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State of the Offshore Wind Industry in Northern Europe

Lessons Learnt in the First Decade

2011

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Preface

The past decade has seen the realisation of the first large-scale commercial offshore wind farms. As of 2010, 3 GW of installed capacity has been commissioned and numerous lessons have been learnt; however the true growth of the industry still lies ahead. The sum of national targets for the North Sea countries will exceed 35 GW of offshore wind capacity by 2020. The offshore wind sector is considered to be fundamental to the achievement of renewable energy targets in EU countries.

The POWER cluster aims to tackle crucial challenges for the further development of offshore wind in Northern Europe by cooperating beyond borders and sector barriers. The POWER cluster has commissioned Ecofys to analyse the current state of the offshore wind industry in Northern Europe. This report is a literature and industry review that includes lessons learnt over the past decade, the issues that the industry currently faces and the requirements necessary for further development. It is intended for both public and private audiences and presents the opportunities and challenges that exist in offshore wind energy today.

The findings in this report are structured upon the following narrative:

Situation	Current state of the industry is reflected in offshore wind projects and the supply chain
Opportunity	Expected growth in offshore wind sector offers opportunities for business and economic growth
Enablers	Investments required in supply chain and construction require clear predictions for an offshore wind pipeline. This can be supported by effective stakeholder management and stable Government policies.

POWER cluster

The POWER cluster project aims at implementing a transnational offshore wind energy cluster in the North Sea region. In that respect, the POWER cluster project will help to ensure that the North Sea countries remain world-leading in offshore wind. Core project activities include creating a strong stakeholder and business-to-business network leading to knowledge transfer and bringing together complementary expertise to create more innovation in the sector. The project is 50% funded by the Interreg IVB North Sea Region Programme.

Summary and Conclusions

The offshore wind industry has experienced rapid development over the past ten years and a supply chain is gradually developing towards maturity. Some regions and businesses have successfully taken advantage of this opportunity and have grown into centres for manufacturing, construction and servicing for the offshore wind energy industry. This has generated regional economic growth and jobs. The continued growth of offshore wind is set to provide a major contribution to reaching the EU 2020 CO2 reduction targets of North Sea countries. This is also a valuable opportunity for the development of a major industry that will contribute added economic value and increase potential for exports of leading technology to other regions.

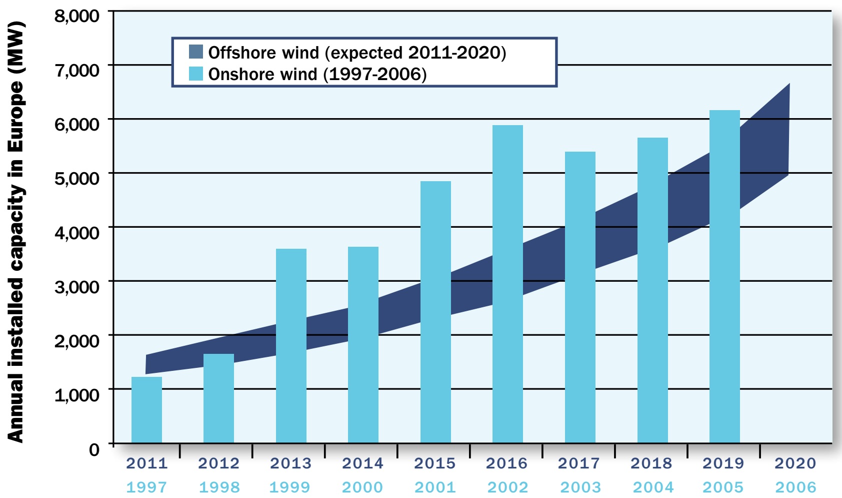
There are however, significant challenges to overcome. These relate to the rate at which projects must be realised, the corresponding growth rate in the supply chain and the scale of the investments required. Effective stakeholder management will be necessary to ensure an efficient acquisition of permits and approvals for projects. Clarity on a long-term policy outlook is also a precondition for the investments required in both supply chain and offshore wind projects. National and regional governments can play a key role in providing a solution to this, by being pro-active and enabling. This looks set to enable a progressive spiral of cost reduction and efficiency, allowing further growth of the offshore wind market

Track Record Offshore Wind Projects

A series of offshore wind projects of increasing scale and technical complexity have been successfully realised over the past decade. The common challenges of twelve pioneering projects are considered in this study, as well the accumulated experience that was utilised to overcome each challenge. The offshore wind industry was able to supply the required technology, materials and construction capacity necessary, although it learnt some difficult lessons in the process. These were primarily related to the new technology required, complex technical interfaces and challenging conditions offshore. In many cases, the development time frame was often lengthy due to complicated permitting procedures and financing.

Growing Supply Chain to match the projects

The supply chain has had to grow rapidly to provide for the 25% annual growth rate in new realised offshore wind capacity. This has proved to be a challenge and will continue to do so. Manufacturers must drastically increase their production capacity, while developing new and reliable designs adapted specifically to wind farms in deeper water and those further offshore. Large up-front investments are required to finance R&D effort and the development of new manufacturing capacity. There are a small number of established players who have manufactured and built the pioneering offshore wind projects and there are also a number of businesses that are poised to enter the market, introducing new designs aimed specifically at offshore wind energy.



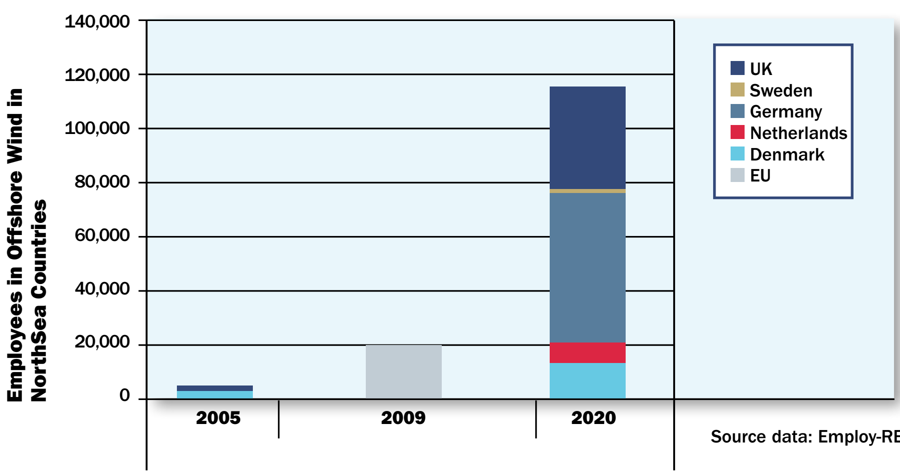
The ability to prove their reliability is an essential condition for market adoption and financing for these market entrants. The main players in the industry agree that improving the supply chain to meet the expected demand is technically feasible, however the multi-billion euro investments required in new manufacturing facilities requires clear and confident expectations for the market growth of offshore wind energy.

Economic Opportunities

The opportunities offered by the offshore wind sector for economic growth and job creation are increasingly apparent and acknowledged in North Sea countries. The current state of the macro-economic climate has provided a significant impetus and urgency for grasping these opportunities. These security and supply benefits were however, already acknowledged at a time of high world market energy prices.

The anticipated rapid growth in the supply chain constitutes huge opportunities for the public and private sector in the North Sea Countries. Employment opportunities totalling approximately 100,000 jobs dedicated to offshore wind energy are estimated, as well as a direct added value of offshore wind industry exceeding €7 billion. A significant proportion of these benefits are expected to apply to coastal regions, where manufacturing and construction and also operation and maintenance will be centred.

This report presents some examples of companies that have flourished by making the switch to offshore wind. Other examples include regional or local authorities that have been pro-active in making upfront investments in basic infrastructure and networking. Through these investments, they have planted the seed for the growth of new centres of excellence for technology and manufacturing, which has created new economic growth and employment opportunities in their locality. Positive actions such as these are also enabling some companies or regions to benefit from further investment and business that accompanies the expected growth of offshore wind sector.



Source data: Employ-RES & EWEA

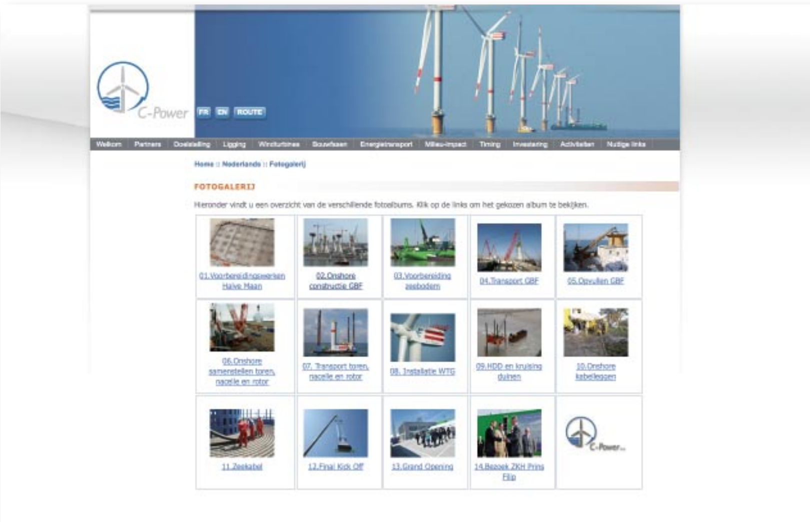
Confident expectations for the rate at which offshore wind projects will be realised is a crucial condition for the investments required to realise the associated economic opportunities. This expectation not only depends on a predictable rate at which offshore wind projects can obtain the required permits and approvals, but also a stable Government policy towards offshore wind energy.

Effective Stakeholder Engagement

Effective stakeholder management is a key enabler for a predictable rate for the realisation of offshore wind projects. If some stakeholders oppose a project, this can present a serious challenge to its realisation or it can lead to significant delays and extra costs. Alternatively, stakeholders that favour the development can be enormously helpful to the progression of a project and a streamlined permitting process managed by a single government body can achieve a clear and efficient consenting procedure.

Project developers and wind energy associations commit significant resources to engaging all relevant stakeholders. Based on the positive experiences of early offshore wind farm developments, stakeholder engagement plans should be guided by:

- Involvement of a wide range of stakeholders in order to identify all concerns.
- Early engagement of stakeholders.
- Clear, honest and interactive dialogue to find lasting and widely acceptable solutions.



Stable Drivers

Reliable expectations for policies and support schemes for offshore wind is another key enabler for unlocking the investments required to achieve a high growth rate for offshore wind energy. In some countries, decisive policies and clear procedures have played a vital role in boosting the growth of the offshore wind sector.

Offshore wind energy is capable of providing a major contribution to the European Union target of 20% of supplied energy from renewable sources by 2020. The National targets of North Sea Countries for offshore wind energy have been set accordingly, exceeding 35 GW by 2020. To reach these targets, support mechanisms ranging from feed-in tariffs, premiums or green certificates have been implemented in these countries. The feasibility of offshore wind projects currently relies on these national subsidies.

Another key factor is the availability of funds for investment in manufacturing capacity and offshore wind projects. A recent study suggests that there are shortages of €95 billion in financing for the required capital investments in offshore wind projects. This is likely to result in competition for funds, with the available finance flowing towards countries with the most stable policy environments and favourable return-risk ratios. Additional sources of finance will need to be found if the EU targets are to be achieved.

Country	*Installed capacity (end 2010) [MW]*	*Consented (end 2010) [MW]*	*2020 targets [MW]*
UK	1,341	2,591	13,000
Denmark	854	418	1,300
The Netherlands	247	2,719	6,000
Belgium	195	1,210	2,200
Sweden	164	995	3,600
Germany	92	8,435	10,000
Norway	2	350	N/A

Recommendations

Offshore wind is set to provide a major contribution to reaching the EU 2020 CO2 reduction targets in North Sea countries. This is a tremendous opportunity for the development of a major industry with associated added value for the economy and potential for exports of leading technology to other regions.

Investments in infrastructure, facilitating effective stakeholder management and stable policy drivers can facilitate this development. National and regional governments can play a key role in this respect through a pro-active and enabling role. Instructive examples for this can be found among realised offshore wind projects and new hubs that are emerging for technology, manufacturing and construction. Such enabling steps will help kick-start a virtuous spiral of cost reduction and efficiency, allowing further growth of the offshore wind market.

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1. Lessons Learnt from Offshore Wind Projects

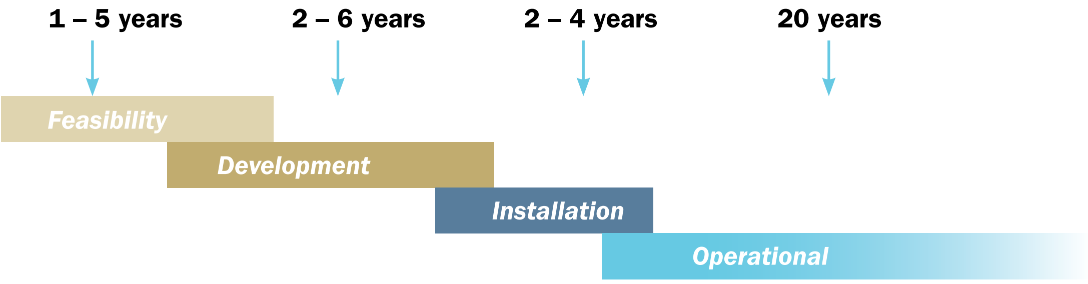
This report discusses some of the key opportunities and challenges expected to materialise as the offshore wind industry rapidly progresses. We will begin with an examination of previous achievements. This chapter will focus on the lessons learnt from twelve successful wind farms. The combined experience gained from these twelve wind farms provides a broad impression of the development of the offshore wind industry over the past decade. The individual case studies are presented in Appendix A and the main lessons are summarised in this chapter.

1.1 Case Studies

Twelve wind farm projects have been selected and analysed in detail to outline common problems and the lessons learnt from these problems. These projects were chosen because they incorporate a wide range of conditions: in six different countries; some are consented, some operational and others currently under construction; some are pilot projects of a few wind turbines and one is the largest offshore wind farm produced to-date; distance to shore ranges from 2.5 to 45 km and water depths vary from 5 to 30 m.

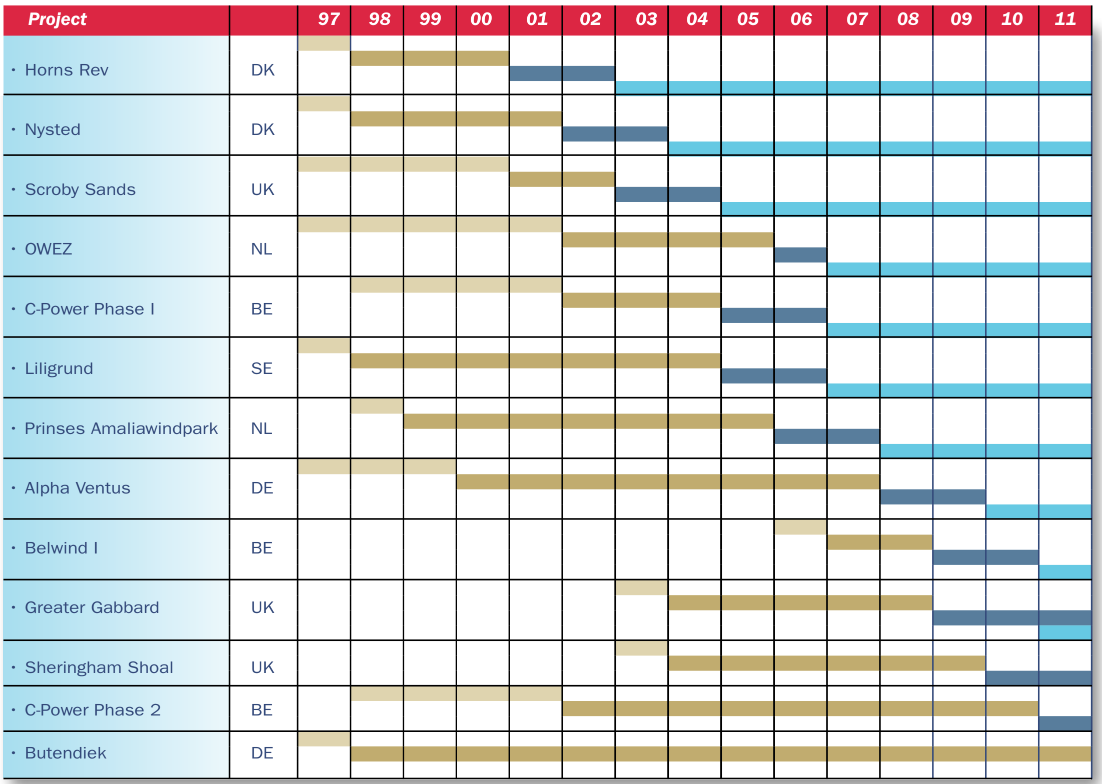
Figure 1 - 1 Overview of Offshore Wind Farms considered

The development activities of each offshore wind farm can be grouped into four phases:



In the table below, these four phases are shown for each of the twelve case studies

Table 1-1 Offshore Wind Farm Development Timeline



1.2 Feasibility Phase – Selecting the site

The initial phase in any project is to define the site and the scope of the wind farm. Interested parties, either in government or private investors, investigate possible sites and make their selection. They are generally looking for the same conditions: high wind speeds, suitable water depths and soil conditions and a minimal impact on stakeholders and the environment. However, the variations in sites within this case study indicates that priorities can vary widely.

For example, the Alpha Ventus site was chosen over 45 km from shore with no visibility from the coast and at a maximum distance from shipping lanes. Clearly, limiting impacts on stakeholders was a key concern. Scroby Sands however, is only 2.5 km offshore on a sandbank with limited water depths. The developers felt that the improved economics of the wind farm would outweigh the risks and costs of increased stakeholder involvement. For this site, the focus was on community involvement and the benefits of a near-shore wind farm.

Government involvement

National governments are becoming increasingly involved in the site selection through detailed screening exercises to identify the most suitable areas for offshore wind development. Some governments provided support early in the development of specific pilot projects, specifying the sites to be developed and the wind farm capacity. In other countries, early offshore wind farm developers had greater flexibility in site selection, proposing sites based on their own criteria.

After the first few projects, governments increased their involvement in site selection. However, a few countries continue to pre-select specific sites upon criteria, including the wind farm size. Instead of direct governmental involvement, national spatial planning exercises are carried out to determine the most suitable offshore wind farm areas. Developers are then able to select their preferred sites within these offshore wind zones.

Site selected by…	*Example projects*
Government	Horns Rev (DK), Nysted (DK), OWEZ (NL)
Developers	Alpha Ventus (DE), Butendiek (DE), Lillgrund (SE), Scroby Sands (UK), Prinses Amaliawindpark (NL)
Developers - within zones selected by government	C-Power (BE), Greater Gabbard (UK), Sheringham Shoal (UK), Belwind I (BE)

These national screening exercises are intended to involve stakeholders at an early stage and to properly balance the interests of multiple users of the sea. Developers should therefore benefit from the reduced risks in site selection.

1.3 Development Phase – Gaining consents

Once a site has been identified, detailed environmental impact assessments (EIAs) and stakeholder consultations are required in order to obtain all the necessary permits. The developer will need to carry out site investigations, define the planned wind farm, evaluate its likely impacts and submit permit applications.
This phase can take between two to six years.

Risks
In some cases, developers receive exclusivity for the site prior to the consenting process, while others face the added risk of competition for the site throughout this procedure.

Many governments now have clear procedures in place and coordinate the consent applications through a central office, although this has not always been the case. The first few proposed offshore wind farms in Germany had to define their own site investigations plan. However, after these initial projects, the investigation concepts were standardised and Germany now has clear guidelines for permit applications. Similarly, the OWEZ project in the Netherlands required consents from numerous different authorities, but the process is now managed by a single ministry. A clear procedure is critical to increase developments, as it reduces the developer's risks at an early stage in the project.

Pilot Projects
One feature of the early consent, was the construction of some wind farms in phases. The pilot phase then consisted of a few wind turbines with a much larger extension phase. This system allowed the impacts of the pilot phase to be evaluated before a full-scale wind farm was approved. However, this reduced project size means an increase in the costs per wind turbine and a consequential reduction in the economic feasibility of the project. This is due to many of the fixed costs, such as electrical infrastructure, that remain high when divided over fewer wind turbines or megawatt hours (MWh) produced.

Other countries also planned pilot projects, but on a larger scale. These projects were large enough to be economically feasible, yet small enough to provide an initial evaluation of the environmental impacts of offshore wind.

Country	Pilot Project	Wind farm capacity
Denmark	Horns Rev	160 MW
Netherlands	OWEZ	108 MW
Germany	Alpha Ventus	60 MW (first phase)
United Kingdom	Scroby Sands	60 MW
Belgium	C-Power	30 MW (first phase)

Although the smaller pilot phases may have delayed financing and required additional government involvement, they do present some advantages, most notably to wind turbine manufacturers. C-Power and Alpha Ventus have both acted as demonstration sites for 5 MW wind turbines, allowing REpower and Multibrid to gain significant offshore experience, with fewer risks than supplying a larger wind farm. These risks were highlighted by the expensive repairs necessary for 80 Vestas wind turbines at the Horns Rev wind farm.

