EWEA
THE EUROPEAN WIND ENERGY ASSOCIATION

Wind at Work

Wind energy and job creation in the EU

By the European Wind Energy Association

This report is based on EWEA research coordinated by Isabel Blanco and carried out for the 'Wind Energy – The Facts' publication, 2008 edition: www.windfacts.eu.

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FOREWORD

In 2007, wind energy capacity increased more than any other power generating technology in the EU. It has experienced dramatic expansion in recent years and is meeting a growing share of Europe's electricity demand. In a world confronted with the imperatives of combating climate change while securing energy supply, the benefits the technology offers put it in an ideal place to lead the charge in reaching a truly renewable energy future.

However, beyond its advantages in terms of combating climate change and addressing the historic need for increased electricity generating capacity, wind energy should also be looked upon as a major contributor to economic welfare and as one of the solutions to the looming spectre of economic turmoil. Wind power not only has the potential to satisfy the increasing electricity demand in a sustainable manner; it is also a significant and vital stimulus to economies. Greater energy independence, lower energy costs, reduced fuel price risks, improved competitiveness, increased technology exports and major employment opportunities are among the low-hanging fruits the technology has to offer.

Wind energy has come of age and more and more Europeans are attracted by the jobs created in the industry. Over the past five years, the EU wind energy industry has created more than 60,000 new jobs. On average, the wind energy sector in Europe has employed 33 new people every day, seven days a week over the past five years. This report aims to shed light on one of those capital aspects: it analyses wind energy's benefits in terms of employment by looking into the tremendous evolution the sector has experienced in terms of job creation, offering an in-depth analysis of the current situation and investigating the industry's current shortage of human resources and prospects up to 2030.

At a time where economists turn to investments in job-intensive infrastructure as one way to revitalise economies and where many rightfully fear our economy will suffer and lag behind if we continue to increase our reliance on energy imports, this report presents the employment benefits of putting money to work in European economies, to the benefit and welfare of its citizens.

Arthouros Zervos
EWEA PRESIDENT

Christian Kjaer
EWEA CHIEF EXECUTIVE

Photo: Enercon

EXECUTIVE SUMMARY:

Energising Europe's Employment

In recent years, the amount of wind energy capacity installed in the EU has shot up. Between 2000 and 2007, capacity increased by 339%, reaching a total of over 56 GW by the end of the seven-year period (EWEA, 2008) and providing 3.7% of EU electricity.

It is impossible to manufacture, build, install and maintain wind turbines without people. It is equally impossible to plan, gain permits for and supervise a wind farm without them. Unsurprisingly then, employment related to wind energy has also gone up strikingly in recent years.

Wind energy employed 154,000 people in 2007

The EU wind energy sector directly employed approximately 108,600 people in 2007 (see Table 01). Including indirect employment, the wind energy sector employs 154,000 in the EU. A previous EWEA study on EU-15 employment found that wind energy directly employed 48,363 people in 2002 (EWEA, 2003). Direct employment has increased by 60,237 (125%) since then. On average, 12,047 new direct wind energy jobs have been created per year in the five-year period 2002-2007. In other words, 33 new people have been employed every day, seven days a week in the wind energy sector over the past five years.

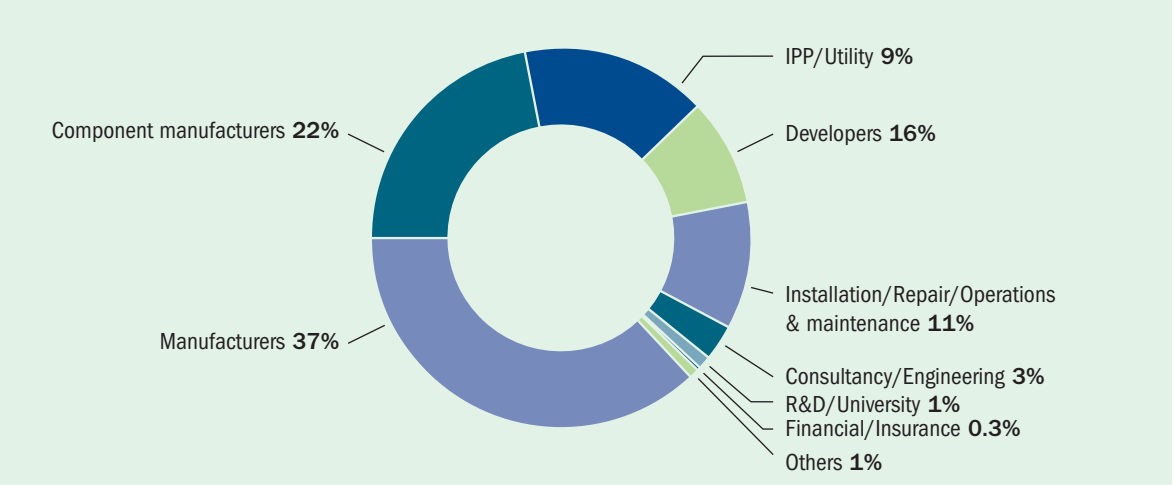
Wind turbine and component manufacturers are responsible for the lion's share of direct wind energy employment (59%), as can be seen from Figure 01.

TABLE 01: **Direct employment from wind energy companies in European countries**

Country	No. of direct jobs
Austria	700
Belgium	2,000
Bulgaria	100
Czech Republic	100
Denmark	23,500
Finland	800
France	7,000
Germany	38,000
Greece	1,800
Hungary	100
Ireland	1,500
Italy	2,500
Netherlands	2,000
Poland	800
Portugal	800
Spain	20,500
Sweden	2,000
United Kingdom	4,000
Rest of EU	400
TOTAL	108,600

Sources: EWEA survey; ADEME, 2008; AEE, 2008a; DWIA, 2008; Federal Ministry of the Environment in Germany, BMU 2008.

FIGURE 01: **Direct employment by type of company, according to the results of the EWEA survey**



In addition to direct employment, the wind energy sector also affects employment in sectors not directly related to wind energy.

From Table 02 it can be seen that wind turbine and component manufacturing employed some 64,000 directly and 43,000 indirectly in 2007. Wind farm development, installation, operations and maintenance (O&M) employed 29,000 directly and an additional 15,000 were employed directly in other wind energy-related jobs.

TABLE 02

	Share of direct employment	Direct employment	Indirect employment	
Wind turbine manufacturing	37.0%	40,182.0	42,716.0	
Component manufacture	22.0%	23,892.0		
Wind farm development	16.0%	17,376.0		
Installation, operation and maintenance	11.0%	11,946.0		
IPP/utilities	9.0%	9,774.0		
Consultants	3.0%	3,258.0		
R&D/universities	1.0%	1,086.0		
Financial	0.3%	325.8		
Others	0.7%	760.2		
Total	100.0%	108,600.0	42,716.0	151,316.0

From Table 03 it can be seen that 15.1 jobs are created in the EU for every MW installed. In addition, 0.4 jobs are created per MW of cumulative capacity in operations and maintenance and other activities.

These figures do not take into account the higher employment effect of installing, operating and maintaining offshore wind turbines. The additional employment effect of including the higher cost (and higher employment per MW installed) of offshore capacity is estimated at 2,800 jobs, taking the **total employment from wind energy in the EU to 154,000 in 2007**.

TABLE 03

Employment/MW (2007)	Jobs	Jobs/Annual MW	Jobs/Cumulative MW	Basis
WT Manufacturing – Direct	64,074	7.5		Annual
Wt manufacturing – Indirect	42,716	5.0		Annual
Installation	10,665	1.2		Annual
Operations and maintenance	18,657		0.33	Cumulative
Other direct employment*	15,204	1.3	0.07	75% annual/25% cumulative
Total employment	151,316	15.1	0.40	

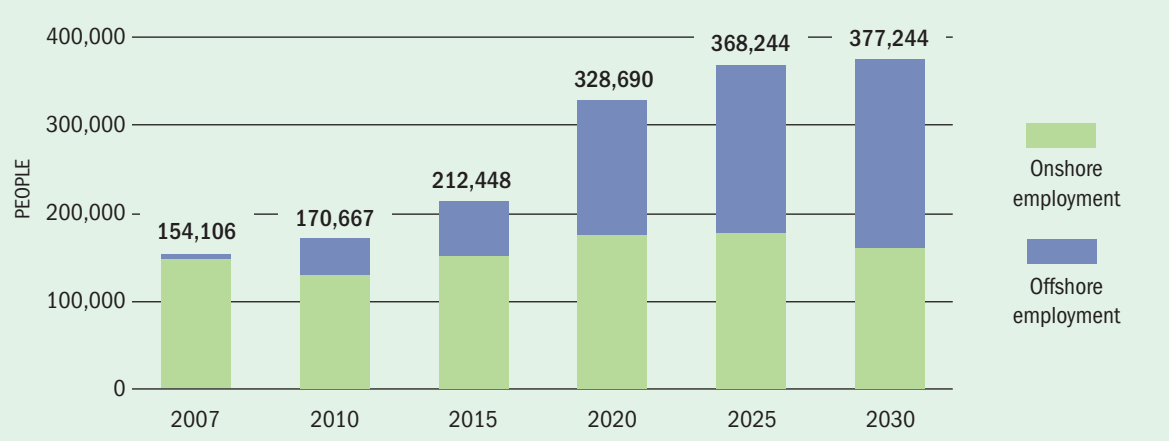
* IPP/utilities, consultants, research institutions, universities, financial services and other.

More than 325,000 wind energy jobs in the EU by 2020

According to EWEA's Baseline Scenario (EWEA, 2008), 180 GW of wind energy will be operating in the EU in 2020 and 300 GW by the end of 2030. Over that period, an increasing share of the installations will be offshore. Using EWEA's Baseline scenarios for onshore and offshore wind energy and the assumed onshore and offshore capacity cost of wind energy between 2008 and 2030[1], we can estimate future employment in wind energy in Europe[2].

Wind energy employment in the EU will more than double from 154,000 in 2007 to almost 330,000 in 2020 (Figure 02). Onshore wind energy will continue to be the largest contributor to employment throughout the period. By 2025, offshore wind energy employment will exceed onshore employment. By 2030, more than 375,000 people will be employed in the European wind energy sector – 160,000 onshore and 215,000 offshore.

FIGURE 02: **Wind energy sector employment (EU 2007-2030)**



1 In 2005 prices, the cost of wind energy is estimated at €1,300/MW onshore and €2,300/MW offshore in 2007; €1,150/MW and €2,300/MW respectively in 2010; €826/MW and €1,274 in 2020; €788/MW and €1,206/MW in 2030 (EWEA, 2008).

