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Pushing Offshore Wind Energy Regions

Qualification Requirement Analysis

Offshore Wind Energy Industry

Final Report – July 2005

Final Report

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Management Summary

This qualification requirement analysis for the offshore wind energy industry in Europe has been created as part of the transnational EU project POWER (Pushing Offshore Wind Energy Regions). In the five EU member states Belgium, Denmark, Germany, Great Britain and the Netherlands, 32 companies from all sectors of the business area of offshore wind energy were investigated. Companies from the fields of Planning and Development, Foundation Technology and Tower Construction, Mechanical Engineering and Plant Construction, Fibre Composite Technology, Electrical Engineering and Network Connection, Assembly and Logistics fields were represented, as were companies which focus on service, maintenance and repairs and maritime construction and consulting. Expert interviews with managers and employees directly on-site have increased the requirement for further training and qualifications in multinational groups as well as in small and medium size enterprises, so that all plant sizes are represented accordingly in the analysis.[1]

To begin with, this study presents a profile of the status of wind energy use in the five European partner states and shows the particular challenges presented by offshore wind energy use with regard to new technologies and the qualification of employees. An evaluation of the expert interviews shows a wide range of new qualification requirements, some of which are cross-sector and others sector-specific.

New requirements with regard to employee qualifications in the areas of project management, national and international law, quality assurance, occupational safety and health care, technical English and English for negotiations as well as offshore training arise in almost all sectors of the value added chain. In addition, sector-specific qualification requirements have been demonstrated which concern the areas of engineering training, welding and fibre composite technology as well as additional mechatronic knowledge for assembly and service employees. Preferred types of further education were also enquired about, as was experience in cooperation with research institutes and competence centres.

Finally, the detailed analysis of the transnational cooperation of companies in the whole European market also revealed deficits which can be attributed to a lack of comparability and transferability of national professional qualifications, certificates and standards and which repeatedly lead to cost-intensive friction in cross-border cooperation.

Therefore, the creation of comparable European training and qualification standards would be one factor leading to an improvement in cooperation.

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[1] The Project EQUIB carried out in 2003 an investigation on qualification requirements with focus on onshore windenergy industry in Germany (Hammer, Gerlinde; Röhrig, Rolf: Qualifikationsbedarfe im Windenergiesektor, Bremen/Bremerhaven 02/2004) This study was supported by the cities Bremen, Bremerhaven, Cuxhaven, the district of Cuxhaven and the Windenergie-Agentur Bremerhaven/Bremen e.V.

A Qualification Requirement Analysis for Offshore Wind Energy Use: Aims and Methods of the Analysis

Following the enormous growth of the wind energy sector in recent years, the area potential for onshore plants in many areas has been almost exhausted. The future of wind energy use is in the sea. The first offshore wind parks in Europe have already been added to the network and numerous projects are in the planning and approval stage.
The offshore technology is not without new challenges. Ultramodern wind energy plants must endure the burden of wind, waves and salt air under harsh weather conditions far from the coast. This presents new requirements in terms of qualifications of the employees in the companies involved.

1. Aims of the Analysis

This aim of this study concerning offshore wind energy use is to determine the **qualification requirements** in the various sectors which are involved in wind energy use and which are planning and building wind parks and safeguarding their smooth operation.
Offshore wind energy use has high political priority in all European countries bordering the North Sea and the Baltic Sea. Companies are also committed beyond national borders and often form syndicates to manage major projects. This study has been carried out as part of the transnational EU project **POWER** (Pushing Offshore Wind Energy Regions) and includes the countries **Belgium**, **Denmark**, **Germany**, the **Netherlands** and the **United Kingdom** in the analysis.
Recommendations for the **provision of further education capacity in line with requirement** are to be developed on the basis of the qualification requirement determined for the wind energy sector and its individual sectors.

2. Methods

The wind energy field of business can be seen as a complex value added chain ranging from planning to production, through to maintenance and repair of the plants.

2.1 Definition of the Offshore Wind Energy Use Value Added Chain

The value added chain sequence can be shown as follows:

1. Planning/Development/Finance/Insurance
2. Foundation technology and tower construction

3. Mechanical engineering and plant construction (e.g. gears)
4. Plastics and fibre composite technology (e.g. rotor blades, nacelle cladding)
5. Electrical engineering (e.g. construction of generators)
6. Assembly and logistics
7. Service, maintenance, repairs
8. Maritime construction & consulting

On the basis of this process chain, companies were selected from all sectors in the aforementioned European countries in order to obtain material for a qualitative analysis of the qualification requirement.

2.2 Expert Interviews

This material was gathered on the basis of expert interviews on site. In-depth conversations were held with managers and employees in representative companies from all areas of offshore wind energy in order to gain information. The interview was based on an **Expert Interview Manual**, which was made available to all interviewees prior to the interview.

The study is therefore not to be regarded as a statistical analysis. However, due to their representative character, the qualitative results can be compressed into trends.

2.3 Selecting the Company to be questioned

One criterion in selecting the company panel was that the entire value added chain should be covered. Therefore, companies from all the eight aforementioned sectors were included in the analysis. The relevance and the size of the company in the wind energy sector was also an important factor since the offshore business is increasingly controlled by global players which often cooperate with small and medium sized enterprises as subcontractors. For this reason, the company panel included **large, small and medium-sized enterprises**.

A second criterion for selection was that all European partner states should be represented with their companies to at least roughly the same level on the company panel. Thus, the expert interviews were not held on-site only in Germany but also in Belgium, Denmark, the Netherlands and Great Britain, in order to benefit from European operating expertise.

2.4 Design of the Study

Secondary studies analysing offshore wind energy use and comprehensive internet research represented the starting point.

This was the basis for the design of the value added chain outlined above as well as the Expert Interview Manual.

The study was accompanied by specialist seminars, contacts with universities and technical colleges as well as interviews with associations and experts.

The first results were presented to the cooperation partners in the POWER project as well as to invited experts and well-known figures from the world of business at a transnational workshop so that the feedback could be incorporated into the study.

The final report was subsequently also provided to a wide international audience at trade fairs on wind energy.

B Wind Energy Use in Europe

In recent years, the wind energy field of business has established itself as a worldwide growth industry. Growth rates have been 20 to 30 percent. Europe in particular has pushed ahead with this expansion of the sector. Reasons for this course of action include political, economic and ecological factors.

However, wind energy use has for a long time not been limited to onshore plants. The first large offshore wind energy parks are already part of the network in Europe and a considerably higher number of planned projects are being prepared.

1. Political, Economic and Ecological Aspects of Wind Energy Use

Fossil energy sources such as oil and coal, but also the generation of electricity from nuclear power have important disadvantages even if used economically. Non-regenerative energies are limited. If they have to relate to the world market, dependencies on foreign supplier countries and price conditions may arise, which may be detrimental for a country in terms of securing an economical energy supply.

Against this background, the use of the renewable energy source wind is one contribution to the **diversification** of the national energy supply. It also makes use of a resource the **availability of which is unlimited** by its very nature. This is the political significance of using wind energy.

Moreover, generation of energy using wind power plants has nothing to fear in **economic** terms from a comparison with other types of electricity production. In addition to this, the expansion of the wind energy sector, which employs a relatively high number of people, also has an enormous secondary employment effect so that this field of business can be seen as a job engine. Every direct workplace in the use of wind energy generates two additional workplaces in the supplier industry, which provides steel, gears, generators, foundation laying as well as other components and services.

Lastly, wind power serves an excellent **ecological** purpose. With the Kyoto Protocol, the majority of industrial nations stated their wish for an effective reduction of carbon dioxide emissions. As early as 1997, therefore, in the interests of climate protection, the European Commission’s White Book specified its aim of doubling the proportion of renewable energy in the total energy supply in Europe from 6% to 12% by 2010. Some member states have even set their national climate goal considerably higher.

2. Onshore: a Success on the Land

In the past, the expansion of wind energy use has taken place mainly on the land. The windiest areas have now been exhausted in many European countries, with the result that sales in this field have been on the decline.

Compensation has come from **repowering**. This means that old wind energy plants are replaced by new and more powerful types. With a service life of approximately 20 to 25 years, therefore, the early replacement of still functioning plants can still be profitable because the marketable innovative technology of today functions more effectively while costing less.

The other field in which onshore business can be expanded is in the **export** of plants. Particularly the Eastern European countries acceding to the European Union are possible purchasers of exports since they have to manage the modernisation of their national energy supply on limited financial budgets. There may also be demand for innovative energy technology in China and India.

3. Offshore: the Future at Sea

The greatest growth potential for the wind energy industry is at sea. The sea offers high wind speeds, which can also be better exploited than on land, covering extensive areas.

These are great advantages over onshore operation. The disadvantages, such as acoustic and visual burdens (shadows) on inhabitants, hardly apply at all due to the fact that the wind parks are a long way from the shore.

