European Commission
Directorate-General for Energy

WIND ENERGY - THE FACTS

Volume 3

INDUSTRY AND EMPLOYMENT

EXECUTIVE SUMMARY

Introduction

The wind energy industry has grown in capacity and maturity very rapidly over the last 15 years. It has created a new means of generating clean electricity, new jobs and new factories. This volume explores the industrial aspects of the development and sets out the conditions required to ensure that the industry continues to realise its potential in an effective and economic fashion.

Jobs

Under current European market conditions the installation of each 1 MW of wind power creates jobs for between 15 and 19 people. In more labour intensive parts of the world this figure may double. Further jobs will also be created, including jobs in operation, service and maintenance. The timetable for this development is set out in the table below.

Year	EWEA goals MW	Jobs created Man years
1996	3,500	
2000	8,000	72,000
2010	40,000	512,000
2020	100,000	960,000

Anatomy of the industry

As is common for a new area of activity the wind energy industry started with a large number of small players. The development of the technology and the market have gone hand in hand. Over the last five years there has been a rationalisation and reduction of the number of participants and a strengthening of the capital base which supports them. There has also been a move towards vertical integration of both manufacture and development of wind farms. Wind energy is a growth area and is considered as such by the financial sector. The main players are becoming established with utilities and members of the conventional power industry are taking a keen interest in wind.

As markets distant from the home manufacturing bases are established technology transfer has been successfully implemented to provide local facilities. This approach is expected to find widespread use in the future.

Offshore wind energy provides opportunities for the development of a whole new branch of technology within the wind energy industry which will involve companies from the established offshore energy field. It will provide a major new market with negligible effect on the environment.

Conclusions

The wind industry is developing rapidly. It is moving from the pioneering stage in both technological and commercial terms. 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. This move is to be welcomed and is a clear sign that, in commercial terms, wind is just one of the alternatives along with coal, oil and gas - part of the energy industry. Given appropriate market conditions wind energy will provide hundreds of thousands of new jobs in an exciting clean industry.

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1 EUROPEAN WIND INDUSTRY IN A GLOBAL CONTEXT

1.1 Brief historical review

A more detailed introduction to the history of the market development is provided in Volume 5. A brief summary is reproduced here.

The first large market to appear was in California, USA. The growth of this market stimulated the development of wind technology in many other countries. Newly established manufacturers of wind turbines from Denmark, the UK, Germany, Japan and the Netherlands shared the market in California with several US companies. About 14-15,000 wind turbines were installed within very few years. Nearly 60 per cent of the wind turbines came from European manufacturers (mainly Denmark) and during this period of time the size of the average wind turbine increased from 55 kW to 100 kW. Many different designs were installed and tested during these years and the industry gained a lot of experience. The market in California demanded a maximum return from available sites and led to larger scale projects which we now know as "wind farms".

In the years from 1986-1990 the market in California declined causing major financial difficulties in the wind industry. The market had grown very fast and many companies had been too reliant on it. Many companies went bankrupt and disappeared, while others were reconstructed with new capital The numbers of manufacturers had been reduced and so had the many design concepts. The simple Danish, 3-bladed, stall regulated design survived and was up-scaled to provide more cost effective 250 kW units. Pitch regulated wind turbines became more prevalent. These technological developments suddenly made it economically feasible to install wind power in many new markets and this was the beginning of the second era of global wind power development.

The Californian developments were followed by more sustained market stimulation in Europe which has continued to the present. The European Union (EU) share of the market has been relatively high throughout the whole period of time. Table 1.1 shows that the average European market share over the past 6 years has been more than 70 per cent of the global market. A similar figure is expected for 1997.

Year :	MW World wide	Increase %	European MW	Increase %	Europe 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 %

- 1997 figures still estimate as per November 1997.

Table 1.1: Installed capacity per year world-wide 1990-96 and the European percentage

1.2 Market creates industry

There are several major milestones in the development of the modern wind industry. California was the training ground for the European wind industry. Some fifty per cent of the generating capacity in California came from European made wind turbines, in particular, Danish 3-bladed stall regulated concept machines. In California it was proven that tax incentives and lucrative utility contracts, together with high wind regimes could create a market boom. For the European wind turbine industry a record high rate of exchange of the US currency made it a genuinely economic wind rush. A more modest, but still lucrative, market in Denmark provided encouragement to new manufacturers in the period 1980-1986. Both markets collapsed in the mid 1980s. In California, the tax incentives disappeared and in addition a weak dollar made the market somewhat bleak. In Denmark an overnight political decision introduced a new requirement that investors must live in the municipality where the wind turbines were located and have a prescribed level of electricity consumption. This political step sent warning signals to bankers financing wind turbine projects. The manufacturers experienced a shrinking credit facility and the market expansion in Denmark came to a dramatic halt.

Markets were re-established in the beginning of the 1990s. The STREG "Stromeinspeise-gesetz" in Germany marked a new era for the wind industry and the manufacturers concentrated on upscaling the wind turbine designs successfully. The NFFO programmes in the UK government set goals in Spain and activity in other European countries gave further stimulation to the industry.

2 CHARACTERISTICS OF THE EUROPEAN INDUSTRY IN GENERAL

In the beginning of the 1980s the average wind turbine size was only about 55 kW and this has increased by more than ten times in just a decade. California and Denmark both have a large number of small wind turbines since they were among the first markets to be developed. Thus, although Denmark and Germany had almost the same number of units installed by the end of 1995, the installed capacity amounted to 1,132 MW in Germany as opposed to 630 MW in Denmark. Table 2.1 illustrates the growth in wind turbine unit rating and the trend towards reduced generating cost since 1980.