2 It is further assumed that the ratio of onshore O&M cost to offshore O&M cost is equal to the ratio for capacity cost. Finally, it is assumed that jobs / MW falls linearly from 15.1 per new MW installed plus 0.40 per cumulative MW onshore installed in 2007 to 11 and 0.29 respectively in 2030.

75% of direct employment in Germany, Denmark and Spain

The three wind energy 'pioneers' – Denmark, Germany and Spain – were the first countries to realise the vast potential of the winds sweeping across their lands and to begin installing significant amounts of wind energy capacity. Although other EU Member States are now catching up, three-quarters of the jobs in the sector are still to be found in the three pioneer countries, and certain regions that are especially advanced in wind energy installation have an even higher than average concentration of jobs.

Entire local communities have been revitalised as a consequence of wind turbine manufacturing and related activities. There are many examples of this from the three pioneering countries.

Cities such as Nakskov and Esbjerg in Denmark; the region of Schleswig-Holstein in Germany and the region of Navarre in Spain are all examples of areas where the wind energy sector continues to have a dramatic impact on the local economies and overall employment.

Shortage of skilled workers

In the last two to three years, wind energy companies have repeatedly reported an acute shortage of workers within certain fields. The general pressure on human resources, resulting from strong economic growth, is reinforced by the extraordinary performance of the sector itself since the end of the 1990s. From 2000 to 2007, wind energy installations in the EU increased by 339%. This has led to a multiplication of job offers in all the sub-sectors, especially in manufacturing and development activities.

Photo: Vestas

- Manufacturers report a shortage in two types of jobs: firstly, engineers and secondly, O&M and site management activities.
- Wind energy promoters need more project managers – the professionals responsible for getting the permits in the country where the wind farm is going to be installed. The position requires a rare combination of a specific knowledge of the country in question, wind energy expertise and negotiating skills.
- Other profiles, such as financiers or sales managers can occasionally be hard to find, but in general are less of a problem for wind energy companies, maybe because the qualifications that they require are less specialised.
- For R&D institutes the picture is not clear: of the two consulted, one did not report any problems, while the other is suffering from a lack of experienced researchers. It is worth noting that the remuneration offered by R&D centres is often below the levels offered by private companies.

The wind energy sector is facing a serious shortage of candidates to fill the existing and future job vacancies. This is particularly true of the positions that require more years of study and experience to fill: engineers, operations and maintenance technicians and site managers, to name but three.

In order to tackle these shortages, information on careers in the sector needs to be distributed at secondary school, before students decide which courses to take, and by employment offices and training centres. Another issue – the disparity between the skills required to go into the sector in the different Member States – should be ironed out, perhaps by the creation of an EU-wide diploma.

Photo: Stiftung Offshore-Windenergie/Oelker

Photo: RePower

1. **Wind energy employment in Europe:** current status and forecasts

1.1 Direct employment

The EU wind energy sector directly employed 108,600 people in 2007. Including indirect employment, the wind energy sector employs more than 150,000 in the EU (see section 1.2). In this study, the term 'direct jobs' relates to employment within wind turbine manufacturing companies and manufacturers, whose main activity is the supply of wind turbine components; it also takes into account wind energy project developers, utilities/IPPs selling electricity from wind energy and major research and development (R&D), engineering and specialised wind energy services. Any other company producing intermediates or components, providing services or sporadically working in wind-related activities is deemed to provide indirect employment.

A previous EWEA study on EU-15 employment found that wind energy directly employed 48,363 people in 2002 (EWEA, 2003). Employment has increased by 60,237 (125%) since then. On average, 12,047 new direct wind energy jobs have been created per year in the five-year period 2002-2007. In other words, 33 new people have been employed every day, seven days a week in the wind energy sector over the past five years.

A significant proportion of direct wind energy employment (around 75%) is based in three countries: Denmark, Germany and Spain. Nonetheless, the sector is less concentrated now than it was in 2003, when these three Member States accounted for 88% of EU employment. This is due to the opening of manufacturing and operation centres in new markets and to the local nature of many wind-related activities, such as project development, operation and maintenance (O&M), engineering, legal services and so on.

TABLE 04: **Direct employment from wind energy companies in European countries**

Country	No. of direct jobs
Austria	700
Belgium	2,000
Bulgaria	100
Czech Republic	100
Denmark	23,500
Finland	800
France	7,000
Germany	38,000
Greece	1,800
Hungary	100
Ireland	1,500
Italy	2,500
Netherlands	2,000
Poland	800
Portugal	800
Spain	20,500
Sweden	2,000
United Kingdom	4,000
Rest of EU	400
TOTAL	108,600

Sources: EWEA survey; ADEME, 2008; AEE, 2008a; DWIA, 2008; Federal Ministry of the Environment in Germany, BMU 2008.

Germany (Federal Ministry of the Environment, BMU 2006 and 2008) is the country with the most wind-related jobs – a total of 36,249 are directly attributable to wind energy companies[3] and a slightly higher amount, 48,051, are indirectly related to the sector. According to the BMU, over 80% of the value added in the German wind energy sector in 2007 was exported.

In Spain (AEE, 2008a), 20,781 people are directly employed in the wind energy sector. Including indirect jobs, wind energy employs 37,730 people in Spain. According to the AEE, almost half of the workers are in wind turbine and component manufacturing companies; 30% are employed in energy services and engineering companies, and the remaining 21% are involved with development and operation of wind farms.

By the end of 2007, Denmark (DWIA, 2008) had 23,500 employees mainly in wind turbine and blade manufacturing and the manufacturing of major sub-components to wind turbines[4].

The opening-up of new wind energy markets has provided new employment in other EU countries. Factors such as the size of the market, proximity to one of the three traditional leaders (see above), national regulation, labour costs and so on determines a nation's industry structure.

France, for instance (2,454 MW of cumulative installed capacity, 888 MW added in 2007, and an estimated figure of 7,000 direct wind energy jobs) has a wealth of small developers, consultants, engineering and legal service companies. All the large turbine manufacturers, developers and some utilities have opened up branches in the country, and major component manufacturers have set up factories there.

In the UK, the importance of offshore wind energy and small-scale wind turbines is reflected by the many businesses working in these segments of the industry; the country also has some of the largest wind energy engineering and consultancy companies. The British Wind Energy Association (BWEA) is carrying out a study on present and future wind energy employment; preliminary results point to the existence of around 4,000 to 4,800 direct jobs.

A third example of a flourishing new wind energy market can be found in Portugal, where the growth of the market initially relied on imported wind turbines. From 2009 onwards, two new factories will open, adding around 3,000 new jobs to the 800 that already exist.

Other EU Member States, like Italy, Greece, Belgium, the Netherlands, Ireland and Sweden employ between 1,500 and 2,500 people directly. The situation in the new Member States is varied, with Poland in a leading position. Wind energy employment in these countries will probably rise significantly in the next three to five years, boosted by a combination of attractive markets, an abundance of well-qualified labour and relatively low labour costs.

3 The 2006 BMU study found that 43% of gross* wind energy jobs (63,900) were direct; the rest – including O&M – indirect. The BMU published new data in 2008 (84,300 jobs) but it does not distinguish between direct and indirect jobs. For the purposes of this report, we have made the split based on the same assumptions (43% direct and 57% indirect).

*"Gross" here means that jobs lost from other areas due to funds being re-diverted to wind energy are not subtracted from the total.

4 It is difficult to define "major sub-component-suppliers", since most of them produce for more than one sector. In this study, such companies are included within the category of "direct employment" when at least 50% of their turnover comes from sales to wind turbines manufacturers or operators. In addition, the questionnaire that was used to gather the statistics asked about "jobs that can be attributed to wind-related activities", thus leaving out the part of the staff that is devoted to other activities.

Photo: RES/Loiez

Photo: LM Glasfiber

In terms of gender, the survey conducted by EWEA shows that men make up 78% of the industry's workforce. In the overall EU labour market, the percentage is 55.7%. The larger proportion of men in the wind energy industry corresponds with their traditional predominance in the production, building and engineering sectors. Women, by contrast, are more concentrated in other sectors of the labour market such as health and social work, education, retailing and other service activities, which are rarely directly linked to wind energy (Eurostat, 2008a).

Wind turbine and component manufacturers are responsible for the lion's share of direct employment (59%). These results are consistent with what has been found by other studies (AEE, 2008b; Federal Ministry of the Environment, BMU, 2006).

FIGURE 02: **Direct employment by type of company, according to the EWEA survey results.**

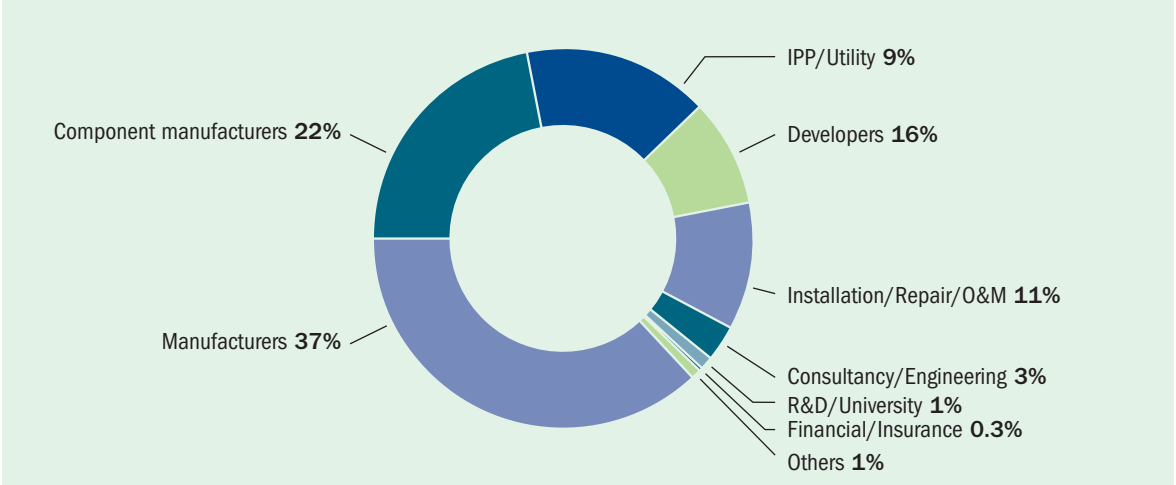


TABLE 05: **Summary of employment profiles (direct jobs) in the different EU Member States:**