However, the requirements in terms of planning, construction and operation of wind energy plants at sea are also greater. On the one hand, numerous conservation, fishing and seafaring rights have to be taking into account during the planning phase. On the other hand, the offshore plants are planned mainly in very deep waters of 20 to 40 metres, far from the coast. There, they are exposed to far greater stress from the wind and waves than onshore plants. The salty sea air makes heavier demands on corrosion protection. Maintenance and service work depends heavily on weather conditions at sea and is very cost intensive.

All in all, however, these more difficult operating conditions are balanced out by the greater efficiency of larger, more innovative plants which have two to three times the onshore capacity of a windmill and are expected to produce an output of 5 MW in the future.

With few exceptions, wind parks at sea require an investment volume which can only be provided by large banks, energy groups and other global players. The profile of companies involved in offshore development is changing accordingly.

4. Offshore Wind Energy Use in Europe: Status and Prospects

The expansion of the offshore wind energy industry in the five European partner states analysed in this study is at different stages of development. While Denmark and Great Britain play pioneering roles with regard to wind parks already constructed or under construction, Germany brings up the rear in this respect. However, the size of the capacity projected here, which is in the planning and approval phase, is extraordinary. The Netherlands has also already completed offshore plants, while a showcase project in Belgium is still under construction.

The European Wind Energy Association, EWEA, estimates that by the end of this decade 10,000 megawatts of wind energy in European territorial waters will flow into the grid. By 2020, this output is expected to rise even further to 70,000 megawatts.

The following overview deals with the European partner states in alphabetical order and does not involve any evaluation with regard to quality and output capacity of individual countries' plans.

4.1 Belgium

On the basis of the Kyoto Agreement, Belgium has set itself impressive targets in the reduction of greenhouse gases. A reduction of 7.5% is planned by 2010 and 15% by 2030.

In order to achieve these political goals, the law on liberalisation of the electricity market (1999) obliges energy suppliers to obtain at least 3% of their capacity from renewable energies.

The Belgian state grants applicants extensive freedom in drawing up plans and identifying regions suitable for wind parks. The results are to be presented for evaluation and approval to the regulatory authorities for gas and electricity.

In spite of the sector's high political priority, a subsidy specifically for offshore development is not currently planned in Belgium. However, the Government has specified a minimum purchase price of €0.09 per kWh for energy suppliers who feed offshore electricity into their grids.

In the past, the expansion of offshore parks was rather modest, as the following table shows:

Project name	Developed by	**No. of turbines**	Output in MW	Status
Thornton Bank	C-Power	60	300	Approved

The plant is approximately 40 km from Oostend and will not be visible from the coast, one aspect which greatly simplified the approval procedure. Once it is in operation, Thornton Bank will provide 1.3 % of the country's electricity supply[2].

[2] References:

(1) German Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU) (publ.), Internationale Aktivitäten und Erfahrungen im Bereich der Offshore-Windenergienutzung [International Activities and Experience with Use of Offshore Wind Energy], January 2002

(2) Palmers, G., et.al. Renewable Energy Evolution in Belgium 1974 – 2025, Scientific Support Plan for a Sustainable Development Policy, Final Report

(3) Shaw, S. et.al., Enabling offshore wind developments, 3E & EWEA, 2002

(4) Hull, F.V. et. al., Optimal Offshore Wind Energy Developments in Belgium, 2004

4.2 Denmark

The expansion of renewable energy sources and in particular offshore technology is lead by the national energy plan ”Energy 21”. The plan of action was worked out by the two large electricity companies ELSAM and ELKRAFT in cooperation with the state authorities *Danish Energy Agency* and the *National Forest and Nature Agency*.

”Energy 21” foresees a 50% reduction in carbon dioxide emissions by 2030 with reference to the base year 1998. To achieve this high target, the aim is for 35% of the country’s total energy supply to come from renewable energy sources. The plan is for 5,500 MW to come from wind energy, 4,000 MW of which is to come from offshore plants.

The Danish concept of expansion seeks to concentrate output on a few large regions in which plants are to be built at a great distance (up to 40 km) from the coast. Smaller wind farms close to the coast, such as the Middelgrunden project, are exceptions. Demonstration projects for testing and improving reliable operation have also been installed.

However, there have been setbacks. In particular, the *Horns Rev* wind park, hailed by the experts as the first genuine wind park in the harsh North Sea, hit the headlines. The tough operational conditions have affected transformers and generators so badly that breakdowns in the cooling system and corrosion damage made it necessary to overhaul all 80 V80 turbines within two years from the date of commissioning. They all had to be dismantled and repaired on land.

Despite such setbacks, the offshore expansion continues because the operators have learnt from their mistakes. For example, wind parks such as *Tuno Knob* and *Vindeby* achieve availability of 98%, a significant indication of the reliability of the plants.

The economic efficiency of the plant can be achieved. The electricity generation costs of the *Tuno Knob* wind park, which corresponds to an investment volume of approximately DKK 77 million, are approximately DKK 0.48 per kWh. A value which is only slightly higher than the production costs for onshore electricity and which will continue to decrease as a result of the potential for savings in the field of plant technology and network connection.

The following table provides an overview of the status of offshore expansion:

Project name	Project developed by	No. of turbines	Output in MW	Status
Vindeby	Energi E2	11	4.95	Built 1991
Tuno Knob	Midtkraft	10	5	Built 1995
Middelgrunden	Middelgrunden Wind Turbinen Kooperative / E2	20	40	Built 2000
Horns Rev	Elsam/Eltra	80	160	Built 2002

Nysted	Energi 2/Dong/Sydkraft	72	165.6	Built 2003
Samso	Samso Havind	10	23	Built 2002
Frederikshavn	MBD/Elsam	4	10.6	Built 2003
Horns Rev II	Open	Approx. 80	200	Planned
Nysted II	Open	Approx. 80	200	Planned

Implementation brings the national energy plan "Energie 21" closer to its goal. If offshore expansion does actually continue to take place in the four identified main regions of the sea, the output installed at sea would correspond to approximately 8,000 MW. This would mean that 50% of Danish energy consumption is covered by offshore wind energy.[3]

4.3 Germany

In the next 20 years, 50% of all power station capacity in the Federal Republic of Germany will be replaced by new plants. Wind energy will play an important role in this. The Federal German government has set itself the goal of doubling the proportion of renewable energy in the electricity supply by 2010. Thus, approximately 12.5% of electricity would come from renewable energy sources by 2010. This proportion has prospects of increasing to as much as 20 % in 2020. In the long term, if this strategy is continued into the middle of the century, 50% of the total energy requirement would come from renewable energy sources.

Climate protection targets are high priority in Germany too. In 1990, the German Federal Government undertook to reduce carbon dioxide emissions by 25% by 2005. This strategy corresponds to the guidelines contained in the Kyoto Protocol.

This policy has created an important tool for the promotion of the wind energy industry in particular in the *Erneuerbare Energien Gesetz (EEG)* [Renewable Energy Law (EEG)]. According to the amended EEG law in 2003, the support for onshore plants was continued, albeit at a lower level. Energy suppliers are obliged to purchase electricity from wind energy at a state-defined feeder price, which the amended law reduced by 0.1 cent to 8.7 cents per kWh. A price which was then further reduced to 5.5 cents per kWh. At the same time, however, the amended EEG law increased support for offshore energy. The law classifies wind parks as offshore plants to be given financial support if they are erected at least three nautical miles from the coast. Remuneration is 9.1 cents per kWh and is granted for a period of 12 years. This

[3] References:

(1) Olesen, G., Guidelines for spatial planning of wind turbines. Danish Organisation for Renewable Energy, Predac Project, 2002

(2) DEA, Danish Energy Authority, December 2004, www.ens.dk/sw1108.asp

(3) Krohn, S., Wind Energy Policy in Denmark, "25 years of success – what now?", Danish Wind Industry Association, 2002

(4) German Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU) (publ.), Internationale Aktivitäten und Erfahrungen im Bereich der Offshore-Windenergienutzung [International Activities and Experience in the Use of Offshore Wind Energy], January 2002

(5) Neue Energie, Das Magazin für erneuerbare Energien [New Energy, the magazine for renewable energy sources] 12/2004

period is extended according to the distance of the plants from the shore, by 0.5 months per nautical mile and by 1.7 months of financial support per additional meter of water depth. With this, the legislators wish to do justice to the higher costs of constructing and operating wind parks as well as promoting their economic efficiency.

Here, the potential regions for erection of wind parks, as is the case with the European neighbours, are also part of the communal waters for fishing, the use of mineral resources (oil, gas), seafaring and other purposes, while not forgetting the interests of nature conservation and the protection of birds. In the German exclusive economic zone (EEZ), prospecting for offshore plants must take into account the rights of other user interests.

Wind energy in Germany has now become an important branch of industry which provides clear stimulus for employment. 50,000 people work in turbine construction. Nevertheless, after exhausting land regions for onshore plants, the expansion of the offshore industry is still in its infancy.