Flexibility

This case study has shown that several wind farms encounter a significant delay between the EIA and the construction of the wind farm. This delay highlights the importance of scoping the EIA to include expected advancements in wind energy technology. For example, the Prinses Amaliawindpark received consents in 2002 for Vestas V80 – 2 MW wind turbines. By the time of construction in 2006, larger wind turbines were already more common in the offshore industry, but it was then, not possible to use these larger turbines in the Prinses Amaliawindpark without re-applying for permits. It is possible that a more efficient wind farm could have been built if the permits were more flexible or if the scope of the EIA had been wider.

In contrast, the EIA system in the UK allows the definition of multiple options and assesses the impact of a realistic, ‘worst case scenario’. This allows the developer to maintain a necessary degree of flexibility in the final wind farm design, within a comprehensive EIA.

Media strategies

Public support is critical for the successful consent of an offshore wind farm and developers have all made efforts to highlight the benefits of their project publically. Websites, public information centres, newsletters and press conferences have all been used to project a positive image. The focus of the media strategies varies by location, but generally reflects the same themes.

Focus of media strategies
• Powering homes with reduced greenhouse gas emissions
• Contribution towards national and EU commitments
• Improved energy security
• Increased employment and economic development
• Local community benefits

Financing

The financing phase can be loosely defined as all activities leading to the financial close of the project. The agreements for financing and construction of the project are set up at this stage. This process leading to the final investment decision and financial close of the project can take anywhere between one to four years for successful projects. Some projects happen not to be financially viable enough for the company bearing and are therefore sold to bigger players or abandoned.

There are two primary models for financing large-scale offshore wind farms, dependent on the type of developer. Utilities are generally able to finance offshore wind farms on the strength of their balance sheets. Independent project developers utilise non-recourse project finance however, which means that loans rely primarily on the cash flow of the project for repayment.

Financing	***Example Projects***
Balance sheet	Horns Rev (DK), Nysted (DK), OWEZ (NL), Alpha Ventus (DE), Scroby Sands (UK), Greater Gabbard (UK), Sheringham Shoal (UK), Lillgrund (SE)
Non-recourse project financing	Prinses Amaliawindpark (NL), C-Power (BE), Belwind I (BE)

The first wind farm to be financed on a non-recourse basis was Prinses Amaliawindpark in 2006. It established a precedent in the banking sector and encouraged further projects. The recent financial crisis however, has affected banks' willingness to lend, which means that independent developers are highly constrained and now rely heavily on development banks for financing. This has been highlighted with the European Investment Bank taking part in the recent projects Belwind and C-Power (Phase II).

Projects developed by utilities have been less affected by the financial crisis, due to their continued ability to fund investments from their balance sheets. Large utilities therefore continue to construct the majority of offshore wind farms. This has led several independent developers to sell their consented projects to utilities who are able to progress the project further.

1.4 Installation Phase - Contract arrangements and constructing

The Installation Phase starts from financial close. The contract set up are implemented, material is procured. Depending on the contracting strategy, different construction organizations have been seen.

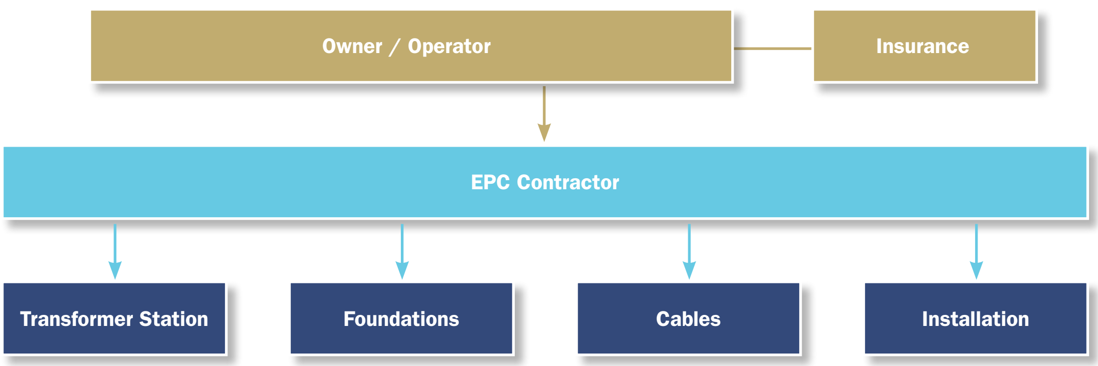
Contracting strategies

Constructing an offshore wind farm involves a complex interaction with many suppliers and installers of different components. Developers have chosen to manage these interactions either through a single contractor (EPC), separate contractors for each aspect (multi-contractor) or through a mixed system (package management). Each option involves a different balance of risks, and therefore different costs.

Engineering, Procurement and Construction (EPC) contracts transfer full responsibility for all parts of the project to a single contractor. This contractor then coordinates the design, supply and installation of the project, handling the interactions between all parties. This reduces the requirements of the developer's own team and reduces their risks. However, as the contractor adopts these additional risks, the price of the contract will consequently be higher.

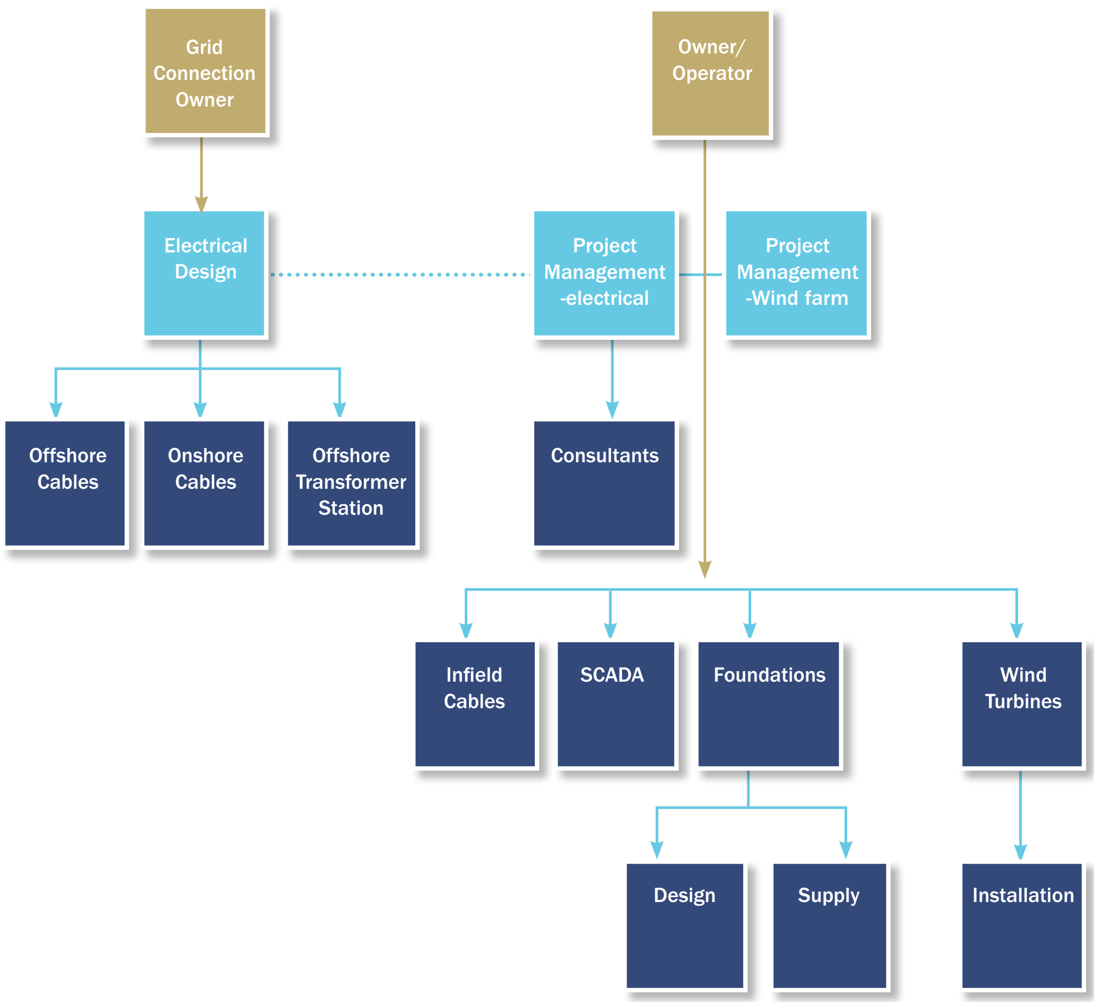
Early wind farms followed this model, including Scroby Sands, where E.ON contracted Vestas as EPC contractor for all offshore works and OWEZ contracted Bouwcombinatie Egmond (a joint-venture of Vestas and Ballast Nedam). The project structure of OWEZ is illustrated below, (Figure 1-2). EPC contracts for offshore wind farms were initially quite attractive for developers without the internal capacity or experience to manage the project themselves. However, this project structure is now rare, which suggests that although developers have more experienced teams and are willing to adopt greater risks to reduce costs, contractors appear to be less willing to take on EPC contracts against these risks.

Figure 1 - 2 OWEZ project organisation



Other early offshore wind farms, such as Horns Rev and Nysted, have favoured a multi-contractor approach where developers aim to reduce costs by shouldering more of the project risks. This creates a complex interaction between suppliers, as each technology choice affects another. The project organisation for Nysted below, shows that the ENERGI E2 team had to manage interactions between four suppliers for wind turbines, foundations, SCADA and infield cables, as well as SEAS Transmission arranging the supply of electrical infrastructure with three contractors.

Figure 1 - 3 Project organisation of Nysted Offshore Wind Farm.



More recent projects tend to follow an approach that combines the benefits of both systems. The work is divided into a number of packages, which are then contracted to different parties. In this way, the developer maintains overall control of the project and takes some of the risks. Work packages can then be contracted to specialised parties with particular expertise, such as wind turbine manufacturers or marine contractors, which allows risks to be attributed to the most appropriate parties and encourages competition for each work package.

Some projects have been divided into two work packages, such as Greater Gabbard (wind turbines and all other works); and others had three packages, such as Belwind I and Sheringham Shoal (wind turbines, marine works and electrical).

Design
As wind farms become larger, further from the shore and stationed in deeper waters, new technologies become necessary. However, the majority of offshore wind farms are still designed upon the same basis: wind turbines mounted on steel monopiles, connected to an offshore transformer station and an AC connection to the coast. This was the concept for Horns Rev, in 2002, in 14 m water depth and is also the basis for Belwind I, in 2009, in up to 37 m water depth.

Innovations such as floating foundations will be necessary for the full exploitation of offshore wind potential, but large-scale projects in the near-future are more likely to rely on proven technologies.

1.5 Operational Phase – Maintenance

Offshore wind farms are typically intended to be operational for twenty years, making this the longest phase of the project. Although few offshore wind farms have been operating for more than three years, some lessons have already been learnt from these early experiences.

Reliable technology
The risks of offshore wind became apparent early in the Horns Rev project, as the transformers in all 80 wind turbines had to be replaced. The scale of the project and the additional costs of repairs offshore placed serious financial burdens on Vestas, the wind turbine supplier. In contrast, the Nysted wind farm was constructed around this time, but did not face such widespread and expensive failures. This can be attributed to the selection of proven wind turbine technology and the installation of a demonstration turbine onshore for testing and training purposes.

Availability levels of 80-90% were common in early offshore wind farms, far below levels seen onshore. However, some recent projects have recorded availability in the range of 92 to 98%. This can partly be attributed to the deployment of proven technologies and the focus on improved reliability. Availability levels in offshore wind projects are likely to stay lower then onshore due to accessibility constraints caused by weather and waves.

The use of proven technologies does not remove all risks however, as evidenced by the discovery that multiple offshore wind farms suffer from the same design flaw in the connection between foundations and transition pieces. In 2009, the wind turbines at OWEZ were found to be sinking on their foundations. Inspections at other offshore wind farms revealed that this was an industry-wide issue.

O&M Strategies

Wind turbine manufacturers generally include five-year O&M contracts with guaranteed levels of availability and financial compensation for better-than-expected availability. This combination of “stick” and “carrot” appears to benefit both operators and suppliers and further drives the focus on reliable technologies.

Offshore access to the wind farm depends on weather conditions and the choice of access technology. Although Horns Rev opted for helicopter access to improve response time and allow access in rough seas, most operators rely on boat access. Typically, this is limited to wave heights of 1.5 m and this can severely limit access during the winter. Planned maintenance is generally avoided during the winter however and it is still possible to carry out emergency actions during brief periods of calm weather. Offshore access can be improved with new technologies such as new vessel designs or transfer systems. Examples of these include the SWATH-Tender vessel and the Ampelmann, a ship-based, self-stabilising access platform.

The offshore wind industry can and has learnt many things from the offshore oil and gas industry and there are many areas where both industries can collaborate to their mutual advantage. As highlighted in the 2010 POWER cluster report “Overcoming Challenges for the Offshore Wind Industry and Learning from the Oil and Gas Industry,” the costs and risks of offshore wind could be reduced by applying further lessons such as open technology development and excellent HSSE practices.

2. Growing Supply Chain

The offshore wind market has the potential to become a major industrial market. Meeting the offshore wind targets set by the different Northern Countries would require an improvement at all stages of the supply chain, with capacity multiplied by ten. Such a development is technically feasible, but wholly dependent on a large timely upfront investment from parties such as, manufacturers, grid operators, harbour authorities and universities. This requires confidence in the future market, inspired by governmental actions. The development of a large supply chain will benefit the offshore wind industry through potentially decreasing prices. Coastal areas are the most likely to be affected by large industry developments.

2.1 Overview

The cumulative targets set by the governments of the North Sea countries under their 2020 National Renewable Energy Action Plans (NREAP) amount to 36 GW of installed offshore wind capacity; the industry is expected to reach installation rates of 5 to 7GW per year in 10 years. This is an ambitious figure, considering that the current installed capacity is 3GW and that the installation rate in 2010 was 883 MW.

The offshore wind energy sector is expected to boom over the coming decade, following a similar growth pattern to that of the onshore wind sector. EWEA has highlighted the parallel between offshore wind growth scenarios of 36GW by 2020 and onshore developments in the late 1990s and early 2000s, as illustrated in Figure 2-1.

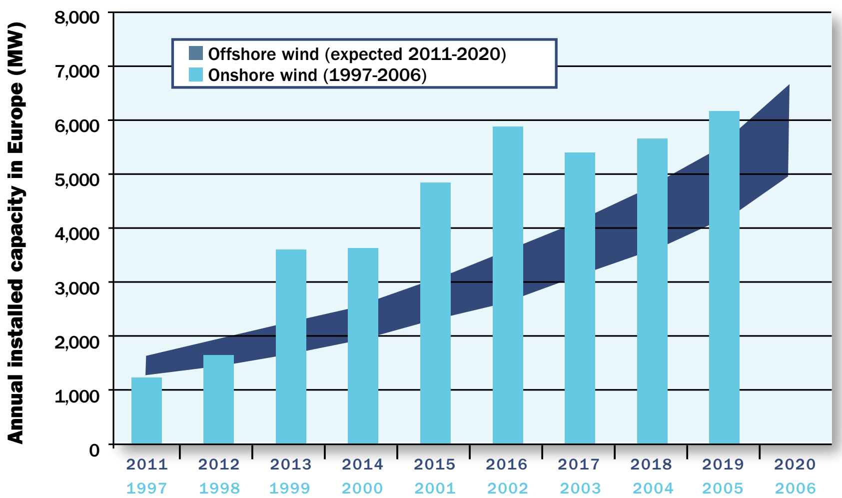


Figure 2-1: Expected offshore wind energy and historical onshore wind energy growth in Europe. The offshore growth projections are based on EU targets of approximately 36 GW by 2020 in the North Sea countries.

The technical challenges to increasing the production for offshore wind are greater than those that materialised for onshore. Heavy offshore foundations, long HVAC export cables, offshore transformer stations and installation vessels means that building offshore wind farms will require the commitment and investment of a wider range of players and businesses.

To follow the potential demand, supply chain actors need to invest in new construction facilities, assembly lines and vessels. This is a process with lead times of one to several years. Large, upfront investments are required that involve substantial risks related to the actual rate of progress of the planned projects.

Meeting the targets requires, not only a substantial increase in the number of skilled technicians, engineers, researchers and project managers (see chapter 3), but also the development of a suitable infrastructure. Examples of essential infrastructures include:
- Construction and O&M harbours require investment to provide sufficient water depth, quay length, storage space and crane capacity
- Grid capacity must be strengthened not only, at the coast, but also inland to avoid congestion and the interconnection between countries must be improved to enable further integration of wind energy in the power systems.

For an overview of the geographic spread of the offshore wind supply chain in Northern Europe, see the POWER Cluster website http://mapping.power-cluster.net/

2.2 Wind turbines

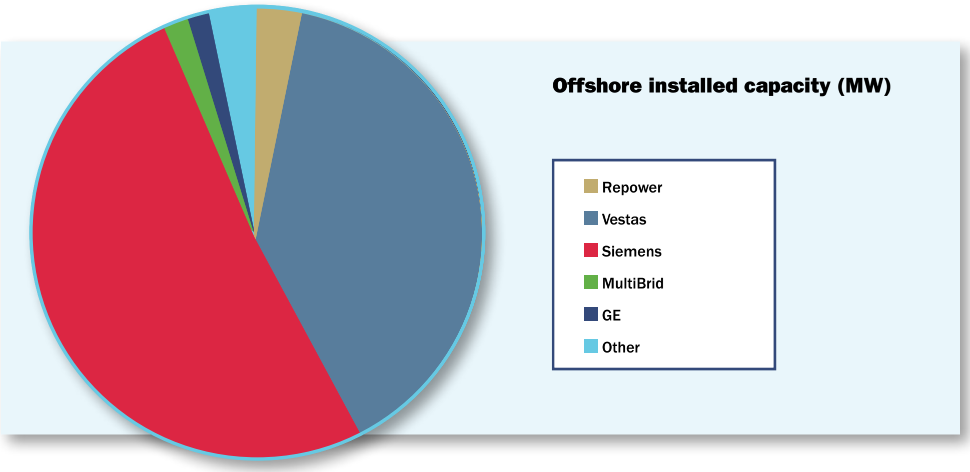
The wind turbine is, as a key component of the wind farm, at the centre of the supply chain worries of wind farm developers. Installation rates are anticipated to reach 5,000MW to 7,000MW per year which would require the production of 1,000 to 1,400 turbines per year.

Several bottlenecks have been identified, particularly in the production of the larger parts (main bearing, gearbox, main shaft). The common understanding is that, if the proper development frame is set up, inspiring confidence for businesses and investors, wind turbine manufacturers will be able to increase their production capacity to meet demand.

Finally, the principal concern of the developer regarding the wind turbine within the supply chain, is the lack of proven dedicated wind turbine concepts for offshore. Six manufacturers currently dominate the market: Siemens, Vestas, Repower, GE Energy, Multibrid and Bard have installed large offshore wind turbines. However, only two of these, Siemens and Vestas, can claim to have produced turbines on a large scale. These established manufacturers are currently developing new wind turbine concepts designed only for the offshore market.

A set of new turbine manufacturers are currently preparing to enter the market with new turbine models intended for the offshore market (Bard, Repower, Multibrid). A second group of companies, (Clipper, XEMC Darwind, Windenergy, 2-B Energy and all other large onshore wind turbine manufacturers, such as Gamesa and Nordex), are designing, installing and testing prototypes designed specifically for offshore conditions with the objective of entering the market between 2013 and 2015. This broadening of the base of manufacturers means a greater wind turbine supply capacity by the time UK Round 3 comes to construction, but it may also mean greater price competition.

Figure 2-2 European Offshore Wind Market Share (MW) as of June 2010



The answer to whether wind turbine manufacturers will be able to increase their production to meet the targets is, yes. The question of whether wind turbine manufacturers will have time to create new concepts with improved reliability, test them and increase their production to meet the demand is still uncertain.

2.3 Foundations

Foundations are not a priority supply chain concern of developers. The market is currently dominated by large steal mills, yards and construction companies. Be it monopile, gravity base, jacket or tripod foundations, the factories seem able to increase production in a relatively short time, although this would still require a large assembly space and a skilled work force.

So far, most operating wind farms have been built using either of these two concepts of foundations:

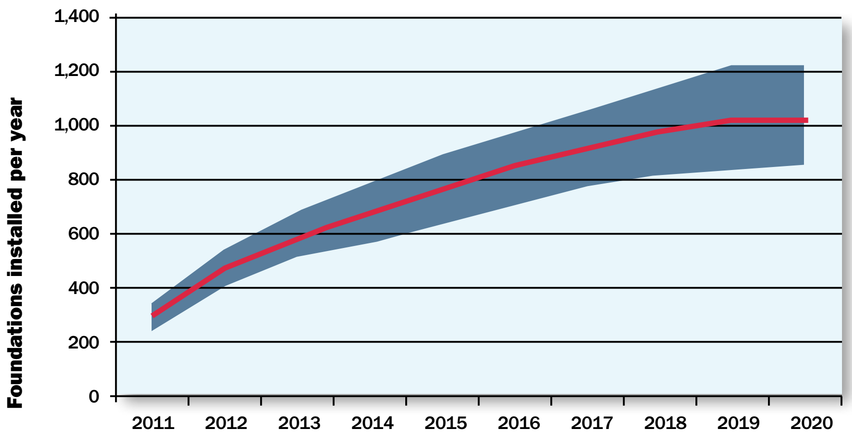
- Gravity base foundations, large concrete structures, have been used for most shallow water wind farms (1 to 15 meters), particularly in the Baltic Sea. These are produced by large building and civil engineering firms and large infrastructure contractors, such as MT Højgaard and Aarslef (Denmark).
- The monopile foundations, large steel cylinders, have been used for most deep water wind farms (10 to 25 meters). These are manufactured by large steel mills and steel contractors, such as Smulders (The Netherlands), Bladt (Denmark).