Year	Capacity (kW)	Rotor (m)	kWh/year [1]	Costs ECU/kWh
1980-1983	55	15	110,000	0.090
1984-1985	75	17	140,000	0.076
1986-1988	120	21	260,000	0.067
1989-1992	250	27	470,000	0.049
1993-1994	400-500	37-40	1,200,000	0.045
1995-1996	500-750	40-48	1,500,000	0.040
1997-	600-1500	43-66	na	na

Table 2.1: Upscaling of commercial machines

The reduction in costs over the years is based on a combination of several factors. The two most significant factors are that the total efficiency has increased (rotor power coefficient (Cp max) has increased from 0.35 to 0.38) while the installed mass per swept m^2 has been reduced. The size increase of wind turbines has also had a positive effect by reducing the costs associated with operation and maintenance (O&M). Today O&M costs are approximately 0.009 ECU/kWh compared to 0.036 ECU/kWh in the mid 1980s. Availability has also been improved significantly from a value of about 60% for the best machines in the 1980s to about 98-99% for a typical commercial wind farm in 1997.

Government R&D programmes for wind power were initiated in the mid 1970s and the test station at Risø in Denmark was founded to establish the standards for wind turbines connected to the public grid. Research stations appeared at ECN Petten in the Netherlands and at Kaiser Wilhelm Koog in Germany. Several other countries launched R & D programmes to investigate wind technology in depth. Market stimulation programmes were introduced in several EU countries. In Denmark the market was stimulated by a subsidy in which 30 per cent of the capital costs of the certified wind turbine was refunded. This was gradually phased out as wind turbines became more and more effective and the programme came to a stop in 1989. In Germany, the introduction of the large scale 250 MW R & D programme and the law *(Stromeinspeisegesetz)* that 90 per cent of the average utility price should be paid for renewable energy generation, made a tremendous step forward in the market. In the UK the NFFO programmes encouraged large wind farm projects. In Spain the P.E.N. - 91 plan aimed for 1,200 MW of connected wind energy supply for the period 1991 - 2000. Direct investment incentives and incentives in the form of support per kWh of electricity produced are among the support mechanisms employed.

Also several other EU countries have set goals in their energy planning where wind energy will play a part in new installed capacity. Overseas, India and the People's Republic of China are setting goals for the exploitation of wind energy.

2.1 Manufacturers

By the early mid 1980s several large companies such as Westinghouse, Boeing, Grumman, MAN and MBB had attempted to enter the wind turbine industry. The aerospace background of these companies impeded them in developing the most appropriate civil technology. More or less all of these industries left the wind turbine business at the time when it was most turbulent and unsure. This left the market place to small and medium sized companies looking for new niche markets related to their established skills. Their origins were the agricultural machinery business, shipyards, electronics industry, mechanical engineering industries. Company development has been substantial since the mid 1980s and the ten largest European wind turbine manufacturers now have very significant sales revenue. In Denmark, for example, the two largest companies, Vestas Wind Systems A/S and NEG Micon, are among the largest 300 companies in terms of sales and these companies alone directly employ some 1,700 people.

Some 8 years ago the only wind turbine manufacturer offering serious competition to the Danish wind industry was US Windpower (later Kenetech). This situation has now changed substantially, and today there are a number of other European manufacturers supplying grid connected wind turbines in the size range of 100-1500 MW. The US industry is represented by Zond Energy Corp. The start up of these manufacturers has been much assisted by national programmes which support the development of wind power utilisation. The nature of the support varies throughout the EU states.

	Accu. MW 1995	**Installed MW 1996**	**Share 1996 %**	**Accu. MW 1996**	**Share accu. %**
1.VESTAS, DK	996	308	23.8%	1304	20.6%
2.KENETECH, US *	686	20	1.5%	706	11.1%
3.MICON, DK **	397	134	10.4%	531	8.4%
4.ENERCON, D	355	153	11.8%	508	8.0%
5.BONUS, DK	347	117	9.1%	464	7.3%
6.NORDTANK, DK **	344	110	8.5%	454	7.2%
7.TACKE, D *	201	83	6.4%	284	4.5%
8.NEPC, India	226	36	2.8%	262	4.1%
9.MITSUBISHI, Japan	200	4	0.3%	204	3.2%
10.WIND WORLD, DK	154	29	2.2%	183	2.9%
11.NEDWIND, NL	118	32	2.5%	150	2.4%
12.WIND MASTER, NL	121	19	1.5%	140	2.2%
13.NORDEX Balcke-Dürr, DK	97	38	2.9%	135	2.1%
Other manufacturers	937	72	5.6%	1009	16.0%
Total	**5179**	**1155**	**89%**	**6334**	**100%**

* Kenetech is in a mode of declared bankruptcy. Tacke GmbH has been bought by Enron.
** Nordtank Energy Group A/S and Micon A/S merged into the new company NEG Micon A/S on July 4 1997. The combined turnover of these companies will place NEG Micon in 2nd place.

Table 2.2: The largest manufacturers market share
(Ranking based on cumulative capacity)

Among some of the newcomers to this list since 1990 are Enercon, Tacke and NEPC. All of these companies have had ideal conditions in their domestic market, but they have little experience outside of their own country. The Danish manufacturers situation is quite the opposite, their main market has been in export.

Among the EU states the Danish participation is the most significant in the world market development. Nearly 50 per cent has been delivered by Danish manufacturers and the equivalent figure in the European market context is 65.6%. In the world market only Kenetech, USA (now in receivership), Mitsubishi Heavy Industries, Japan and NEPC of India have played a significant role in the development of global wind power.

2.2 Size and type of companies

In this section a brief summary of the major wind turbine manufacturers is provided. An exchange rate of 7.4DKK = 2DM = 1 ECU has been used.

Bonus Energy, a Danish manufacturer, has developed and sold wind turbines for more than 15 years. Bonus has sold more than 2000 units. The Bonus wind turbine range extends from 150 kW to 1 MW and their design is based on a 3-bladed, constant speed, stall concept. The new 1 MW machine is a little different from previous models as it employs active stall.

Number of employees	230 people
Annual turnover latest financial year	98 million ECU
World-wide installed MW during 1996	117 MW

Micon A/S, a Danish manufacturer, has developed and sold wind turbines since 1983. Micon has sold more than 2000 wind turbines and manufactures in Denmark, India and the USA. Micon has a license agreement in India with NEPC. Micon´s wind turbine range extends from 225 kW to 1 MW and their design is based on a 3-bladed, constant speed, stall concept. Micon A/S merged with Nordtank Energy Group A/S on July 4, 1997.