Various factors are responsible for this. Firstly, the legal process of approval is very complex and time-consuming. Secondly, the planned parks are so large that they can probably only be financed by large banks or global players in the energy and oil sector. Many questions are still to be answered. The German projects are to be implemented in extremely deep waters at a depth of up to 30 meters and are often 40 km from the shore. This presents new challenges in terms of foundation technology, logistics and networking. Profitability calculations are regarded as uncertain. Cable connection and grid feeding will result in costs of €1.15 billion, feeding into the German electricity supply system is considered by experts to be problematic according to the most recent "network study" by the German energy agency DENA, commissioned by the German Federal Government.

This contributes to uncertainty in the sector. A clear direction is needed if the expansion of wind energy is to progress quickly. In Bremerhaven and in the port of Emden, 5 MW demonstration plants are in operation. They are, however, on land, i.e. dry. Regardless of this, the expansion of offshore wind energy use in Germany is still a project on paper, albeit an enormous one, as the following overview shows.

Project Name North Sea	Project Developer	No. of turbines (in brackets: expansion phase)	Output in MW (in brackets: expansion phase)	Status
Emden	Enova	1	4.5	Built 2004
Butendiek	OSB Offshore-Bürger-Windpark	80	240	Approved 2002
Borkum West	Prokon Nord	12 (208)	60 (1,040)	Approved 2001
Wilhelmshaven	Winkra/Enercon	1	4.5	Approved 2001
Borkum Riffgrund West	Energiekontor	80 (458)	280 (1,800)	Approved 2004
Borkum Riffgrund	Plambeck	77 (180)	231 (746)	Approved 2004

Amrumbank West	Rennert Offshore/Eon Energy Projects	80	400	Approved 2004
Nordsee Ost (Amrumbank)	Winkra	80 (250)	400 (1,250)	Approved 2004
Sandbank 24	Sandbank 24/Projekt GmbH	120 (980)	420 (4,720)	Approved 2004
Dan Tysk	Geo	80 (300)	400 (1,500)	Planned
Meerwind	Windland	75 (234)	265 (819)	Planned
Weiße Bank 2010	OSB Offshore-Bürger-Windpark Butendiek	540	2,700	Planned
Forseti	Prokon Nord	1,750	17,500	Planned
Globaltech I	Nordsee Windpower	80 (320)	360 (1,440)	Planned
Offshore North Sea Windpower	Enova	45 (251)	202 (1,255)	Planned
Hochsee Windpark Nordsee 54 25	EOS Offshore	119 (508)	535 (2,286)	Planned
Godewind	Plambeck	80 (224)	320 (896)	Planned
Uthland	Geo	80	400	Planned
Weiße Bank	Energiekontor	80 – 90 (170)	280 – 315 (595)	Planned
Jules Verne	Plambeck	3,000	13,500	Planned
Ventotec Nord 1	Arcadis (Deutsche Bank, GHF, Vestas)	50 (200)	150 (600)	Planned
Ventotec Nord 2	Arcadis	50 (200)	150 (600)	Planned
Nördlicher Grund	Geo/ABB/Global Renewable Energy Partners	87 (402)	360 (2,195)	Planned
Hochsee Windpark He dreiht	Eos Offshore	119	535	Planned
TGB North	ep4 offshore	287 (596)	1,004 (2,549)	Planned
H2-20	Geo	80 (800)	400 (400)	Planned
Nordergründe	Energiekontor	25 (45)	125 (270)	Planned
Riffgat	Enova	44	220	Planned
Bard Offshore I	Bard Engineering	80 (320)	400 (1,600)	Planned
Austerngrund	Rennert Offshore	80	400	Planned
Deutsche Bucht	Rennert Offshore	80	400	Planned
Baltic Sea				
Arcona Becken Südost	AWE(Eon, Brockmüller)	80 (201)	400 (1,005)	Planned
Pommersche Bucht	Winkra	70 (200)	350 (1,000)	Planned
Adlergrund	OWP	80 (160)	280 (720)	Planned
Beltsee	Plambeck	25 (59 – 83)	75 (415)	Planned

Kriegers Flak	Offshore Ostsee Wind AG	40 (80)	140 (320)	Planned
Ventotec Ost 2	Arcadis	50 (200)	150 (600)	Planned
Sky 2000	Geo/Eon Energy Projects	5 (50)	10 (100)	Planned
Baltic I	Offshore Ostsee Wind AG	21	51	Planned
Breitling	Offshore Ostsee Wind AG	1	2.3	Planned
Wismar	Arcadis	1	2	Planned

The wind energy sector relies on resilient political conditions in order to be able to implement the projected wind parks.[4]

4.4 The Netherlands

Since 1997, the *Duurzame Energie in Opmars* agenda has specified the direction for expansion of wind energy use on land. A formal agreement between the national government and the provincial government BLOW (Bestuursovereenkomst Landelijke Ontwikkeling Windenergie) was made to facilitate at least 1500 MW of wind power onshore. Furthermore the government is also pushing a strategy of offshore application in order to implement the ambitious political goals of the Netherlands in terms of renewable energy.

According to agreements of the Dutch government conclude in the EU white paper, the proportion of renewable energy in electricity generation is to increase to 9% by 2010. At the same time, the plan is to reduce the emission of greenhouse gases by 6% between 2008 and 2012.

The latest scheme that has been developed in 2004 by the government is the MEP (Milieukwaliteit Energy Production) a subsidiy scheme for electricity produced by renewables.

Overall, the government has plans for an installed output of approximately 7,500 MW in the field of wind energy by 2020. 6,000 MW of this will come from offshore plants. The Netherlands Energy Research Institute ECN calculated a capacity of as much as 8,000 MW by 2030.

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[4] References:

(1) Strategy of the German Federal Government regarding Use of Wind Energy at the Sea, 2002

(2) Neue Energie, Das Magazin für erneuerbare Energien [New Energy, the magazine for renewable energy sources] 12/2004

(3) Weser-Kurier 20.1.2005, Wind-Studie sorgt für kräftigen Wind [Wind Study Causes Strong Wind]

(4) Der Spiegel 4/2005, Windige Rechnungen

(5) Hammer, Gerlinde, Röhrig, Rolf, Qualifikationsbedarfe im Windenergiesektor: On- und Offshore [Qualification Requirements in the Wind Energy Sector: Onshore and Offshore], Bremen/Bremerhaven 2/2004

(6) Windenergie 2003, Bundesverband Windenergie [Wind Energy 2003, German Wind Energy Association], 2/2003

(7) DEWI, Deutsches Windenergie Institut, Windenergienutzung in der Bundesrepublik Deutschland [German Institute for Wind Energy: Use of Wind Energy in the Federal Republic of Germany], DEWI Magazin 2/2003

(8) Hille, Maren, Gabriel, Jürgen, Entwicklung der Kraftwerkskapazitäten an der deutschen Nordseeküste bei Ausbau der Windenergienutzung, Gutachten Bremer Energieinstitut, Bremen [Development of Power Station Capacity on the German North Sea Coast with the Expansion of Wind Energy Use, Expert Report by Bremen Energy Institute], 2004

The strategy for development of wind energy was worked out by a cooperation group made up of government authorities and energy suppliers. The central body in this governmental process is SenterNOVEM, an operating agent for Dutch Ministry for Economic Affairs. Their task is to push ahead with the development of wind power.

No offshore windfarms will be realised within a distance of 15 km from the coast line, the exeption being the demonstration farm NSW in front of the bathing resort Egmond aan zee. In order to accelerate the process, the government is currently developing a concession system for offshore wind parks. The approval procedure only begins after procurement of a concession.

Prior to obtaining a concession the interested parties could express their interest in the development of an offshore windfarm by writing a so-called start notitie (starting note). Directly after opening of the procedure it turned out that many parties were interested and a total of 59 starting notes, with a total of more than 5000 MW were submitted to the government. The reaction of the Ministry of Economic Affairs on this overwhelming interest was an immediate stop on the MEP support for offshore windenergy. This again brought offshore windenergy to an almost complete stop, except for the Q-7 and the NSW offshore windfarms, for which an official approval for the MEP subsidy was already submitted by the government.

Again, the following overview shows the status of expansion and planning.

Project name	Project developer	No. of turbines	Output in MW	Status
Lely (Ijsselmeer)	Nuon	4	2	Built 1994
Dronten (Ijsselmeer)	Nuon	28	16.8	Built 1996
IJmuiden (Q-7)	E-Connection	60	120	Approved 2004
NSW (demonstration project)	Noordzeewind (Shell/Nuon)	36	100	Planned

To avoid or to resolve legal conflicts in identifying regions to be used – in particular, nature conservation and bird protection interests are of importance here, the Dutch government has initiated the *Integral Management Plan North Sea 2015*.[5]

[5] References:

(1) www.vrom.nl, Material zur Raumordnung, Planung und Identitfizierung von Flächen [Material for Regional Development Planning, Planning and Identification of Areas]

(2) www.noordzee.nl Portal zur Windenergienutzung in den Niederlanden [Portal for Wind Energy Use in the Netherlands]

(3) Neue Energie, Das Magazin für erneuerbare Energien [New Energy, the magazine for renewable energy sources] 12/2004

(4) German Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU) (publ.), Internationale Aktivitäten und Erfahrungen im Bereich der Offshore-Windenergienutzung [International Activities and Experience in the Use of Offshore Wind Energy], January 2002

4.5 United Kingdom (Great Britain)

Although Great Britain with its windy coastline excellently fulfils geostrategic preconditions for use of wind energy, its expansion has been slow. Annual growth rate values of approximately 80 MW are very low in comparison with the rest of Europe.

