Review of Current Activities in Offshore Wind Energy

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ABSTRACT

This paper gives an overview of the many developments in offshore wind energy in the last two years, since the 12th ISOPE conference in Kitakyushu, Japan in 2002, in terms of the technology of the support structure and wind turbine, the construction of new projects and the development of the legal framework. Notwithstanding some delays and difficulties experienced in construction and operation of wind farms, overall progress has been remarkably rapid and successful, due to positive collaboration between government and industry. All in all, offshore wind energy is bound to fulfill its potential for success.

KEY WORDS: Offshore; Wind; Energy; Review; Development; Policy.

INTRODUCTION

At the end of 2001 offshore wind energy was just emerging from a pioneering phase, with six pilot projects and three multi-megawatt projects in place. Experience with the first wind farms, and the projected market potential of offshore wind energy, appeared so positive that a special topic conference on offshore wind energy, organized by EWEA in December 2001, attracted over 500 participants, most of whom were new to the field and eager to participate in the expected rapid growth. At that time, plans were presented for the construction of over 800 MW of wind farms by the end of 2003. That only half of this has been realized on time is nonetheless an impressive achievement, increasing the capacity of offshore wind energy by a factor of four in two years (See Fig. 1 and Table 1).

By far the largest impact, both in terms of numbers and as a representation of the new era, has been made by the Horns Rev wind farm off the west coast of Denmark, which came into operation at the end of 2002. With 80 Vestas 2 MW turbines at an exposed offshore site, the project has focused the attention of the industry. A similarly sized wind farm was installed a year later in the Baltic Sea, south of Nysted. The installation of the 73 concrete gravity base foundations, including one for the transformer substation, can be considered a major logistical achievement.

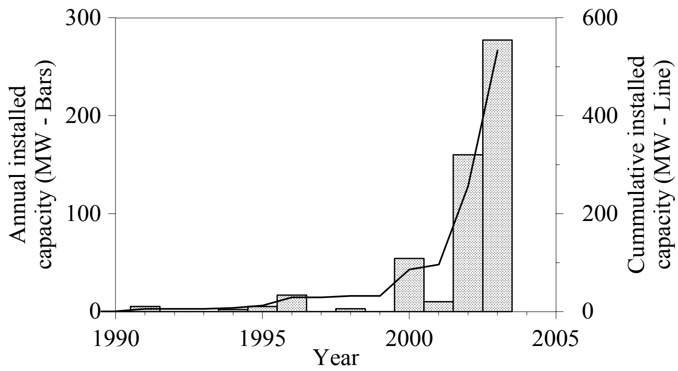

Fig. 1: Annual and cumulative installed capacity

A smaller wind farm has been erected near the Danish island of Samsø, as part of the island's attempt to generate 100% of its electricity from renewables. Its wind turbines are erected in a water depth of 20 meters, requiring monopiles of 42 meters in length and 4.5 meters in diameter, which set the record at the time. This record is already surpassed by the monopiles of the Irish wind farm on Arklow Bank, in water depths up to 26 meters. Although by offshore standards these water depths are by no means impressive in itself, they illustrate the progress in designing cost-effective solutions for the exploitation of offshore wind energy.

Two other offshore projects further illustrate the development of the industry. At Yttre Stengrund, Sweden, holes for the 5 monopiles needed to be drilled in rock covered by several meters of cohesionless sand, which had to be prevented from filling the boreholes. At Frederikshavn, Denmark, a 3 MW turbine has been installed on a mono-bucket foundation, a concept novel to offshore engineering. The upside-down bucket is sucked into the seabed, a procedure that avoids drilling or pile-driving, and which can be reversed to remove the bucket during decommissioning.

With the recent completion of the North Hoyle wind farm, north of Wales, the UK has taken off on its ambitious quest to become a leader in offshore wind energy.