Number of employees	249 people
Annual turnover latest financial year	102 million ECU
World-wide installed MW during 1996	162 MW

Nordtank Energy Group A/S, a Danish manufacturer, has produced and sold wind turbines since the early 1980s. More than 2000 Nordtank wind turbines are producing electricity in 15 different countries today. Nordtank´s wind turbine range extends from 550 kW to 1.5 MW and their design is based on a 3-bladed, constant speed concept. Nordtank was floated on the Danish stock exchange in 1995 - the first European wind turbine manufacturer to take such a step. Nordtank Energy Group A/S merged with the Danish Company Micon A/S on July 4, 1997 forming the new company NEG Micon A/S.

Number of employees	225 people
Annual turnover latest financial year	97 million ECU
World-wide installed MW during 1996	110 MW

NEG Micon A/S, a Danish manufacturer formed in late 1997 as a result of a merger between Nordtank Energy Group A/S and Micon A/S. The company is the second largest wind turbine manufacturer in the world. NEG Micon A/S offers WTG´s in the range 150 kW to 1500 kW.

Nordex, a Danish manufacturer, has developed and sold wind turbines since 1987. Nordex was the first to commercialise their 1 MW model especially in Germany. Nordex' wind turbine range extends from 225 kW to 1.2 MW and their design is based on a 3-bladed, integrated gearbox, constant speed, stall concept. Nordex was bought in 1996 by the German company Balcke-Dürr GmbH which is part of the large Deutsche Babcock Group.

Number of employees	130 people
Annual turnover latest financial year	21 million ECU
World-wide installed MW during 1996	31 MW

Vestas Wind System A/S, a Danish manufacturer, is the largest in the world. Since the early 1980s Vestas have installed some 1,200 MW (5500 units) in more than 20 different countries. Vestas manufactures a large proportion of their machines themselves which includes blade production (>12,000 blades have been produced). Vestas' wind turbine range extends from 225 kW to 1.65 MW and all of these are pitch regulated. Vestas uses a partial variable speed system on their 600 kW and 1.65 MW model.

Number of employees	1200 people
Annual turnover latest financial year	257 million ECU
World-wide installed MW during 1996	308 MW

Wind World A/S, a Danish manufacturer, has developed and sold wind turbines since 1987. Wind World has produced more than 900 wind turbines. Wind World's wind turbine range extends from 170 kW to 750 kW and their design is based on a 3-bladed, integrated gearbox, constant speed, stall concept. Wind World introduced a semi variable speed system in 1996. This system is available on the most recent models.

Number of employees	98 people
Annual turnover latest financial year (estimates)	45 million ECU
World-wide installed MW during 1996	40 MW

Enercon GmbH is the largest German wind turbine manufacturer. Enercon was established in 1984 and has worked with energy converters and wind turbine development since then. Enercon introduced a new design concept to the market in 1992/93 which was a multipoled gearless wind turbine. By the end of 1996 some 300 MW of the E-40/500 kW had been installed. They have especially been strong in Germany where they have had a market share of more than 30% between 1994-1996. During 1996 Enercon made a new alliance with the German utility PreussenElektra which is only for export purposes. Enercon has established their own facilities for blade manufacturing.

Number of employees	900 people
Annual turnover latest financial year (estimate by BTM Consult)	144 million ECU
World-wide installed MW during 1996	153 MW

Tacke Windtechnik GmbH is the second largest German wind turbine manufacturer. Tacke started to develop wind turbines in 1984 and grew from a long established gearbox manufacturer. A separate wind turbine company (Tacke Windtechnik) was established in 1990. Tacke manufacture wind turbines in the range 80 kW to 600 kW and installed a prototype of their newest 1.5 MW model in April of 1996. Tacke´s design is a based on a 3-bladed, integrated gearbox, constant speed, stall concept, although their latest 1.5 MW model is pitch regulated and operates at variable speed. Tacke like Enercon has only a little experience outside Germany. Tacke Windtechnik went into receivership in July 1997. Tacke Windtechnik was taken over by Enron Wind Corp in October 1997.

Number of employees	160 people
Annual turnover latest financial year (estimates)	67 million ECU
World-wide installed MW during 1996	83 MW

NedWind Rhenen BV is the largest Dutch wind turbine manufacturer. NedWind was established in 1990 as a merger between 3 different smaller companies who had all been involved in the wind industry since the early 1980s. NedWind is mainly active in the Netherlands but have also installed wind turbines in the USA and India. NedWind´s wind turbine range includes both 2 and 3-bladed WTG´s. They are mainly known by their 2-bladed N40/500kW and N54/1MW.

Number of employees	130 people
Annual turnover latest financial year (estimate by BTM Consult)	30 million ECU
World-wide installed MW during 1996	32 MW

WindMaster Nederland, formerly part of the Belgian HMZ WindMaster company, a very early user of pitch system regulation of the blades, is the second largest wind turbine manufacturer in the Netherlands. WindMaster has been involved in the industry as a manufacturer since 1978 and has installed wind turbines in Belgium, the Netherlands, India, UK and the USA. WindMaster´s wind turbine range also includes both 2 and 3-bladed WTGs. They are mainly active with their 2-bladed 750 kW models today but a 3-bladed 300 kW model is also available from WindMaster. It seems likely that WindMaster will supply WTGs for one of the early offshore developments in the UK.

Number of employees	75 people
Annual turnover latest financial year (estimate by BTM Consult)	17 million ECU
World-wide installed MW during 1996	19 MW

Emerging manufacturers

The following list represents companies who are smaller in terms of production than those listed above, but who nevertheless have significant production.

Desarrollos Eólicos is a Spanish wind turbine manufacturer and 100% owned by Abengoa, a Spanish company engaging in wide ranging activities within the field of power electrics and electronics. Abengoa first initiated a joint venture with the then US Windpower (now Kenetech). This joint venture was ended in 1992. Abengoa then moved on to start a new company called Desarrollos Eólicos. Since then, they have been working on an upgraded 300 kW model based on their AWP 100 turbine and are developing a 600 kW model. Some 60 units of their new 300 kW WTG were installed during 1996. Desarrollos Eólicos has a strong financial partner in Abengoa. Abengoa also owns a company which provides blades for Desarrollos Eolicos WTGs.