According to experts, there are various reasons for this. Firstly, in sparsely populated coastal regions which are suitable as locations for wind parks, the electricity network cannot deal with the feeding of large amounts of electricity produced by wind energy. Secondly, the so-called bidder system in Great Britain is held responsible for the slow development. According to this, potential operators of wind energy plants offer an electricity price in competition with other planning companies. There is no feed-in remuneration fixed by the state and, as a result, the bidder system has generated more uncertainty than it has promoted economic efficiency.

Nevertheless, the government is committed to the expansion of wind energy and is pushing ahead increasingly with the creation of offshore parks. To solve the problems of feeding into the network, sea cables are planned on the west coast of Great Britain parallel with the coastline which are meant to transport the electricity directly into the centres of consumption.

Use of wind energy is high priority as the British government also wishes to achieve its ambitious climate protection goals in this way. By 2010, the state intends to exceed the Kyoto goal of 12.5% emission reduction by committing itself to 20%. This makes the use of renewable energies essential. The proportion of the country's electricity generation is to increase to 10% by 2010.

With the *Renewable Obligation (RO)*, Great Britain has committed itself to the promotion of wind energy and has resolved to promote the economic efficiency of this sector in the long-term. The RO obliges energy suppliers to obtain a fixed percentage of electricity from renewable sources. The percentage is 4.9% to begin with and increases to 15.4% by 2015. Companies which fail to meet this target must pay a "buy-out" price, which is approximately 4.4 cent per kWh for each kilowatt hour not bought. With this income, the government supports those electricity suppliers which either fill or exceed their goals.

The approval procedures are complicated. The Crown Estate is the owner of the sea territory within the British territorial waters and invites tenders for leases on regions to be used by potential wind park operators. After a provisional lease has been granted by the Crown Estate, the approval itself must be granted by three ministries. Responsible are the Department for Trade and Industry (TDI), the Department for Environment, Food and Rural Affairs (DEFRA) and the Department for Transport, Local Government and the Regions (DTLR).

The question of network connection is not regulated by the state.

Under civil law, every planner and operator must sign a feed-in contract with the responsible network operators.

The contracts are monitored only by a state regulatory authority, the *Office of the Gas and Electricity Markets.*

The following table shows the status of expansion and planning in the offshore industry in Great Britain[6].

Project name	Project developer	No. of turbines	Output in MW	Status
Blyth	Eon UK/Amec/ Shell/Nuon	2	4	Built 2000
North Hoyle	RWE npower renewables	30	60	Built 2003
Scroby Sands	Eon UK	30	60	Built in 2004
Kentish Flats	Elsam/Global Renewable Energy Partners	30	90	Under construction
Solway Firth	Offshore Energy Ressources	60	216	Approved
Barrow	Centrica/Dong/ Statkraft	30	108	Approved
Burbo Bank	Elsam/Seascape Energy	30	90	Approved
Rhyle Flats	RWE npower renewables	30	150	Approved
Scarweather Sands	United Utilities	30	108	Approved
Gunfleet Sands I	GE Gunfleet Ltd.	30	108	Approved
Cromer	Norfolk Offshore Wind	30	108	Approved
Lynn	Centrica/Amec	30	108	Approved
Inner Dowsing	Centrica/Offshore Wind Power	30	120	Approved
Shell Flat	Cirrus Energy	90	324	Planned
Teeside	Northern Offshore Wind	30	90	Planned
Walney	Dong/Statkraft	-	450	Planned
West Duddon	Scottish Power	-	500	Planned

6 References:

(1) EWEA, Wind Directions – Focus on UK, November/December 2004

(2) www.thecrownestate.co.uk, Überblick über Windfarmen in UK [Overview of Wind Farms in the UK]

(3) British Wind Energy Association, www.bwea.com

(4)German Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU) (publ.), Internationale Aktivitäten und Erfahrungen im Bereich der Offshore-Windenergienutzung [International Activities and Experience in the Use of Offshore Wind Energy], Januar 2002

(5) New Energy. Magazine for renewable energy, 1/2005-04-25

(6) refocus. The international renewable energy magazine, March/April 2005

(7) BWEA Briefing Sheet, Offshore Wind, November 2004

(8) BWEA Briefing Sheet, Wind Power and Intermittency: The Facts, April 2005

Gwynt y Mor	RWE npower renewable	200	750	Planned
Thanet	Warwick Energy	-	300	Planned
London Array	London Array	300	1,000	Planned
Gunfleet Sands II	Delatic	-	64	Planned
Greater Gabbard	Airtricity/Flour	140	500	Planned
Sheringham	Ecoventures	80	315	Planned
Docking Shoal	Centrica/Amec	-	500	Planned
Lincs	Centrica/Offshore Wind Power	-	250	Planned
Race Bank	Centrica/Amec	-	500	Planned
Dudgeon East	Warwick Energy	-	300	Planned
Triton Knoll	RWE npower renewable	-	1,200	Planned
Humber	Humber Wind Ltd.	-	300	Planned
Westernmost Rough	Total	-	240	Planned

C Results of the Expert Interviews

To obtain a comprehensive overview of the offshore wind energy business field and its new challenges, companies from all eight areas of the value added chain were included in the analysis:

1. Planning/Development/Finance/Insurance
2. Foundation technology and tower construction
3. Mechanical engineering and plant construction (e.g. gears)
4. Plastics and fibre composite technology (e.g. rotor blades, nacelle cladding)
5. Electrical engineering (e.g. construction of generators)
6. Assembly and logistics
7. Service, maintenance, repairs
8. Maritime construction

Despite being very similar to wind energy use on land, offshore wind energy is more than simply a continuation of the onshore business only ”with wet feet”.

This is true not only with regard to technology but also economics. Offshore technology presents research and innovation with new challenges and, as a result of the sheer volume of tasks to be undertaken in the construction of wind parks at sea, the business enters financial dimensions which can only be resolved in cooperation with global players from the banking and energy sectors. For this reason small and medium-sized companies were included in the analysis of qualification requirements as well as genuine major concerns.

Both the purposes of this analysis as well as the offshore business itself are transnational in nature. Large groups have branches and establishments in other European countries and the orders from small companies are often processed beyond their own national borders. This study has taken a look at the on-site work of offshore companies in Belgium, Denmark, Germany, the Netherlands and the United Kingdom and has made available the experience and expertise of specialists in in-depth discussions.

The interviews, which were based on an ”Expert Interview Manual” sent out beforehand, focused on five central questions:

1. What is the current qualification profile of your employees?
2. What new qualification requirements arise from use of offshore wind energy?
3. How is the personnel of the company expected to develop (redundancies, new appointments) in the face of the offshore expansion?
4. What concrete further education requirements can the company name and for how many employees?
5. From the point of view of the companies, is it necessary to make changes to professional and university education?

In the following, the study documents the main results of the qualitative analysis. It will be shown that some results are sector-specific while others are cross-sector.

The presentation of the results begins with the **qualification profile** of the companies. We then provide a profile of the new **challenges in the offshore wind energy business field**, as shown by the experts from the companies studied. A tour of the individual branches in the value added chain provides an overview which ends, in each case, with a reference to new **qualification requirements** arising.

This qualification requirement is condensed in the subsequent section into a **list of qualification components**. There is a reference in each as to the sectors in which there is demand for these qualification components. Following this, the **preferred forms of further education** and the requirement registered as well as the **personnel development** to be expected are presented.

As most offshore projects are processed in the form of a trans-national cooperation between companies, a separate chapter explains the **deficits and prospects of trans-national cooperation** from the point of view of the experts interviewed. The need for action in this field is enormous. Harmonisation of national standards concerning occupational safety and health care, environmental protection and quality assurance is urgently required. Without certified comparability of national professional examinations and qualifications, time and cost problems arise which greatly impair cooperation between European countries.

Finally, many of those interviewed formulated requirements for improved **international research cooperation**, which we present separately. In particular, cost benefits are expected as a result of innovative technologies and the transition to series production of various components.