Austria No. of direct jobs: 700	Austria has significant employment in renewable energies, especially in the hydro, biomass and small hydro sub-sectors. Most of the direct employment linked to wind energy technology comes from R&D institutes, universities, consultancies, developers and independent power producers. In contrast with other EU Member States, many wind energy investors are small companies made up of local residents, which explains a high local acceptance.
Belgium No. of direct jobs: 2,000	Since the early years of wind energy development, Belgium has been a pioneer in wind energy related component-manufacturing, specialising in gearboxes, cranes, dredging and software. Nowadays, the country is taking another important step with the operation of the first 6 MW offshore wind farm and the construction of a 30 MW far-shore farm, which has opened up a variety of job opportunities not only in the traditional sectors of construction, development and operation, but also in vessel construction and logistics, remote control devices and so on.
Bulgaria No. of direct jobs: 100	The approval in 2007 of a feed-in tariff for wind energy in Bulgaria has attracted the main international wind energy developers and power producers. Currently there are no large manufacturing facilities in the country, but this could change soon, since several large investors have ambitious plans there. For now, wind energy jobs are concentrated in development (both local and foreign) and utility companies. There are some companies that produce electrical equipment and subcomponents.
Czech Republic No. of direct jobs: 100	There are a variety of wind energy developers and operators, both national and international, present in the Czech Republic. The future growth of the wind industry and its corresponding impact on employment will depend on whether the government removes the administrative and grid access barriers that currently hinder wind energy projects
Denmark No. of direct jobs: 23,500	Denmark was the first country in the world to start mass-production of wind turbines. In 2007, wind energy produced over 20% of its annual electricity production. The country is a world leader in wind energy, especially turbine and component manufacturers, R&D centres and specialised service companies. Almost 40% of global installed capacity is produced by Danish manufacturers. In some regions, the wind energy sector has proved a valuable employment alternative at a time when other traditional sectors were declining: this was the case for the north-west part of the country, where the wind industry was able to hire people that had lost their jobs in other industries, mainly blue collar labour from slaughterhouses and other agriculture-related businesses. Much employment has also flowed from the ship-building industry to wind turbine manufacturing.

Finland
No. of direct jobs: 800

Finland has a competitive renewable energy industry, driven by the biomass and biofuel segments and is strongly export-orientated. The country specialises in the production of certain wind turbine components and one Finnish company manufactures turbines for cold climates. An improvement of the support mechanism could drive large investments, since there is a good wind resource, and the Nordic power market Nordpool offers good framework conditions for the integration of large-scale wind energy into a large power area.

France
No. of direct jobs: 7,000

The rapid growth of wind energy installations in France (sixth in terms of national installed wind energy capacity globally) has led to an industry based on developers of different sizes, component manufacturers (transformers, cranes, masts, electric equipment), engineering and consulting companies. France is also a leader in the manufacturing of anti-cyclone wind turbines that do not need cranes for installation. The interest of the national power company in renewable energy investments and the fact that the main international groups are now opening up factories and offices in France reflect increased belief in the French market, and point to the establishment of a string national industry (up to 16,000 direct jobs in 2012 according to a recent report from ADEME, the French National Energy Agency).

Germany
No. of direct jobs: 38,000

The Federal Ministry of the Environment in Germany, BMU, periodically carries out studies on the employment created by the renewable energy sector. According to the most recent ones (BMU, 2006 and 2008) and to the EWEA survey, around 38,000 jobs are directly attributable to wind energy companies. If indirect jobs are included, the number of jobs stands at 84,300. It is interesting that "only" one-third of total employment is direct, while the other two-thirds relate to suppliers, sub-suppliers and service companies. The reason is that over 80% of the value chain in the German wind energy sector in 2007 was exported and used in "foreign" wind turbine manufacturing.

Greece
No. of direct jobs: 1,800

There are many wind farm owners in Greece, and the main turbine suppliers and developers have established offices there, although they do not produce locally. Major subcontractors include erection specialists, tower and crane manufacturers, as well as a number of institutes devoted to engineering and R&D activities.

Hungary
No. of direct jobs: 100

The Hungarian wind energy market is growing, and wind industry jobs are linked to wind farm development and construction, legal and technical services. There is also a large carbon-fibre group which, since 2004, has devoted a significant part of its business to supplying this important raw material to large wind turbine and blade manufacturers.

Ireland
No. of direct jobs: 1,500

The wind energy landscape of Ireland is dominated by wind farm developers, some of which have gained strong international positions. The country also boasts a variety of companies specialising in engineering, legal services, insurance and finance. The construction of the first offshore wind farms has led to some new specialist offshore companies.

Italy
No. of direct jobs: 2,500

The steady growth of the Italian market has encouraged a number of international turbine manufacturers to expand operations to Italy. There are also several local wind turbine manufacturers – some of which have specialised in small-scale and off-grid applications – and a combination of local and foreign developers. The former national power company decided to invest in renewable energy installations and some other EU utilities have followed their path. Other sources of employment are linked to the construction and operation of wind farms, as well as engineering, financial and legal services.

Netherlands
No. of direct jobs: 2,000

Farmers, co-operatives, small and medium-size wind turbine manufacturers and independent power producers were important for the development of wind energy in the Netherlands, especially during the 1980s and 90s. Today, large utilities and developers dominate the scene, and this is reflected in the employment figures. On the manufacturing side, there are several small and medium-size wind turbine manufacturers, as well as component manufacturing centres. The Netherlands is also well-known for the excellence of its R&D centres. Nowadays, the market and employment opportunities seem to be moving towards the offshore segment.

Poland
No. of direct jobs: 800

There are around 100 companies operating in the wind energy market in Poland, many of which are local developers. The country does not yet have any manufacturing centres, but at least one company is planning to open up a factory. Prospects are good and employment figures should rise significantly in the next two to three years.

Portugal
No. of direct jobs: 800

Two wind turbine manufacturers will open production facilities in Portugal by the end of 2008 and the beginning of 2009 respectively, creating over 3,000 new jobs. Excluding these, there are already around 350 jobs in development, 50 to 100 in consultancy and engineering, and 50 to 100 in sub-supplier businesses. Wind energy operation is important, and the former national utility has one of the largest renewable energy portfolios in the world.

Spain
No. of direct jobs: 20,500

Spain is ranked third in terms of capacity installed worldwide and has some of the largest wind turbine manufacturers, developers and operators. According to a recent study carried out by the Spanish Wind Energy Association (AEE), the sector employs 20,781 people (data from December 2007), most of whom are involved in the production of wind turbine components (32%) and in the provision of specialised services (31%). Wind turbine manufacturers account for 16% of the wind workforce, and the remaining 21% are in development and operation companies. When indirect employment is taken into account, the total number is 37,730 workers (end of 2007).

Sweden
No. of direct jobs: 2,000

Sweden has supplied components to the wind turbine industry for a long time. This is still the case, but new players are entering the market, notably wind farm developers. Most of the large wind energy companies are present in Sweden. The emergence of the first offshore wind farms will benefit the local industry, not only in pure wind energy activities, but also in support services such as vessel construction and transportation, other logistics, remote control devices and so on.

UK
No. of direct jobs: 4,000

In the UK, the importance of offshore wind energy and small wind turbines is reflected by the many businesses working in this area. There are also large wind energy operators and developers, some of them with a solid international position. Finally, a variety of internationally leading wind energy engineering, consultancy and advanced service companies are based in the UK.

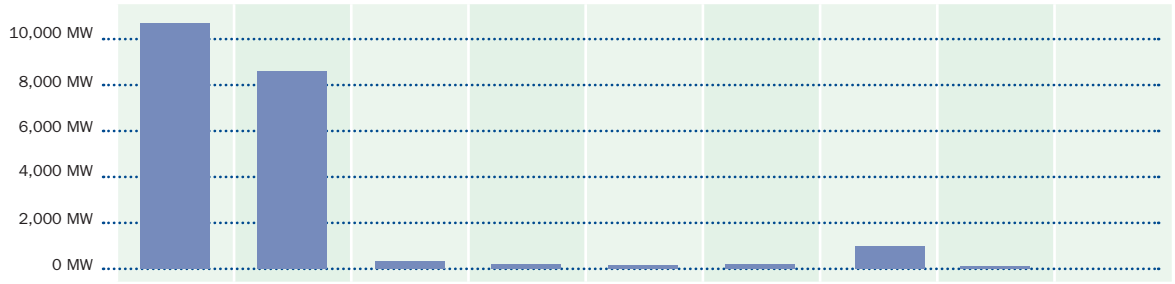
Rest of EU
No. of direct jobs: 400

Eastern European countries like Estonia and Romania are rapidly expanding and there are plans to build several wind turbine and turbine component factories in the next couple of years. In the meantime, the main international groups are opening up national branches in the key locations. Local companies are springing up in the fields of development, construction and engineering.

Sources: EWEA survey; ADEME, 2008; AEE, 2008a, b; DWIA, 2008; Federal Ministry of the Environment in Germany, BMU 2008; National Wind Energy Associations contributions.

Wind energy employment figures can be measured against overall employment statistics provided by Eurostat (2007). The energy sector provides jobs for 2.69 million people, accounting for 1.4% of total EU employment. This figure, however, does not include the construction of power plants and therefore can not be compared to the analysis of direct and indirect employment in wind energy manufacturing. Approximately half of energy sector workers are involved in the production of electricity, gas, steam and hot water. The wind energy capacity installed by the end of 2007 meets 3.7% of EU electricity demand and 40% of all new EU electricity generating capacity installed in 2007 was wind energy (see Figure 03). Wind energy is more capital intensive than most other power generating technology (but has zero fuel and very low maintenance cost). For this reason, earlier research indicates that wind energy is more labour intensive. Hence, in terms of manufacturing jobs, wind energy is likely to contribute to more than 40% of manufacturing jobs in the EU power sector.

FIGURE 03: **New power capacity installed in 2007 by fuel in EU-27 (MW)**



	Natural Gas	Wind	Coal	Fuel Oil	Large Hydro	Biomass	Nuclear	Other	Total
MW	10,670	8,554	332	212	175	196	987	122	21,245
% of total	50.2%	40.3%	1.6%	1.0%	0.8%	0.9%	4.6%	0.6%	

Other: Geothermal, small hydro, peat, waste and other gas
Sources: Platts PowerVision and EWEA, January 2008

It has been widely documented that employment in the European energy sector is in decline, particularly in the coal sector. For instance, British coal production and employment have gone down steeply, from 229,000 workers in 1981 to 5,500 in 2006. In Germany, it is estimated that the total jobs in the sector will

Photo: Soyut

drop from 265,000 in 1991 to fewer than 80,000 in 2020. In EU countries, more than 150,000 utility and gas industry jobs disappeared during the initial liberalisation of the sector in the second half of the 1990s and it is predicted that another 200,000 jobs will be lost during the first half of the 21st century (UNEP, ILO, ITUC, 2007). The outcomes reported in the previous paragraphs demonstrate that the job loss in the energy sector in Europe is quite independent of renewable energy deployment and that the renewable energy sector is helping to mitigate these negative effects.