Wind farms are planned to be established at a greater water depth with larger turbines, particularly in Germany and for the UK Round 3 projects. This new criteria will require new concepts of foundation, specifically jacket or tripod foundations.

So far, less than ten tripod and ten jacket foundations have been installed in Europe, including six of each at the Alpha Ventus test site. Thirty more jacket foundations are being installed at the Ormonde wind farms. The market will therefore need to increase supply, from virtually zero foundations to approximately 1,000 or more foundations per year by 2020.

For the steel or construction manufacturers leading the market, such an increase of capacity at suitable coastal locations appears feasible, by investing in new manufacturing facilities and renovating existing ones. A clear expectation for this market is again, essential to encourage the required investments. This is reflected by the developers feeling, as reported by BTM consult: "wind farm developers did not show much concern about foundation, with more attention being given to design innovation".

Figure 2-3 Offshore wind turbine foundations projected to be installed each year



CASE STUDY - BiFab (Burnt Island Fabrications Ltd.)

Moving into Offshore Wind

BiFab is a steel structure manufacturer based in Scotland that previously undertook work for the offshore oil and gas industry. The company began building jacket structure foundations for offshore wind energy for the Beatrix wind farm in 2007. Since then, the company has been growing rapidly, producing 32 foundations in 2010 (Ormonde wind farm + OHVS Greater Gabbard). The company now provides jobs for 950 employees.

Over the next four years, BiFab expects to increase production to 150 jacket foundations annually, after the recent investment in new production lines. The company now focuses on achieving manufacturing time reductions through better designs and automation in the production process.

Regarding the future, General Manager John Robertson is confident that BiFab will be producing 150 structures per year, according to the target. He believes that the demand for jacket foundation will increase, but that the competition will also increase as new companies enter the market. If opportunity for further development materialises in the future, BiFab is capable of increasing production with its existing facilities by a further 70-80 structures annually. Further expansion could also occur in other yards, in the UK or overseas, by either land purchase or by licensing part of the design and processing to the right partners.

2.4 Electrical infrastructure

Export and in-field cables

Export cables have been identified as a potential supply chain bottleneck. According to the BVG study, investments are urgently required to ensure sufficient capacity in six years time.

To increase their production, the current market players will need to rapidly extend current production lines, developing new extrusion lines at coastal locations that enable transportation of the enormous cables. Manufacturers suggest that a new extrusion line takes up to four years to build and two years to test, a minimum development time of six years.

The supply chain for infield cables is considered to be a lesser concern, as a greater number of suppliers are poised to enter the market. Building new extrusion lines results in shorter lead time therefore, “most purchasers believe that the market will deal reasonably effectively with supply issues around these cables, though new investment certainly will be needed” (BVG 2009).

Offshore High Voltage Station (OHVS) and onshore transformer

With a lead time of two years for supply, OHVS are a primary planning concern of offshore wind farm developers. Lead times are considerable and are likely to grow even further with the introduction of new technologies, such as HVDC for German wind farms and a large share of UK Round 3 projects. These lead times are not the result of a long waiting list, but the lengthy construction time of these massive one-off structures.

Industry experts indicate that the large players dominating the market, (Siemens T&D, Areva T&D and the consortium GDF-Iemants-CG Power systems) will be able to meet the increasing demand. Space is available at existing construction yards and an increase in production capacity can be achieved through the addition of new bays at existing yards without a need to establish entirely new facilities (BVG study).

The project-specific part of the onshore electrical infrastructure does not represent a supply chain issue, as it is comparable to onshore transmission system operation.

2.5 Vessels

A number of different vessels are essential to the construction of a wind farm. In particular, special vessels for wind turbine and foundation installation and cable laying are expected to become an acute supply chain issue.

So far, the construction of offshore wind farms has relied primarily on installation vessels (jack-up barges or self propelled vessels) that have worked traditionally in the Oil and Gas or infrastructure industries and an increasing number of vessels that have been constructed specifically for offshore wind installation works.

With an increasing number of MWs to be installed per year, the competition for these integral vessels is high. Waiting times are an issue and construction costs are driven up. This may be further exacerbated due to the fact that a substantial share of the vessels available at this time are unsuitable for deeper water depth, longer distance to shore and larger wind turbine and foundation size.

The industry is therefore hoping for more vessels and new concepts adapted to the future conditions, to avoid further congestion in the near future (2011 to 2015) (New Energy Finance). Developers (RWE) and turbine manufacturers (Bard, Siemens, Repower) now pro-actively tackle the problem by investing in their own vessels to strengthen their market positions. BVG associate estimated in 2009 that the number of dedicated wind turbine and foundation installation vessels should increase by 500% by 2020 to meet the planned demand. EWEA (September 2009) counted only three vessels operating that were dedicated to wind turbine installation and three more that were under construction. It was estimated that another six would be necessary to support the installation rates up to 2020.

The required investments are substantial and difficult to acquire. Following the recent financial crisis, immersed in a market that is still relatively unstable, banks have been reluctant to invest in vessels dedicated purely to wind farm installation and are asking developers to provide guarantees by taking shares in the future vessels. A new vessel costs upwards to € 200 to 250 million, which makes the overall capital required between €1 and 1.5 billion. EWEA considers the market conditions to be extremely difficult and has suggested that the European Investment Bank should step in and, “take the necessary measures to support the risk related to these significant investments”.

Investments need to be made soon to avoid future bottleneck. Shipyards worldwide have busy order books and the lead time for vessel construction is expected to be approximately three years. The necessity of increasing the fleet should however, also prove to be an opportunity for the offshore wind industry. Dedicated offshore wind installation vessels would, theoretically, enable higher installation rates and therefore lower the overall cost per installed MW offshore.

2.6 Harbour

To meet the increasing demand, further development of manufacturing capacity is necessary, not only for the turbines themselves, but also for steel and concrete foundations, electrical cables and OHVS. For logistical reasons, this is expected to primarily benefit coastal sites with large assembly and manufacturing capacities and sufficient space. Offshore wind farm construction also requires harbour facilities with a high water depth and reinforced quaysides to support the weight of the turbines, large storage areas, suitable space to move foundations and heavy lift cranes.

This represents large potential opportunities for harbours and local and regional authorities. Substantial investments will be necessary across the North Sea region to upgrade harbour facilities to sufficiently support the planned offshore developments. However, in many countries, harbour developments are not believed to become a supply chain issue.

Numerous harbours have identified offshore wind as an opportunity and are preparing for the future demand, by attracting public and private investment. Likewise, various government bodies are also starting to react. In the UK, the government recently announced an investment of £60 million to upgrade the country's harbours. According to the Wind Energy Update, such an investment is considered to many industry watchers as an initial step that must be followed by private investment to ensure sufficient harbour developments.

A trend is materialising of developing large wind energy hub harbours instead of reinforcing mid-size harbours. Bremerhaven (Germany) is one example of integrated development. The harbour managed to attract over €200 million investment over the last few years and now gathers on-site manufacturers of blades, wind turbines, steel foundations and research institutes and is expecting to produce about 1GW of wind turbines per year (See case study in Chapter 3).

If similar regional developments are undertaken, six to eight equivalent ports, supported by a network of installation and O&M harbours, would be necessary to accommodate the targeted 36GW in 2020. Several North Sea ports can expect to become hub-harbours (see Figure 2-4). The Danish harbour of Esbjerg already has a long history of supplying construction facilities for Danish and UK wind farms. Ijmuiden in the Netherlands has experience in the construction of two offshore wind farms. Zeebrugge, in Belgium, with the support of the harbour of Antwerp has enabled the construction of the 165MW wind farm in Belwind. In the UK, Wind Energy Update expects the harbours of Forth, Tyne, Tees and Humber to become serious contenders in the competitive race to attract investments.

In most North Sea countries, the existing harbour infrastructure already provides a strong basis for offshore wind manufacturing and construction, provided that some upgrades are realised. The UK is an exception, with few large harbours and significant investments required to cater for the anticipated scale of offshore wind project realisation.

Figure 2-4: Offshore harbours in Europe: potential regional hubs

2.7 Electrical Grid

Throughout Europe, integrating large volumes of offshore wind energy into the grid requires significant grid upgrades on the coasts and from the shore to the largest load centres. Large investments are therefore required to overcome this challenge. Enhancing the electrical infrastructure will also be time consuming, in both consenting and construction. The issue is more acute in some Northern European countries, depending on the age of the transmission grid and the location of the planned offshore wind farm and large load centres.

The Danish, Belgian, Dutch and Swedish transmission system operators (TSOs), for example, appear to be relatively confident that the grid upgrade will be implemented in time, even though major investments are necessary. Energinet.dk, the Danish TSO, is planning a €3.5 billion investment over the coming few years while Elia, the Belgian TSO, announce that the upgrade costs will be “enormous”. Tennet, the Dutch TSO is already working on large grid upgrades between the west coast and the ring connecting the largest Dutch load centres.

The issue is more acute in Germany and the UK, where the largest offshore developments are planned. The UK grid has been the source of much concern for developers. In May 2010, National Grid announced an investment of €22 billion into the grid over the next five years. This announcement was welcomed by developers; however the upgrades still remain to be carried out, yet the UK provides a good example of how communication between developers, government and grid operators enabled bottlenecks to be identified and timely solutions to be implemented.

Germany presents the biggest bottleneck of all the North Sea countries: all offshore wind farms will be located in the North of the country, 17GW, in particular, in the North Sea. A DENA study calculated that the 850km of cable needed to accommodate the expected capacity planned to be operational by 2015, with an estimate of 1,000 km extra to accommodate the 20GW planned by 2020 (estimated). The upgrade would consist of large onshore transmission lines, considered by experts to be extremely challenging from a planning and permitting perspective. More details on the issue in Germany are given in the case study below. Country-specific analysis was carried out and is presented in Appendix D.

CASE STUDY - German GRID

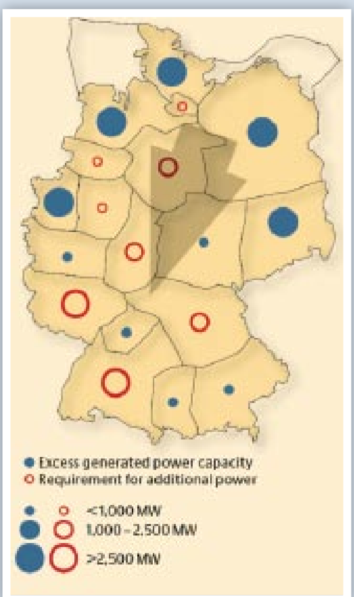
With its ambitious renewable energy development plan, Germany is facing major grid challenges. Looking at offshore wind energy, all the 10GW planned capacity is concentrated in the north of the country a region which presents relatively low electricity demand. The weakness of the grid at the coast and the lack of transmission capacity from the north to the large load centers are stringent problems.

To ensure the success of the development of offshore wind energy the Federal Network Agency has published a 2009 position paper specifying the obligation for German TSO to give unconditional grid access assurance to those offshore wind power projects which meet certain development criteria.

From the perspective of technical feasibility of these developments, the German Energy Agency, DENA, has commissioned two studies. A 2005 study assessed that onshore wind energy developments up to 2015 would require about 850km of onshore transmission lines. In addition, a preliminary estimate of 1,000km of further extension was given to accommodate the planned offshore capacity. At that time, DENA considered that "Compared with the new (grid) construction of recent years, the timeframe for necessary network extension is very ambitious" and that "The further extension of the transmission network will decisively affect the speed of growth of renewable energy sources".

DENA Grid Study II was recently released, and considered renewable energy sources contributing to 39% of the German power supply. The study assesses the grid upgrades necessary to connect and integrate the expected intermittent capacity, amongst which 12 GW of offshore wind capacity. The study concludes that up to 3,600 km of conventional 380kV lines would be necessary, at a cost of nearly €10 billion. Other technologies were assessed, e.g. high temperature conductor cables or high voltage DC underground cables, and also concluded in the need for very large extension (1,700km to 3,400km), large network upgrades, and estimating the costs above €15 billion.

This is considered by experts to be extremely challenging from a planning and permitting perspective. Grid development therefore appears as a major bottleneck for the large German development plan. Even if strong developments are announced soon, the speed of implementation will still remain an issue.



Picture: DENA 2010

3. Economic Opportunities of Offshore Wind

The opportunities offered by the offshore wind sector for economic growth and job creation are increasingly apparent and acknowledged in North Sea countries. The current state of the macro-economic climate has provided a significant impetus and urgency for grasping these opportunities. These security and supply benefits were however, already acknowledged at a time of high world market energy prices. National governments and local bodies have taken and are currently taking a pro-active approach to developing local and regional centres of excellence to attract economic benefits to their locality.

3.1 Introduction

In this chapter, we have provided an assessment of the effects of developing the offshore wind sector on employment and the economy in Denmark, the Netherlands, Germany, Sweden, Great Britain and Norway in 2005 and up to 2020. The assessment is based on the comprehensive Employ-RES study. This study was commissioned by the European Commission in 2009 and assessed the economic effects of supporting renewable energy in detail. It considered not only jobs in the RES sector itself, but also took into account the impact on all sectors of the economy in the EU Member States.

In addition to the employment and economic effects, this chapter assesses the origin of businesses involved, the personnel requirements for the coming years and strategies that can be pursued by both authorities and industry to attract offshore wind related activities, bridging the skills and personnel gap the industry is currently facing.

3.2 Economic effects

The economic relevance of the offshore wind sector has been modest so far, compared to the onshore wind sector. EWEA reports that in 2010 the annual offshore wind power market was worth €2.6 billion, compared to €10 billion in the European onshore markets. The value added from the offshore wind sector and related industries is largely concentrated in Denmark, Germany and the UK. Denmark is in a prominent position in this respect due to the fact that wind turbine and component manufacturing has historically been strong in Denmark.

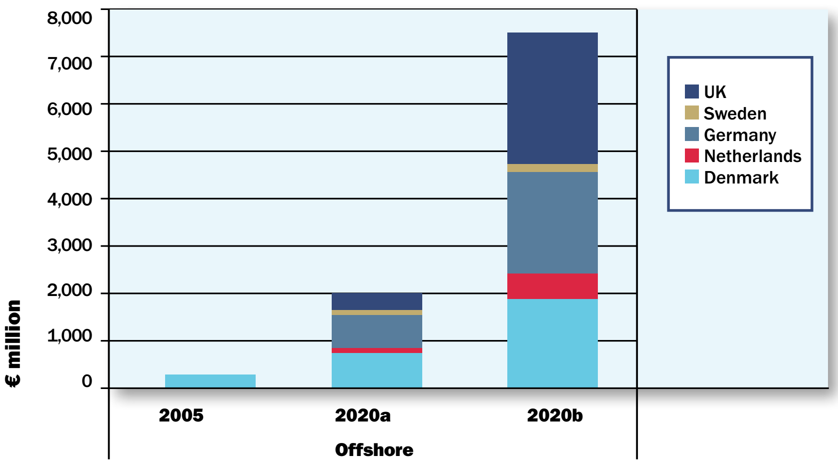
Up to 2020, the offshore wind sector is expected to grow exponentially. The EU renewable targets are a key driver, aiming for 20% of energy to be generated from renewable sources. Once these targets have been met and the relevant supporting conditions are put in place, in 2020 the gross value added from offshore wind in Denmark, Netherlands, Germany, Sweden and the UK, could total €7.5 billion[1] (see Figure 3-1), compared to a little over €9 billion in the onshore wind sector. Therefore, by 2020, the offshore wind sector could be of comparable economic size to the onshore wind sector. Economic value added is likely to continue to be concentrated in Denmark, Germany and the UK.

The role of Norway in offshore wind energy will remain minimal. This can largely be explained by the power generation mix dominated by hydro power, in addition to the deep coastal waters that would prove challenging to the country's offshore wind development. The offshore wind sector here is therefore likely to be focused primarily on research and development efforts on a modest scale.

3.3 Employment Effects

The offshore wind energy sector directly employed approximately 2,600 people in 2005, in the Netherlands, Germany, UK, Denmark and Sweden combined. More recent EWEA figures show that in Europe, on average 20,000 people were working directly and indirectly in the offshore wind sector in 2009. The majority of these jobs are likely to be found in the countries bordering the North Sea. Despite its recent growth, direct employment in the offshore sector is modest compared to that of the onshore wind sector (a further 170,000 people across Europe in 2009).

Figure 3-1 Direct Value Added in the offshore wind energy sector in 2005 and in 2020 under two scenarios: (a) business as usual; (b) EU RES targets are met



Source data: Employ-RES

1 The total gross value added depends strongly on necessary support conditions and it is assumed here that the EU renewable energy (RES) targets are met. Following a business-as-usual scenario with moderate exports, the gross value added from offshore wind is less, and totals about €2 billion.

CASE STUDY – BREMERHAVEN

Development of an Offshore Wind Hub

Bremerhaven, a German port facing the North Sea, is often cited as an example of a successful model for regional development for offshore wind power. It also highlights the economical opportunities that offshore wind energy has created in the region.

The harbour has realized a dazzling conversion of its workforce and facilities to wind energy, both onshore and increasingly also offshore. The harbour has attracted over €250 million of investment. Three wind turbine manufacturers (Repower, AREVA Wind and one new market entrant: PowerWind), a blade manufacturer (PowerBlades) and a foundation manufacturer (WeserWind Offshore Construction Georgsmarienhütte) installed production line in the harbour area. In addition, two German research institutes (Deutsche WindGuard and the Fraunhofer institute) have opened testing facilities. These include one of the largest wind tunnels in the world and a wind turbine blade testing facility. Many businesses have followed. Today, a total of 1,500 local jobs are directly related to offshore wind energy.

Key factors in this development have been a skilled work force, strategic location and a strong pro-active approach by political and regional authorities. For example, construction permits for wind turbines could be obtained extremely quickly and the regional government supported financially R&D efforts by companies situated in Bremerhaven.

The growth of Bremerhaven as a hub for offshore wind energy continues. More companies are currently building facilities, further 200-hectare expansion of the harbour is planned to accommodate new installation vessels and the harbour is gearing up to become a prime construction port for the German offshore wind farms. It expects to be the base harbour for the construction of the Nordsee Ost project, followed by others. (Innogy I)

The majority of jobs directly related to offshore wind production and technology can also be found in Denmark and, to a lesser extent, in Germany. The expected growth of the sector is spread more evenly over the North Sea countries, which will lead to jobs shifting to other nations and areas, as new manufacturing plants and operation centres are built close to where support conditions and policies are most attractive. Activities related to offshore wind, such as project development, operation and maintenance, engineering and legal services are also located close to where wind farms are planned or built. This provides opportunities for local or regional economic development.

Most direct employment is a result of activities related to planning, construction and manufacturing. Apart from the effects on direct employment, maintenance and operation causes demand for products and services in forward- and backward-linked sectors. These, in turn, increase production and (indirect) employment in these sectors.

Once a wind farm is built however, a reduced number of employees are necessary for operation and maintenance of the facility. The 2008 employment survey conducted by EWEA for the EU confirms this (see Figure 3-2). The study shows that wind turbine and component manufacturers are responsible for the largest proportion of direct employment (59%), followed by developers (16%). Operation and maintenance related activities make up only 11%. Typically, 25% the total Cost of Energy is driven by spending during the operation and maintenance phase that drives direct employment. It is likely that the discrepancy in these data can be explained by the role that manufacturers currently play in operation and maintenance.

The EmployRES study points to expected gross employment in the offshore wind sector, in the selected North Sea countries, of 115,000 jobs. This figure is based on the assumption that the EU renewable energy targets are met in the member states. By 2020, most offshore wind employment is likely to be concentrated in the UK and Germany, which together could potentially employ over 90,000 people (55,000 in Germany and 37.000 in the UK[2]). Denmark is expected to remain a strong player, despite a relatively small domestic market. Approximately 14,000 people could work in the offshore wind industries in Denmark by 2020.

There are other studies on the employment effects of growth in the onshore and offshore wind sector. However, in many cases these results are difficult to compare because different timeframes, sector breakdowns or geographical areas were considered. A summary of other recent studies on employment is presented in Appendix E.

An EWEA study into the future wind energy employment, for example, estimates the total employment figures for the wind energy sector employment to be 320,000 by 2020. This incorporates the employment figures for all the EU Member States and results in a value over twice as high as the estimates from the figures presented above. The actual effects of the development of the offshore wind sector on the economy and employment, particularly

2 *The figures for the UK more or less match with the lower end of the estimates in a study conducted by the Carbon Trust in 2008 (40.000 jobs by 2020).*

Figure 3-2 Direct employment by type of business, according to EWEA survey (source EWEA 2008).