1. The Current Qualification Profile of the Offshore Sector

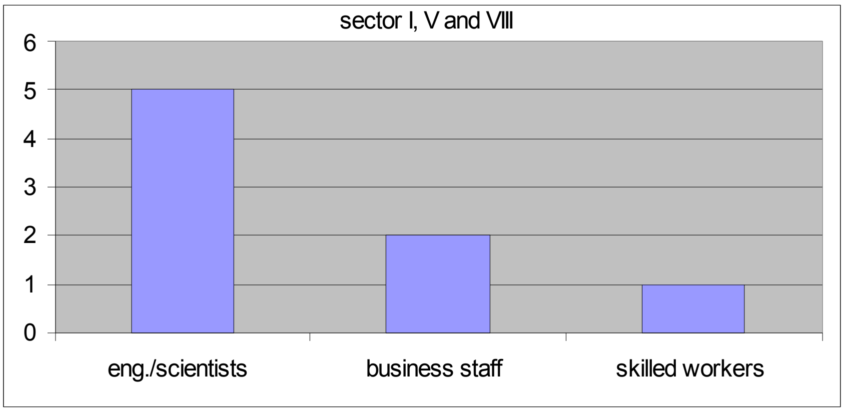
The offshore industry offers a wide range of company strategies. In addition to highly-specialised companies which concentrate exclusively on the wind energy field of business and develop into sector leaders in turbine construction or ship logistics, for example, there are numerous companies with a diversified operational structure. For example, the market leaders in the construction business are also active in foundation technology and construct the foundation of wind parks only in addition to structural and civil engineering on land. Depending on the order situation, "offshore teams" are created which turn their attention to other tasks again once the order has been completed.

Finally, in the face of the considerable financial volumes for the construction of large wind parks at a distance from the shore, national energy suppliers and oil multi nationals are increasingly entering the offshore wind business for which they found subsidiaries which focus on the renewable energy field of business.

Companies which work exclusively in the wind energy sector are therefore by no means the norm. Large companies with a widely varied profile of activities are increasingly active in the market. The presentation of the qualification profile of the sector must reflect this and always includes only that part of a company’s workforce which is actually employed in the wind energy sector.

The qualification profile of the employees naturally varies depending on the sector concerned. There are, however, similarities between the various branches. The following charts show the evaluation of scientists and engineers, commercial and administrative professions, specialists and semiskilled workers in the respective workforce of a sector. The evaluation is based on a scale from 1 (qualification represented to only a very low extent: generally below 10%) to 5 (represented to a very high extent: 50% and more).

I Planning/Development, V Electrotechnics, VIII Maritime Construction:

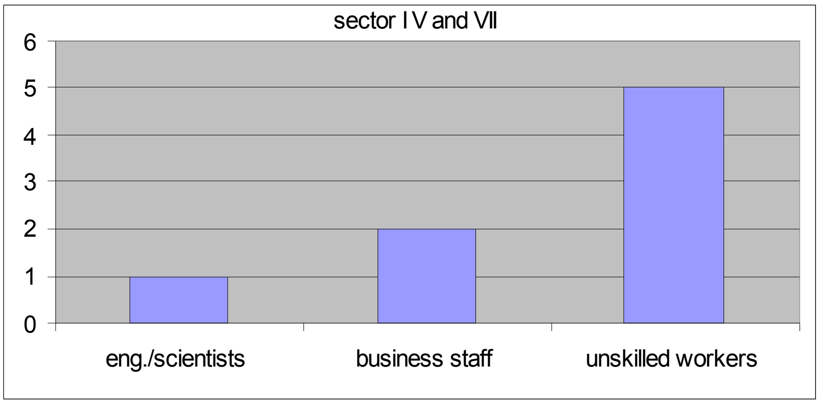


Engineers from all subject areas, particularly construction engineering, mechanical engineering and electrical engineering, are represented. The scientists are recruited mainly from the ranks of geologists, marine biologists and physicists. The commercial professions include a few business management graduates, the majority are business people and office workers.
The specialists are mainly electricians, construction mechanics and related professions. Added to this is a small number of semiskilled workers, which cannot be quantified in greater detail, some of whom have qualifications unrelated to the profession or were unskilled.

II Foundation Technology/Tower Construction, III Mechanical Engineering and Plant Construction:

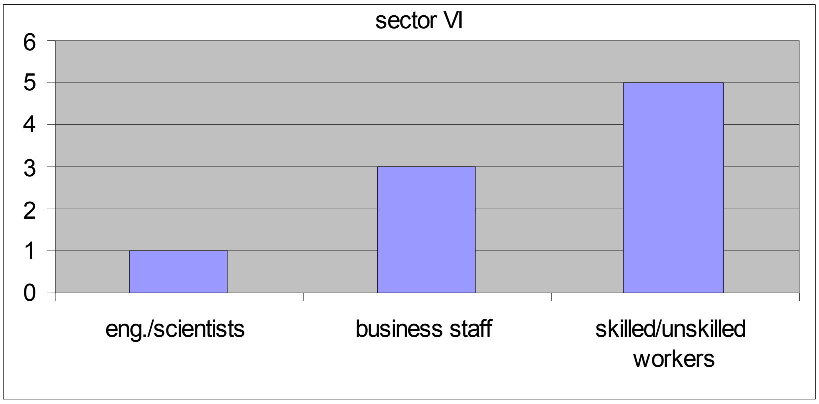
Electrical and mechanical engineers as well as a few physicists provide the scientific expertise of the companies. Specialist qualifications here refer mainly to industrial mechanics and concrete workers. Added to this are a small number of unskilled and semiskilled (= skilled in practice) workers.

IV Plastics and Fibre Composite Technology, VII Service and Maintenance:



In addition to engineers from various specialist areas, chemists are also represented. The evaluation of qualifications is reversed among the workforce without academic certificates. The qualification profile of the workforce is dominated not by specialists but by semiskilled workers.

VI Assembly and Logistics:



In this sector, specialists (mainly in inventory management) and semiskilled workers (storers and packagers) roughly balance out one another. There is a relatively high proportion of business people.

2. New Offshore Challenges Define New Qualification Requirement: a Survey of the Sectors

2.1 Planning, Development, Finance, Insurance

Planning offshore wind parks is a complex sequence of individual steps. The first step is *to identify locations* in which wind farms can be erected. National and international rights, which can vary from country to country, are the general conditions. Bird protection and nature conservation, fishing and extraction rights (oil, gas) as well as rights of use for civil and military seafaring must be complied with. Ultimately, only those regions which are not subject to conflicting rights can be built on.

Trans-national business, which is frequent in the offshore field, also requires sound knowledge of *tax and financial law, customs regulations* and regulations concerning trade and employment in other countries.

The next step is an official *approval procedure*, which can also vary depending on the respective country (see part B).

Finally, wind-technological as well as marine-geological and marine-biological investigations are necessary. Wind measuring masts detect the predominant wind directions and strengths in a given area of the sea which are necessary for the productive operation of offshore parks. *Marine-geological investigations* investigate the condition of the ground in order to assess its suitability for foundations. External specialists and experts are often commissioned to do this by the planning companies.

Generally, major offshore projects can no longer be *financed* by fund models for private investors. The investment volumes are too great for this. In Germany, the so-called "Bürger Windpark Butendiek" is probably the last project to be financed by a fund created by small private investors. Large banks are in demand. National energy suppliers which in the past were in charge of the electricity, oil and gas business, are discovering the offshore wind industry as a new prospect.

The *banks* in particular have great expectations of the reliability of the technology and the availability of offshore plants. Countries in which offshore technologies have not yet been tested to any great extent are distinguished by a certain hesitancy during the planning phase as the banks insist on reliable calculations. The *insurance* situation is comparable. The phase in which the insurance industry insisted on so-called re-opener clauses seems to be coming to an end. These clauses in insurance contracts state that replacement of relevant components such as gears and generators can be required regardless of wear and tear in order to avoid technical errors and resulting downtimes at the expense of the insurers. This however means a drastic increase in operating costs. Now, not only offshore parks have begun operations and amassed their first experiences. Insurance companies have also checked their calculations. The industry now expects an insurance sum of 2% per offshore park with regard to the investment volume.

It is the financial and insurance agencies which provide a comprehensive implementation of *quality standards and quality assurance procedures*. Without certified quality assurance in line with DIN ISO 9000 ff, companies generally have little chance of taking part in major projects carried out by the global players. Germanischer Lloyd (GL), Det Norske Veritas and similar surveying companies operate in this field throughout Europe.

This complex procedure of legal planning, technical and commercial work packages results in **new qualification requirements** for the personnel.

1. The management needs in-depth knowledge of **national and international laws** which are to be complied with in the planning of offshore parks and are often represented in the cost calculation. A taxation of products for export unknown in one's own country can make a project more expensive, a subsidy for energy sources unusual here could have the opposite effect. Therefore, it also pays to have legal knowledge.
2. Project managers must cooperate with representatives of authorities in the approval procedure as well as with banks and insurance companies in matters of finance. **Negotiating skill** is therefore a must.
3. Planning an offshore project involves technical questions as well as legal and commercial ones. A planning company looking for financially strong partners for its project must have a management which can present the entire project as an integrated whole and explain all important technical, official and financial aspects concisely and convincingly. The **dovetailing of technical, commercial and legal skills** is a qualification requirement of project managers on the EU market.
4. Strategies for **quality assurance** are increasingly becoming the standard. Certification in line with DIN ISO 9000 ff should be the goal, as the competition will have an advantage over companies without certification of quality.
5. Last but not least: English is not only a specialist language but also the language of negotiation. **Technical English and English for negotiation** are part of the requirement profile for transnational planners and developers.