1.2 Total employment (direct and indirect) in wind energy

In addition to the direct employment outlined in the previous section, the wind energy sector also affects employment in sectors not directly related to wind energy. The Global Wind Energy Council (GWEC) assumes that wind energy creates 15 jobs (man years) per MW of annual installation, through turbine manufacturing, component manufacturing, wind farm development, installation and indirect employment. In addition, operations and maintenance work contributes an additional 0.33 jobs per MW of total installed capacity. Based on these assumptions, the global wind energy sector employed 329,000 directly and indirectly in 2007.

Using these assumptions, the total direct and indirect wind energy employment in the EU can be estimated at 147,000 for 2007, of which around 18,500 jobs would have been related to operations and maintenance. This would indicate that 45% of global wind energy employment is in Europe. However, some uncertainty must be assumed, since more wind turbine components are exported from Europe to other areas of the world than imported into the EU, indicating higher EU employment. On the other hand, Europe imports more raw materials, for example steel and energy than it exports, indicating a lower level of EU employment than indicated by the 147,000 figure.

A 2003 EWEA analysis of wind energy employment in the EU-15 by the European Wind Energy Association found that, at aggregated EU level, direct employment constituted 60% of total direct and indirect employment in wind turbine manufacturing. By applying that finding to the survey on direct employment (see section 1.1) we can estimate the total direct and indirect wind energy employment in the EU in 2007.

From Table 06 it can be seen that wind turbine and component manufacturing employed some 64,000 directly and 43,000 indirectly in 2007. Wind farm development, installation, operation and maintenance employed 29,000 directly and an additional 15,000 were employed directly in other wind energy-related jobs.

In total, the EU wind energy sector employed more than 151,000 people in 2007, which corresponds closely to the 147,000 employed in the EU using the GWEC methodology.

TABLE 06

	Share of direct employment	Direct employment	Indirect employment	
Wind turbine (WT) manufacturing	37.0%	40,182.0	42,716.0	
Component manufacture	22.0%	23,892.0		
Wind farm development	16.0%	17,376.0		
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Others	0.7%	760.2		
Total	100.0%	108,600.0	42,716.0	151,316.0

The EWEA analysis on direct employment (section 1.1) bundles installation, operation and maintenance into one group, which makes it difficult to calculate numbers for employment per MW. The reason is that installation employment is a function of annual wind power installations, whereas operation and maintenance is a function of all turbines in operation. In addition, it must be expected that activities in the group 'wind farm development' include operations and maintenance employment. However, if we assume, in line with previous EWEA findings and the findings of GWEC, that 0.33 jobs are created in operations and maintenance per MW of cumulative installed capacity, it is possible to construct the following ratios for wind energy employment as a function of annual MW/cumulative MW.

TABLE 07

Employment/MW (2007)	Jobs	Jobs/Annual MW	Jobs/Cumulative MW	Basis
WT manufacturing – Direct	64,074	7.5		Annual
WT manufacturing – Indirect	42,716	5.0		Annual
Installation	10,665	1.2		Annual
Operations and maintenance	18,657		0.33	Cumulative
Other direct employment*	15,204	1.3	0.07	75% annual/25% cumulative
Total employment	151,316	15.1	0.40	

* IPP/utilities, consultants, research institutions, universities, financial services and other.

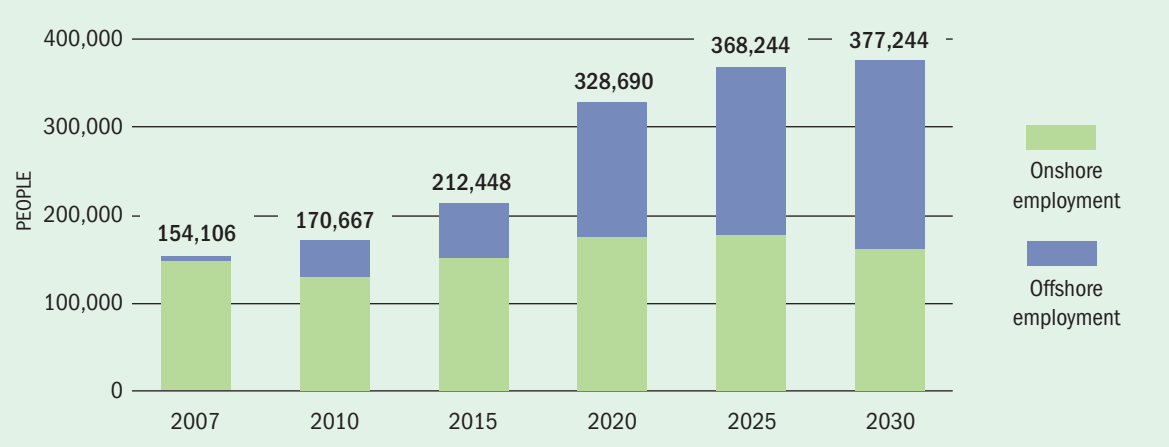
From Table 07 it can be seen that 15.1 jobs are created in the EU for every MW installed. In addition, 0.4 jobs are created per MW of cumulative capacity in operations and maintenance and other activities. The figures are slightly higher than reported by GWEC (15 jobs and 0.33 jobs respectively). The reason is that the EWEA study covers more direct employment effects, e.g. IPP/utilities, financial services, research institutions etc.

The figures above do not take into account the higher employment effect of installing, operating and maintaining offshore wind turbines. The additional employment effect of including the higher cost (and higher employment) of offshore capacity is estimated at 2,800 jobs, taking the total employment from wind energy to 154,000 in 2007 (see section 1.3).

1.3 Wind energy employment up to 2030

According to EWEA's Baseline Scenario (EWEA, 2008), 180 GW of wind energy will be operating in the EU in 2020 and 300 GW by the end of 2030. Over that period, an increasing share of the installations will be offshore. Using the EWEA Baseline scenarios for onshore and offshore wind energy and the assumed onshore and offshore capacity cost of wind energy between 2008 and 2030[5], we can estimate future employment in the wind energy sector in Europe[6].

FIGURE 04: **Wind Energy Sector Employment (EU 2007-2030)**



As can be seen from Figure 04, wind energy employment in the EU will more than double from 154,000 in 2007 to almost 330,000 in 2020. Onshore wind energy will continue to be the largest contributor to employment throughout the period. By 2025, offshore wind energy employment will exceed onshore employment. By 2030, more than 375,000 people will be employed in the European wind energy sector – 160,000 onshore and 215,000 offshore.

Table 08 shows EWEA's baseline scenario up to 2030 (EWEA, 2008) and the corresponding employment figures. Although the annual market for onshore wind turbines will grow steadily from 2010 to 2025, the offshore market will be the biggest driver of employment growth in manufacturing. Operations and maintenance jobs will continue to increase throughout the period as total capacity increases.

5 In 2005 prices, the cost of wind energy is estimated at €1,300/MW onshore and €2,300/MW offshore in 2007; €1,150/MW and €2,300/MW respectively in 2010; €826/MW and €1,274 in 2020; €788/MW and €1,206/MW in 2030 (EWEA, 2008).

6 It is further assumed that the ratio of onshore O&M cost to offshore O&M cost is equal to the ratio for capacity cost. Finally, it is assumed that jobs / MW falls linearly from 15.1 per new MW installed plus 0.40 per cumulative MW onshore installed in 2007 to 11 and 0.29 respectively in 2030.

TABLE 08

	Annual capacity (MW)			Cumulative capacity (MW)			Employment		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
2007	8,344	210	8,554	55,500	1,100	56,535	147,736	6,370	154,106
2010	6,873	1,331	8,205	76,500	3,500	80,000	129,271	41,396	170,667
2015	8,086	2,300	10,386	112,500	12,000	124,500	151,047	61,401	212,448
2020	9,949	6,805	16,754	145,000	35,000	180,000	176,199	152,491	328,690
2025	10,519	8,504	19,023	164,800	74,500	239,300	177,194	191,744	368,938
2030	9,882	9,590	19,472	180,000	120,000	300,000	161,606	215,637	377,244

1.4 Regional and local employment

The three initial pioneers of wind energy were Denmark, Germany and Spain, and they are still key players for the industry, with 3 GW, 22 GW and 15 GW of cumulative installed capacity respectively by the end of 2007. The installations will provide 21% of Denmark's electricity, 12% of Spain's and 7% of Germany's in an average wind year. Given their head start, it is worth looking at these countries in more detail and focusing on particular regions that demonstrate the effect of the wind energy industry on local and overall employment. In all three countries, entire local communities have been revitalised as a consequence of wind turbine manufacturing and related activities.

Denmark

Denmark was the first country that believed in wind energy as a large-scale solution for electricity generation. The country hosts some of the world's largest wind energy companies, especially in turbine and component manufacturing, R&D centres and specialised service companies. According to the Danish Wind Industry Association, 23,500 people are directly employed in the Danish wind energy sector (2007), an increase of 8.7% compared to 2006.

Photo: Vestas

Almost 40% of the capacity installed globally is made up of turbines produced by Danish manufacturers. In some regions, the wind energy sector proved a timely employment alternative at a time when other traditional sectors were declining. This is the case for the North-West part of the country, for example, where the wind industry was able to pick up people that had lost their jobs in other industries, mainly blue collar labour from manufacturers of steel products, shipbuilding, slaughterhouses and other agriculture-related businesses.

The city of Nakskov, population 15,000, and its surrounding area, Lolland, in south-eastern Denmark, were struck by rapid economic and social decline when the city's shipyard closed in 1987 together with many of its local sub-suppliers. In addition, much of the area's agricultural processing plants moved abroad or laid off workers to rationalise production. House prices fell sharply and skilled people left the city. They were replaced by people on social welfare from all over the country, attracted by the low housing cost. At some point in the 1990s, three out of four people moving to Nakskov were on social welfare.

Through an active business development policy combined with targeted housing initiatives, the Nakskov municipality was able to attract the attention of the world's largest wind turbine manufacturer. In 1999-2000, Vestas set up a factory in Nakskov making wind turbine blades, which created 650 new jobs – 600 of them in production and 50 in support services. Another 600 jobs were indirectly created in other companies in the area as a result. Since then the unemployment rate has fallen below the Danish average and by the end of 2006, the city was actively trying to attract more skilled labour, predominantly from Northern Germany, to fill 500-600 positions.