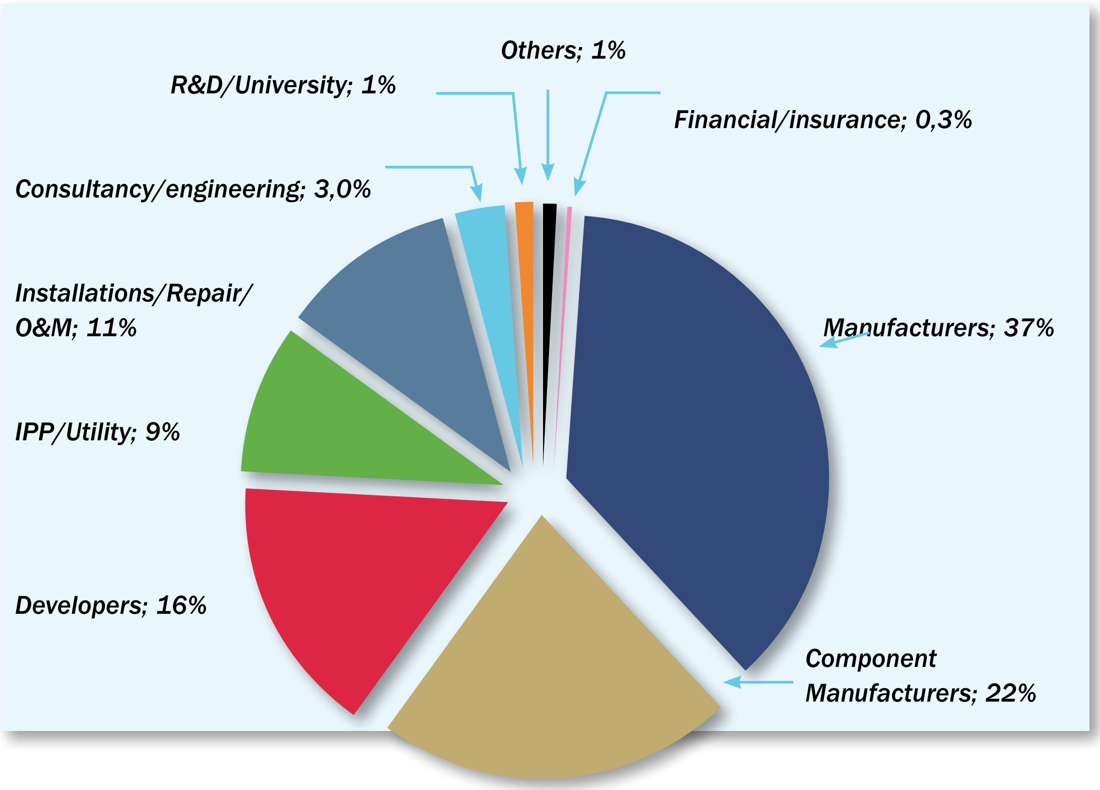
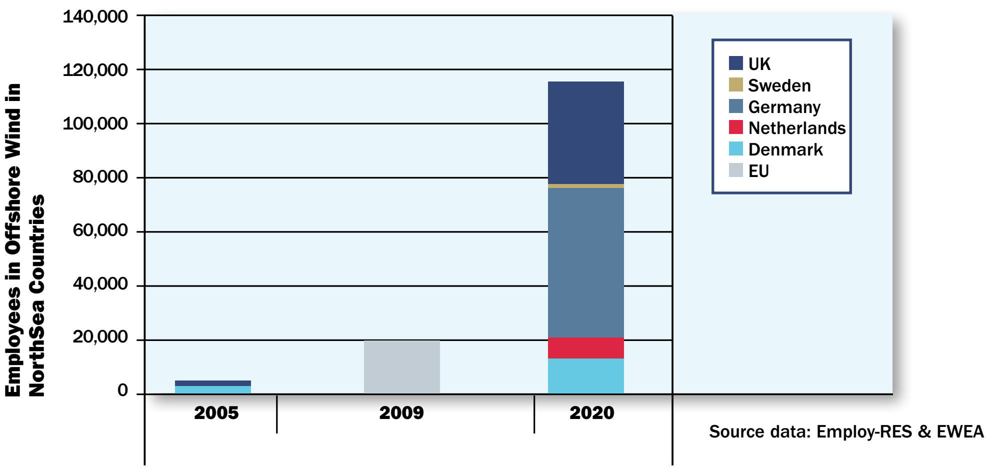


Figure 3-3 Total employment in offshore wind in 2005, 2009 and in 2020 (scenario b). Employment data from 2009 is only available as a total for the EU, but the majority of these jobs are likely in North Sea countries.



on a local or regional level, depend strongly on geographical location (e.g. the presence of a seaport), the presence of existing knowledge infrastructures, (offshore) wind related sectors, relevant other (offshore) industries, and (local) policy conditions and incentives[3].

Germany and Denmark are likely to continue to play a strong role in manufacturing as well as related up and downstream activities. However, the UK is also in a good position to develop a strong and integrated sector because of its geographical location and ambitious targets. Other countries such as Norway, Sweden and the Netherlands have less economic opportunities, due to their smaller domestic markets. However, exports and indirect activities may offer opportunities, including RD&D, project management, installation (vessels) as well as financial, engineering and other services. An unstable policy framework in the Netherlands currently inhibits the domestic sector from growing in domains such as manufacturing.

The (offshore) wind industry is a highly international business where both companies and individuals are familiar with working across country borders, particularly during the construction phase. It is likely that this is reflected in employment effects: localities that are developing manufacturing or logistical centres that cater for the offshore wind industry can generate employment based on money invested elsewhere.

Currently, the origin of companies involved in component and turbine manufacturing is highly international and dominated by a few, large companies active in areas of Europe where financial incentives are highest. These activities and the associated investments may fall once these incentives are removed. Local authorities in suitable, well-positioned regions with a weak economic structure can serve their community by playing a role in reducing such risks and facilitating the growth of local clusters and local businesses with stronger ties to the region. This business could then potentially employ those whose jobs were lost in declining industries.

3.4 Skills, occupations and qualifications

The availability of an appropriately skilled and qualified workforce is a key factor in the success of the offshore wind industry. In recent years, wind energy companies have repeatedly reported an acute shortage of skilled and qualified people and difficulties faced in filling their vacancies (EWEA wind at work). The offshore wind sector however, is set to double in size between 2010 and 2020. Particularly in the UK and Germany, the strong growth of the offshore wind sector will lead to enormous employment opportunities and challenges to fulfil the demand for skilled workers. The shortage of skilled staff in the offshore wind sector is likely to become more acute due to developments in other parts of the energy sector, such as the expansion of the nuclear sector, decommissioning of oil and gas platforms. This has been identified as an issue with particular relevance for the UK.

3 The 'Northern Europe cluster map for organizations involved in the offshore wind sector' could form a basis for local policy makers to assess potential possibilities and opportunities for their region. Please see the POWER Cluster website http://mapping.power-cluster.net/.

The skills, occupations and qualifications required in the offshore wind sector are highly diverse (see Figure 3-4). Generally, the availability of human capital is limited throughout the supply chain: from R&D to Operation and Maintenance. According to the EWEA study (Wind energy the fact), engineers and experienced and qualified project managers are particularly scarce. The demand for higher-level skills (university, post-graduate and professional education) is relatively high compared to other sectors. This is a consequence of the early stage of development of the sector; knowledge is still under development and less explicit or codified in standards and training materials. The constraint is not the number of engineers graduating from universities, but that the skills of graduates do not often match the specific skills needed in the industry. Emphasis is therefore placed on additional in-house or on-the job training.

Despite adapting graduate programmes to the skill requirements of the industry, there is a particular gap in the secondary level of education for skilled technicians. The range and quality of courses dealing with wind-related activities (mainly manufacturing, O&M, health and safety, logistics and site management) is inadequate . The increasing demand for people with relevant secondary education as the industry matures makes this an increasingly important issue. Many new training programs have begun in recent years or are currently being set-up, particularly in Germany and the UK. Efforts to encourage greater worker mobility between sectors can also play an important role in alleviating these concerns.

A large proportion of the skills required in the offshore wind sector are similar to those required in the oil and gas industry. As that skill base is already strongly present in most North Sea countries, this could help to fill some of the shortages. Simultaneously, however, the oil and gas sector is competing for the skilled workforce and generally offers higher wages.

The companies involved in the offshore wind sector operate internationally. This creates a highly mobile workforce that operates in a global market environment. The availability of human capital currently depends on inter-professional and international mobility. These can

Figure 3-4 Skills, occupations and qualifications (source SQW energy 2008)

Skills	Control Systems and design	Construction/ cabling	Rotor hub/gear boxes/gears/ bearings	Foundations	Planning and development	Installations/ operations	Onsite assembly	Steel tower erection	Operations			
Occupations	Electrical and electronical engineers	Civil engineers	Mechanical engineers	Structural engineers	Instalation engineers	Environmental specialists	Health and safety specialists	Construction project managers	Fabrication engineers	Service engineers	Wind turbine operations	Offshore operation specialists
Qualifications	2/3D CAD systems	Graduate MA, PhD	Chartered Engineer Status	Professional Qualification	NEBOSH Diploma	Project management experience training	Health and safety training	Basis Engineering and steelwork qualification	Higher in E&E engineering	Knowledge of SCADA systems	Level 3 and up	

act both as positive or negative mechanisms. With the right programmes and incentives from public authorities at national and local levels, more human capital can be attracted from other sectors, professions and regions. Regional skills centres that combine public, private and academic sectors can also address the industry's skill needs, in order to ensure a suitably trained workforce. Examples of such skills centres are the East of England Skills for Energy partnership and the centre for Vocational Education Bremerhaven GmbH (Berufliche Bildung Bremerhaven) in Germany.

The industry itself can play an important role in ensuring an adequate workforce, by:
• Providing (EU-wide) certified vocational training (possibly aimed at unemployed workers)
• Improving the education system at university and pre-university level
• Creating initiatives that match the needs of the offshore wind sector to the qualifications offered at university and pre-university level
• Establishing local entrepreneurship programmes (including incubators)
• Creating awareness and dissemination activities targeted at young people

4. Effective Stakeholder Engagement

Stakeholder support plays a key role in offshore wind projects. If some stake-holders oppose a project, this can present a serious challenge to its realisation or it can lead to significant delays and extra costs. Conversely, stakeholders that favour the development can also be enormously helpful.

Developers can gain acceptance and support for an offshore wind farm by working together with all stakeholders. For this reason, project developers and wind energy associations commit significant resources to engaging all relevant stakeholders and an engagement plan is necessary to communicate the impacts, both positive and negative, of a proposed offshore wind farm.

Based on the positive experiences of early offshore wind farm developments, stakeholder engagement plans should be guided by:
- Involvement of a wide range of stakeholders in order to identify all concerns
- Early engagement of stakeholders
- Clear, honest and interactive dialogue to explore lasting and widely acceptable solutions

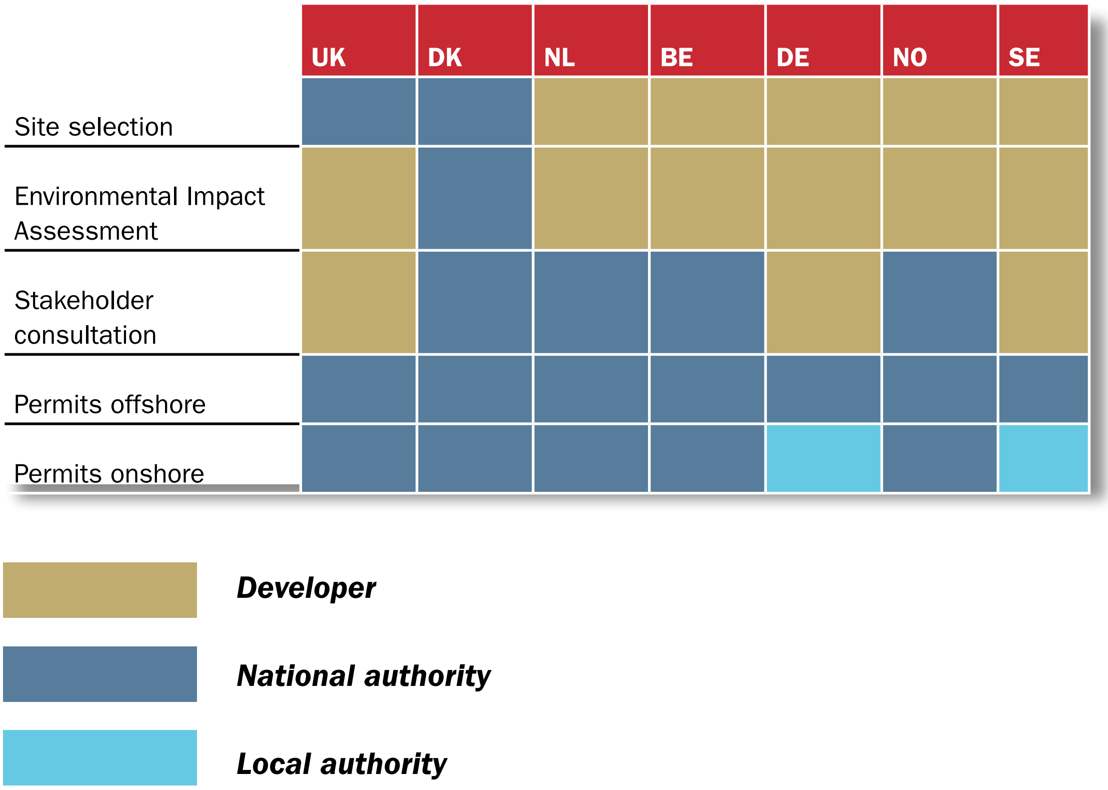
4.1 Wide range of stakeholders

Offshore wind farm developers will engage many stakeholders, including those involved in the regulatory process, those with broader strategic interests and communities that are directly affected by the development.

1. Regulatory stakeholders
The application for project permits requires the involvement of a number of stakeholders, defined by legislation. These stakeholders typically include national, regional and local govern-ment agencies. Each stakeholder will have a role in the consenting process, including defining the requirements for the Environmental Impact Assessment (EIA), a thorough study of the likely impacts of the offshore wind farm on the environment, shipping, fishing, defence, etc.

Depending on the regulatory framework, an offshore wind farm may need to apply separately for several permits; for example, there may be different consenting processes for onshore works, within territorial waters, and beyond. These different legislative approaches, as well as the involvement of many different agencies divided over sectors, can lead to difficult coordination across stakeholders and therefore slow progress.

Figure 4-1 Different regulatory requirements per country



The level of direct involvement of a developer with regulatory stakeholders differs from one country to another. Depending on the approvals process, the consultation process may be run by either the developer or a government agency. This can affect the relationships with stakeholders and the process towards agreement.

These differences highlight the need for project-specific stakeholder engagement strategies.

2. Strategic stakeholders

Developers will also engage a number of organisations that have a strategic interest in offshore wind energy, even if not required to do so by law. This can include any groups that may significantly influence the development, either with their support or their opposition.

These stakeholders include environmental organisations, such as WWF or Greenpeace, or nature protection agencies that can advise the EIA process. Strategic stakeholders also represent the interests of other sea users, such as shipping, fisheries, military, oil and gas operators, or subsea cable and pipeline owners. These groups can have economic interests that may be affected, or they may be able to advise on Health & Safety issues. Stakeholders such as regional development agencies and local ports can be important supporters of the project based on the strong economic benefits and can help to secure the local supply chain.

3. Community stakeholders

Developers will also strive for acceptance and support for their development from the local community. These are individuals or organisations that will be directly affected by the development and will therefore have a strong interest.

A 2008 study in Denmark found that offshore wind farms are preferred to onshore projects; only 5% of respondents presented a negative attitude towards more offshore wind farms, compared to the 25% opposed to more onshore development.

Although offshore wind energy generally has a good public reception, it is still important to properly consider the community acceptance of specific wind farms. A 2007 study of an Irish offshore wind farm development found that public reaction suggests “that coastal communities are just as sensitive to threats to seascapes as rural society is to visual disturbance in highland areas. This implies that developers of offshore proposals should recognise the potential for objection and adopt processes that are sensitive to such a context.”

Local community support for the Horns Rev and Nysted offshore wind farms (both in Denmark) was found to be linked to the reduction in carbon emissions, as well as increased employment. Opposition was based on visibility, impacts on tourism and business, and nature conservations. Offshore wind farm development is now moving increasingly far from shore, largely in response to these stakeholder concerns.

CASE STUDY – STAKEHOLDER ENGAGEMENT AT SCROBY SANDS

Active stakeholder engagement helped to shape the Scroby Sands offshore wind farm design. Consultations with the local harbourmaster, the Port Authority, fishermen and the local Borough Council led to an agreement on an appropriate export cable route for the project. In addition, the developers worked with the Royal Society for the Protection of Birds and the Sea Mammal Research Unit at the University of St Andrews in order to design a construction methodology that would minimise the impacts on pupping seals and the little tern colony during breeding season.

4.2 Early engagement

The key to a successful stakeholder relationship is early engagement, avoiding feelings that decisions have already taken without their involvement. Once stakeholders are identified, initial consultation activity should begin as soon as possible. Ideally, this should take place prior to site selection, or as soon as the site is identified.

Stakeholders will need some information about the proposed wind farm(s) and the development plan at an early stage.

Maritime Spatial Planning

One of the earliest instances of stakeholder involvement is during the formation of maritime spatial plans to identify rational and sustainable use of the sea, balancing a variety of different issues including environmental impacts. A thorough screening process prior to the selection of sites can provide a major advantage for later stakeholder engagement.

Maritime Spatial Planning (MSP) is a key tool in this site selection process helping authorities and stakeholders to coordinate and optimise the use of the sea to benefit economic development and the environment.

The European Union encouraged its members in 2007 to implement integrated maritime spatial planning through a transparent decision-making process and to achieve optimal site selection. The level of response from stakeholders during consultations on this policy indicates the scale of the challenge to sustainably manage the increasing, and often conflicting, demands for use of the sea.

The lack of integrated strategic planning and cross-border coordination have also been identified as major challenges to stakeholder engagement and the deployment of offshore power generation. Cross-border cooperation on MSP is key for developing a streamlined planning approach and making fully optimal use of the marine space. EWEA has recommended that MSP should be based on a common vision shared at sea basin level. Improved international MSP would also benefit developments in the supply chain and the Europe-wide electricity market (through possible synergies with interconnectors in a pan-European grid).

The offshore wind industry must remain aware that community stakeholders are generally under-represented in maritime spatial plans, which tend to focus on regulatory and strategic stakeholders. This can lead to the risk that individuals will feel that decisions have already been taken by central authorities. A survey of communities near the Horns Rev wind farm found that most interviewees felt that they were being ignored in the decision-making process.

Country Marine Spatial Planning for Offshore Wind	
United Kingdom	The 2009 Marine and Coastal Access Act, together with the 2010 Marine (Scotland) Act and upcoming Northern Ireland Marine Bill, have set up a maritime planning system for all UK waters. Suitable areas for offshore wind development have been identified through Strategic Environmental Assessments (SEA).
Belgium	Zoning in a 'Master Plan' allocates marine space for specific maritime uses. An offshore wind energy zone has been identified.
Sweden	The 2009 Government Bill A coherent Swedish maritime policy calls for an "integrated and cross-sectorial" approach to national maritime policy.
Germany	Terrestrial planning law and thus federal powers for MSP have been extended to the EEZ. The recently developed maritime spatial plan identifies zones for specific maritime activities, including offshore wind energy.
The Netherlands	An Integrated Management Plan for the Netherlands Economic Zone in the North Sea 2015 introduces an integrated assessment framework for all activities requiring a permit. On of the key motivators for this plan is the need to plan for offshore wind energy. Specific zones have been identified where future offshore wind development should be concentrated.
Denmark	MSP exercises relating to offshore wind have included the 1997 "Action Plan for Offshore Windfarms in Danish Waters" and the 2007 update "Future offshore wind power – 2025" which identified 23 specific offshore wind farm sites.
Norway	Currently has an Integrated Management Plan for the Barents Sea and the sea area off the Lofoten Islands, with plans to extend it to the Norwegian Sea and the Norwegian part of the North Sea. It provides a framework for sustainable resource use and for existing and new activities.

Source: "Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU", European Commission, COM(2008) 791.

4.3 Clear and interactive communication

The most important aspect of engaging stakeholders is to be honest, clear and traceable in all communication. To provide correct information about the developments is vital for nurturing understanding and acceptance by stakeholders and the general public. They need to be kept aware of progress and understand how the consequences of each new development in the process affect them, the environment, local communities and the economy.

A detailed targeted communication plan typically includes the following elements:

1. Local media
A professional media strategy is helpful to increase public awareness for offshore wind farms in general or for specific projects. There are also clear opportunities to promote offshore wind energy in a positive way and present the advantages that offshore wind energy offers in terms of economic development, local job creation and security of power supply. These aspects are increasingly appealing to a wide range of stakeholders.

Public awareness can be raised by distributing newsletters, information packages, educational programmes and through interviews with local newspapers, radio and television.