2.2 Foundation Technology and Tower Construction

Strictly speaking, *tower construction* consists of the production of cylindrical or conical steel or concrete piles. Structural steel engineering, which is sometimes suppressed due to increasing steel prices, dominates the offshore market. Generally steel segments are welded and assembled on top of one another using flanged joints. These constructions are far greater than currently applied for onshore technology. Firstly, offshore wind energy plants are considerably higher and more powerful, therefore also heavier than onshore plants. For example a 4.5 MW prototype recently erected in Germany in the near shore area has an imposing hub height of 108 meters with rotor blades 53 meters in length. The nacelle is 440 tonnes and at a great height. Added to this are combined loads from wind, waves and the effects of salty air. All in all, these are tough requirements with regard to the steel and its processing. Old welding technologies do not provide the necessary fusion mass because the fission masses of the steel giants increase. New visual methods of flange measurement are used to assemble the segments together with a perfect fit. Innovative means for sustained corrosion prevention are indispensable.

Foundation technology lays the foundation for the tower of the plant. This work step is of decisive importance. Not only because the stability and load-bearing capacity of the whole plant depends on it. The foundations also account for 30 to 50% of the costs of an offshore tower. The real challenge comes not so much from the absolute dimensions of the forces which occur. Decisive is the endurance produced by dynamically effective forces which range between 10^8 and 10^9 cycles. Various procedures can be used depending on the nature of the seabed. If the seabed is rocky, axle tubes are bored and driven into the bed depending on the degree of hardness of the stone. If the bed is soft, consisting of sand, clay or marl, the basic construction is driven. This type seabed, which occurs frequently around the Baltic Sea, may become a problem for the project as a whole, as was recently observed in a German project. Instead of hard stone, the technologists came across thick silt at 20 meters.

There are three alternatives for foundations. So-called gravity-based constructions are common and are used in less demanding sea conditions up to sea depths of less than 15 metres and in benign wave conditions. Heavy concrete blocks which are cast on land are transported by ship to the destination and lowered into a hollow dug out by excavators on the seabed. The concrete heads reach above the surface of the sea so that the towers can be assembled by bolting above the water level.

Monopiles are the most widespread alternative. A large steel pile which is an extension of the wind turbine tower is driven or fitted into a drilled hole into the seabed, depending on the nature of the seabed. The majority of offshore windturbines presently realised in the North Sea is equipped with monopiles.

However, the great water depths of more than 30 m for the planned plants in the German North Sea particularly require new methods. The plinth on which the tower will stand consists in this case of a tripod, a three-legged steel structure with an extent of of approximately 40 metres wide and weighting between 600 and 800 tonnes. The geometrical design of the tripod's legs, their dimensioning and the procedure for processing them (casting or welding) are decisive in terms of their stability and load-bearing capacity. Their design and testing is the task of computer-supported IT programs. Finally, the steel plinth must be protected against corrosion with a suitable paint coat structure. In the case of offshore projects, the scale of work means that large structural engineering and civil engineering companies, whose traditional field of business is not wind energy, become general contractors for foundation.

Occupational safety gains new significance in the case of transnational offshore projects. Working at sea makes the conditions for all activities more difficult. In view of the heavy technical apparatus on site, accidents and downtimes are extremely expensive. As a rule, general contractors take on smaller and medium-sized companies as subcontractors and require meticulous evidence of accident statistics for the respective company as well as internal training measures concerning occupational safety which is, generally, supplemented by compulsory training by the general contractor.

This results in a **bundle of new qualification requirements** for craftsmen and technologists:

1. New welding technologies must be taught by appropriate institutes. **Submerged arc welding** replaces shielded arc welding.
2. Technologists and engineers need new **software knowledge** concerning computer-supported analysis of statistics and stress profiles for tripods and towers.
3. **Quality assurance strategies** are becoming essential. As a rule, quality certificates from certifying institutes are required for international offshore operation.
4. **Occupational safety** is becoming a decisive qualification component and lever in competition for orders. Small and medium-sized businesses which do not have suitable measures and certificates are at a disadvantage.
5. **Offshore training** is indispensable for all craftsmen and technologists who assemble towers on site, i.e. at sea. This includes abseiling, man-over-board manoeuvres and basic knowledge of nautical safety.

2.3 Mechanical Engineering and Plant Construction (Especially Gears)

The important mechanical engineering components of a wind energy plant are as follows: main gearbox, yaw system, generator, as well as hydraulic, attenuation and electromotive aids to control the plant.

Due to current developments, the gears are of particular importance. The larger a windturbine rotor, the higher its rated power, but the lower its rotational speed will be. This means that gearboxes for larger windtubines need more steps in order to gear up from the rotor speed to the generator speed. This makes the gearbox one of the most demanding components of modern large wind turbines, and for offshore windturbines, still becoming larger the design and maintenance of the gearbox needs special attention Some manufacturers try to avoid the use of a gearbox (e.g. Enercon and Zephyros), but in that case a huge generator is needed (of typically 5 m diameter). Others try to find hybrid solutions where a single step gearbox is connected to a medium speed generator.

As with the other components, the generator must be up to the task of satisfying the stringent requirements and withstanding the dynamic stresses. This means on the one hand that, in gear construction, new processes to reduce surface roughness with new finishing technologies are being introduced, and on the other hand the sector is working to optimise lubricants. Both aspects are important for the offshore industry. It is because plants at sea are difficult to reach that a reduction in wear and tear and susceptibility to repairs, as well as a lowering of maintenance intervals, with oil changes for example, are making an important contribution to reducing operating costs.

In addition, sensors are being used which compare the vibrations, temperature, noise development and other parameters with the required target values. Integrated into a condition monitoring system, this technology helps in recognising cases of damage in the preliminary stages, and either minimising their effects or avoiding them completely. There are also new **qualification requirements** here:

1. Industrial mechanics, structural steel engineers and electricians involved in plant construction require an additional qualification which provides knowledge of **mechatronics** or at least an area of it. It is in this segment of plant construction that mechanical and electrotechnical activities are becoming more and more intermeshed.
2. Engineers in this sector, who are concerned with construction and design of gear units, usually have a degree in mechanical engineering or electrical engineering. However, the complex technology involved in wind power plants brings together a number of different areas of knowledge: mechanics, aerodynamics, electrical engineering. This is where **additional wind-specific modules** for vocational and further training of engineers are necessary.

2.4 Fibre Composite Technology (Especially Rotor Blade Technology)

Rotor blades make up approximately 15% - 20% of plant costs and have a service life of around 20 years. In the offshore area, they have different demands placed on them than in the onshore area, as at sea the wind conditions are different. Although the average wind speed is high, turbulence is low compared with locations on land. This reduces the mechanical fatigue stresses. Leading manufacturers of rotor blades are therefore working on lighter and at the same time more economical designs for blades.

Fundamentally, glass fibre-reinforced or carbon fibre-reinforced plastic materials are available, as widely used in shipbuilding and in aircraft construction. The major advantage of carbon fibres, namely the lack of weight and extreme load-bearing capacity, must however be paid for with higher costs. As a result, markets leaders in rotor blade construction have hitherto used almost exclusively glass fibre materials.

There are three processing methods available. Manual laminating consists of collecting the glasfibre textile fibres into a built-up pattern and coating them with polyester or epoxy resin. The second variation, so-called vacuum infusion, inserts the fibres stored in the built-up pattern into a vacuum through film or other suitable coverings which completely soaks up the resin and saturates the fibres. Finally, the third process uses industrial pre-impregnated glasfibre textiles. These are cut to size extremely precisely by IT-controlled machines and are delivered frozen. As they are warmed up, the material is adapted to the shape of the blade and connected. High quality by means of precise design and quantity distribution in the blade ensures exact matching to the rotor. Nevertheless, the costs of the process are so high that leading manufacturers use the vacuum infusion method almost without exception. In addition, this method can be so well isolated from the environment that toxic effects on the workforce are avoided.

New designs to lower the weight while retaining a high degree of strength and flexibility are being used. In particular, the breaking strength of the contact surfaces and the adhesive joints are tested for a year by means of vibrations under laboratory conditions and with original-sized test rotor blades before prototypes go into series production.

Unlike operations on land, offshore plants are particularly exposed to the risk of lightning strikes. Wind power plants at sea are popular targets for lightning strikes on the rotor blade tips, although their effect is far more wide-ranging. An electric arc makes its way from the point of the lightning strike, via other conductive components, to the base of the entire plant and can cause serious damage with temperatures of up to 30,000°C.