In Esbjerg, south-west Denmark, the wind industry provides the bulk of the city harbour's business. The Horns Rev offshore wind farm is maintained from there, and a recent agreement with Siemens Wind Power will develop large areas of the harbour for manufacturing and storage of wind energy technology for exports, potentially creating several hundreds new jobs in the sector.

Germany

The Federal Ministry of the Environment in Germany, BMU, periodically carries out studies on the employment created by the renewable energy sector. According to the most recent ones (BMU, 2006 and 2008) and to an EWEA survey, around 38,000 jobs are directly attributable to wind energy companies. If indirect jobs are included, the number of jobs stands at 84,300. It is interesting that "only" one-third of total employment is direct, while the other two-thirds relate to suppliers, sub-suppliers and service companies. Over 80% of the value added in the German wind energy sector in 2007 was exported.

One of the main centres of Germany's wind energy industry is Schleswig-Holstein, a northern state situated between the Baltic and the North Seas. Since 1980, the region has been one of the most popular for building new wind farms, and this has boosted competition in wind energy. Today, around one-third of its electricity consumption is met with wind energy, and the sector employs over 7,000 people (Government of Schleswig-Holstein, 2008). The business structure is made up of a large number of small and middle-sized companies, complemented by a solid network of R&D institutes, training and educational centres, universities and financial institutions.

The development of wind energy in Schleswig-Holstein has been supported by the regional government, which has created an attractive environment for investment and ensured that the labour force and the public infrastructure are attractive to the sector. This effort has paid off. According to Prognos Institute (2006), each MW installed produces more than €100,000 of tax revenue during its 20 years of operation. In 2004, fiscal income from wind activity amounted to €7.8 million in Lower Saxony, €5.8 million in Schleswig-Holstein and €1.6 million in Mecklenburg-Vorpommern. By 2009 this amount will have doubled.

The sector is now starting to move offshore. Indeed, another area of Germany which has seen strong development, thanks to the offshore wind industry is the northern state of Bremen, particularly the city of Bremer-

Photo: Megajoule

haven on the North Sea coast. In the last two years, €250 million has been invested in offshore wind energy industry development in the city – mainly private funds but also public investments.

Formerly blighted by declining shipping and fishing industries, the burgeoning offshore wind energy industry has revitalised Bremerhaven, creating up to 1,200 direct jobs in companies manufacturing turbines and components between 2006 and 2008.

There are currently around 40 MW of wind energy capacity installed onshore around Bremerhaven, mostly in the form of prototypes of offshore turbines. It is estimated (Wind Energy Agency Bremerhaven/Bremen, 2008) that by the beginning of 2009 this wind energy capacity will provide electricity roughly equivalent to the needs of all the city's households (115,000 inhabitants)

Spain

Spain is ranked third in the world in terms of installed capacity, and it is home to some of the largest wind turbine manufacturers, developers and operators. According to a recent study carried out by the Spanish Wind Energy Association (Asociación Empresarial Eólica), the sector employs 20,781 people (data from December 2007), most of whom are engaged in the production of wind turbine components (32%) and specialised services (31%). Wind turbine manufacturers account for 16% of the wind workforce and the remaining 21% are employed in development and operation companies. When indirect employment is taken into account, the total number is 37,730 workers (end of 2007).

Wind energy development has brought about increased employment in the Spanish regions in which wind farms have been built. This is a consequence of the country's regional legislation, which obliges wind energy developers to install manufacturing and industrial centres in the municipalities where the wind farms will be located. While this requirement benefits the local inhabitants and has contributed to a positive attitude towards wind energy, it can bring about economic disadvantages, because it prevents sufficient economies of scale from being acheived.

The region of Navarre has been able to attract large wind turbine manufacturing facilities which are not always linked to new wind farms. In the 1980s, the region became an example of wind energy development; today its 1,000 MW of installed capacity supply 70% of the electricity it consumes (Pintor Borobia et al, 2006). Navarre is home to four wind turbine assembly factories, four blade manufacturing centres, two component manufacturing factories and the largest wind turbine testing laboratory in the world (AEE, 2008b). Many smaller service companies have sprung up around the manufacturing centres, and 5,000 people make a living from these activities. The key to this success is a combination of factors: the region having been an early mover; the strong support given by the regional government, and the existence of a qualified workforce and advanced infrastructure.

Photo: Stiftung Offshore-Windenergie

2. **The shortage of workers in the wind energy sector:** analysis of the situation and suggested actions

2.1 Job profiles

The lack of an official method of classifying wind energy companies makes it difficult to categorise jobs in wind energy. The table below summarises the main types of job profile required by wind energy companies, depending on the nature of their core business:

TABLE 09: **Typical wind energy job profiles demanded by different types of industries**

Company type	Field of activity	Main job profiles
Manufacturers	Wind turbine producers, including major sub-component and assembly factories.	Highly qualified chemical, electrical, mechanical and materials engineers dealing with R&D issues, product design, management and quality control of production process. Semi-skilled and non skilled workers for production chains. Health and safety experts. Technical staff for O&M and repairing wind turbines. Other support staff (admin., sales managers, marketing, accounting, others).
Developers	Managing all the tasks related to the development of wind farms (planning, permits, construction…).	Project managers (engineers, economists) to co-ordinate the process. Environmental engineers and other specialists to analyse the environmental impacts of the wind farms. Programmers and meteorologists for wind energy forecasts and prediction models. Lawyers and economists to deal with the legal and financial aspects of project development. Other support staff (admin., sales managers, marketing, accounting, others).

Photo: EWEA/Brolet

Photo: RES/Esler Crawford Photography

Construction, repair and O&M	Building the wind farm, regular inspection and repair activities*.	Technical staff for O&M and repairing the wind turbines. Electrical and civil engineers to co-ordinate the building work. Health and safety experts. Specialists in the transport of heavy goods. Electricians. Technical staff specialised in wind turbine installation, including activities in cranes, fitters, nacelles, etc. Semi-skilled and non-skilled workers for the building process. Other support staff (admin., sales managers, accounting, others).
Independent power producers, utilities	Operation of the wind farm and sale of the electricity produced.	Electrical, environmental and civil engineers for the management of the plants. Technical staff for the O&M of the plants, if this task is not sub-contracted. Health and safety experts. Financiers, salespersons, marketing people in order to sell the electricity. Other support staff (admin., accounting, others).
Consultancies, legal entities, engineering, financial institutions, insurers, R&D centres, others.	Diverse specialised activities linked to the wind energy business.	Programmers and meteorologists for analysing wind regimes and output forecasts. Engineers specialised in aerodynamics, computational fluid dynamics and other R&D areas. Environmental engineers. Energy policy experts. Experts in social surveys, training and communication. Financiers and economists. Lawyers specialised in energy and environmental matters. Marketing staff, event organisers.

* The Windskill project (www.windskill.eu) funded by the European Commission, offers a good summary of the profiles that are required in this area

Some of the job profiles mentioned above (engineers, non-qualified and semi-qualified workers, secretaries, sales managers, drivers of light trucks) are common to other sectors of the economy, particularly the power sector. Others are much more specific to wind energy, and it is for this second, specific type of role that there is a shortage of workers.

2.2 Lack of skilled labour in wind energy

In the last two to three years, wind energy companies have repeatedly reported an acute shortage of workers in certain fields. This shortage has come about as the European economy has expanded, its growth rates among the highest in the world since the end of the Second World War. Eurostat statistics (2008b) indicate that job vacancies have been difficult to fill in all sectors[7]. The turnover of both skilled and non-skilled wind energy sector workers is high, and the general pressure on human resources brought on by strong economic growth has been reinforced by the extraordinary performance of the sector itself since the end of the 1990s: from 2000 to 2007, wind energy installations in the EU increased by 339% (EWEA, 2008). Accordingly, jobs have multiplied in all the sub-sectors, especially in manufacturing and development.

Generally speaking, the shortage is more acute for positions that require a high degree of experience and responsibility:

- Manufacturers report a shortage in two types of jobs: firstly, engineers and secondly, O&M and site management activities.

- Wind energy promoters need more project managers – those responsible for obtaining the building permits in the country where the wind farm is going to be installed. The role requires a specific knowledge both of the country in question and of wind energy, along with negotiating skills.

- Other profiles, such as fi nanciers or sales managers can occasionally be hard to find, but are usually less of a problem for wind energy companies, maybe because the qualifications that they require are less specialised.

- For R&D institutes the picture is not clear: of the two consulted, one did not report any problems, while the other is suffering from a lack of experienced researchers. It is worth noting that the remuneration offered by R&D centres is often below the levels offered by private companies.

Photo: Stiftung Offshore-Windenergie/Oelker

7 Job vacancy statistics, annual data. Eurostat, 2008.

Most of the interviewees agree that the low number of students in relevant courses at university is a bigger problem than the quality of the teaching. However, several pointed out that new graduates often need an additional specialisation to work in wind energy. This specialisation is normally organised by the individual company. The general view is that the number of engineers that graduate from European universities every year is insufficient for the needs of the power sector in Europe, including the wind energy sector.

There also seems to be a gap in secondary education, where the range and quality of the courses dealing with wind-related activities (mainly O&M, health and safety, logistics and site management) are insufficient. The skills needed for these profiles change from country to country and sometimes between regions, which is an additional barrier to worker mobility.

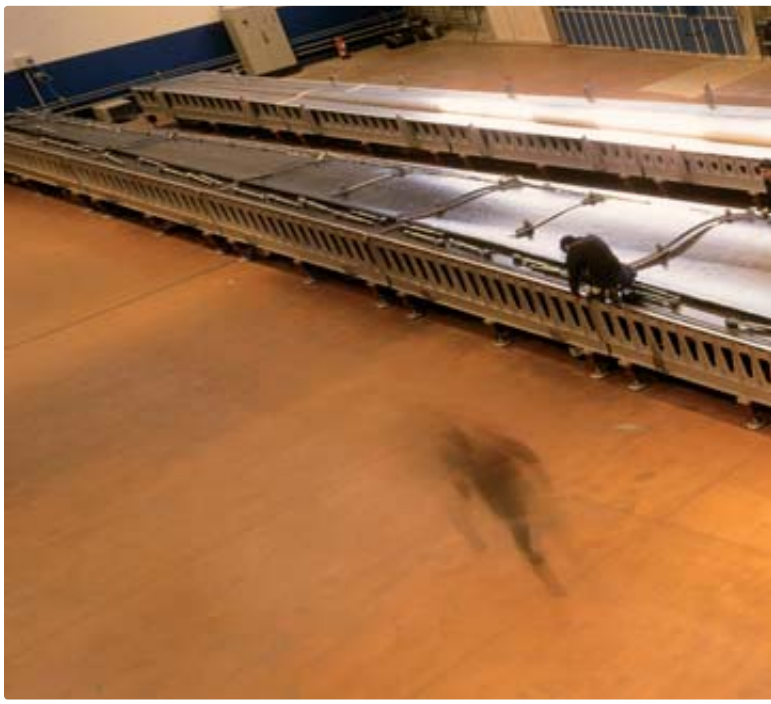
All experts agree that the wind energy sector provides attractive opportunities for the younger generations. Often, however, not enough clear information is provided on these opportunies at an sufficiently early stage. The main complaint of human resource managers is that students at university or secondary school do not learn about wind energy as a career option until they have started their university or secondary studies in other subjects, which reduces the number of potential candidates.