Number of employees	102 people
Annual turnover latest financial year	20,4 million ECU
World-wide installed MW during 1996	19,8 MW

Ecotécnia is a Spanish wind turbine manufacturer. They have a 225 kW wind turbine on the market and installed 2 units of their new 600 kW during 1996. This model is expected to be used in several larger projects during 1997. Ecotécnia started working with renewable energy in the late 1970s, primarily solar energy at the beginning. Ecotécnia has like other Spanish companies mainly sold their wind turbines in Spain, with 10 units installed in India in 1995.

Number of employees:	53 people
Annual turnover latest financial year (estimates)	12 million ECU
World-wide installed MW during 1996	18,3 MW

Gamesa Eólica is a Spanish joint venture established and owned by Gamesa Group (51%), Vestas (40%), and Sodena (9%). Sodena is a branch of the local government. Gamesa Group is a large company with activities in most parts of the world. The company is owned by the electricity company Iberdrola (40%), a bank, BBV, (49%), and the founder owns the last 20%. The Gamesa Group has a wide product range including parts for the aviation industry, gear boxes, electronics, composite components etc. The Gamesa Eólica joint venture began at the end of 1993 and is today the largest wind turbine manufacturer in Spain.

Number of employees	250 people
Annual turnover latest financial year (estimate by BTM Consult)	120 million ECU
World-wide installed MW during 1996*	130 MW

* this figure is included in Vestas MW

MADE is 100% owned by the Spanish electricity utility ENDESA. MADE´s largest model on the market is a 330 kW wind turbine, but they are working on a 5-600 kW model of which the first models were installed in 1996. Production is expected during 1997.

Number of employees	(estimated) 80 people
Annual turnover latest financial year (estimates)	17 million ECU
World-wide installed MW during 1996	18,5 MW

It is clear from the descriptions above that only relatively few of the European manufacturers of wind turbines have decided to manufacture their own blades. The rest of the remainder purchase them from specialist manufacturers. A list of the major suppliers follows:

LM Glasfiber A/S, a Danish company, was established in 1940 and is today the largest manufacturer of glass fibre reinforced polyester in Scandinavia. The company has more than 40 years experience with fibre reinforced plastics including some 15 years with advanced carbon fibre construction. Today LM Glasfiber A/S delivers rotor blades for wind turbines to the major part of the wind turbine manufacturers. LM Glasfiber A/S has subsidiaries and/or offices in 6 different countries throughout the world. The company has a turnover of approximately ECU 81 million.

Aerpac bV was established in 1989 as a spin off from Dutch Stork. The company employs some 150 people. Aerpac bV delivers blades for wind turbines in the size range of 200-1500 kW. The company is also active in Spain, the UK and the United States. The company has a turnover of approximately ECU 20 million.

Atout Vent S.A. This French company was launched in 1988. The company`s first blades were for the Darrieus vertical axis wind turbines. Since 1990 the company has built blades for horizontal axis machines in the range from 4 m diameter to 65m diameter. The company employs some 70 people and the turnover is said to be around ECU 5 million.

Rotorline bV This Dutch Company grew from the parent company NedWind bV and is now manufacturing blades for several other manufacturers of wind turbines. Presently the company delivers blades for machines with diameters between 30 and 55m. Lately the company has delivered blades for the 1 MW NedWind wind turbine. Presently the company employs some 60 people and is expected to have a turnover of approximately ECU 5 million.

Abeking & Rasmussen Faserverbundtechnik GmbH This company was established in 1990 as a daughter company of the old shipbuilding company Lemwerder near Bremen. The company employs 130 people and had a turnover of approximately ECU 15 million in the year 1996.

2.3 Export trends

Table 2.3 shows the export share for the largest wind turbine manufacturers during 1996. This year did not show any considerable changes in the export trends among the leading companies. The Danish companies are still exporting a very large proportion of their machines although there was a slight decline in 1996 [2] due to an extremely good year in the domestic market. The German companies are still only exporting a small part of their total sales.

	Total sales 1996 MW	Domestic/MW	Export MW	Export share %
VESTAS	308	80	228	74.0%
ENERCON	153	135	18	11.8%
MICON*	134	74	60	44.8%
BONUS	117	23	94	80.3%
NORDTANK*	110	24	86	78.2%
TACKE	83	74	9	10.8%
NORDEX	38	2	36	94.7%
NEPC	36	36	0	0%
NEDWIND	32	7	25	78.1%
WIND WORLD	29	11	18	62.1%
KENETECH	20	0	20	100%
WIND MASTER	19	14	5	26.3%
MITSUBISHI	4	0	4	100%
Total	**1083**	**480**	**603**	**55.7%**

BTM Consult ApS - November 1997

* Nordtank Energy Group A/S and Micon A/S merged into the new company NEG Micon A/S on July 4 1997.

Table 2.3: Sales to domestic market and export share in 1996

Table 2.3.1 below shows the total sales for the same companies for the past 3 years and the average export share in this period of time.

	Total sales 1994 MW	Total sales 1995 MW	Total sales 1996 MW	Sum 3 years MW	Average Export share
VESTAS	149	273	308	730	79.9%
ENERCON	102	163	153	418	9.3%
MICON*	63	117	134	314	60.8%
BONUS	55	88	117	260	80.4%
NORDTANK*	61	66	110	237	85.7%
TACKE	79	110	83	272	8.5%
NORDEX	22	55	38	115	98.3%
NEPC	62	164	36	262	0%
NEDWIND	23	39	32	94	60.1%
WIND WORLD	24	83	29	136	87.9%
KENETECH	104	150	20	274	52.6%
WIND MASTER	1	23	19	43	49.5%
MITSUBISHI	0.5	2	4	6	66.7%

Total	**746**	**1333**	**1083**	**3161**	**54.0%**

* Nordtank Energy Group A/S and Micon A/S merged into the new company NEG Micon A/S on July 4 1997. Totally this company's turnover will place NEG Micon in 2nd position.