2. Internet
Project websites are an essential aspect of a transparent communication plan. Developers keep the public informed about development progress and upcoming meetings and events in a convenient way.

Specific information provided about the Projects can be:
- Factual information: e.g. size, location, visual impact, offshore and onshore works
- Planning information: the programme of development activities
- Environmental information: planning of EIA surveys and the findings

Websites are also increasingly used to gather information from the public. Interested stakeholders can contact the project team with concerns or request regular email updates.

3. Meetings
Communication should operate both ways and feedback from the general audience and stakeholders should be gathered throughout the development period. This can be achieved through one-on-one meetings and public information sessions.

Face-to-face meetings are an excellent way to directly address concerns and to provide accurate responses to specific questions. Public meetings are also less resource-intensive and allow many viewpoints to be vocalised. Increased participation is possible in a workshop format, where developers and groups of stakeholders discuss topics together.

4. Public exhibitions

A well-advertised exhibition can be an effective method to engage the public. A wide range of materials can be made available, with sufficient time for individuals to browse at their own pace. Knowledgeable staff can answer questions directly and record pressing concerns.

5. Surveys

Public attitude surveys and interviews are direct ways to gather information about the views of stakeholders. They can be useful exercises for collecting a wide range of views that summarise the general public mood.

Best Practice Guidelines Stakeholder Consultation

BWEA (now RenewableUK) has worked together with dozens of stakeholders to identify the following principles of effective stakeholder consultation:

- Enable all stakeholders to make their views known
- Work together to ensure all viewpoints are addressed
- Be inclusive
- Judge ideas on their merits rather than their source
- Share responsibility for the process and the feedback
- Consider using independent professional facilitators
- Ensure transparency in the process, especially regarding uncertainties

Source: "Best Practice Guidelines: Consultation for Offshore Wind Energy Developments"

5. Drivers of Offshore Wind Energy

The European Union adopted as a target in 2007, that 20% of the energy supply will be generated from renewable sources by 2020. Offshore wind energy will provide an important contribution to achieving these national targets.

To achieve this, all the countries have implemented support mechanisms; either through feed-in tariffs, premiums or green certificates. In addition, The Netherlands and Sweden provide tax deductions and/or tax exemptions.

A recent study executed for the Dutch government indicates a shortage of approximately €95 billion in financing for the required capital investments in offshore wind projects. This is likely to result in competition for funds, with the available financing flowing towards countries with the most stable policy environments and favourable return-risk ratios. Additional financing must be sourced to achieve the EU targets.

5.1 Overview of National policies and support mechanisms

A compact overview of the national support mechanisms for offshore wind energy is presented for North Sea countries below.

Applicable policies and/or support mechanisms per country			
Denmark	Feed in premium	Compensation for balancing costs	
Germany	Feed in tariff scheme	Possible change to feed-in premium scheme parallel to the feed-in tariff	Low interest loans
Netherlands	Feed in premium through tendering	Tax deduction scheme for investing companies	Low interest loans
Norway	Shared system of certificates with Sweden coming up		
Sweden	Quota Obligations and Tradable Certificates	Tax exemptions	Environmental bonus for wind energy
United Kingdom	Renewables Obligation Certificates		

Although the details of the support mechanisms vary from country to country, there are many parallels. Appendix B presents a detailed description of the schemes in place in Denmark, Germany, the Netherlands, Norway, Sweden and the United Kingdom.

5.2 Available funds for investments in offshore wind projects

Additional financing must be found to achieve the EU targets. These can be sourced potentially from the larger pool of funding available in the market for investments in infrastructure. To enable this however, it is essential that the risk and return profile of investments in offshore wind energy becomes aligned with the mature infrastructure sector.

An example of available funds is the €5 billion loan programme by KfW (Kreditanstalt für Wiederaufbau). Herewith the German Government allows investors to gain the necessary experience for the competent management of technical risks of offshore technology. This should result in a fast construction of the first ten offshore wind farms. The programme will be launched mid 2011.

CASE STUDY – UK SUPPORT SCHEME OFFSHORE WIND

Offshore wind power in the UK has been growing at an impressive rate, resulting in a current installation of 500MW. Many acknowledge a continued strong outlook for offshore wind power in the UK for the years ahead, based on the 42 GW target set by the Government. The UK clearly has an impressive offshore wind potential with an immense sea domain, high wind and shallow waters. However, the strong and continuous political drive supported across political parties has proved to be an even more significant factor. This has resulted in an effective support mechanism, a set of dedicated public or semi-public bodies with a pro-active approach to offshore wind energy and a will to address obstacles and overcome them in a timely.

The support mechanism has been adapted twice to ensure the attractiveness of the UK market. For example, the level of Government support was increased in 2009 in response to the economic downturn.

The Crown Estate, owner of the UK seabed, has played a pro-active role in commissioning studies, supporting development costs and preparing four large scale tenders for concession rights. This has been complemented by efforts by organisations such as the Carbon Trust and Renewable UK to identify obstacles and propose ways to overcome them. Furthermore, discussions are ongoing about streamlining the process of obtaining construction permits and how to best arrange grid connections. The National Grid operator has also recently announced a GBP 22bn investment in upgrading part of the grid to accommodate wind energy both onshore and offshore.

Many challenges remain but, it appears that the UK is set to reach its target.

5.3 The financial crisis and financing of offshore wind

The financial crisis has had a significant impact on the overall financing of large offshore wind projects. Although banks are more interested in financing large projects, offshore wind projects are currently considered to be risky.

The offshore wind farm market is increasingly dominated by utilities. These utilities are in a position to use their balance sheets for financing, to some extent (liability of utility). This ability generally simplifies the process of financing projects compared to the alternative; project financed projects (non-recourse financing). However, even the capacity of large utilities to finance projects through their balance sheets is limited, if you consider the scale of the capital investments that is required. Recent trends suggest an increasing use of project financing by utilities for new projects or the refinancing of operational offshore wind projects. Banks prefer a combination of portfolio financing and balance sheet financing. This way, the risks are spread and liabilities are primarily allocated to the owners. Utilities can setup their projects to meet this preference and improve their opportunity for re-financing existing projects and adding new projects to the portfolio.

Offshore wind projects require high investments, even for the project financing market. The attraction for banks to project finance offshore wind projects can be increased with the potential for portfolio financing, which spreads risks over a range of existing and new wind farms results in a more attractive risks profile. Risks are evened out related to different productivity, technologies, countries (and their policies), wind climates and availability.

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- Lillgrund: http://www.vattenfall.se/sv/lillgrund-wind-farm.htm
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Appendix A

Case Studies of North Sea Offshore Wind Farms

These case studies represent an update of the 2006 POWER project report, “Case Study: European Offshore Wind Farms - A Survey for the Analysis of the Experiences and Lessons Learnt by Developers of Offshore Wind Farms.” The status was updated for the eight offshore wind farms covered in the 2006 report and four additional wind farms have also been investigated. Project information was gathered from project press releases, websites and environmental statements as well as industry publications. Interviews with project leaders complemented this research.

Figure A0-1 Overview of Offshore Wind Farms.

A1 Horns Rev, Denmark
A2 Nysted, Denmark
A3 Scroby Sands, UK
A4 OWEZ, Netherlands
A5 C-POWER, Belgium
A6 Lillgrund, Sweden
A7 Prinses Amaliawindpark, Netherlands
A8 Alpha Ventus, Germany
A9 Belwind 1, Belgium
A10 Greater Gabbard, UK
A11 Sheringham Shoal, UK
A12 Butendiek, Germany

A1. Horns Rev, Denmark

Horns Rev was the first large-scale offshore wind farm, completed in 2003. The Danish government selected the site as a pilot project and ordered utility companies to build the 160 MW wind farm. The project was developed and constructed on a tight schedule with all 80 foundations and wind turbines installed over a few months. Unfortunately, the speed of installation and the selection of a prototype wind turbine led to some major maintenance works in the first few years. Since resolving these issues, the wind farm has been operating smoothly for several years.

Figure A1-1: Location of the Horns Rev offshore wind farm.

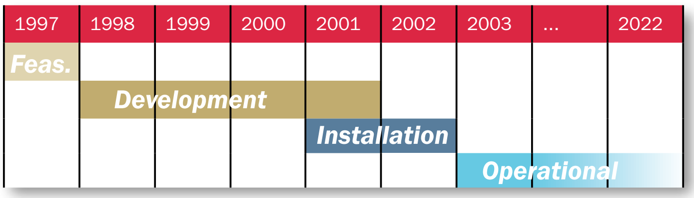


Figure A1-2: Loading quay space at Esbjerg Harbour. (Copyright Gunnar Britse)

Feasibility Phase

As early as the 1980's, the Danish government performed an initial screening process for offshore wind farms. Two test sites were built, close to shore and in shallow water. By 1997, the government established an 'Action Plan for Offshore Windfarms in Danish Waters' which identified five key areas for offshore wind farms and planned a large-scale pilot project at each site. The utility companies, Elsam and Eltra were ordered to jointly build the Horns Rev project. Elsam was in charge of the offshore wind farm and infield cabling, while Eltra was responsible for the grid connection, to the offshore substation.

Development Phase

The screening exercise within the Action Plan had already demonstrated that there were minimal conflicts with other sea users. Local fishermen had to be compensated and visual impact from the coast was a minor issue (although the wind farm is now considered a tourist attraction). After a one-year EIA, the project received permission from the Danish Energy Agency (DEA), the authority responsible for the entire approval process.

Extensive measurement campaigns were also carried out on-site to determine wind and sea conditions. The wind resource assessment showed good yields for the proposed wind farm and the wave climate was suitable for installation works.

The primary focus for Elsam for the public was that offshore wind is a new business area with significant future opportunities. Wind energy is one of Denmark's largest industries, with both Vestas and Siemens based in Jutland.

Installation Phase

The project was set up on a multi-contractor basis, as the developers felt they could lower costs by taking on more of the project risks. The tendering process was carried out simultaneously for all project components. This led to a complex interface between suppliers, as each technology choice affected the other. It was also a challenge to settle the division of weather risk between parties.

The project maintained a tight schedule. After permits were received in March 2001, the procurement process was completed quickly and the initial foundations were installed in March 2002. By August 2002, the last foundations and wind turbines had been installed. The quick pace of the installation was managed, despite delays in the onshore assembly and testing of the wind turbines. This led to a substantial and expensive delay in the commissioning of the wind turbines as final assembly work had to be done offshore.

The biggest bottleneck in the installation process was the onshore harbour logistics. The required area was significantly underestimated by the offshore contractors and the harbour treated the wind farm installation as a lesser priority compared to long-term activities such as container shipping.

Operational Phase

The selection of a prototype wind turbine (the offshore version of the proven Vestas V80) proved to be problematic during the first few years of operation. Within the first year, the insulation of transformer windings was found to be insufficient for the marine environment and a significant number of transformers failed. After less than a year of operation, all wind turbine transformers had to be replaced with a different type. In the second year, there were severe generator problems, as well as issues with the blade coating and lightning protection systems. The rotors and nacelles had be dismantled and repaired onshore.

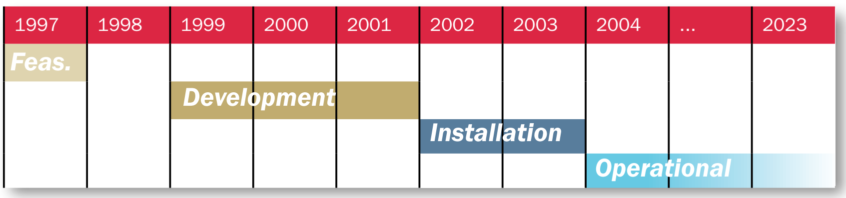
Since 2005, after these repairs, Horns Rev has been operating smoothly with high availability. However, in 2010 it was revealed that the wind turbine superstructures have sunk relative to their foundations, with problems comparable to the grouted connection of OWEZ in the Netherlands. In summer 2010, the entire wind farm also had to be shut down because of a fault in the transformer station.

Project name	***Horns Rev***
Country	Denmark
Area	20 km2
Water depth	6-14 m
Distance to shore	14 km
Total capacity	160 MW
Number of wind turbines	80
Wind Turbine type	Vestas V80-2 MW
Foundation type	Monopiles
Export cables	150 kV
Transformer station	Offshore

A2. Nysted, Denmark

The 165.6 MW Nysted offshore wind farm was built shortly after Horns Rev. The site was identified as part of the same Action Plan for Offshore Windfarms. The project used a multi-contractor approach to supply and install. Unlike with Horns Rev, the developers selected a proven wind turbine and even set up a demonstration wind turbine onshore for testing and training. As a result, the wind farm has reported excellent availability and limited required maintenance.

Figure A2-1: Location of the Nysted offshore wind farm.



Feasibility Phase

The site for the Nysted offshore wind farm was identified in the screening process that led to the 1997 Action Plan for Offshore Windfarms in Danish Waters (which also identified Horns Rev). Agreement between major Danish utilities and the Minister for Energy saw ENERGI E2 develop the Nysted wind farm and SEAS Transmission made responsible for the grid connection, including the offshore substation.

Development Phase

A one-year environmental monitoring campaign formed the basis of the EIA, which was submitted to the Danish Energy Authority, who approved the application for an offshore wind farm in 2001. The environmental monitoring campaign continued, to establish a two-year baseline prior to construction. Monitoring continued during construction and for the first two years of operation. An international team of independent experts assessed the campaigns, which were intended to determine the effects of installation noise, operational noise, underwater vibrations and electromagnetic fields from cables. The impacts on migratory birds, porpoises, seals and fish were investigated.

Four offshore wind measurement masts were also installed to determine site conditions.

Installation Phase

ENERGI E2 managed the procurement process on a multi-contractor basis, preparing highly detailed tender documents for each component of the project. The manufacturers maintained

Figure A2-2: Installing Siemens turbine with the MS Ocean Ady. (Source Siemens Wind power)

full control of the design process, but a good working relationship with ENERGI E2 meant that the developer had full access to the design process and quality control.

The wind turbine manufacturer proposed a new type of blades, which were tested on a prototype wind turbine, onshore, for a full year prior to their serial production for the Nysted offshore wind farm. A full-size model of the lower tower sections was also built onshore and tested prior to serial production. The wind farm developers also required a prototype of the exact model of wind turbine for Nysted to be installed at a site onshore to practice the installation and removal of major components and run tests.

An innovative rack was installed on the wind turbine installation vessel that allowed four rotors to be stacked on top of each other, meaning that the vessel could carry up to four complete wind turbines.

Operational Phase
In the first year of operation, wind turbine availability was 97%. The wind farm has also reported higher than expected output.

In 2005, a static VAR compensator was installed for the wind farm because of unacceptably large and frequent voltage fluctuations on the 132-kV transmission system.

The wind turbine manufacturer included a five-year O&M contract, based on a nearby small ferry port. The owners phased in their own O&M team to take over after the contract expired.

The wind farm can be reached by boat for 80% of the year. Only two visits per year per wind turbine are planned for the first ten years, but this number is expected to later rise with increasing problems of the ageing wind turbines.

Project name	***Nysted***
Country	Denmark
Area	24 km2
Water depth	6-9,5 m
Distance to shore	9 km
Total capacity	165,6 MW
Number of wind turbines	72
Wind Turbine type	Bonus 2.3 MW
Foundation type	Gravity base
Export cables	132 kV
Transformer station	Offshore

A3. Scroby Sands, United Kingdom

Scroby Sands was one of the first offshore wind farms, built in the United Kingdom in 2004 by E.ON UK Renewables Offshore Wind Ltd (EROWL). The wind farm is very close to shore, but has experienced high levels of public support. The tendering of the EPIC contract was rushed, creating delays when a revised tender proved necessary. The construction schedule was however, modest, allowing for installation of foundations and wind turbines in separate years. The wind farm has been operating smoothly, becoming a local tourist attraction.

Figure A3-1: Location of the Scroby Sands offshore wind farm.

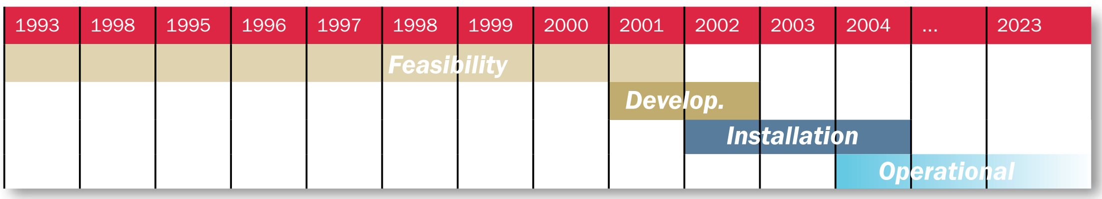


Figure A3-2: Elements at quayside. (Source: E.ON UK, Chatterton)

Feasibility Phase
The site was first selected in 1993-94, with a meteorological mast installed offshore in 1995. However, the landlord of the seabed (The Crown Estate – TCE) did not approve a lease for the location until 2001.

Development Phase
Despite a location very close to shore (2.5 km), the public acceptance of the offshore wind farm was high. The developers credit this to early involvement of stakeholders, project charities and a visitor's information centre on the coast. The environmental impact assessment identified pupping seals and a breeding tern colony in the area. A mitigating installation methodology was developed together with stakeholders and presented at a public exhibition.

Installation Phase
EROWL tendered the Engineering, Procurement, Installation and Construction contract in 2002, allowing six weeks for bids. Six parties submitted bids, but the developers determined that the process had been too rushed and requested revised bids. This decision delayed the construction. The winning bidder, Vestas Celtic, took on most of the project risk and was in charge of all offshore procurement, installation and operations.

The construction schedule was spread over two building seasons, starting in 2003, with foundations and wind turbines installed separately. This allowed for some buffer time in the planning minimising the impact of any delays. The subsea cable installation was more time-consuming than anticipated and strong currents prevented diver assistance. The commissioning of the wind turbines was also delayed due to unseasonably strong winds.

Operational Phase

The wind farm has been operational since 2004, with generally high availability and without major incidents or major repairs. In 2008, the generators in eleven of the thirty Vestas V80 wind turbines had to be replaced. It was planned that these repairs would lead to an annual availability level of 79%, but it was kept to 84% through other improvements in reliability.

O&M is carried out by a Vestas Celtic team, with a specially designed “transfer vessel” able to operate with wave heights up to 1.5 m. The 2008 annual report states that the wind farm is only accessible for two-thirds of the year, so maintenance must be carefully planned.

Only 2.5 km from shore, the wind farm has become a tourist attraction. Around 35,000 visitors a year have been through the visitors information centre.

Project name	***Scroby Sands***
Country	United kingdom
Area	10 km2
Water depth	3-12 m
Distance to shore	2,5 km
Total capacity	60 MW
Number of wind turbines	30
Wind Turbine type	Vestas V80 - 2 MW
Foundation type	Monopiles
Export cables	3x33 kV
Transformer station	Onshore

A4. Offshore Wind Farm Egmond aan Zee (OWEZ), the Netherlands

The first Dutch offshore wind farm is the Offshore Wind Farm Egmond aan Zee (OWEZ). It is owned by NoordzeeWind, a joint-venture of Shell Wind Energy and Nuon Renewable Energy. As a pilot project, this wind farm benefited from strong government support, both during the permitting process and through a stable financial commitment. The government will also benefit from the various research projects associated with the wind farm, in terms of future developments.

Figure A4-1: Location of the OWEZ offshore wind farm.

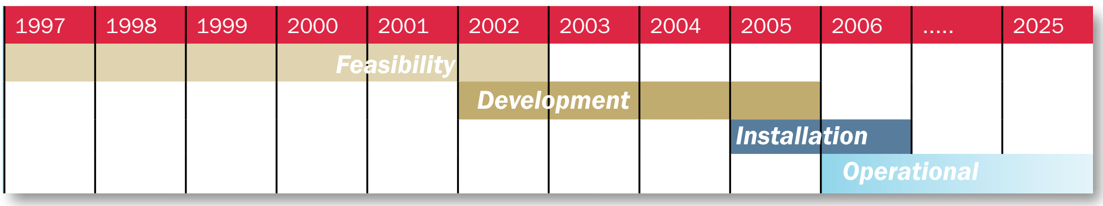


Figure A4-2: The Svanen heavy lift vessel installing foundation at OWEZ.

Feasibility Phase

The Dutch government determined the OWEZ location. In 1997, the government decided to start a pilot offshore wind farm and conducted an initial Environmental Impact Assessment, considering six possible sites. In 2000, the site offshore of Egmond aan Zee was selected. The government then carried out a consultation procedure, with extensive stakeholder and inter-governmental participation, to reach a Key Planning Decision (KPD) on the project. The focus of this procedure is on cooperation and consensus in accordance with traditional Dutch infrastructure planning practices.

Development Phase

In 2002, the KPD became definite and NoordzeeWind was selected as the developer through a tender process. The developer then began a site-specific EIA process, which required consents from five different authorities for the onshore works two for the offshore works. The active role of government during the earlier KPD procedure meant that the authorities worked together, although this second EIA process still lasted over two years and the permits were not made irrevocable until 2005. However, the lengthy consenting process did not necessarily delay the project, as a pre-construction Monitoring and Evaluation Programme was required (to assess benchmark environmental parameters) and NZW used this time to prepare financing and resolve technical issues.