2.3 Suggested actions towards a balanced supply and demand for labour in the wind energy sector

The following paragraphs suggest ways to overcome the human resource challenge in the wind energy sector and to facilitate the integration of unemployed people, providing a suitable alternative to declining regions and sectors. Some measures require the intervention of the public authorities, while others must be undertaken by the industry itself.

Measures to promote worker mobility

Wind energy companies in western Europe can offer attractive manufacturing opportunities to skilled technical workers from the newer Member States, who sometimes have difficulties finding suitable positions at home. National governments or the European Commission could consider creating and promoting a programme to help bring such workers into the industry. Wind energy companies could also keep public authorities updated as to the types of position available, and advertise their job offers in suitable Member States.



Moreover, the wind energy sector can absorb some of the former workforce of declining economic sectors. Public authorities and private companies could work together to provide the necessary training.

One idea could be to create an observatory (or work with an existing one) that would help match the needs of wind energy companies to the qualifications offered at university and pre-university level.

Measures aimed at the educational system

There is room to improve the educational system at university and pre-university levels, particularly in activities related to O&M, site management, the transportation of heavy material, and health and safety rules. The European Wind Energy Technology Platform (www.windplatform.eu) has suggested creating a "European Wind Energy Training Centre", with correspondents in various Member States and local partnerships with universities.

The creation of an EU-wide certification system could also be a valuable initiative (see, for instance, the objectives of the EU-funded Windskill project (www.windskill.eu), which aims to establish a European Qualification Profile for the key onshore and offshore process assignments) and the vocational training that is given to unemployed people could focus more on expanding sectors like wind energy.

Dissemination measures

It is crucial that potential workers, including the younger generation, are aware of the opportunities that the wind energy sector offers. Ideally, they should start learning about careers in wind energy in secondary school. Job fairs, training centres and university employment offices are a good way to reach potential candidates. In some cases, the training centre or university may lack teachers with an in-depth knowledge of new career paths such as wind energy: in this case it would be worth launching a training course for the teachers themselves.

Photo: Gamesa

Photo: Vestas

ANNEX 1:

Description of previous research

Some early examples can be found in the famous ExternE study (European Commission, 1995) and its North American equivalent "Estimating fuel cycle externalities" (Oak Ridge National Laboratory and Resources for the Future, 1994). Their common aim was to scrutinise and, where possible, quantify the external benefits and costs of different electricity generation options. Both reports were carried out in the 1990s, although ExternE has been regularly updated since then (European Commission 2004, 2005). The methodology is based on input-output tables, which assess the effect a greater proportion of wind energy in the electricity mix has both on direct and indirect jobs in a geographical area.

The results of past studies have indicated a net positive impact on employment, and demonstrated the fact that renewable energies in general are more labour intensive than other centralised power generation options.

Since the beginning of the 21st century, and following the spectacular increase in wind energy installations in Europe – and, more recently, worldwide – the subject of employment has become popular, and a fair number of studies have been completed. A careful revision of their methodology shows that many of them are meta-analyses (that is, critical re-examinations and comparisons of earlier works). Research based on questionnaires and/or input-output (I-O) tables is less common. The bulk of the studies refer to the EU and the US. Those that focus on other areas of the world have not been discussed in the present report.

The following table summarises the main findings of studies on employment and renewable energies. The list is non-comprehensive; the emphasis has been put on the studies that are most often cited in the specialised literature, and on those that cover the EU and large countries, such as Denmark, Germany and Spain.

Summary of the main recent studies
on employment creation in the wind energy sector

SOURCE	ADEME, 2008
TITLE	**ADEME&Vous. Stratégie & Etudes. Maîtrise de l'énergie et développement des énergies renouvelables.**
GEOGRAPHICAL COVERAGE	France
METHODOLOGY	Net production/ employment ratios (imports have been disregarded).
MAIN RESULTS	7,000 jobs in the manufacturing of wind turbines and major sub-components; 500 in companies operating wind energy farms.

SOURCE	AEE, 2007
TITLE	**Eólica 07. Todos los datos, análisis y estadísticas del sector eólico.**
GEOGRAPHICAL COVERAGE	Spain
METHODOLOGY	Questionnaires to Spanish wind energy companies, complemented by information from official tax-related registries
MAIN RESULTS	There are more than 300 wind energy companies in Spain, which create 15,450 direct jobs and another 19,560 indirect jobs. This figure may go up to 58,800 if government objectives (20,000 MW in 2012) are achieved. 29.97% of the jobs are in the O&M sub-sector; 22.72% in the manufacturing of the machines; 19.42% in technical and engineering services; 9.12% in manufacturing; 3.24% in R&D and 4.53% in "others".

SOURCE	AEE, 2008a
TITLE	**Estudio macroeconómico del impacto del sector eólico en España.**
GEOGRAPHICAL COVERAGE	Spain
METHODOLOGY	Analysis of annual reports + information in the government's tax office. Indirect employment was calculated on the basis of questionnaires and the subsequent modification of I-O tables.
MAIN RESULTS	Over 430 companies were studied. Direct employment stood at 20,781 by the end of 2007; 48% of which in manufacturing activities, 30% in service companies and the remaining 16.2% in development and operation. The total number of jobs (direct + indirect) was 37,730 at that time. The study estimates that direct employment in 2012 will account for 31,134 people.

SOURCE	Algoso D.; Rush, E., 2004
TITLE	**Job Growth from renewable energy development in the Mid-Atlantic.**
GEOGRAPHICAL COVERAGE	Mid-Atlantic States of the United States of America: Maryland, Delaware, New Jersey and Pennsylvania
METHODOLOGY	The number of jobs was calculated with the I-O "Renewable Energy Policy Project". The technical coefficients were estimated by means of a survey to 19 wind energy companies in 2001. Indirect employment figures come from the Texas Comptroller's office.
MAIN RESULTS	An installed capacity of 10,200 MW in 2015 would entail 11,100 year-long jobs in wind turbine manufacturing and installation, 740 permanent jobs in O&M and supporting areas and around 12,700 indirect jobs. The jobs/MW ratio is 2.48. Choosing wind energy over a comparable amount of natural gas installations would create more than twice as many jobs.

SOURCE	DWEA, 2008
TITLE	**Sector statistics.**
GEOGRAPHICAL COVERAGE	Denmark
METHODOLOGY	Questionnaires to Danish wind energy companies.
MAIN RESULTS	In 2006, 23,500 people worked for the wind energy sector (direct).

SOURCE	European Commission, 2006
TITLE	**European Commission's 2007 Impact Assessment on the Renewable Energy Roadmap.**
GEOGRAPHICAL COVERAGE	European Union (27 Member States)
METHODOLOGY	I-O tables, based on Green-X, PRIMES and ASTRA models.
MAIN RESULTS	Meeting the 20% renewable energy (RE) target in 2020 will entail a net increase of 650,000 jobs in the European Union, half of which may come from the biomass sector. The increase in RE will favour changes in the composition of the labour market, rather than its size.

SOURCE	European Parliament, 2007
TITLE	**Employment potential of renewable forms of energy and increased efficiency of energy use.**
GEOGRAPHICAL COVERAGE	European Union
METHODOLOGY	Meta-analysis of past employment studies.
MAIN RESULTS	A rapid switch to renewables appears to have an unambiguous benefit in terms of overall employment. The growth of a particular segment of the clean energy business (renewables, energy efficiency or sustainable transport) is often partially dependent on the growth in other parts, because the markets for products and technologies are linked. The report recommends that workers who lose their jobs in the fossil fuel industry have the opportunity to retrain for employment in the clean energy industry.

SOURCE	EREC, 2007
TITLE	**New renewable energy target for 2020 – a Renewable Energy Roadmap for the EU.**
GEOGRAPHICAL COVERAGE	European Union (15 Member States)
METHODOLOGY	I-O tables, based on Sapphire model.
MAIN RESULTS	The wind energy sector will account for around 184,000 jobs in 2010 (direct and indirect) and 318,000 in 2020 (if the 20% RE target is reached).

SOURCE	EWEA, 2003
TITLE	**Survey for Wind Energy – The Facts.**
GEOGRAPHICAL COVERAGE	European Union (15 Member States)
METHODOLOGY	Survey tof wind energy manufacturers, supplemented by the use of technical coefficients.
MAIN RESULTS	Direct employment in turbine manufacturing en Europe for 2002 accounted for 30,946 people, turbine installation for another 14,649, O&M for 2,768.

SOURCE	EWEA and Greenpeace, 2005
TITLE	**Wind Force, 12. A blueprint to achieve 12% of the world's electricity from wind power by 2020.**
GEOGRAPHICAL COVERAGE	World
METHODOLOGY	Meta-analysis of past employment studies.
MAIN RESULTS	2.3 million jobs will be linked to the wind energy sector worldwide in 2020, if the 12% target is reached. 444,000 jobs in North America; 222,000 in Europe; 251,800 in South America; 44,400 in Africa, 44,400 in the Middle East; 325,600 in Eastern European and transition economies; 444,000 in China; 148,000 in East Asia; 266,400 in South Asia and 148,000 in OECD Pacific approx.

SOURCE	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2006
TITLE	**Renewable Energy: Employment Effects. Impact of the expansion of renewable energy on the German labour market.**
GEOGRAPHICAL COVERAGE	Germany
METHODOLOGY	Comprehensive study using a questionnaire and extensive theoretical models (I-O table). The study presents net results on the overall economy; direct, indirect and induced impacts.
MAIN RESULTS	The wind energy sector is responsible for around 64,000 jobs in Germany (2004 data). Half of them are direct jobs. By 2030, around 300,000 new jobs will be created in the renewable energy sources sector. The net impact should be between 80,000 and 130,000, depending on future energy prices.