Table 2.3.1: Average export share for the past 3 years

2.4 Alliances in the market

The companies in the industry are becoming more international. Many of the European companies have established subsidiaries or joint ventures on their export markets. In India more than 20 companies have found local partners. Among these companies are:

Bonus	REPL Engineering Ltd
Micon	NEPC
Nordex	Bharat Heavy Electricals
Nordtank	Textool Company Ltd
Vestas	RBB
Wind World	Arul Mariamman Textiles Ltd
NedWind	Windia Power Ltd
Made	Baron Industries Ltd
Lagerwey	DAS Lagerwey

Several other European manufacturers also took immediate action when the Indian government set the goals in the wind energy exploitation. Some formed their own subsidiary. Enercon established their own subsidiary, Enercon (India) Ltd. LM Glasfiber A/S, the Danish blade supplier, linked up with NEPC.

In 1996 Enercon made a new alliance with the German utility PreussenElektra. This alliance is only for export purposes and has not yet been utilised in any projects.

Vestas established a joint venture in Spain in 1994 with Gamesa Eólica S.A. and with the Italian conglomerate Ansaldo Spa in 1997.

Kenetech of the US established a partnership in the UK (1995) with one of the big utilities in Northern Wales, MANWEB. This alliance has been dissolved as a result of the bankruptcy of Kenetech.

In 1996 the German company Balcke-Dürr GmbH bought 51% of the stocks in Nordex. Balcke-Dürr is part of the large Deutsche Babcock Group which consists of 200 different companies and some 36,000 employees. Balcke-Dürr is mainly active in development of technology for power plants and they had a turnover of about 1 billion ECU in 1995. Enron's arrival in the wind energy business is thus highly significant.

Zond Systems Inc., (the major US developer) was bought by Enron Corporation in January 1997. Zond will hereby become a subsidiary of Enron Renewable Energy Corp. Enron is involved in the conventional energy business all over the world and also has an interest in solar energy (PV) in the Amoco/Enron Solar partnership. Enron operates the largest natural gas transmission system in America (second in the world) and is also the largest purchaser

and marketer of natural gas and non-regulated electricity producer in North America. Enron´s total assets are approximately USD 15 billion [3].

As the American market returns, it is expected that new alliances will be made between US developers and European manufacturers. One alliance has formed outside the USA, between Bonus and SeaWest, directed specifically at the market in Spain (Galicia).

The annual turnover of the wind industry, in the range of USD 1.5 billion, will undoubtedly attract more international companies to the industry. They may come from the utility industry as well as from the financial sector. Alliances between manufacturers and utilities may be a significant future trend.

An interesting development of the past two years is the entry of European Banks into two Danish companies as majority shareholders.

- UBS (Union Bank of Switzerland) became a 75% shareholder of Nordtank Energy Group in December of 1993. Nordtank was floated on the Danish Stock Exchange in the fall of 1995 after which UBS' share was reduced to 14.6%.

- Mees Pierson, previously part of ABN Amro Bank of the Netherlands, bought 70% of the shares in Vestas which since then has increased to some 80% of the total (Dec. 1996).

Mergers

Two major competitors Nordtank Energy Group A/S and Micon A/S have merged to form the new NEG Micon A/S. For historical reasons and in order to provide background information both Nordtank Energy Group A/S and Micon A/S have been listed above as two independent companies.

2.5 Marketing abroad and short term excess capacity

There has been fierce competition in the wind industry over the years. A comparison of world market estimates in Volume 5 (Market Development) with the present manufacturing capacity of the 10 leading manufacturers shows that there may be, in the short term, an excess of manufacturing capacity. Production capacity among present wind turbine manufacturers is approximately 35-40 per cent higher than the present demand. It is estimated that there is a present capacity among manufacturers to cope with a world wide demand of about 2,300 MW without new manufacturing facilities. However, the EWEA's target for the period beyond 2000 envisages a 3,200 MW production rate. Manufacturing capacity is therefore not a constraint on the wide scale exploitation of wind energy.

It is likely that the market place will remain very competitive. The manufacturers' capacity is reflected in their marketing and sales efforts and finally in the price structures and their willingness to accept lean orders. The Indian market in 1993-1994 clearly illustrated the highly competitive nature of the business. It is estimated that the five largest wind companies

in the world could have supplied almost all the wind turbines installed during 1995 and 1996.
According to Volume 5: Market Development, the annual global market for wind power will not exceed 2,300 MW until beyond the year 2000.

2.6 The role of the European utilities

After early involvement, the major utilities later withdrew from the wind energy market place. The present players have, however, now developed the industry to a level where it is again of interest to the power supply companies.

A major force in the development of wind energy has been the close cooperation between a large group of committed private people as investors, a group of committed manufacturers, and, in some countries, politicians with the political will and vision to create favourable market conditions. To date the role of the utilities has been, at best, passive and, in some cases, actively negative. It is fair to say that the development of the wind energy industry has happened independently of the utilities. This position might change as wind turbines grow to MW scale.

The industry has developed its technology to a point where it is ripe for exploitation by the power companies. The power industry see their customers now dealing with the present wind sector in a context where the share of the global market for energy production is being transferred from fossil fuels to renewables. The most interesting of the emerging renewables, moreover, is wind energy.

It is very difficult to envisage the structure of the electricity industry in 10, or even 5 years, but trends have emerged that suggest the way of the future. Electricity markets are becoming more global. Utilities are looking for development in the international market to expand their activities. Utilities will seek to merge and the number will reduce. The traditional boundaries between utilities such as electric, natural gas and oil are blurring. In order to compete in the impending deregulated energy market many utilities are becoming more diverse energy providers offering electricity and gas and even telephone and other communication services. To the benefit of the wind industry, they will also be providers of green electricity, mainly produced by wind energy, which is presently established as the leading renewable. The pace of these developments will be dictated by the timing and means of implementation of retail market competition. Such competition will occur but a lot of monopolistic road blocks have yet to be removed. It is still not known how comprehensive EU legislation will be.

In order to analyse the likely changes in the electric utility industry, it is necessary to differentiate various elements of the business. The production, the transmission and to a certain extend the distribution will still remain as monopoly businesses. This sector will be controlled by government appointed regulators. Only experience will prove how the legislative world will come to function in the new regime of liberalised energy.