NoordzeeWind have indicated that they favour a similar leading role for government in future projects. They found that tendering for a pre-defined location and project size led to a more stable and orderly environment in which to consider the investment.

Installation Phase

The developer of the project, Noordzeewind, was a partnership of Shell Wind Energy & Nuon Renewable Energy. However, these companies did not have the internal capacity to design and contract the offshore wind farm. An EPC contractor was appointed for their specific knowledge and experience.
This reflects the relatively young market in 2005; various companies had the specific knowledge and capacities needed for the project.

The wind farm capacity was initially defined as 100 MW in the KPD and EIA, however, wind turbine technology advanced significantly from the beginning of the Feasibility Phase, which meant that a larger capacity (108 MW) was in fact possible, with fewer wind turbines (36 instead of 50). Governmental policies were flexible enough to accommodate these changes.

The Svanen heavy-lift vessel installed the 36 foundations and wind turbines in 2006, (April to August). Environmental monitoring during construction showed that birds and porpoises were not harmed by underwater piling noise, as the operations were carried out during a period (summer) where relatively few animals were in the area.

Operational Phase

The offshore wind farm has been operational since 2006 and is generally performing well. The wind farm has however, required more maintenance than originally planned, due to failures in the gearboxes and issues with the foundations.

Within one year of commissioning, the gearboxes of nine wind turbines had to be replaced. This maintenance was carried out by Vestas over a period of 4 weeks. By 2008, Vestas had developed a modified gearbox, and retrofitted all of the wind turbines. This work was entirely covered by the O&M contract with Vestas.

In 2009, inspections revealed that the transition pieces had sunk slightly, due to problems with the connecting grout and bonding to the steel parts. Although OWEZ has a unique design for this connection, similar problems have since materialised in other offshore wind farms. A joint industry project is currently underway to study the issue in detail and new design standards are expected within the coming year. For OWEZ, contractor, a specific solution for this design was devised together with the EPC and tested on three wind turbines. The foundations were filled with concrete to prevent further slipping. This solution has since been extended to all wind turbines.

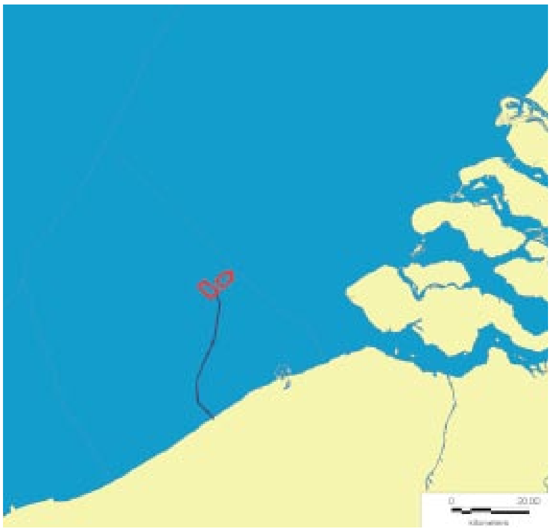
A detailed environmental Monitoring and Evaluation Programme is required for this pilot project in order to assess the impacts of this offshore wind farm. This programme is not intended to restrict this project, but to improve the government's understanding of the environmental consequences of future wind farms.

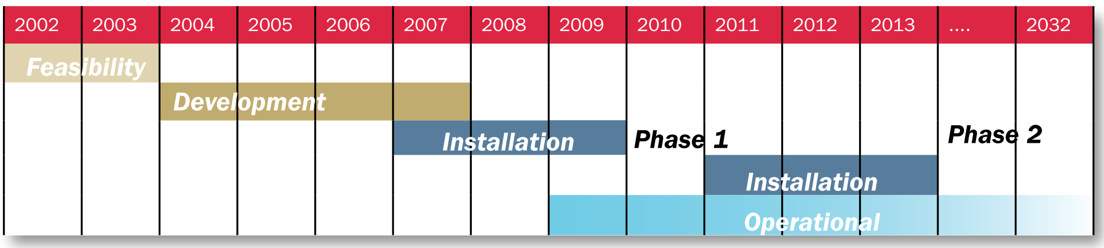
Project name	***Offshore Wind Farm Egmond aan Zee (OWEZ)***
Country	The Netherlands
Area	3 km^2
Water depth	15 - 20 m
Distance to shore	10 - 18 km
Total capacity	108 MW
Number of wind turbines	36
Wind Turbine type	Vestas V90 - 3 MW
Foundation type	Monopiles
Export cables	3 x 34 kV
Transformer station	Onshore
Website	www.noordzeewind.nl

A5. C-Power, Belgium

C-Power is the first offshore wind farm in Belgium. The developer originally proposed a location closer to shore but the government decided to shift the site outside the 12 nautical mile territorial waters. The government also mandated that the project be split into phases, with an initial demonstration of only six wind turbines. Both decisions have greatly increased the project costs, so the government subsequently increased the value of the resulting green certificates and co-financed the grid connection costs. The pilot phase is now operational and the remainder of the 300 MW project will be constructed in two phases by 2013.

Figure A5-1: Location of the C-Power offshore wind farm.





Feasibility Phase
C-Power was formed as a consortium of four Belgium private companies (Interelectra, Ecotech Finance, Socofe & Dredging International) and one French company (SIIF Energies)[4]. In 1998, C-Power applied for permits for a wind farm, 6 km from shore. The government refused the building and environmental permits in 2002 and designated an area further offshore to mitigate environmental concerns. The government then launched a tender for a concession area 30 km offshore, which was awarded to C-Power.

Development Phase
A single office of the Belgian government was made responsible for all consents for offshore wind farms. This office had to manage the application process in cooperation with all affected ministries and government offices which greatly simplified the permitting process. Permits for the offshore site, offshore cable, onshore cable, and grid connection were applied for and granted over a two-year period.

C-Power has made a particular effort to keep the public informed, with a comprehensive website, press conferences, interviews, public debates and information campaigns in the coastal region. The focus on C-Power's role within European and Belgian renewable energy targets has helped maintain public acceptance. The developers also feel it has had a positive effect on the opinions of policy makers.

The economic feasibility of the wind farm was greatly affected by the government decisions to move the site further offshore and to require a pilot phase with only six wind turbines, because the cost of foundations and grid connection increased. As a result, a higher value for the green certificates was negotiated and the government decided to co-finance the cable costs.

Rather than back the offshore project with their balance sheets, C-Power used non-recourse project financing for the first phase. This is the second offshore wind farm to receive this financing, after Prinses Amaliawindpark did so, in the Netherlands, the previous year. Compared to the Prinses Amaliawindpark project, greater risks were taken on by the project partners. As the chosen wind turbines have a limited track record, REpower has provided generous performance guarantees. The limited size of the project is ideal for a commercial demonstration of their new technology.

C-Power reached financial close for a second phase of the project in November 2010 through non-recourse financing and through a group of seven commerical lenders, two export agencies (from Denmark and Germany) and the European Investment Bank. The installation of these remaining phases is planned for 2011 to 2013.

4 The consortium now consists of four Belgian shareholders: DEME (Dredging International), SRIW Ecotech Finance, Socofe & Nuhma; with two European strategic partners: EDF Energies Nouvelles (formerly SIIF Energies) & RWE Innogy.

Installation Phase
The environmental monitoring campaign, begun 2-years prior to the construction of Phase I, to establish the base case, will continue during construction and operations. The monitoring will be performed by a governmental agency at the wind farm operator's expense.

The rest of the project will be built in a subsequent phase, consisting of 48 Repower 6.15MW wind turbines. The Phase I wind farm will be connected directly to shore through an export cable, without OHVS. An OHVS will be built in Phase II. The Phase I turbines will then be disconnected from their temporary export cable solution and permanently re-connected to the OHVS.

Operational Phase
One year after commissioning, REpower announced that the six wind turbines had achieved an availability rate of 94% in the first six months and 97% in the following six months. This high level of availability is similar to that of onshore wind farms. REpower attributes this to a thorough monitoring system and an optimised maintenance concept.

Project name	***C-Power***
Country	Belgium
Area	13.8 km2
Water depth	10-24 m
Distance to shore	27-30 km
Total capacity	325 MW
Number of wind turbines	6 – Phase I 48 – Phase II
Wind Turbine type	REpower RE5M & RE6M
Foundation type	Gravity base foundations
Export cables	2 x 150 kV
Transformer station	Offshore

A6. Lillgrund, Sweden

Lillgrund is the largest Swedish offshore wind farm and was developed by the Swedish utility, Vattenfall. Situated in the strait of the Öresund, south of the Öresund bridge, connecting the greater Copenhagen to Malmö, the wind farm consists of 48 2.3MW wind turbines. Its development was begun in 1997 and the wind farm has been operating since 2007. The Lillgrund wind farm has been partially financed by the Swedish Energy Agency (STEM) as a pilot project. It has been stipulated that experiences gained in the process, must be reported. This includes a series of online reports.

Figure A6-1: Location of the Lillgrund offshore wind farm.

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	...	2026
Feas.												
	Development											
								Installation				
										Operational		

Figure A6-2: Aerial View of Lillgrund offshore wind farm. (Copyright: Siemens press picture Power)

Feasibility Phase
The wind farm is located in shallow waters (4 to 8 meter water depth) and relatively close to shore (7-10 km off the coast). With wind speed estimated at 8.5 m/s, the consortium Eurowind AB (owned by Fred Olsen Renewables and the Fred Olsen's holdings), considered the area to be suitable for wind energy development and obtained a permit to build in 1997.

Development Phase
The consortium began an extensive environmental impact assessment (EIA) in 1998. The process was relatively long, passing through the Government, a dedicated Environmental Court and finally the Supreme Court, before the Environmental Permit was given in 2003.

The Building permit was granted in 2004 by the City Council of Malmö, the County administrative board and the government after several rounds of appeal. In Autumn, 2004, Vattenfall sold the project's permit to Eurowind AB. However, the long lead time in acquiring the permits led to a situation where the intended wind turbine size was no longer available when permission was finally given and therefore, technically, the permits were no longer valid. After discussions with the authorities, the 1.5 MW limit was removed and a current wind turbine model could be selected.

Since its acquisition of the project in 2004, Vattenfall has worked actively to generate a widespread acceptance of the project by using public meetings, press releases, a website, exclusive contact to journalists and newspapers. Local population associations were invited to a number of private meetings and monthly meetings were held with the authorities to ensure that all issues were carefully considered. This was an opportunity for Vattenfall to receive input to the project and for authorities to gain experience with large wind power projects.

Installation phase

After a bidding process completed in 2005, Vattenfall awarded the contract for foundation and seabed preparation work to the Danish- German joint venture of Pihl & Sohn A/S and Hochtief Construction AG, and the contract for wind turbines and electrical systems to Siemens Wind Power A/S.

Despite a difficult autumn and winter in 2006, that prevented offshore construction from proceeding, the construction of the wind farm was considered to be successful and within planning expectations. Vattenfall did note a set of lessons that were learnt. Installation of export cable was carried out during the winter. Due to a technical problem the cable was left under-water and was only picked up two months later when both vessel and weather conditions were suitable. This created delays and discussions about who was responsible for these weather risks. Finally, Vattenfall has noted that minor problems and disputes with contractors could have been prevented by the presence of a company representative on site.

Operational Phase

Due to the change of turbine size at a late stage of the project without modifying the layout, the Lillgrund wind farm is quite dense. This results in relatively high wake losses. Its availability is however, good, with an availability of 94% recorded in its first year of operation.

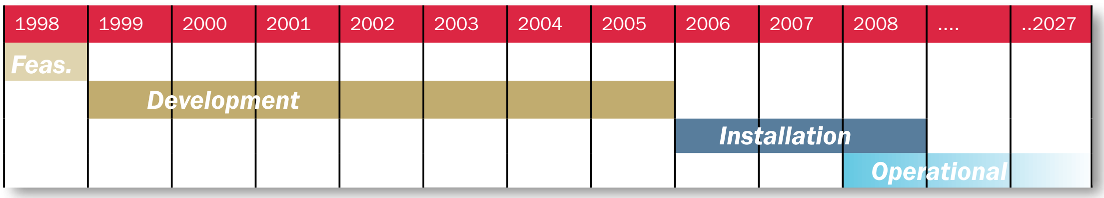
The O&M work on the wind farm is planned to gradually shift from the Original Equipment Manufacturer to Vattenfall. In 2012, Vattenfall technicians should constitute 50% of the O&M work force.

Project name	***Lillgrund***
Country	Sweden
Area	6 km2
Water depth	4-13 m
Distance to shore	10 km
Total capacity	110 MW
Number of wind turbines	48
Wind Turbine type	Siemens SWT-2.3 93
Foundation type	Gravity base
Export cables	145 kV AC
Transformer station	Offshore

A7. Prinses Amaliawindpark, the Netherlands

The 120 MW Prinses Amaliawindpark was opened in June 2008 and is the largest wind farm off the coast of the Netherlands. It was the first wind farm located at such a distance from the shoreline (entirely outside territorial water) and also the first to receive non-recourse project finance. Separate contractors were responsible for the wind turbines, foundations and electrical packages.

Figure A7-1: Location of the Prinses Amaliawindpark.



Feasibility Phase

The wind farm project was started in 1998 by several companies, including E-connection, Vestas, Mammoet van Oord, Smulders and Fabricom. The project was originally known as Q7, referring to its grid location in the Dutch North Sea. The large distance from shore was chosen in order to reduce the visual effect from the coast as well as the impact on migrating birds

Development Phase

E-Connection applied for a permit for the construction and operation of the wind farm in late 1999 and the EIA began a few months later. The environmental report was completed by the government in 2001 and the permit was issued in February 2002. The permits for the construction and the maintenance of the offshore and land cables (required for tunnelling through the sand dunes) were also obtained in early 2002.

Figure A7-2: Loading export cable for Prinses Amaliawindpark.

In 2004, E-Connection agreed to transfer the project permits and rights to a firm called Q7 Holding, a joint-venture between Econcern and Energy Investments Holding. The transfer was finalised in 2006, and Eneco took a 50% stake in the wind farm.

The development of the wind farm was made possible by the unique financing arrangement agreed with three international banks - Rabobank, Dexia and BNP Paribas. Prinses Amaliawindpark was the first wind farm in the world to be financed on a non-recourse basis, meaning that it was financed purely on future cash flow projections. The financial close was reached in October 2006.

Installation Phase

The approvals were based on the Vestas V80-2 MW wind turbine, which was state-of-the-art at the beginning of the project. However, this proved to be a constraint on the selection of wind turbine technologies, as it was no longer the largest capacity wind turbine on the market by the time of construction.

The cable connection running from the sand dunes to the onshore substation was installed alongside the land cable of the OWEZ wind farm in 2005, prior to financial close of the wind farm. As a result, onshore cable installation was necessary only once.

Marine contractor, Van Oord installed the foundations, using a jack-up barge to form a stable work platform. The same vessel was used by Vestas to install the wind turbines. In July 2007, the onboard crane collapsed while loading at the port. Although noone was hurt, the replacement of the crane led to delays in construction. Strong winds in the autumn delayed commissioning until spring 2008.

Operational Phase

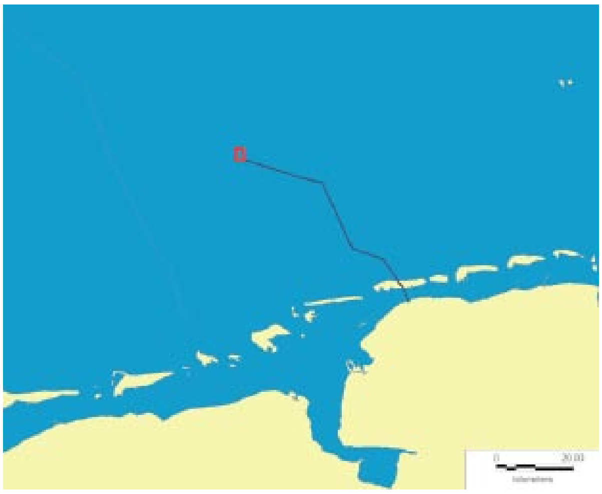
After six months of operations, the wind farm owners announced that the wind farm met all of their expectations in terms of availability and energy yield. The wind turbine availability is at 98% which the owners credit to the selection of a proven technology; the Vestas V80 is now a highly reliable offshore wind turbine, having been in operation since 2003 (Horns Rev). Vestas is in charge of the O&M for the first five years.

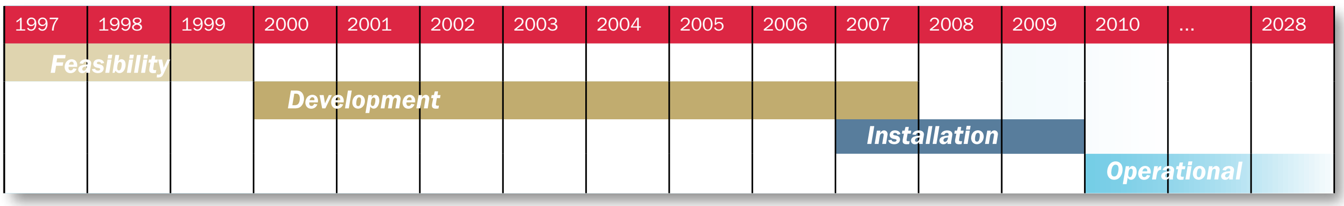
Project name	***Prinses Amaliawindpark***
Country	Netherlands
Area	14 km2
Water depth	19-24 m
Distance to shore	23 km
Total capacity	120 MW
Number of wind turbines	60
Wind Turbine type	Vestas V80 - 2 MW
Foundation type	Monopiles
Export cables	150 kV
Transformer station	Offshore

A8. Alpha Ventus, Germany

Alpha Ventus is the first offshore wind farm in Germany. It is a pilot project with twelve 5 MW wind turbines. The project was initially developed by Prokon Nord, as part of a larger wind farm. As one of the first proposed offshore wind farms, the site investigation plan has become the foundation for the approvals process. The government sought to support the stalled offshore wind industry in Germany via a grant to Stiftung Offshore-Windenergie to enable the purchase of the rights to the approved pilot phase and with an extensive R&D programme.

Figure A8-1: Location of the Alpha Ventus offshore wind farm.





Feasibility Phase
Borkum West was one of the first proposed offshore wind farms in Germany. The developers, Prokon Nord, selected a site over 45 km from shore, in order to minimise environmental impact and conflicts with other sea users. Since this project was proposed, a number of other offshore wind farms have been planned in the German Bight that are closer to shore and have smaller buffers to shipping corridors and nature conservation areas. The developers now acknowledge that they may have been too conservative in their site selection process.

Development Phase
As the first offshore wind farm development in Germany, Prokon Nord helped to define the site investigations process, together with the German authority responsible for installations outside the territorial waters (Federal Maritime and Hydrographic Agency – BSH). Since 2001, this investigation concept has been obligatory for all offshore wind farms in Germany. The main requirements are an EIA with environmental monitoring for two years, ship collision risk analysis, an investigation of the impact of sea cables and a scan of the seabed to determine the suitability of different wind turbine foundations.

Prokon Nord planned the wind farm in two separate phases; a 60 MW pilot phase, followed by a 1000 MW extension phase. This concept of a pilot phase and extension phase was also adopted by the BSH as a requirement for future offshore wind farms. However, the economic viability of the smaller pilot phases presents a challenge.

The cable route within the 12nm territorial waters and onshore, required approval from the State of Lower Saxony. Eleven cable routes were considered and a cable that crossed the island of Norderney and a National Park was found to have the least impact. Prokon Nord applied for four cables, one for the pilot phase and three others for the extension phase. However, the government also received applications from other offshore wind farm developments and they decided to include them all in a spatial planning process. So far, only the export cable for the pilot phase has been approved.

In 2005, offshore wind farm developments in Germany were stalled due to grid connection and financing issues. The Federal Ministry for Environment (BMU) decided to support the industry by building an offshore test site. Stiftung Offshore-Windenergie purchased the offshore wind farm rights to the 60 MW pilot phase from Prokon Nord, with the support of a BMU grant. The site was then leased to Doti (Deutsche Offshore- Testfeld und Infrastruktur GmbH), a joint venture of EON, EWE and Vattenfall. In addition, BMU supports an extensive R&D programme called RAVE (Research at Alpha Ventus).

Installation Phase
Supply contracts were secured with two wind turbine suppliers: Areva (Multibrid) and REpower. Both wind turbines are rated at 5 MW, but the manufacturers chose different foundation types with tripod and jacket structures for the Multibrid M5000 and REpower 5M respectively.

Figure A8-2: First turbine being transported to Alpha Ventus - July 2009. (Copyright: ©DOTI 2009)

The offshore transformer station was installed in autumn 2008, but the construction of the remainder of the wind farm was pushed back to summer 2009 because of bad weather. The twelve wind turbines were installed between April and August, with commissioning over the winter.

Operational Phase

In June 2010, after six months of operation, REpower announced that their six wind turbines were operating without problems and they posted positive output figures.

After eight months of operation, Areva announced that two of their wind turbines needed to be replaced due to parts of the gearbox overheating. All six wind turbines may need replacement, with the nacelles transported to shore to repair bearings in the gears. Areva plans to invest in an onshore facility to fully test their prototypes prior to offshore installation.