SOURCE	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2008
TITLE	**Kurz – und langfristige Auswirkungen des Ausbaus der erneuerbaren Energien auf den deutschen Arbeitsmarkt. Interim report.**
GEOGRAPHICAL COVERAGE	Germany
METHODOLOGY	Update of the 2006 report (questionnaire + I-O table). 84,300 employees in the wind energy sector by the end of 2007 (direct + indirect).

SOURCE	Kammen, D.; Kapadia, K.; Fripp, M., 2004
TITLE	**Putting Renewables to Work: How many jobs can the clean industry generate?**
GEOGRAPHICAL COVERAGE	EU and the United States of America
METHODOLOGY	Meta-analysis of past employment studies.
MAIN RESULTS	The renewable energy sector generates more jobs per MW of power installed, per unit of energy produced and per US$ of investment than the fossil-fuel based energy sector. The distribution of employment benefits across regions can vary considerably. In the US, a 20% RE share by 2020 could create between 176,440 and 240,850 new jobs, as compared with a figure of 86,369 in the business as usual scenario. The jobs/MW ratio for wind power ranges between 0.71 and 2.79.

SOURCE	Lehr et al, 2008
TITLE	**Renewable energy and employment in Germany.**
GEOGRAPHICAL COVERAGE	Germany
METHODOLOGY	Comprehensive study, using a questionnaire and extensive I-O tables, INFORGE and PANTA RHEI models.
MAIN RESULTS	Gross employment figures in 2004: 63,944 workers. The wind sector lacks skilled personnel, but the situation is expected to improve in 2010. Global market share of wind energy products coming from Germany was 40% in 2004, and is expected to decrease to between 15 and 20% in 2020.

SOURCE	Pedden, M., 2005
TITLE	**Analysis: Economic Impacts of Wind Applications in Rural Communities.**
GEOGRAPHICAL COVERAGE	United States of America
METHODOLOGY	Meta-analysis of 13 studies.
MAIN RESULTS	Wind installations have a large direct impact on the economies of the local communities, especially those with few supporting industries. A number of local and construction and operation jobs created by a wind energy installation depends upon the skills available in the local community. The jobs/MW ratio is highly variable: from 0.36 to 21,37.

SOURCE	Pfaffenberger, W.; Jahn, K.; Djourdjin, M., 2006
TITLE	**Renewable energies – environmental benefits, economic growth and job creation.**
GEOGRAPHICAL COVERAGE	European Union, with emphasis on Germany
METHODOLOGY	Meta-analysis of previous studies.
MAIN RESULTS	All studies predict a growth in gross employment The net employment impacts are substantially less, and can even be negative. None of the studies have taken into account the recent increase in energy prices, which ought to exacerbate the positive effect of RES on employment.

SOURCE	UNEP, ILO, ITUC, 2007
TITLE	**Green jobs: towards sustainable work in a low-carbon world. Preliminary report.**
GEOGRAPHICAL COVERAGE	World
METHODOLOGY	Meta-analysis of previous studies.
MAIN RESULTS	The wind energy sector created 300,000 jobs in 2006 worldwide. The jobs/MW ratio in manufacturing, construction and installation can be situated between 0.43 and 2.51; 0.27 for O&M and 0.70 to 2.78 in total.

SOURCE	Whiteley, O. et al, 2004
TITLE	**MITRE project. "Meeting the targets and putting RE to work". Overview report.**
GEOGRAPHICAL COVERAGE	European Union (15 Member States)
METHODOLOGY	I-O tables, based on Sapphire, model.
MAIN RESULTS	The wind energy sector will create between 162,000 and 368,000 new jobs in the EU (net effect; direct, indirect and induced) by 2020, according to the current policies and advanced renewables strategy respectively. After 2010, employment levels will only be maintained if the sector is capable of keeping its leading role and finding new markets outside the EU.

ANNEX 2:

Employment prediction and methodologies

2.1 Methodological approaches to employment quantification

The wind energy sector includes job profiles from many different economic sectors, such as equipment manufacturing, electricity generation, consulting services, engineering services, finance and insurance. Frequently national statistics bureaus do not provide data specific to wind energy employment. Tailored surveys and input-output tables thus constitute the only sources of reliable information, but they are limited by the rapid evolution of the sector, and regular updates are necessary.

In Europe, employment data is collected by means of surveys, which are sent out periodically by national governments. These are generally known as "labour force surveys", and they follow the NACE methodology (***S**tatistical **C**lassification of **E**conomic **A**ctivities rev 1.1*; Statistical Office of the European Communities, Eurostat, 2008). The bulk of wind energy companies fall into two categories:

D	Manufacturing
31.	Manufacturing of electrical machinery and apparatus n.e.c.[8]
31.1	Manufacturing of electric motors, generators and transformers
31.2	Manufacturing of electric distribution and control apparatus
31.6	Manufacturing of electrical equipment n.e.c.
E	Electricity, gas and water supply
40.	Electricity, gas, steam and hot water supply
40.1	Production and distribution of electricity

8 In the NACE methodology, 'n.e.c.' stands for 'not elsewhere classified'.

Photo: EWEA/Brolet

Photo: Stiftung Offshore-Windenergie

Other wind-related activities appear in the following categories:

F	Construction
45.	Construction
I	Transport, storage and communication
60	Land transport, transport via pipelines
J	Financial intermediation
65.	Financial intermediation, except insurance and pension funding
66.	Insurance and pension funding, except compulsory social security
K	Real estate, renting and business activities
73.	Research and development
M	Education
80.	Education
O	Other community, social and personal service activities
91.	Activities of membership organisations n.e.c.

The official statistics lack the level of detail that would allow employment directly attributable to the wind energy sector to be quantified. The alternative to using the official statistics would be to design an *ad-hoc* approach, and the studies that have been carried out on this matter apply a range of methodologies that can broadly be grouped under two headings:

- Data collection based on surveys and other documents (for example company annual reports, official tax-related enterprise registers and government statistics).
- Data collection based on theoretical relationships between sectors, vectors of activity and input-output tables.

Pros and cons of surveys and other written information

The advantages and limitations of social surveys as tools for quantifying social/economic phenomena are extensively covered in specialised literature (see, for instance Rubio, M.J. and Varas, J., 1999; Weisberg *et al* 1996; Schuman *et al* 1996). This report does not go into similar details.

We have quantified indirect employment using previous results, notably (EWEA, 2003) and results from the detailed survey on direct employment. For direct employment, it is essential to choose an appropriate subject for the study – either the whole "population" or a representative sample of it. Secondly, the questionnaire needs to be easily understood by the respondents and avoid answers that could be biased (for example if the interviewee suspects that their opinion will have political or financial consequences, if they

Photo: RES/Sébart

change their replies in order to please the interviewer, or if they like or dislike the subject matter). Thirdly, the information gathered must be studied and analysed properly. For surveys such as these, the response level tends to be low in proportion to the total population/sample selected, and this can mean the results have to be completed from other sources.

When an official register – such as a national census – is used, the validity of the information depends on its comprehensiveness, reliability and how often it is updated. Very often the registers include only part of the data that is being investigated, and that is why they tend to be used in combination with other techniques.

Advantages and disadvantages of input-output models

The input-output (I-O) approach is used to estimate the direct and indirect interrelationships and impacts (including employment) of one sector of an economy on all the other sectors. The methodology was first introduced by Wassily Leontief in the 1930s (Leontief, 1986) and in its most basic form consists of a system of linear equations containing productive coefficients that describe the relationship between the materials – the physical input – used by the sector and the final product – the output. The input-output table traces the sources of the input used by each sector and whether it is purchased from other firms in the economy or imported, and provides a breakdown of the sector's output, with a quantification of sales to other industries and final demand (Kulisic *et al*, 2007). The table provides quantitative data on the size of the effect on total employment, income and gross output.

As may seem obvious, designing I-O models is difficult, and there are very few research institutes in any country which can boast of having such a model – normally only the national statistics office and the government. When an emerging sector like wind energy needs to be studied, the I-O table must be adapted, either by adding a new vector to the model or by extending the table to include the new sector. In both cases, the analyst will need detailed information on the characteristics of the emerging sector, and this is normally gathered through questionnaires and expert interviews (Mattas *et al*, 1984; Millet and Blair, 1985).

In the field of energy, the reference models at EU level are PRIMES and Green-X, prepared by the National Technical University of Athens and the University of Vienna respectively. Employment and GDP interactions are given by the ASTRA model, which is then developed further by the Fraunhofer Institute. These models provide the figures that are published by the European Commission in its impact assessment reports, for example its 2007 Impact Assessment on the Renewable Energy Roadmap (European Commission, 2006).

The advantages of the I-O models are the comprehensiveness of the data gathered and the fact that it reflects net economic changes – changes in the sector being studied, in other economic sectors that are linked to it, and in the whole of the economic system through taxation, consumption, the accumulation of capital and export capacity. The disadvantages relate to the cost of carrying out such studies and the need to get hold of an appropriate model. In addition, these types of study do not provide any details at sub-sector level and do not examine issues of gender, qualification or shortages in human resources.

2.2 EWEA survey on direct employment

Several studies on wind energy's effects on employment have been carried out over the last six or seven years, as the sector has grown. A list of the most relevant works can be found in Annex 1.

Denmark, Germany and Spain, the three world leaders in wind energy production and installation, have informative recent studies (AEE, 2008a; DWIA, 2008; Lehr et al, 2008 and Federal Ministry of the Environment, BMU 2008), but the level of employment in other EU countries remains largely uncertain. In particular, there is a lack of information on some key factors that affect the wind energy labour market, like the profiles that are currently most in demand, shortage and gender issues. These issues can best be dealt with through ad hoc questionnaires sent to wind energy companies.

In response to these gaps, EWEA has sought to quantify the number of people employed directly by the wind energy sector in Europe by means of a questionnaire.

As explained in Section 1, direct jobs relate to employment within wind turbine manufacturing companies and sub-contractors whose main activity is supplying wind turbine components. They also include wind energy developers, utilities selling electricity from wind energy and major R&D, engineering and specialised wind energy services. Any other company producing intermediates, components, providing services or sporadically working in wind-related activities provide indirect employment.

The questionnaire was drafted after a careful analysis of previous research in the field, notably the questionnaires that had been used in the German, Danish and Spanish studies and a discussion with the researchers responsible for them. A draft was sent to a reduced number of respondents, who then commented on the clarity and comprehensibility of the questions and use of the excel sheet, the length of the questionnaire and other aspects. The document was modified accordingly.