There is a future for renewable energy technologies especially because of the environmental benefits. There is interest in renewable energy in many European countries and in the USA. These benefits have not yet been given a market value, and wind energy has failed to have a widespread appeal among the European utilities because of perceived costs and limitations. There is still a risk that, in a world in transition into a deregulated and competitive utility industry, the utilities interest in renewable energy can diminish. Nevertheless, political and public demands for clean energy can force the utilities to think in new directions. Last, but not least, the continually falling prices per kWh generated by wind power together with growing public interest and political support has given the electricity companies some surprises in their monopoly world.

There are a number of good reasons for an involvement/commitment from the utilities to enter into the world of wind power generation of electricity:

- It is renewable.
- It is pollution free.
- It is cheap - as a supplementary energy source.
- It has grown in size with commercially available wind turbine units large enough to be attractive to the electric utilities.
- It can be installed offshore in large wind parks with fewer planning restrictions
- The main players have become increasingly familiar in utility terms.
- The utilities can buy coal fired plants, nuclear plants, hydro plants and now also wind plants from the same company. The portfolio has been extended with the addition of the wind farm package.

In addition to the continuously improving technology, continuously decreasing prices, there has been a significant shift in the structure of the industry which has made the industry, as well as the machine, more “utility friendly”.

2.7 The internal and deregulated market

Wind energy in a liberalised European electricity market

In December 1996, the Council of Ministers of the European Union decided to launch a Directive on Liberalisation of the electricity market in Europe. The purpose behind this action is to include trading of electricity into the free market, as already done for almost all other goods and services. The reason for the late opening of the electricity market has been in the complexity of the utility industry, which in most countries has been a national monopoly or in other ways a protected sector without competition. The directive has been under negotiation for eight years, indicating how politically sensitive a subject it is! The directive will be in force by January 1st 1999 and before that all member states must include legislation and regulation on a national level to fulfil their contribution to the opening of the market.

The main contents of the new directive, which is a limited opening of the market over a period of 5 years, are listed below:

- Each country shall open its market to the extent of about 22 % from January 1999 and, the preparation will be increased to 32 % by January 2003.
- The liberalisation is created by the so-called TPA (Third Party Access), to be effected after two models: Negotiated Access/Regulated Access or by the Single Buyer Model (National System Operator take care of all trade on behalf of national consumers).
- Consumers who take more than 100 GWh (one hundred million kWh) per year, will always be allowed to buy their electricity where they want within the Union.
- Utilities will be reorganised in a way which separates production, transmission and distribution and the individual cost elements will be made transparent to the consumers.
- Monopoly status will only be available for System Operators and they will be under a strong control by the government to secure equal and non-restrictive access to the grid for all "free consumers" and electricity generators (providers).
- The member states are allowed to include extra costs for environmental requirements, and for other national strategic requirements related to their energy sector, e.g. security of supply. This allowance, which is not governed by the free market competition, is called PSO (Public Service Obligations). PSO costs will be distributed equally to all consumers within the country, and also among those buying cheap electricity from a foreign supplier.

The main intentions behind the Directive are:

- To increase the efficiency of electricity production and distribution.
- To make the cost of electricity production and distribution transparent to the customers.
- To stimulate cross-border trade and alliances within the utility industry.
- To save "surplus capacity" costs by more efficient use of existing power capacity.
- To maintain "security of supply" and secure low electricity prices for European consumers taking into account environmental issues related to electricity production.

The new Directive is being discussed in the electricity sector all over Europe. Many utilities have already taken strategic decisions about how to prepare themselves for the competition and to secure their future business. Alliances between producers in many countries and agreements on back-up capacity, etc. are under negotiation.

The big questions for the wind industry and other renewable technologies are : “Will renewable technologies be able to survive in that market? How will the prices move? Will priority be given to renewable generators?”

The answers are not simple. Experience from a few markets, which have established some kind of liberalisation is sparse. The UK, Norway, Sweden and Finland have started deregulation and/or privatisation of their utility sector.

No simple conclusion is evident as to whether deregulation favours or disadvantages the development of wind energy. The UK is a special case in this context - they have developed wind energy projects in the period when deregulation has taken place. This expansion in the UK is a result of the way in which the details of privatisation were organised and not as a result of privatisation per se.

Several studies have been carried out assessing the impact of the future liberalised electricity market on new renewable technologies. Some studies conclude that there will be hard times for renewable energy due to the fact that established utilities will be able to offer electricity at "short-term" marginal prices. Others rely on the use of the PSO tool, to provide security for a continued development and on national priority to support demand for renewable electricity.

The crucial point is: Will PSO costs - defined by national authorities and government - be accepted by the Commission and the EU Court if they contravene "free competition" requirement? There will be broad areas in which it can be a matter of interpretation of the directive whether a specific cost is a PSO element or a trade barrier.

The following advantages accrue for wind power in a liberalised market :

- Access to renewable generators will be easier.
- If the local supplier refuses to buy the electricity from a wind turbine there may be other customers elsewhere in the Union.
- Transparency of cost for thermal and nuclear generation will be to the benefit of wind energy, because wind energy does not have the "hidden costs" associated with conventional generators.
- Groups of consumers which have a preference for electricity from renewable energy sources, will be able to pool their purchase and find renewable generators to provide their electricity.
- Future offshore plants in the northern Europe may benefit from the expected strengthening of transmission lines from north to mid and south of the European continent.

There are also threats to wind energy in a liberalised market:

- Established and economically consolidated utility companies can offer very low prices to gain market shares, based on marginal cost calculations.
- Discussion between national parliaments and the EU Commission about justification of certain regulations for wind power (priority or prices) may create sustained periods during which the business is "stalled", awaiting notification of new laws and regulations.

The wind industry must examine the liberalised market treating it as a challenge which offers new opportunities for the sale of electricity. It must then fight hard to maintain the legitimate rights of renewable energy in the European electricity systems.
This argument is likely to be sustained on the basis of advantages to the environment and in "use of local resources".

If the European Union decides on specific targets for individual countries for reduction of CO_2 emission and makes such quotas tradable, then the liberalised market might be an excellent tool for rapid development of a "CO_2 free market" for electricity within the traditional market - a market with its own price level.

