity from wind energy by creating fierce competition between manufacturers and developers. That is the good side of “competitive bidding”. The negative effects are that, as the bidding process and awarding of contracts takes place once a year or every two years, this leads to a lot of discontinuity in development and makes it very expensive for small enterprises to participate. Another lesson learned from the UK is that without systematic planning in place in the form of general guidelines, which include zoning land areas for wind energy utilisation, competitive bidding results in competition around the same sites - the best sites. This is the principle reason behind objections from the public directed towards wind energy. However, the nature of “competitive bidding” matches the spirit behind an open and competitive European electricity market very well.

From a Government’s point of view, it seems more politically responsible to support “kWh’s” - they get what they pay for, instead of supporting “kW’s”. The latter has in some cases lead to manipulation of the subsidy system instead of the minimisation of costs.

Tax subsidies have also been shown to be an efficient tool. However, this model does not encourage the optimisation of technology. Some of the worst examples have been seen in past developments in the US. The public image of wind energy is not enhanced if it is seen as being a means of tax reduction rather than an environmentally friendly way of producing electricity.

Based on the experience described above, an ideal model should include:

- A fair price paid for wind generated electricity which reflects the environmental benefits of producing electricity without the emission of pollutants.
- A well-organised institutional framework.
- Planning regulations which favour wind energy.

6.3 Schemes and models by country within EU-15

Table 6.3 presents a brief review of the stimulation means used by countries within the EU and it can be seen how they are combined in individual markets. Furthermore, remarks about some of the special conditions linked to the incentives are given in the table under comments.

7 CONCLUSIONS

This volume has outlined the history of the wind energy market, summarised the present status and attempted to predict its future. The analysis has shown that the market remains political and that various means have been used in different countries to stimulate it. Some means have been considerably more effective than others and recommendations, based on these experiences, have been made about the most effective means for the future. It is concluded that given the proper conditions and, particularly, the proper recognition of the environmental benefits which are brought by the use of wind energy the market is large and is growing. Although it still remains dominated by the EU countries at present the future projections suggest that this will change in the near future and major export markets for the European industry are developing. The European industry is very well placed to exploit this market as well as to make a major contribution to the supply of the EU market for clean energy provided proper support continues.

Country:	Public funded R&D	Public funded Demo	Support to investment (direct grants)	Premium kWh payment	Financial incentives, loans etc.	Tax incentives	Comments
Austria		x (low)		x (low)			
Belgium		x (utilities)		x (green payment)			
Denmark	x (high)	x (utilities)	x (expired'89)	x (modest)		Cooperatives	The kWh-price is set by law to 85 % of the consumer price
Finland			x				
France				x (Eole 2005)			A 250-500 MW programme managed by EdF recently
Germany	x (high)	x (Länder)	x Länder in the past)	x (high) + "250 MW-pro"	Deutsche Ausgleichbank		The kWh-price is set by law to 90 % of the consumer price
Greece	x	x (utilities)	x	x (modest)	Soft loans		Do not work so far. In spite of new legislation in 1994.
Italy	x (utilities)	x (utilities)		x (licenses)	GEPI		A high start payment declining after 8 years.
Rep. Ireland	x	x	x (AER)	x (AER)			
Luxembourg				x			Premium paid for CO2 reduction and for capacity credit
Netherlands	x (high)	x	x (expired)	x	Green funds	"free depreciation"	
Portugal	x	x	x	x (low)			Payment to IPP's regulated by law.
Spain	x	x (P.E.R 81)		x	?		Tariffs regulated each 5 year
Sweden	x (high)	x (utilities)	x (15% today)	(clean energy premium.)			
UK	x (high)	x		x (NFFO)			The NFFO-schemes have created very low prices

As of September 1997, the "shaded" countries have shown most successful by their use of incentives. All have installed> 50 MW/year in the past.

Table 6.3: Means of stimulation of wind energy in the EU-15.

8 REFERENCES AND NOTES

1 Danish International Development Assistance

2 In the "Best Practice" Scenario of the TERES II report, the contribution from renewable energy by 2020 comes to a potential to be utilised of 228 Mtoe of which wind power will cover 4,4 % equal to approx. 116 TWh calling for about 50,000 MW of installed capacity.

3 Wijk & Coelingh, Utrecht University, 1993.

4 The technical potential are defined as, 4-10 % of available land area swept with average wind speeds higher than 5,5 m/s 10 above ground level.

5 Boston Consulting Group.

6 This is presently not the case in the USA.