The final version of the questionnaire was dispatched by e-mail on 19 February 2008 to around 1,100 organisations from 30 countries (the 27 EU Member States plus Croatia, Norway and Turkey). It went to all EWEA members and the members of the EU-27 national wind energy associations. The questionnaire was also distributed to participants at two European Wind Energy Conferences (EWECs 2006 and 2007). Recipients included wind turbine and component manufacturers; developers, independent power producers and utilities, installation, repair and O&M companies, consultancies, engineering and legal services, R&D centres, laboratories and universities, financial institutions and insurers, wind energy agencies, associations and some other interest groups directly involved in wind energy matters.

Photo: Gamesa

The document was translated into five EU languages (English, French, German, Spanish and Portuguese), and some national wind energy associations decided to write the introductory letter in their own languages. A reminder was sent on 11 March and was followed up by telephone in April, May, June, July and August 2008.

The questionnaire consisted of 14 questions, divided into three blocks:

a) The first four questions collected information on the profile of the company, its field of activity (according to the classification given in section 4.1 of this report) and the year in which it started operating in the wind energy sector.
b) The next three questions aimed to gather relevant employment figures. The questionnaire asks for both the total number of employees in the company and the number of employees in the wind energy part, and gives some indication as to how to calculate the second figure when a worker is not devoted to wind-related activities full time. The figures were split by country, since some companies are transnational, and by gender. It would have been interesting to have this data by age and level of qualification too, but the draft sent to a sample of respondents showed us that this level of detail would be very difficult to get and that it would have a negative impact on the number of replies.
c) The final four questions address the issue of labour force scarcity in the wind energy sector, trying to obtain information on the profiles that are lacking and the prospects of wind energy companies in terms of future employment levels and profiles. Questions 9 and 10 were more speculative than the rest, since it is difficult to quantify the exact number of jobs likely to be created in the next five years, but they aimed to give an order of magnitude that could be then compared with the quantitative approaches used by other researchers who have applied input-output tables.

Photo: Gamesa

A copy of the questionnaire in English can be found in Annex 2 of this report. The questionnaire was complemented by in-depth reviews to a selection of stakeholders reflecting the main wind energy sub-sectors and countries. The interviews were carried out by phone, e-mail or face-to-face. They aimed to verify the data coming from the questionnaires and to address some of the topics that could not be dealt with in them, notably a more thorough explanation of the job profiles required by the industry, the scarcity problem and a rough estimate of employment according to age and qualification.

By the end of August 2008, 324 valid questionnaires had been received, implying a response rate of 30% approximately. In terms of the size of the companies that replied, most of the large turbine and component manufacturers, as well as the major utilities answered the questionnaire, which means the proportion of replies received is not an accurate representation of the significant contribution to overall wind energy employment these particular companies make.

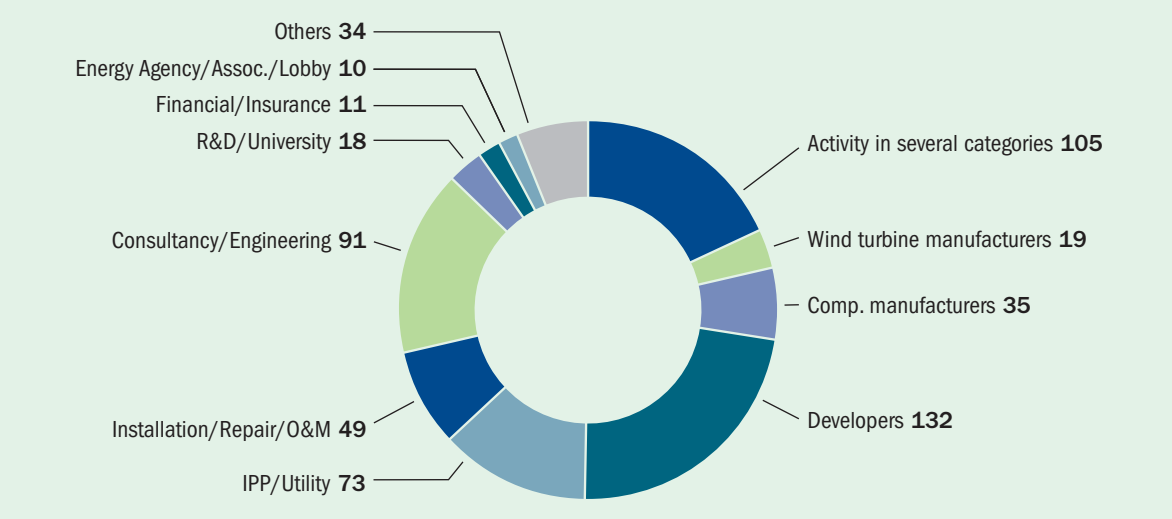
TABLE 10: **Survey results[9]:**

Country	No. of direct jobs reported by the survey	No. of direct jobs estimated in this report	Country	No. of direct jobs reported by the survey	No. of direct jobs estimated in this report
Austria	270	700	Latvia	6	(a)
Belgium	1,161	2,000	Lithuania	6	(a)
Bulgaria	91	100	Netherlands	824	2,000
Cyprus	1	(a)	Poland	312	800
Czech Republic	52	100	Portugal	425	800
Denmark	9,875	23,500	Romania	27	(a)
Estonia	5	(a)	Slovakia	22	(a)
Finland	194	800	Slovenia	4	(a)
France	2,076	7,000	Spain	10,986	20,500
Germany	17,246	38,000	Sweden	1,234	2,000
Greece	812	1,800	UK	2,753	4,000
Hungary	11	100	Rest of Europe	70	400
Ireland	870	1,500			
Italy	1,048	2,500	**TOTAL**	**50,380**	**108,600**

(a) These countries have been included in the "Rest of Europe" category – last row of the table.

9 In a few cases, the questionnaires were filled in by the researchers themselves. This happened when the figures were communicated through a phone call or an e-mail, or when the information needed was available in an annual report or some other publicly-available document.

FIGURE 05: **Number of questionnaires received by type of company:**



The figures are good for this type of survey, but required the use of supplementary sources in order to fill in the gaps and to validate the results. This was done by:

(1) Using thematic surveys and I-O analysis from the three main wind energy markets – Denmark, Germany and Spain. The latter two countries base their numbers on questionnaires very similar to the ones used by EWEA, an exhaustive analysis of the governmental registers for tax-related purposes, and national input-output tables and other technical coefficients in order to estimate the effects on indirect employment. The Danish Wind Industry Association, in turn, collects information about employment from all its members on an annual basis.

(2) Reviewing the annual reports and websites of the main wind energy companies, notably the large wind energy manufacturers, component manufacturers, wind energy developers and utilities. As these companies are on the stock market, they publish some information on their activities and structure that can be used to roughly estimate wind energy figures.

(3) Using the data compiled by the national wind energy associations. France, the UK and Portugal are currently carrying out thematic studies covering employment issues amongst others. Their preliminary conclusions have been incorporated into this report. For the other countries, experts from the national and governmental associations were contacted in order to get a geographical balance of information.

Additionally, this study examined the factors behind the reported shortage of workers in the wind energy business. This was done through in-depth interviews (conducted face-to-face, by e-mail and by telephone) with the human resource managers of a selection of wind energy companies covering a range of types of work and geographical areas. The results were compared with those from Questions 7 to 10 of the general questionnaire.

ANNEX 3:

EWEA questionnaire

Organisation: .....

Name: .....

Date: .....

I COMPANY PROFILE

1 Company name .....

2 Do you work at head office? .....

If not, in which country is the head office? .....

3 To which category does your company belong (please tick '1' for 'yes'):

☐ Wind turbine manufacturer

☐ Component manufacturer

☐ Developer

☐ Independent power producer, utility

☐ Installation, repair, operation & maintenance

☐ Consultancy, engineering, legal services, certification

☐ R&D centre, laboratory, university

☐ Financial institution, insurance company

☐ Energy agency, energy association, other lobby organisation

☐ Other (please explain)

4 In which year was the wind energy activity set up in your company? .....

II EMPLOYMENT PROFILE

5 Please list the <u>total number of employees</u> (those involved in wind energy and all other sectors) of your company in each of the EU countries where it has an office. We don't need data from non-EU countries. Please, indicate when the data was collected (e.g. December 2007).

	Head office/ Country 1	Country 2	Country 3	Country 4	Country 5	Country 6	Country 7	Country 8
(please select the EU country from the list)								
Men								
Women								
TOTAL								

Date of data collection: .....

6 **Please list the number of employees active in wind-related activities of your company in each of the EU countries where it has an office.** If a worker is not 100% dedicated to wind-related activities, please give the most accurate estimate of how much time he/she spends on them e.g. if approx. 25% of a worker's time is spent on wind-related activities, he/she should be counted as 0.25. We don't need data from non-EU countries. Please, indicate when these data was collected (e.g. December 2007).

	Head office/ Country 1	Country 2	Country 3	Country 4	Country 5	Country 6	Country 7	Country 8
(please select the EU country from the list)								
Men								
Women								
TOTAL								

Date of data collection: .....

7 **Please indicate whether your company is facing a shortage of workers** .....

8 **If you answered 'yes' or 'occasionally' to the previous question, tick the profiles you lack (please tick '1' for 'yes'):**

☐ Executive, top managers, directors

☐ Engineers

☐ Commercial, marketing, sales managers

☐ Operation & Maintenance technician

☐ Low-skilled workers

☐ Others (please explain)

9 **In your opinion, is the number of people your company employs in the wind energy sector likely to increase, decrease or remain stable in the next five years (as from 31 December 2007)?** (please tick '1' for 'yes')

☐ Increase by how much, approx. % .....

☐ Decrease by how much, approx. % .....

☐ Remain more or less stable

10 **What type of profiles do you think your company will mainly be looking for in the next 5 years?** (please tick '1' for 'yes')

☐ Executive, top managers, directors

☐ Engineers

☐ Commercial, marketing, sales managers

☐ Operation & Maintenance technician

☐ Low-skilled workers

☐ Others (please explain)

11 **If you have any further comments, please write them below.**

.....

.....

Please send this questionnaire back to zoe.wildiers@ewea.org by 14 March 2008.
Your data will be treated confidentially and will be used for the purpose of the study only.
We thank you very much for your collaboration!

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1 IPP/utilities, consultants, research institutions, universities, financial services and other.
2 IPP/utilities, consultants, research institutions, universities, financial services and other.
3 The Windskill project (http://www.windskill.eu/) funded by the European Commission, offers a good summary of the profiles that are required in this area

About EWEA

EWEA is the voice of the wind industry, actively promoting the utilisation of wind power in Europe and worldwide. It now has over 500 members from 50 countries including manufacturers with a 90% share of the world wind power market, plus component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants. This combined strength makes EWEA the world's largest and most powerful wind energy network.

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

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