In normal operation, condensation forms inside the rotor blade. To prevent water collecting at the tips of the rotor blades and a synchronicity fault, the water is drawn off through openings. If a rotor blade is not fully drained, a lightning strike can result in such pressure inside the rotor blade, due to the extreme temperatures, that an explosion occurs which can completely destroy the rotor.

For this reason, the outlets for the condensation are natural points to locate lightning arresters and conductors. Sensors, which are not just located at this opening but are distributed across the entire surface of the rotor blade, provide lasting protection.

Leading manufacturers also provide monitoring systems which not only indicate damage, but also display the remaining service life of the rotor blades. If the starting point of the index for the fatigue stress of a rotor blade is 0 and 100 at the end of its service life of 20 years, each intermediate value indicates the current degree of wear and tear on the rotor blade caused by use. This is information which is useful for optimal operation. If, for reasons of capacity, the production of wind a park must be run down, those plants which exhibit the greatest degree of wear and tear should preferably be shut down completely.

New qualification requirements:

1. The proportion of unskilled and semiskilled workers employed in production is relatively large. There is requirement for qualifications to impart basic knowledge in **plastic and fibre composite technology**.
2. Industrial mechanics and timber processors need the additional knowledge of an electrician in order to solve mechanical and electrical problems (lightning conduction, monitoring sensors). At least some **specialist mechatronic knowledge** is desirable.

2.5 Electrical Engineering (Components, Cables and Network Connection)

Offshore plants place high demands on electric components. Sealed and water-cooled generators reduce wear and tear and damage caused by salt in the air. Tests on land in a salt-spray bath are performed before assembly is commenced. Frequency converters and transformers are added as additional components and, depending on the design, are often located in the base of the tower in order to reduce mechanical effects caused by the vibration of the tower.

The installation of condition monitoring systems (CMS) are often included as standard, especially with offshore parks. In this way the plant can be examined preventively for possible faults.

The cables to connect the plants to the mains supply must satisfy a number of special requirements. High-voltage direct current transmission (HVDC technology) requires cables with a relatively small diameter for the interconnection of current with extremely high voltages, in order to reduce the energy loss involved in transport. The laying of cables at sea and their connections must be carried out with great care and by expert technicians. Kinks and twists in the cables ("pigs’ ears" in the technical jargon) must be avoided, and the assembly at the base of the tower must not provide any points for corrosion to attack.

Overall, there are the following new **qualification requirements** in this field:

1. For engineers, **windenergy-specific knowledge** of offshore plants is a great advantage.
2. Technicians and electricians need for installation work involving high-voltage components a sound further education in **occupational safety**.
3. As almost all the components in wind power plants are traded on an international market, the use of the corresponding manuals requires knowledge of **technical English**.

2.6 Assembly and Logistics

The manufacture of large wind energy plants for offshore operation is generally carried out near to the shore for logistical reasons. In this way, complicated land transport of major components which pushes up costs can be avoided, and in many cases complete towers are constructed on land and then transported to sea.

In the offshore area, logistics therefore focuses on ships which are specially equipped for the transportation and assembly of major components. A market leader from Denmark operates with ships which are equipped at the sides with compartments and pillars. They are transported out to water up to 25 m deep and in this way stabilise the ship during unloading and assembly operations at sea. Between two and six plants can be transported at the same time depending on their size, and the construction of a plant takes around six hours.

In many cases, the logistics companies pay attention to clean work interfaces. Splicing, bolting and similar activities are the responsibility of the manufacturers and suppliers of the turbines, towers or turn-key plants in order to avoid questions of liability. Moving cranes, fork-lift trucks and other heavy equipment is carried out by the crew at sea.

In terms of the ship's crew, international standards state that there must be at least six trained seamen onboard (including the captain, first and second officer, first and second engineers), the rest comprises logistics and assembly workers who need no nautical qualifications but a certificate that they have completed an offshore training course. Controversies between major general contractors and logistics companies are often sparked off by the question as to whether the regulations of the IMCA (International Marine Contractors Association) arising from the oil and gas industry should be applied, according to which the number of trained sailors per ship would have to be almost double. The IMCA requires a third and fourth officer so that the bridge is always double-crewed for complex work procedures. This opinion is disputed particularly because the costs for the logistics companies and, as a result, the costs for the entire offshore wind plant would increase substantially.

Nevertheless, there are major obstacles to the cooperation of companies within Europe. For example, international standards – more or less comparable with the European driving licence – are lacking when it comes to operating cranes or telescopic working platforms (see Chapter 5).

New qualification requirements in the logistics sector are limited to the following points:

1. **Offshore training** is obligatory for all those sailing on a ship. The training is provided by state-certified companies.
2. **Knowledge of a foreign language** (English) is vital in view of the need to cooperate with foreign companies during on-site assembly.

2.7 Service, Maintenance, Repairs

Servicing companies require workers who are familiar with the various components involved in wind power plants. In the offshore area in particular, due to the difficulty in reaching the plants, it would hardly be possible to finance the use of different teams of service personnel for each different area.

A service technician therefore needs a basic knowledge of mechanical components. Brakes must be tested, gear oil must be changed and so on. There are also electric and hydraulic components.

Lastly, a service company is often involved with monitoring the condition of a plant. This means that a host of measurement data for the wind power plants of a wind farm is entered into a central server, concerning the vibration of components, electrical flows, temperatures, noise development and much more. For numerous components, target values exist for the named parameters, and these must be compared with the actual values. This requires experience of using digital technology and additional knowledge concerning the interpretation of measurement data and steady state characteristics.

Overall, this bundle of tasks results in new **qualification requirements** as follows:

1. Of course, **offshore training** is obligatory for every service technician.
2. Knowledge of **technical English** is vital due to extensive maintenance literature for individual components.
3. Lastly, a meshing together of the various vocational skills and knowledge into an independent **service qualification** is needed: mechanical engineering, electrical engineering, hydraulics, fibre composite technology – you must have a basic knowledge of these subjects.
4. **IT knowledge** for the operation of the condition monitoring system (CMS) is very useful for service technicians.

2.8 Maritime Construction

Maritime design covers various aspects. If companies are involved in the planning and design of wind parks, project management comes to the fore. The identification of areas, approval procedures, financing and calculation, contractual negotiations with subcontractors – as with genuine planning companies, all this is part of the core business through to the delivery of turn-key projects.

At the same time, however, companies involved with maritime design must also be skilled in engineering work. The mathematical design of wind power plants in the wind field, calculations regarding static and dynamic stresses on components and plants then become part of their range of tasks.

Finally, there is a third segment which contains few specialist companies. They have state-of-the-art machinery for ramming and boring technology at sea in order to complete foundations, monopiles and other similar constructions. Normally, these companies hire out equipment and staff to companies involved in setting up offshore plants.

All in all, this results in the following **qualification requirement**:

1. Knowledge of **project management** is required in order for one person to have both technical and commercial knowledge.
2. In addition, qualifications are required in terms of **national and international law** relevant to area identification, putting together a contract and handling financial matters for major projects.
3. In particular, engineers must rely on new **software** suitable for the mathematical modelling of plant design and wind park layout.

3. All Qualification Modules At a Glance

The following provides an overview of the previously explained qualification requirements. At the same time, there is a note in the right-hand column as to the sectors to which these requirements apply.

Qualification Module:	Requirement in Sector:
1. **Project management:** the planning of an offshore project includes technical questions as well as legal and commercial considerations. The management therefore needs to be competent to negotiate in all areas. The **interlocking of technical, commercial and legal competence** represents a typical qualification requirement for project managers active in the EU market.	Sector I (Planning & Development), Sector VIII (Maritime Design)
2. **National and international laws:** It is not just the managers of major planning companies who need sound knowledge of the national and international laws to be taken into consideration when designing offshore parks, and which are often reflected in the cost calculation. If a tax is imposed on products outside the country which are not taxed at home, this can have the effect of making a project more expensive, while if energy sources which are not usually subject to a subsidy receive one, this may have the opposite effect. Legal knowledge therefore pays off. Enterprises involved as subcontractors in transnational projects also need a basic knowledge of the law.	***All sectors, although with differing degrees depending on the extent of the company's involvement in international projects.***
3. **Quality assurance:** strategies for quality assurance are becoming standard practice more and more. This is directed towards the products on the one hand. Generally speaking, expert bodies will require proof of quality in international offshore operations. As on the other hand the process quality of a company is to be guaranteed, this requirement applies across all sectors. The goal is certification in accordance with DIN ISO 9000 ff, as the competition will have an advantage over companies without appropriate proof of quality.	***All sectors***
4. **Technical English and negotiation English:** English is not only the technical language but also the negotiation language. Technical and negotiation English are part of the requirement profile of transnational planners and developers.	***All sectors, in which technical English is relevant for technical functions, negotiation English for management functions.***
5. **Wind energy-specific additional module for engineers:** In their field of technology, wind power plants combine various specialist areas. Mechanical engineering, aerodynamics, and electrical engineering work side by side. Complex static and dynamic stresses are also included. For this reason, additional wind-specific modules for both vocational and further training are in demand to supplement the traditional courses of studies undertaken by engineers.	***For all sectors in which engineers are employed***