The framework for such a trade of CO_2 reduction must however be considered carefully, in order to ensure that countries do not simply trade CO_2 and avoid making any real efforts at CO_2 reduction in their own territory. There is a benefit to the EU in that such trade would allow better exploitation of the resources in a country blessed with good wind: the wind generated electricity could be exported to another country which has poor resources.

3 EMPLOYMENT AS OF 1996-97

A small survey conducted by BTM Consult ApS on the employment figures among the European manufacturers during the summer 1997 produced the following figures for the direct employment in the wind industry.

Manufacturer	No. of employees
Vestas	1200
Enercon	800
Gamesa	250
Micon	249
Bonus	230
Nordtank	225
Tacke	160
Nordex	130
NedWind	105
Wind World	98
Other European	600
Direct employment	**4047**

Table 3.1: Present employment status at selected wind turbine manufacturers [4]

The European manufacturers delivered some 1000 MW capacity in the year 1996. It should be stressed that the majority of the European wind turbine manufacturers are assemblers of components made by firms in other parts of in Europe. There is, therefore, a long list of associated sub-contracted suppliers providing components to the industry.

4 FUTURE EMPLOYMENT IN A EUROPEAN CONTEXT

Two extensive studies [5] have been undertaken recently on the subject of employment creation in the wind energy sector. A summary of the findings of these two studies is provided in the following paragraph:

In 1995 wind power created some 9,000 jobs in Denmark, including jobs with Danish turbine component suppliers. The impact on global employment from the manufacturing process is some 12,000 jobs. The installation of Danish turbines world-wide created another 4,000 jobs. Danish wind turbine manufacturers supply approximately half of the nameplate generating capacity in the world market. One may therefore estimate world-wide employment in the wind power industry to be in the range of 30,000 to 35,000 jobs in 1995.

However, the calculation of indirect employment is difficult in any industry and wind energy is no exception. Both investigations have shown enough evidence for the following statement to be used in a calculation for present and future employment in the wind energy sector in Europe.

1 MW of wind power installed creates jobs for 15-19 people under present European market conditions. In more labour intensive parts of the world this figure may double.

4.1 Potential future employment in the EU

In this section the figures above are used to estimate how many jobs may be expected within the EU member states. Table 4.1 has been used in Volume 5: Market development, and is now repeated to show how many jobs can be expected in the EWEA scenario.

Year	**EWEA goal** MW of installed Wind Power Capacity by end of the year	**Jobs created by the wind energy installed capacity** Man Years
1996	3,500	
2000	8,000	72,000
2010	40,000	512,000
2020	100,000	960,000

Table 4.1: Jobs created by the wind industry

It is noteworthy that should there be an installed capacity of 100,000 wind capacity there will be considerable maintenance, service and repairs to be undertaken during the operational life. There will also be refurbishment of the installed capacity.

It is estimated that the design life time of a wind turbine is approximately 20 years. From year 2030 and onwards the rate of refurbishment will be 5 per cent of the installed capacity equal to 10,000 MW capacity.

4.2 Offshore

Offshore installations will present a very large new potential for the development of wind energy. Within the EU states there have been offshore installations in Sweden, the Netherlands and Denmark which are listed below:

Location	Units	Made/Size	Capacity MW	Year	Country
Nogersund	1	Wind World 220 kW	0.22	1990	Sweden
Vindeby	11	Bonus 450 kW	4.95	1991	Denmark
Lely (Ijsselmeer)	4	NedWind 40-500 kW	2.0	1994	Netherlands
Tunø	10	Vestas V39-500 kW	5.0	1995	Denmark
Dronten I (Ijsselmeer)	19	Nordtank 600 kW	11.4	1996	Netherlands
Total units	**45**	**Total capacity MW**	**23.57**		

Table 4.2: Installed offshore projects in the world

The first offshore wind turbine was installed in 1990 by Wind World in Sweden. Since then four other projects have been installed, two in Denmark and the other two in the Netherlands. Table 4.2. shows that all together there are 45 wind turbines with a total capacity of 23.57 MW. A new offshore wind farm was installed in the Netherlands by Nordtank. This offshore wind farm consists of 19 units and is the largest so far.

All of these offshore projects are installed relatively close to the shoreline, between 1-5 km. The most recent project which is at Dronten in the Netherlands is located just some few metres off a pier. These projects are all intended as pilot or pre-commercial projects. Many aspects of offshore operations must be explored before large scale development can start, such as technical durability under these conditions, access for service, their impact on birds, fish, etc.

Large scale offshore wind power development will therefore most likely not begin before the end of this century, when the large scale 1.65 MW wind turbines have been well tested on land. A potential of 8,000 MW has already been identified on just 4 different sites in the surrounding waters of Denmark. These areas are all located within 20 km offshore and with shallow water between 5-10 metres. The Danish government estimates that some 4,000 MW of offshore wind power will be installed by the year 2030. The Danish Minister of Environment & Energy announced in March 1996 that a new committee with members from the Danish Energy Agency and the Danish utilities should have a plan prepared for future offshore wind energy development by the 1st July 1997. There are also major plans for offshore wind energy in Sweden, Germany and the Netherlands. A contract has already been let for a 30 MW wind farm under the UK NFFO.

It is likely that the offshore market will demand large scale machines which are already available in prototype form for application onshore. For the most part, manufacturers seem to adhere conceptually to the design principles of their smaller machines in the design of their MW plant.

According to information provided by manufacturers, MW machines will be delivered to projects in 1997 in increasing numbers. It is expected that as the offshore market evolves new machines will emerge which are optimised for that particular application.

Both development in the offshore market and in the MW class of wind turbines will require many new skills from the handling of raw material in the factory to the management of system for access and erection. The development of MW technology for offshore will push transportation and logistical factors to the limit. Much of this way has already been paved by the offshore oil industry but specific issues of power system electrics within wind farms and many others will require attention.

The exercise to locate suitable sites for the installation of offshore wind power requires skill in some new areas:

- archaeology
- biology
- geology
- marine-biology

There will be further requirements to deal with commercial fisheries, defence and communications agencies.