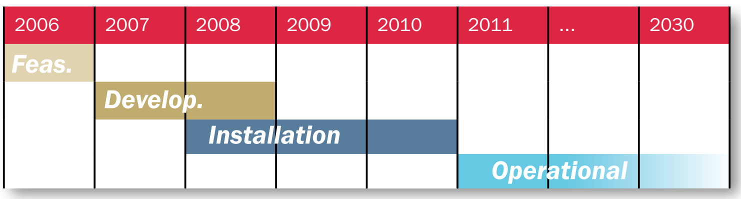
Despite these challenges, first operational results announced by the operator Doti in early 2011 seem to be very promising. A total of 230 GWh of electricity was produced in the first year of operation.

Project name	***Alpha Ventus***
Country	Germany
Area	4 km2
Water depth	30 m
Distance to shore	45 km
Total capacity	60 MW
Number of wind turbines	12
Wind Turbine type	REpower 5M & Multibrid M5000
Foundation type	Tripod & Jacket
Export cables	110 kV
Transformer station	Offshore

A9. Belwind I, Belgium

The Belwind I offshore wind farm is currently the furthest from shore, at 46 km from the Belgian coast and is in the deepest waters, at up to 37 m. It is the first phase of a 330 MW consented wind farm. The project was taken from initial concession to financial close in a record of only 3.5 years. The project was project financed.

Figure A9-1: Location of the Belwind offshore wind farm.



Feasibility Phase
The Belwind site is within a special zone earmarked by the Belgian Government for offshore wind farms. The site was selected by Evelop, a project developer, who applied for an exclusive concession with a special purpose company.

Development Phase
The concession for the entire Belwind site was granted by the Belgian Ministry of Economic Affairs in June 2007 and the permitting process for the Belwind site was finalised in autumn 2008. All necessary permits were obtained from the Belgian government and a connection contract was secured with the Belgian system operator Elia in June 2008.

The project will have a total capacity of 330MW in total, which has been divided into two phases: Belwind I and Belwind II. Although the Belwind site will be developed in two separate phases, the development concept will be identical.

Figure A9-2: The Skagerrak pull the export cable to the OHVS at Belwind. (Courtesy of the Belwind organization)

Geotechnical and geophysical surveys, including a borehole campaign of eleven boreholes were realised, proving the suitability of the investigated sites. Detailed foundation engineering was then concluded.

Evelop divided the works into three packages; Vestas supplied wind turbines, and Van Oord undertook both the marine installation and electrical works. Together with Marsh and Delta Lloyd, a tailor-made insurance structure for offshore wind farms was developed.

Despite the bankruptcy of the group Econcern NV, who owned the project, the project reached financial close in August 2009. A consortium of numerous banks and equity funds was gathered. Belwind was the first offshore wind farm to benefit from the European Investment Bank.

Installation Phase

The green certificate contract was concluded with the Belgian grid operator Elia, who will purchase the green certificates. Elia has granted a grid connection for the entire Belwind site, covering Belwind I and Belwind II.

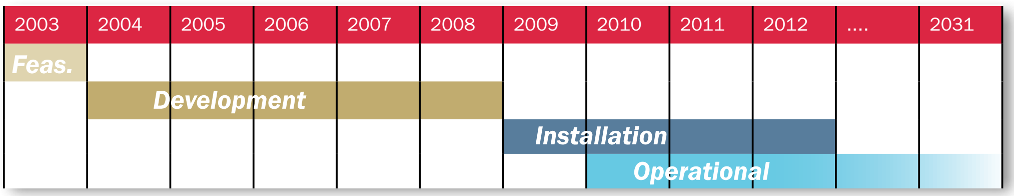
Construction of foundations began in autumn 2009, with the export cable and offshore transformer station installed in summer 2010. The wind turbines were fully installed in autumn 2010, the wind farm has been partly energised and is expected to be fully commissioned by the end of 2010.

Project name	***Belwind 1***
Country	Belgium
Area	17 km2
Water depth	15-37 m
Distance to shore	46 km
Total capacity	165 MW
Number of wind turbines	55
Wind Turbine type	Vestas V90-3 MW
Foundation type	Monopiles
Export cables	150 kV
Transformer station	Offshore

A10. Greater Gabbard, United Kingdom

Greater Gabbard is one of the Round 2 offshore wind farms in the United Kingdom. It is one of the first wind farms outside the 12 nm territorial waters. The 504 MW wind farm obtained consents in 2008, following a detailed EIA. The supply and installation of the wind farm has been contracted as two lots: the wind turbines, and all other works. Construction began in 2009 and is expected to be completed in 2012.

Figure A10-1: Location of the Greater Gabbard offshore wind farm.



Feasibility Phase

Greater Gabbard offshore wind farm is one of the Round 2 projects in the Outer Thames Estuary. The landlord of the seabed (The Crown Estate – TCE) identified three strategic areas around the United Kingdom for offshore wind developments. A joint-venture of Airtricity and Fluor (Greater Gabbard Offshore Winds Ltd – GGOWL) applied for the exclusive right to develop a site in one of these areas. The site was selected because of its good wind resources and grid connection, and a relatively minimal impact on birds, tourism, fishing, military and other sea users.

Development Phase

As part of the consenting process, the developers performed a detailed EIA and published a detailed (650 page) environmental statement in 2005. A non-technical summary was also published for the general public. The EIA assessed the likely impacts during construction, operation and decommissioning and proposed monitoring plans and mitigation measures. An assessment of shipping activity in the area led to revised site boundaries.

A major component of the environmental statement and of the project's media strategy is highlighting the need for this project to reduce greenhouse gas emissions and move towards a more sustainable future. Several government papers, reports and speeches in support of renewable energy were quoted.

The EIA process defines the proposed wind farm by different scenarios with a range of wind turbine parameters, such as number of wind turbines, maximum hub height, rotational speed. For Greater Gabbard, four cases were considered for wind turbines of 3, 3.6, 4.5 and 5-7 MW. This allows flexibility in the selection of technologies after permits are granted.

Unlike Round 1 offshore wind farms, this site was partially outside of the UK territorial waters (12 nm from the coast). The consenting regime was extended beyond UK territorial waters in the 2004 Energy Act.

In 2008, Scottish and Southern Energy (SSE) acquired Airtricity. Fluor sold its half of the project to SSE, who later sold 50% of the project equity to RWE Innogy (npower renewables). RWE and SSE will share the energy output of the wind farm.

Installation Phase

The construction contract for the wind farm was awarded to Fluor for the design, procurement, and installation of all components except wind turbines. It has contracted the grid connection to Siemens, who also supplies the 140 wind turbines.

In 2009, the UK government announced improved subsidies for offshore wind farms built between 2010 and 2014, with two Renewable Obligation Certificates (ROCs) per MWh. The first foundations were installed in late 2009 and the first wind turbines in spring 2010.

Figure A10-2: First turbine installed at the Greater Gabbard offshore wind farm.
(Courtesy of SSE and RWE npower renewables)

There have been two fatalities during the construction of the Greater Gabbard project. In separate incidents, a worker was killed in the port of Vlissingen on a vessel carrying offshore wind components and another was killed when a crane dropped a blade during loading at the portside. These are the first deaths in the offshore wind industry.

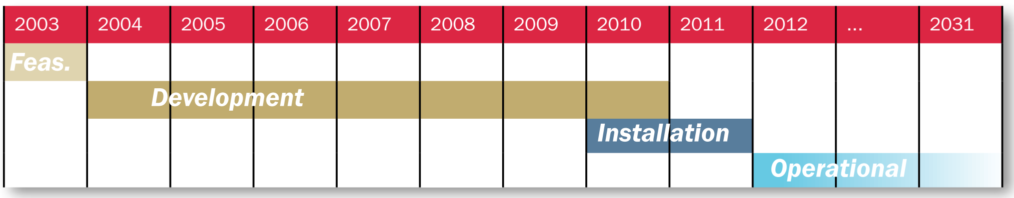
Operational Phase
The Greater Gabbard offshore wind farm is expected to be fully commissioned by 2012 and will operate for 20 years. The owners have a 50-year lease on the site, allowing for possible repowering in 2030.

Project name	***Greater Gabbard***
Country	United Kingdom
Area	147 km2
Water depth	4-10 m
Distance to shore	23 km
Total capacity	504 MW
Number of wind turbines	140
Wind Turbine type	Siemens SWT-3.6-107
Foundation type	Monopiles
Export cables	132 kV
Transformer station	Offshore (x2)

A11. Sheringham Shoal, United Kingdom

The Sheringham Shoal offshore wind farm is located in the Greater Wash strategic area, part of the UK's Round 2 tender. Despite initial screening and site selection away from major bird colonies, site investigations revealed that birds regularly cross the area. This led to a re-design of the wind farm layout. The project also had opposition from the Ministry of Defence regarding radar, but was eventually given permits in 2008, based on a technological solution to the issue. The wind farm is currently under construction.

Figure A11-1: Location of the Sheringham Shoal offshore wind farm.



Feasibility Phase

In 2003, Scira Offshore (a joint-venture of Econcern and SLP) successfully applied for a concession from The Crown Estate in the Round 2 UK offshore wind tender. The area was selected based on a competitors analysis for the Greater Wash strategic area and a limited number of site criteria. The distance to the coast was maximised in order to reduce visibility, while remaining within the UK's territorial waters for legal reasons. A minimum of 15 km was kept from important tern breeding colonies on the coast and the area had suitable water depths and low shipping intensity.

Development Phase

Great effort went into surveying bird use of the site. From the feasibility study it was concluded that the distance to the tern breeding colonies would be sufficient to prevent any impact to the animals, but the surveys showed that Sandwich terns from the colonies were regularly crossing the wind farm site on their way to a distant foraging ground. In order to minimise the impact on the Sandwich tern, the layout of the wind farm was altered so that the main corridors between the wind turbines are aligned with the prevailing flight direction of terns.

In 2004, the Norwegian utility, StatoilHydro stepped in as Econcern's partner. The parties worked together to complete the EIA and to finalise critical consultations with the Ministry of Defence. The onshore cable route was approved in early February 2008, and in July, final consent was obtained, making it the first wind farm in the Greater Wash to obtain full consents.

Figure A11-1: Modeled visualization of Sheringham Shoal offshore wind farm as seen from the shore. (Source Ecofys)

Installation Phase

After consents, StatoilHydro exercised its option to buy out Econcern and later sold the 50% stake to Statkraft, another utility.

Three contractors were selected to supply the main components; Siemens for the 3.6 MW turbines for the project, MT Højgaard for the foundations and AREVA for the onshore and offshore substations.

A survey for unexploded ordnance found a WWII air-dropped bomb that was safely detonated prior to construction activities. The survey took almost four months, but the project director felt that the discovery of the bomb fully justified the detailed survey.

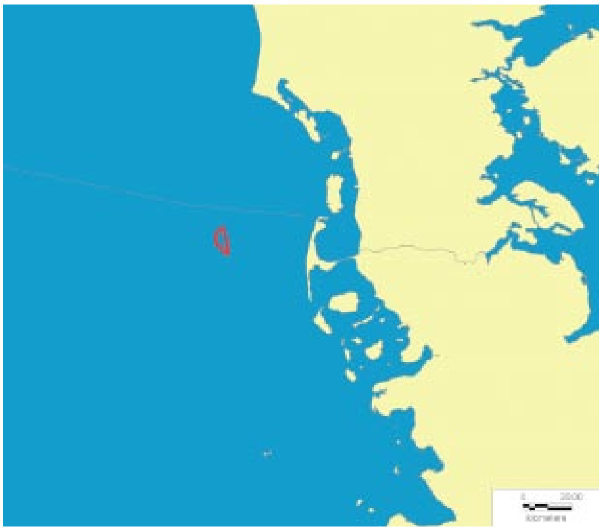
The first foundations were installed in early 2010, with the export cables to be completed the same year. Wind turbine installation shall start in 2011, with full commissioning by the end of the year.

Project name	***Sheringham Shoal***
Country	United Kingdom
Area	35 km2
Water depth	17-22 m
Distance to shore	17-23 km
Total capacity	317 MW
Number of wind turbines	88
Wind Turbine type	Siemens SWT-3.6-107
Foundation type	Monopiles
Export cables	132 kV
Transformer station	Offshore (x2)

A12. Butendiek, Germany

The Butendiek offshore wind farm was planned as a cooperative project, similar to onshore wind farms in Germany and Denmark. 20,000 shares were sold to fund the development of the site. Significant increases in technology and financing costs meant that the cooperative needed to look for a strategic partner and the project was eventually acquired by Airtricity. Supply contracts have been arranged, but the installation schedule has not yet been announced.

Figure A12-1: Location of the Butendiek offshore wind farm.



1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Feas.														
	Development													

Feasibility Phase

Nine private parties from the region of Schleswig-Holstein set up OSB Offshore-Bürger-Windpark Butendiek GmbH & Co. KG (OSB) to develop the Butendiek offshore wind farm as a cooperative project benefiting the local area. Two banks were involved at an early stage to work out a financing scheme. 20,000 shares in the project were sold for €250 each, to raise the €5 million needed for the development phase. It was planned that a further €95 million in equity could be raised through the investment of €4,750 from each of the shareholders and that €320 million would be borrowed from banks.

Development Phase

Butendiek was also one of the earliest offshore wind farm developments in Germany and had to define its own investigation programme for the BSH. This programme was slightly revised in accordance with the similar Borkum West project, eventually forming the basic guidelines for the approval process for all offshore wind farms in Germany.

Delays in the project development neccesitated a further €1 million. The nine project initiators chose to finance this amount themselves, rather than asking for further investment from the shareholders.

The project experienced significant financing challenges, primarily due to increases in wind turbine and financing costs. Wind turbine costs rose sharply due to increased raw material and energy costs, as well as a booming global market for wind energy which led to a shortage in wind turbine supply. The increased financing costs were due to greater demands by banks for all project risks to be covered by expensive guarantees and higher interest rates. In 2006, the project economics improved with the government decision that the offshore grid connection costs should be covered by the grid operator.

Financing banks also required the involvement of an experienced offshore wind farm contractor. After months of negotiations, Airtricity was selected as a strategic partner based on their experience with the Arklow offshore wind farm in Ireland. Over 98% of shareholders approved the sale of the project to Airtricity and retaining an advisory role with an option for future involvement.

In September 2010, the Butendiek project was purchased by the wpd group of Bremen. They announced that negotiations on the possible financing of the project are being held, that may include the participation of the initial shareholders.

Figure A12-2: Drilling and conic penetration test with a platform from Mohiba.

Installation and operational Phases
The park has not yet reached financial close. A preliminary supply contract was arranged with Siemens for 80 wind turbines with a capacity of 3.6 MW. This increases the project's rated capacity from a planned 240 MW to 288 MW, based on 3 MW wind turbines. An arrangement was also agreed with a local port for future O&M work.

Project name	***Butendiek***
Country	Germany
Area	24 km2
Water depth	16-20 m
Distance to shore	34 km
Total capacity	288 MW
Number of wind turbines	80
Wind Turbine type	Siemens 3.6
Foundation type	Unknown
Export cables	Unknown
Transformer station	Unknown

Appendix B

EU and National Targets Offshore Wind

B1. EU and National targets

The European Council unanimously adopted the Renewable Energy Directive (2009/28/EC)[1] on 6 April 2009. This includes the key targets:

- 20% renewable energy in the EU by 2020 and
- binding targets at national level

As part of this Renewable Energy Directive; Article 4[2] requires Members States to submit their national renewable energy action plan by June 30 2010. The goal of these plans was to outline the demand of renewable energy and an outlook on how to reach the 2020 target for each Member State country.

The national target submitted by the Member States and for Norway can be found below.

B2. National Targets Netherlands:

The Dutch objective for renewable energy is 20% of primary energy use in 2020[3].

Offshore wind energy targets

Thus far, the Netherlands has constructed two offshore wind farms. In 2006 OWEZ was commissioned with a capacity of 108 MW. In 2008 Prinses Amaliawindpark added a capacity of 120 MW.

In the national renewable energy action plan of the Netherlands has divided their targets in the national renewable action plan into three phases[4]:

- Phase one: 228 MW (already constructed),
- Phase two: 950 MW (of which agreements for 600 MW have been concluded),
- Phase three: 4800 MW

This confirms the ambition of a total installed offshore wind capacity of almost 6 GW[5].

1 Directive 2009/28/EC of the European Parliament and of the Council
2 Directive 2009/28/EC of the European Parliament and of the Council – article 4 sub 2
3 Nationaal actieplan voor energie uit hernieuwbare bronnen. Richtlijn 2009/28/EG
4 Nationaal actieplan voor energie uit hernieuwbare bronnen. Richtlijn 2009/28/EG page 47
5 IEA Wind Energy Annual Report 2009 – published July 2010

B3. National Targets United Kingdom:

The UK has committed to sourcing 15% of the energy it consumes from renewable sources by 2020[6].

Offshore wind energy targets
Offshore wind is mentioned in the UK national renewable energy plan as a key area for development for which the UK Government will continue to commit and support. A capacity of 13 GW is presented as part of the estimated total contribution per renewable energy technology[7].

Before the release of the UK national renewable energy plan, the Renewable Energy Strategy had been published in 2008, including the aim for a total installed capacity of 14 GW of offshore wind energy[8]. Next, the Renewable Energy Strategy was published in 2009. This indicated that 20 GW of installed capacity offshore wind energy is possible. Also DECC has recently finished a Strategic Environmental Assessment which shows possibilities for 25 GW of installed wind energy. In June 2009 the Minister of State for Energy and Climate change had adopted this possible capacity of 25 GW new offshore wind energy installed in the UK Renewable Energy Zone and territorial waters of England and Wales[9].

B4. National Targets Germany:

For Germany the target is to provide 18% of the total energy consumption by means of renewable energy sources.
In the national renewable action plan it is also stated that Germany expects a 19.6% share of energy from renewable sources in gross final energy consumption by 2020. The share of renewable energy in the electricity sector will be 39%.[10]

Offshore wind energy targets
In it's national renewable action plan, Germany defines the goal of 45,8 GW wind energy in total in 2020. This includes 35,8 GW onshore capacity . This results in a goal of 10 GW of installed offshore capacity. Additionally, it is noted that this assumes successful installation and commissioning of the first wind farms and appropriate power grids and infrastructure on the coast[10].

6 National renewable action plan for the United Kingdom, Article 4 of the renewable Energy Directive 2009/28/EG
7 National renewable action plan for the United Kingdom, Article 4 of the renewable Energy Directive 2009/28/EG
8 BERR Department for Business Enterprise & Regulatory Reform, UK Renewable Energy Strategy, June 2008
9 DECC Department of Energy and Climate Change, A prevailing wind, Advancing UK Offshore wind deployment, June 2009
10 Republic of Germany, National renewable action plan in accordance with Directive 2009/28/EG on the promotion of the use of energy from renewable resources

B5. National Targets Denmark:

Denmark has committed to a renewable energy target of 30% in 2020[11].

Offshore wind energy targets

In the national action plan for Denmark the contribution of offshore wind to the renewable energy target is given on an annual basis. For 2015 the contribution of offshore wind will be 1,251 MW and in 2020 this will have increased to 1,339 MW installed capacity (expecting to produce 5,322 GWh of electricity)[12].

B6. National Targets Sweden:

The proportion of energy from renewable sources in the gross final consumption of energy is forecast to be 50.2% in 2020, which is just over the binding national target of 49% in 2020[13].

Offshore wind energy targets

The Swedish parliament has set the target of wind energy in total to an electricity production of 30 TWh by 2020. A share of offshore wind of 10 TWh[14] is estimated.

B7. National Targets Norway:

There are no national renewable energy targets set by Norway. Since the country relies heavily on hydropower for electricity production, the total share of renewable energy is already close to 100%. In some years it even exceeds 100% due to domestically generated electricity that is exported[15].

For offshore wind no specific target is quoted. A floating 2.3 MW offshore wind turbine was installed as an offshore prototype. However, due to deep waters offshore and the competition of low-cost hydropower, offshore wind development is not expected to play an important role in the domestic electricity production.

11 National action plan for renewable energy in Denmark, June 2010
12 National action plan for renewable energy in Denmark, June 2010 table 10b
13 The Swedish National Action Plan for the promotion of the use of renewable energy in accordance with Directive 2009/28 EC and the commission decision of 30.06.2009
14 This is approximately 3.6 GW based on the relation between capacity and production as stated in table 10b of the national action plan for renewable energy
15 European Energy Agency, Share of renewable electricity in gross electricity consumption (%) 1990-2006 and 2010 indicative targets

Appendix C

National Drivers Offshore Wind

C1. Denmark

Denmark promotes renewable energy through price regulation: a variable premium on top of the market price.

Feed-in premium and compensation for balancing costs
In Denmark the Electricity production from renewable energy sources is supported through price premiums and support mechanisms for offshore wind power are tendered. The instruments are prepared and managed by the Danish Energy Agency (www.ens.dk). The level of support has been amended a number of times over the years. As a general rule, the support scheme that was in place when a production unit is connected to the grid, applies for entire lifetime of that unit. As a result, there is a high degree of certainty about future support at the time of investment.