6. **Welding engineering**: Offshore plants place greater demands on the quality of the tower's weld seams. Due to the thickness of the steel, and the increasing dimensions of the gap, submerged arc welding has taken the place of shielded arc welding.	***Sector II (Tower Construction)***
7. **The process of fibre composite technology:** The proportion of unskilled and semiskilled workers in manufacturing is comparatively large. There is a need for qualification in terms of passing on basic knowledge of plastic composite and fibre composite technology (manual laminating, vacuum injection, prepreg technology).	***Sector IV (Plastic composite and fibre composite technology, especially rotor blade construction)***
8. **Specialist knowledge of mechatronics:** Industrial mechanics, structural steel engineers and specialist woodworkers all need the additional knowledge of an electrician in order to solve mechanical and electrical problems (lightning conduction, monitoring sensors). And vice versa, electricians must use mechanical knowledge in the maintenance and servicing of plant components. At least some specialist knowledge of mechatronics is necessary in virtually every sector.	***Sector III (Plant Construction and Mechanical Engineering), sector VI (Assembly), Sector VII (Service)***
9. **Occupational safety and health protection:** This is not only indispensable for the health of every individual. It also provides decisive leverage when competing for contracts. Small and medium-sized companies which cannot demonstrate appropriate measures and certificates will not get a look-in when it comes to cooperating with industrial heavyweights.	***For all sectors, especially in the area of implementation***
10. **Offshore training** is indispensable for all skilled manual workers and technicians who carry out activities on-site, i.e. at sea. This training includes abseil techniques, man-over-board manoeuvres and basic knowledge of nautical safety.	***For all sectors and workers who are employed directly "on-site".***

4. Personnel Development, Further Education Strategies, Competence Centres

The expert interviews have not only increased the need for qualifications. At the same time, the companies were asked to report on their personnel development over the next few years as well as on further education strategies and favoured forms of further education.

4.1 Personnel Development

The decision to take on new staff or lay people off is not just dependent on the general market situation but also on the respective company profile. For this reason it is not possible to discern a uniform trend towards building up or reducing the workforce.

Companies which are completely or mainly active in the field of wind energy have had to make job cuts in the last two years. The onshore business is on the decline due to the insufficient space and repowering does not fully compensate. In contrast, offshore business is still very much in the planning stage in many respects, so that it is not possible for every company to expand its business in this area. There have been isolated reports of personnel managers having cut staff numbers by between 20% and 30%.

First and foremost, major companies are diverse in terms of profile. In terms of offshore energy, construction companies, planning companies and mechanical engineering companies are involved in just one business segment, and in addition this accounts for just a small proportion of total sales. In these companies, departments for dealing with offshore business are set up when there is a concrete project to be dealt with. At other times, employees seconded to offshore business are allocated tasks in other business segments of the company. Lay-offs or new appointments depend entirely on the general market situation and the specific company strategy and are not accounted for by developments in offshore business.

Lastly, there is a third category of companies which are in overall charge as providers of equipment for wind parks and suppliers of turbines and components for the offshore business and can plan and implement their expansion with new appointments.

4.2 Further Education Strategies

The overwhelming majority of companies questioned deal with the necessary further education of employees by carrying out in-house training. Really large-scale enterprises also run their own competence centres for this purpose with company-specific training programmes. In addition, external experts run in-house training sessions, mostly due to new equipment or new products being introduced. In this case, the producer or supplier is responsible for showing employees how to use the new technology.

In addition, there are external further education seminars. Institutes of Further Education, professional associations, and also higher education institutions and university competence centres are all prepared to cooperate.

Lastly, learning on the job is a common way of introducing employees to their new tasks. This is done by experienced "old hands" in the business mentoring the new employees. In comparison, the role played by e-learning and hybrid forms such as blended learning is very insignificant.

The general rule is that the bigger the company, the more financial capacity it has to run its own training centres. In contrast, smaller companies find the costs of further education too great.

According to the companies, there is a lack of information in this respect in all the countries investigated. It is not very well known which institutes of further education offer what and under what conditions. Remedying this lack of information would be an important step in making companies aware of the need for qualifications. In the short term, a serious lack of qualified employees may not be a problem, so that the orthodox methods of learning on the job are sufficient. But when the huge offshore projects, such as that currently being planned for the German North Sea, come to fruition, the number of employees and their qualifications will be an important factor. Any deficiency in this respect costs both time and money. This is because the intensified competition for qualified employees will be reflected in an increase in wage and salary costs. Further education strategies are therefore preventive measures not only for personnel development, but also for the development of personnel costs.

4.3 Research Institutes and Competence Centres

In view of the need for qualifications outlined above and the further education strategies of the companies, the research institutes and competence centres are faced with a double task.

On the one hand, they are at the forefront of research into new materials and processes. At the same time, however, they are in demand to provide wind-specific knowledge suitable for transfer to industry. Not only engineers but also service technicians and mechatronic engineers can also benefit from such a range of qualifications.

However, looking at the European market, it is clear that the companies questioned had no or only insufficient information regarding the tasks and results of the various research institutes and competence centres. It would therefore be sensible, in terms of circulating the findings, to not only strengthen European cooperation between the national research institutes but also to present them more widely to companies from various sectors.

5. Transnational Cooperation In Europe: Deficits and Perspectives

As the analysis of the need for qualifications presented here is designed to be international, and research has taken place in five European countries, the experiences of the companies in terms of cross-border cooperation also became clear in the numerous interviews carried out with experts. They have considerable weight and therefore deserve to be looked at individually.

5.1 Deficits: Lack of Comparability for National Standards and Qualifications

The size of the volume of business alone inevitably means that the offshore industry must be based on cooperation between companies in Europe. Plant manufacturers equip the entire European market with units and turbines. Due to a complete European standardisation of the internal market in this area, it is possible to compare the products to a large extent. Electric appliances, for example, which are government-approved in one country, may also be used in a neighbouring European country.

However, doubts surrounding compatibility arise with the certification of qualities, whether it be the planning of wind parks or with individual products. According to the companies questioned, the tendency is for the customer in one country to only accept its own national certification companies. Foreign certifying companies are viewed with suspicion even if they are already global players in the business.

Ultimately, however, the comparability of qualities reaches its limits when it comes to vocational qualifications. Vocational training is defined nationally in individual countries, but the application of vocational qualifications is international in the European single market. In this respect it is a moot point whether, for example, a German electrician could work on an English offshore platform. National standards for offshore training and occupational safety may in the meantime run up against problems in terms of acceptance across the whole of Europe. It is a different matter with vocational qualifications.

For instance, Danish companies in the field of assembly and logistics report that the requirements for a crane driver are very different in the various European countries. While in one case a one day course is sufficient, in other cases it is necessary to prove that a four-week training course has been undertaken.

It is not only national standards that differ. Genuine global players from the oil and gas industry which are starting to break into offshore wind energy, bring with them their own standards, and not just in terms of survival training and occupational safety. A company from the Netherlands reports that, when setting up wind energy plants in Great Britain, a so-called "sling licence" was required by the main contractor for all workers involved in setting up the tower. The fastening of the wire cables to the fulcrums of the steel giant requires a great deal of technical understanding in order that the entire lifting procedure is balanced. Constant communication with other workers by walkie-talkie is necessary, and generally this is not in the person's mother tongue. In the case of costly accidents, insurance companies insist on proof that the workers hold appropriate qualifications, or they refuse to accept legal liability.

Such complications are reflected in time delays and cost increases. First of all, it must be clarified what requirements must be fulfilled and what qualifications are known. The successful completion of a crash course to acquire the above-mentioned sling licence is then entered into the books as a time and money allowance.

5.2 Perspectives: Manufacture European Transferability of Qualifications

The outlining of the problem above contains a hint as to the solution. To consolidate cross-border cooperation of European countries, work must be compatible in terms of its qualifications.

In colleges and universities, the so-called Barcelona Process has already been tried in the EU. The European Credit Transfer System makes Bachelor and Master degrees from every college and university in the EU comparable and worth the same. The process invoices modularising study. Each module is allocated a total number of so-called credit points. A course of study is completed when a certain number of such points is accumulated.

A comparable method for making vocational qualifications compatible and transferable is still in its infancy. But an attempt to tackle the problem with the so-called Euro Pass has already been made by the various European countries. The objective is to make vocational qualifications obtained in European countries comparable and worth the same, so that a mechatronics engineer or crane driver from one country can be employed across the entire European labour market without any practical or administrative problems.

It will be a major challenge for both the competence centres and networks of the wind energy industry to raise awareness of the pressing need for standardisation in terms of qualifications and certification to make growth on the European market as smooth as possible.

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