An investigation by a consortium in the Danish utility area showed foundations to be significantly cheaper than was previously anticipated. This implies that deeper water locations can be more readily exploited. One of the major challenges offshore lies in the logistics of maintenance and repair, daily monitoring and control of offshore installations. The present experience is very limited. As can been seen from the Table 4.2, only a few projects have more than three years of continuous operation. Experience gained so far does not show any significant increase in maintenance costs, although problems with access have been experienced.

There is, however, a strong belief that, in the long run, costs may decrease further due to an environment with much less turbulent air flow through the rotor. It is nevertheless a challenge to the manufacturers to present evidence that some of the basic specifications of an offshore wind turbine are fulfilled.

- relatively airtight nacelle
- system for dehumidification
- finish of all surfaces according to highest corrosion class
- heat exchanger for cooling air for generators as well as gearboxes
- permanent crane or lifting equipment in nacelle for small component changes with fixing points for the cranes
- transformer and high voltage switch gear inside tower

These are a few new areas requiring attention to allow the considerable promise of offshore wind power to be realised. Above all it will be a new challenge to the industry to provide this market with effective access and low maintenance costs.

As a result of this new market, new and powerful progress will emerge. Many offshore engineering and oil companies are already showing considerable interest in this new area of business. The entry of such companies into the wind energy industry will add further credibility.

5 WIND ENERGY BECOMES "BIG BUSINESS"

The development of the wind energy sector as indicated by the forecasts presented in Table 5.1 may catch the attention of large companies in the power industry. This table shows the development in the wind energy sector in terms of MW installed. There may be a transitional period with other company takeovers and mergers, but in the long run there is undoubtedly enough turnover and employment in the wind industry to create the necessary interest for the big power supply companies. The pioneering stage is over. The wind industry is entering a transitional phase and within the next decade will be recognised as a conventional form of electricity generation.

Energy conglomerates, such as Royal Dutch Shell, British Petroleum, Amoco, Exxon and Statoil, and industrial combines, for example General Electric, Westinghouse ABB, Siemens, Mitsubishi, Nissho Iwai, Howden Power, and Neste OY are all expressing an interest and are likely to enter into this market in one way or another.

Wind energy is now joining the realms of 'big business' and needs to achieve a better understanding of the structure of the energy industry in order to match its high level of technical innovation with commensurate financial profits.

Country (area)	Installed capacity (MW) by end of 1996	Installed capacity during year						Installed capacity between 1997-2001	
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**Sum**	**Accu.**
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	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**
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	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	9	0	10	100	75	75	75	335	344
Middle East	10	2	15	20	30	30	30	125	135
Former Soviet Union: FSU-countries	18	1	10	10	20	20	50	110	128
Rest of the world	3	3	20	20	20	20	20	100	103
Total other continents and areas:	**46**	**9**	**60**	**170**	**165**	**165**	**205**	**765**	**811**
Total MW new capacity every year:		**1.292**	**1.575**	**2.015**	**2.305**	**2.480**	**2.990**	**11.365**	**17.469**
Accu. capacity (MW)	**6.104**	**6.104**	**7.679**	**9.694**	**11.999**	**14.479**	**17.469**		

Table 5.1: Forecast for wind power development 1997-2001

Country (area):	Installed wind power capacity by the end of 1996 and 2000. Expectations for new capacity between 2000-2005. All numbers are MW/year							
Accumulated installed capacity (MW) by 1996		2000	2001	2002	2003	2004	2005	Accu. 2001-2005
North America	1617	2567	400	500	500	700	700	2800
S & C. America	32	382	120	120	200	250	300	990
Total America:	**1649**	**2949**	**520**	**620**	**700**	**950**	**1000**	**3790**
Denmark	835	1210	150	150	150	150	150	750
Germany	1552	2302	250	300	300	400	500	1750
Netherlands	309	509	150	200	200	250	250	1050
Spain	249	799	200	200	200	300	300	1200
Sweden	103	243	100	100	150	250	300	900
UK	273	723	150	250	250	300	300	1250
Other EU-countries	133	593	150	150	200	200	300	1000
C. Europe + Russia	67	507	100	100	150	150	200	700
Total Europe:	**3520**	**6885**	**1250**	**1450**	**1600**	**2000**	**2300**	**8600**
India	820	2720	500	500	500	500	500	2500
P. R. China	67	617	200	300	400	500	500	1900
Other Asian	13	173	75	100	150	150	200	675
Total Asia	**900**	**3510**	**775**	**900**	**1050**	**1150**	**1200**	**5075**
Australia and New Zealand	6	76	30	30	50	100	100	310
M. East & Africa	18	258	100	100	150	200	250	800
Rest of the world	5	25	10	10	15	15	15	65
Total others	**41**	**386**	**140**	**140**	**215**	**315**	**365**	**1175**
World per year			2685	3110	3565	4415	4865	18640
Annual growth rate				15.8%	14.6%	23.8%	10.2%	
Accu. Installed MW	**6110**	**13715**	**16410**	**19520**	**23085**	**27500**	**32365**	
Accu. Growth rate			19.6%	19%	18.3%	19.2%	17.7%	

Source: 1995-2000, BTM-C forecast from 1995, (adjusted by June 1996). 2001-2005, BTM-C, December 1996
The annual growth in MW of 2 - 5.000 equal to a value of approximately 1.4-3.5 billion ECU per year over the coming years will be interesting for the energy supply society.

Table 5.2: Expectations for global wind power development until the year 2005

6 CONCLUSIONS

The wind industry is still developing at a rapid pace. It is moving from a pioneering stage in both technological and commercial terms. 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 alternatives along with coal, oil and gas - part of the energy industry. Given appropriate market conditions the wind energy industry will provide tens of thousands of jobs in an exciting clean industry.

7 REFERENCES AND NOTES

1 The production is based on an average yearly wind speed of 6 m/s (Rayleigh). Costs are based on a 20 years lifetime and 7% interest.

2 There was a small increase of MW exported, but the domestic market doubled which resulted in a decline of the export percentage.

3 Official News Release from Enron of January 6, 1997 and information from the Internet.

4 Some companies among the investigated have refrained from participating in this survey

5 Danish Wind Turbine Manufacturers Association and Danish Counties and Municipalities Research Institute (Society Value of Wind Power).