Renewable energy in general, is supported through price regulation. Producers receive a variable premium in addition to the wholesale electricity price. The sum of the premium and the market price can not exceed a certain statutory maximum, which depends on the date the system was connected and the source of energy used. Previously, offshore wind operators were granted a guaranteed fixed feed in tariff through tenders and were therefore, not subject to a statutory maximum.

Tendering
The Danish Energy Agency organises tenders for an offshore wind power park at a specific location in the Danish waters in accordance with the conditions for offshore farms stipulated in the Danish Electricity Supply Act. Interested parties can then apply to develop the project. An offshore wind project must acquire a licence from the agency, which aims to operate as a "One-stop-shop" for the project developer.

The price per kWh has, so far, been provided as a fixed settling price (market price + variable premium) by the State, in the call for tenders. That means that the investor is certain that he will receive a stable price for the electricity produced.

Special tenders for wind parks at sea:
Support mechanisms for offshore wind farms have varied over time and the rates are very low compared to other European countries[5]. Maximum prices were in the following range:
51.8 øre/kWh (69.6 EUR/MWh) at Horns Rev II wind park (200 MW, 2009)
62.9 øre/kWh (84,5 EUR/MWh) at the Rødsand II wind park (200 MW, 2010)
105.1 øre/kWh (141.2 EUR/MWh)for the Anholt offshore wind farm (400 MW, 2012-13).

Grid Integration compensation
The balancing market is divided into a regulating power market and a balancing power market. All electricity consumption and production is measured in the grid and the difference

5 Some reasons: Turbine prices were 20-30% below current prices; project has not to pay cable and substation; planning risks are reduced due to extensive pre-planning by authorities including environmental impact assessment.

between planned and measured generation and production is settled according to the prices established in real-time balancing. New offshore wind turbines receive 2.3 øre/kWh (3.1 EUR/MWh) over the entire lifetime of the turbine to compensate for the cost of balancing.

C2. Germany

The main support instrument for renewable energy in Germany, is a feed-in tariff scheme. This is also the basis for support for offshore wind projects. Tariffs are differentiated by technology and size of installation and are subject to annual degression for new installations. Additional bonuses are paid for compliance with further quality criteria. There is no cap on the support as the scheme is not financed by governmental budget, but by allocation to the final consumer.

Responsibility for the scheme is divided between the Federal Ministry of Environment (BMU) and the Federal Grid Agency. The act and the tariffs are reviewed regularly by BMU in accordance with the Federal Ministry of Food, Agriculture and Consumer Protection, and the Federal Ministry of Economics and Technology.

Uniform tariffs are guaranteed for offshore wind for a period of 20 years. Tariffs for new installations are reduced by a fixed rate on a yearly basis (for offshore wind this will only start after 2015) in order to foster technical development. The pre-defined rate of reduction is differentiated per technology.

The EEG 2009 includes an authorisation clause (§ 64 Abs. 1 Nr. 6a) that allows the German Federal Ministry for the Environment to simultaneously introduce a feed-in premium scheme with the feed-in tariff. This clause aims to increase market integration of electricity from renewable energies. For this purpose, the operator of a renewable power plant may choose between the feed-in tariff scheme or direct marketing, in combination with a premium tariff that is being paid in addition to the regular electricity market price. Switching between the schemes is possible on a monthly basis. The exact design of the premium tariff scheme is still under debate.

A project can be supported simultaneously by other support instruments, including low interest loans for some technologies from state-owned bank, KfW. (see Chapter 5.3)

Electricity generated by offshore wind energy receives a base tariff of 3.5 cents per kwh. During the first twelve years after commissioning of the offshore wind farm, the tariff is increased to 13 cents/kWh. Additional to that a bonus of 2 cents/kWh is added to the tariff if the wind farm is commissioned before 2016. The duration of the increased tariff will be extended by 0.5 months for each full nautical mile beyond 12 nautical miles and by 1.7 months for each additional full meter of water depth.

C3. Netherlands

The key support instrument for offshore wind in the Netherlands, is the feed-in premium scheme, SDE that was introduced in 2007 and is scheduled to continue until 2014. The premium is funded from the government budget, but recent plans suggest that these may be funded from electricity consumer tariffs in the future. This would make the scheme more robust and less vulnerable to changes in political climate. A tax relief (EIA) also exists for companies investing in offshore wind that can contribute substantially to a project's economic viability. Annual budgets are limited and regularly exhausted before the end of the year.

There is a cap on the available budget for new installations and, selected renewable energy categories may change from year to year. Both the total budget and budgets allocated per technology category are established at the beginning of each year.

Offshore wind feed-in premium – SDE
The level of the feed-in premium depends on the technology (base price) and the wholesale price of electricity (price adjustment), as follows:

Feed-in premium = base price – price adjustment.

Base prices in offshore wind projects are established in a competitive tender. The resulting price is guaranteed over the full support period of a project (15 years for wind energy), but the feed-in premium will vary annually depending on the wholesale electricity price of developments.

2010 was the first year that offshore wind was eligible for feed-in premiums under the SDE. The 2010 tender procedure was designed to cater for a 950 MW offshore wind capacity. The tender was not integrated with grid development, but does compensate for long distance offshore wind.

Because the price level in the tender was higher then envisaged, the total governmental budget will only be sufficient for 700 MW.

Tax Deduction Scheme: EIA
Under the EIA scheme, renewable energy projects can deduct 44% of the total investment costs from the annual profit in the year of installation, up to a maximum of 110 million € per installation. Roughly 11% of the total investment costs can be subsidised in this way. The government budget for the EIA is revised annually. If the available EIA budget is exhausted, the Minister of Finance can limit the scheme or temporarily suspend it which generates a degree of uncertainty for investors.

The EIA may be combined with the SDE premium.

Low Interest Loans for renewable energy
There are several low-interest loans available through green funds which are subject to favourable tax exemptions. Most renewable energy projects are eligible including, PV and onshore wind. Offshore wind is not yet eligible, although the market foresees this changing.

C4. Sweden

The primary support instrument for renewable energy, including offshore wind, in Sweden, is a quota obligation with tradable green certificates. Sweden and Norway have agreed to aspire to a joint green electricity certificate market from 1 January 2012. In addition, Sweden promotes renewable energy through fiscal measures which include a tax exemption for wind energy.

Quota Obligations and Tradable Certificates
Electricity production from renewable energy is supported by a quota obligation with a tradable electricity certificates system. This system came into effect on 1 May 2003, based on Act No. 2003:113 on Electricity Certificates and Regulation No. 2003:120 on Electricity Certificates. The scheme will be valid until the end of 2030.

The Swedish Energy Agency and "Svenska Kraftnät" take responsibility for the functioning of the system. For each produced and metered MWh of electricity from any renewable energy source, "Svenska Kraftnät" issues electricity certificates and is then responsible for any cancellations. "Svenska Kraftnät" prepares and maintains the certificate register, publishes regular information on the number of certificates issued, traded and cancelled, and their average price. The functioning of the electricity certificate system is based on a quota. The quota has been set for the period 2008 to 2030.

Companies supplying electricity to the consumers, electricity consumers and energy-intensive companies have an obligation to satisfy a quota.

Renewable energy producers can sell their certificate as an additional source of revenue in addition to that which they receive from the sale of the electricity. The price of the certificate is determined by supply and demand, with an average price of € 32/ MWh. Before 2005, the system included a regulation intended to protect consumers against high electricity certificate prices, but this had the effect of creating a price ceiling for certificates. This is no longer in place. The market for the electricity certificates allows trading in forward contracts. Norway and Sweden have agreed on a joint green electricity certificates market beginning 1 January 2012.

Fiscal Measures
Sweden levies an Energy Tax on the consumption of electricity, to be paid by commercial producers or suppliers. Wind energy is not subject to this tax if generated by non-commercial producers. Wind energy supplied by commercial producers may, under certain conditions, be

exempt from energy tax; the supplier of wind energy is eligible for an energy tax credit of 12 öre per kWh (1.12 EURct/kWh), if the wind power station is located in the sea or in Väner lake.

There are some additional facilities relevant to wind energy, onshore and offshore. Land that is used for wind energy attracts a reduced real estate tax. Secondly, subsidies are available for the costs of planning a project that has been confirmed after the end of 2006 and finalised before the end of 2011.

C5. Norway

Norway does not have a specific offshore wind support mechanism but has recently agreed to cooperate with Sweden on a joint green electricity certificates market, from 1 January 2012. The previous paragraph about Sweden and its green electricity certificates is therefore also applicable for Norwegian offshore wind farms. There is currently no feed in tariff or premium scheme.

Until recently, Norwegian's offshore renewable energy production has been limited to experimental production and testing of prototypes. The two main reasons for the low profile of offshore wind energy development are the high cost of offshore renewable energy production compared to land based hydro electric production and onshore wind energy, and the currently fragmented and rudimentary legal framework for renewable energy activities.

In July 2009, Norway entered into the Joint Declaration on Cooperation in the Field of Research on Offshore Wind Energy Deployment, a cooperation programme for offshore wind power development, established last year by Denmark, Sweden and Germany. The objective of this programme is to promote innovative offshore wind development.

C6. United Kingdom

The primary support mechanism for offshore wind (and other renewable energy) in the UK is the Renewables Obligation (RO). This is a quota system with tradable Renewables Obligation Certificates (ROCs). It was introduced in 2002 and is scheduled to run until March 2037, with a 20 year limit on support for projects.

The RO places an obligation on all licensed UK suppliers of electricity to supply an increasing proportion of power from renewable sources. Electricity suppliers can meet their obligation by:

- surrendering ROCs to the electricity market regulator (Ofgem) as evidence of renewable electricity generation
- paying the non-compliance "buy-out" price.

The buy-out price is adjusted annually in accordance with the retail price index. Revenues are fed into a buy-out fund that is recycled annually to power producers, in proportion to the number of ROCs they surrendered in the compliance period.

RO and offshore wind
The RO was originally established on a technology neutral basis, where 1 ROC was issued for every MWh of renewable electricity. In April 2009, “technology banding” was introduced into the scheme. This resulted in an increase in support, specifically for offshore wind, to 1.5 ROCs per MWh.

As a temporary measure to boost the development, despite the economic downturn, the Government announced that it was temporarily increasing the ROC allowance for offshore wind projects in the April 2009 budget. Subject to conditions, projects that arrive at a final investment decision between April 2009 and March 2010 received two ROCs per MWh and projects with a final investment decision between April 2010 and March 2011, will receive 1.75 ROCs per MWh.

RO system
ROCs can be traded through bilateral contracts or through periodic auctions. It is possible to bank ROCs for one year. There is no minimum or maximum price for ROCs. The price is determined by the market. The value of a ROC depends on the price a power producer can receive for trading their ROCs and is equivalent to:
- the buy-out penalty paid by suppliers who do not meet their obligation
- the amount recycled back from the buy-out fund to suppliers in proportion to the number of ROCs they used for compliance

The buy-out recycling mechanism provides an additional incentive for power producers to generate ROCs. This has maintained the ROC market price above the buy-out price. For example, for the 2008/09 period: the buy-out payment was £35.76; plus a recycle premium of £18.54. The most recent (“e-ROC”) auction was held in June 2010. Over 240,000 ROCs were traded in the auction. The average ROC price was £49.16 (~59 €/MWh).

Appendix D

Electrical grid case studies

D1. The UK

Since the UK grid was highlighted as one of the principal obstacles to the development of large offshore wind capacity (R3 and Scottish tender), the National Grid has announced the investment of £22 billion into grid upgrades over the next five years. The investment will be focused on upgrading the ageing onshore grid, developing the offshore grid and implementing the smart grid programme. The primary intention is to support the large renewable energy development plans.

National Grid, in its study, “offshore development information statement” (December 2009) stated the necessity of large grid improvements to support the development of the planned 42GW of offshore wind. For example, two large 2GW HVDC interconnectors should link Scotland to Wales and Scotland to England, in an effort to connect the large wind energy production centres of the north of the country to the main load centres in the South, (London, Birmingham and the Liverpool area). The link should be operative in 2013 and 2016, respectively. The BritNed connector, a 1,000MW HVDC cable, linking the UK with the Netherlands, is also currently under construction and should increase the power exchange capacity with the UCTE network.

The future grid development plans are intended to be implanted over a relatively short time scale, which may prove to be challenging from a consenting point of view. However, the feeling amongst developers is that the grid supply chain constraint is decreasing, if not addressed. The UK constitutes a good example of how communication between developers, government and grid operators enabled bottlenecks to be identified and solutions to be implemented.

D2. The Netherlands

The grid does not appear to be a supply chain issue in the Netherlands. Four available locations for connection of the offshore capacity to the onshore network were identified by the national TSO Tennet, with a large connection capacity to the west of the country (Ijmuiden 3-6GW and Borselle 1 to 2GW).

Tennet is already working on grid reinforcement to the west with a new 380kV ring network connecting Ijmuiden (on the coast) to Bleiswijk (northern ring, Greater Rotterdam) and Maasvlakte (on the coast) to Bleiswijk (southern ring). According to experts, the current reinforcement should be sufficient to support the connection of the planned offshore wind capacity to the west of the country. Further reinforcements will however, be necessary to enable the connection of the planned offshore wind farms in the North of the country and the new power stations planned, near Eemshaven. Tennet has already begun the developments of grid upgrades to extend the power transfer from the North to the West of the country.

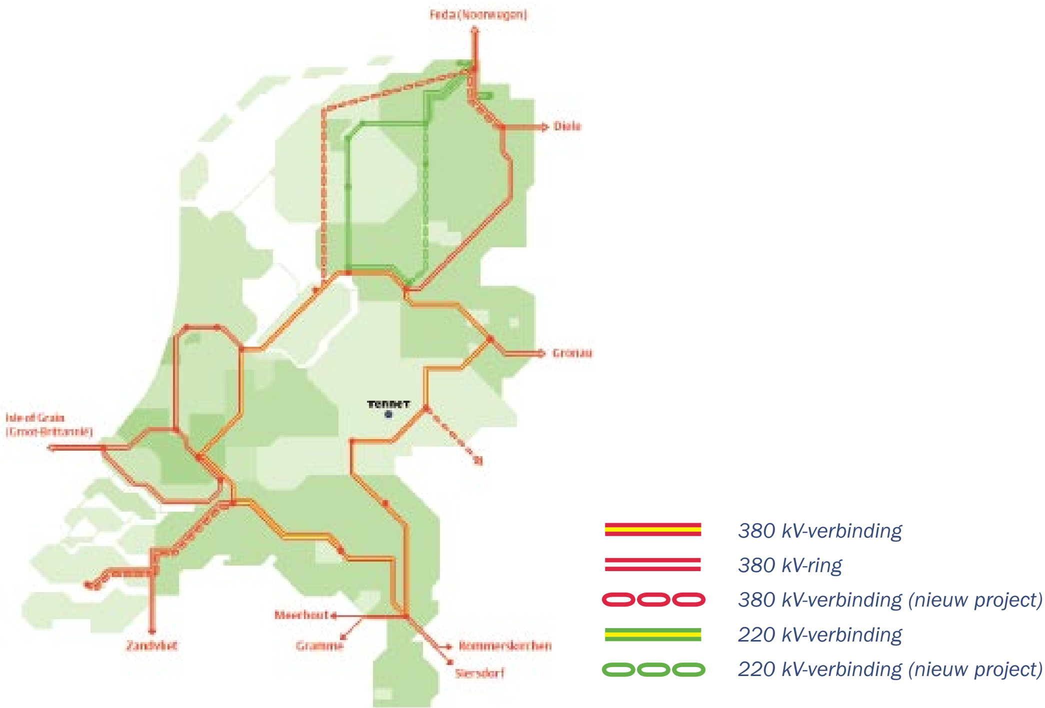


Figure D-1: Electrical grid in the Netherlands, including new projects. Source: TenneT

D3. Belgium

To connect the possible 2GW planned offshore wind capacity, grid reinforcement will be necessary at the coastal locations of Oostende and Zeebrugge. The high voltage network from these two coastal locations must be upgraded to enable the export of offshore power production to the large load centres of Brussels and Antwerp.

Although the cost of the upgrades is considered “enormous” by ELIA, the technical feasibility and planning does not appear to be a major challenge. Plans are currently under development. It is now up to the Belgium governments to take further action.

D4. Denmark

In Denmark, the TSO, Energinet.dk, is preparing for the increasing share of renewable energy to the system, with a final target of 30% of energy consumption from renewable sources by 2020 (Systemplan 2009). The main focal points of the TSO are; the reinforcement of the grid, the development and reinforcement of international interconnectors, the improvement of the production of electricity and the development of smart grid systems.

Numerous interconnectors are being planned and studied (see Figure D-2), but the investments will concern the reinforcement of onshore in infrastructure, the laying of power cables to new large-scale Danish offshore wind farms currently under construction and the construction of a new subsea power interconnector to Norway. Other connectors with the Netherlands and Germany are long-term plans.

In 2009, Denmark's parliament had provisionally approved a plan to invest €3.5 billion into upgrading the country's electricity grid by 2016, which gives a relatively good confidence that an adapted grid for connection will be built timely.

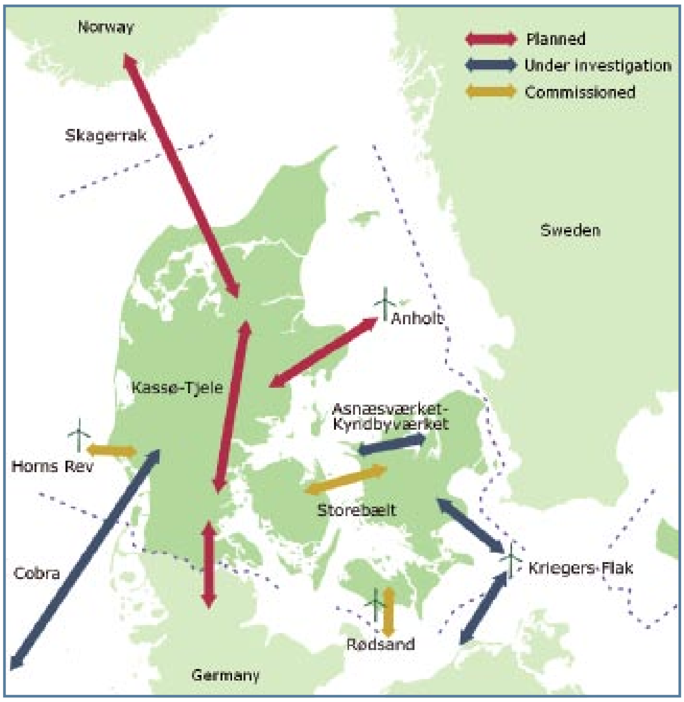


Figure D-2 - Planned interconnectors with Denmark. Source: Systemplan 2010, energinet.dk

D5. Norway

With no large offshore wind energy plan announced, grid reinforcement is not driven by offshore wind development. New HVDC connectors with Denmark and the UK are planned and could enable larger electricity exchanges with southern grids to optimise the use of renewables: primarily hydropower for Norway and (offshore) wind in the more southern countries.

D6. Germany

See the Case Study in Chapter 2.

Appendix E

Economic Impacts Offshore Wind

Useful definitions

Total Gross Value Added
The total value of goods and services in a sector is commonly referred to by economists as the total gross value added. The gross value added is the sum of positive, direct and indirect economic effects. While presenting gross effects illustrates the relative importance of a sector, it does not reflect the impact on the economy as a whole.

Direct Employment
As the term would suggest, direct employment is on-to-one related to RES generation and RES technologies and occur directly in the sector addressed by the policy promotion. Direct employment thus may refer to employment within wind turbine and component manufacturers, utilities/IPPs selling electricity from wind energy, research and development, engineering and specialized wind energy services. Other companies providing services or occasionally conducting wind related activities is regarded as providing direct employment.

Indirect Employment
This is employment only indirectly related to the promotion of RES and might occur with a time delay. It provides an impression of the size of employment of in the offshore wind industry and the industries that depend on it as suppliers. It includes all related economic directly and indirectly activities.

Gross Employment
This provides an impression of the size of employment of in the offshore wind industry and the industries that depend on it as suppliers. It includes all related economic activities.

Table E-1: Summary of other recent studies on employment.

Report	Title	Geographical scope	Industry	Results
EWEA 2008	Wind at Work.	EU	Wind energy	Total employment in 2007: 151,316 (108,600 direct); total employment 328,690 in 2020.
EREC, 2007	New renewable energy target for 2020 – a Renewable Energy Roadmap for the EU.	EU-15	Wind energy	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).
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2008.	Kurz – und Ingfristige Auswirkungen des Ausbaus der erneuerbaren Energien auf den deutschen Arbeitsmarkt. Interim report.	Germany	Renewable energy	Update of the 2006 report (questionnaire + I-O table). 84,300 employees in the wind energy sector by the end of 2007 (direct + indirect).
Carbon Trust 2008	Offshore wind power: big challenge, big opportunity.	UK	Offshore wind	The UK's 29GW of offshore wind will create 40,000 – 70,000 jobs and £12.5bn of annual revenues in 2020.
IPPR/Greenpeace 2009	Green jobs: prospects for creating jobs from offshore wind in the UK	UK	Offshore wind	Review of other studies: between 23,000 – 70,000 jobs in the UK by 2020.