Table 1: Realized wind farms and under construction

Name and country	Turbines	Installed capacity (MW)	Year	Water depth (m)	Foundation type
Nogersund, Sweden	1 Wind World 220 kW	0.22	1990	6	Tripod
Vindeby, Denmark	11 Bonus 450 kW	5	1991	2-5	GBS
Lely, Netherlands	4 NedWind 500 kW	2	1994	5-10	Monopile (driven)
Tunø Knob, Denmark	10 Vestas 500 kW	5	1995	3-5	GBS
Irene Vorrink, Netherlands	28 Nordtank 600 kW	16.8	1996	5	Monopile (driven)
Bockstigen, Sweden	5 Wind World 550 kW	2.75	1998	5.5-6.5	Monopile (drilled)
Blyth, UK	2 Vestas 2 MW	4	2000	8.5	Monopile (drilled)
Middel-grunden, Denmark	20 Bonus 2 MW	40	2000	3-6	GBS
Utgrunden, Sweden	7 Enron Wind 1.4 MW	10	2000	7-10	Monopile (driven)
Yttre Stengrund, Sweden	5 NEG Micon 2 MW	10	2001	6-10	Monopile (drilled)
Horns Rev, Denmark	80 Vestas 2 MW	160	2002	6-12	Monopile (driven)
Samsø, Denmark	10 Bonus 2.3 MW	23	2003	20	Monopile (driven)
Frederikshavn, Denmark	2 Vestas 3 MW, 1 Bonus 2.3 MW, 1 Nordex 2.3	10.6	2003	1	3x Monopile, 1x Suction Bucket
Nysted, Denmark	72 Bonus 2.3 MW	158.4	2003	9	GBS
North Hoyle, UK	30 Vestas 2 MW	60	2003	10-20	Monopile (mixed)
Arklow Bank, Ireland	7 GE Wind 3.6 MW	25.2	2003	5-25	Monopile (driven)
Under construction					
Scroby Sands, UK	30 Vestas 2 MW	60	2004	4-8	Monopile (driven)
Sakata, Japan	5 Vestas 2 MW	10	2004		

THE OFFSHORE INDUSTRY

Installation

The promise of large-scale offshore work has encouraged the offshore service industry into developing a number of installation and maintenance vessels. In 1999, the company A2SEA didn't exist, yet barely three years later it carried out the installation of the turbines at Horns Rev using two modified vessels. Two freight carriers, the Ocean Hanne and the Ocean Ady, are fitted with four jack-up legs with base plates that lift the vessel to become a stable working platform. Unlike other jack-up barges, the vessel is not lifted entirely out of the water. The ship-shape vessel with dynamic positioning, the limited seabed penetration of the legs, the winch driven jacking system and the low jack-up height all aim at a short cycle time of the much repeated transportation and installation. With an overall length of barely 92 meters, the vessels managed to transport all tower segments, nacelles and rotors of 4 turbines, during construction of the Nysted wind farm (Fig. 2). Currently, the company is developing a larger vessel based on the same concept, to facilitate the ever-increasing turbine sizes and water depths.
The Dutch companies Mammoet and Van Oord ACZ joined forces to build the Jumping Jack, a self-elevating offshore support unit. Like A2SEA, Mammoet van Oord has replaced the more common Rack-and-pinion jacking system with a winch driven system. The Jumping Jack has installed the foundations and turbines at Arklow Bank and is currently installing foundations at Scroby Sands in the UK. With a weight of 280 tonnes, a diameter of 5.1 meter and a length of 45 meters, the monopiles of the Arklow project have proven quite a challenge to install, using one of the heaviest existing pile hammers. With a pile hydraulic gripper for piles up to 5.5 meter diameter and a main boom of over 100 meters, Jumping Jack is prepared for the next generation of offshore turbines.
A second, purpose-built tubine installation vessel has been constructed at Shanhaiguan in China for UK company Mayflower Energy. Mayflower's ship '*The Resolution*' has left the shipyard for testing, but has yet to start installation work. In anticipation of commissioning the vessel, the company erected the 30 turbines at the North Hoyle offshore wind farm with existing jack-up barges. With the capability to carry 10 turbines, *The Resolution* is particularly interesting for sites at larger distances from harbour facilities.

Fig. 2: Ocean Ady with 4 turbines at Nysted
(Picture: Gunnar Britse)

Operation and maintenance

The installation vessels are also envisioned and active in maintenance activities, particularly when heavy lifting capacity is required. An equal or larger challenge, however, is placed by the access of maintenance personnel. The operating window can be widened by outfitting the turbines with a heli-hoist deck, an option only chosen by the Horns Rev project, so far.
Of interest to wind farm operators, meanwhile, is the development of the Offshore Access System (OAS) by Fabricom Oil & Gas and P&R Systems. The system provides personnel access to offshore turbines in weather conditions beyond the limits of normal boat landings. The landing ladders at Horns Rev are prepared for the gangway of the OAS, which permits direct connection to the access vessel's transfer platform. The prototype of the system has been tested under controlled conditions and is undergoing further testing in operational conditions in the Middle East (Fig. 3). This technology, initiated for the offshore wind market, has already received attention from oil and gas offshore operators that consider it to be a safe and economic alternative for helicopter access.

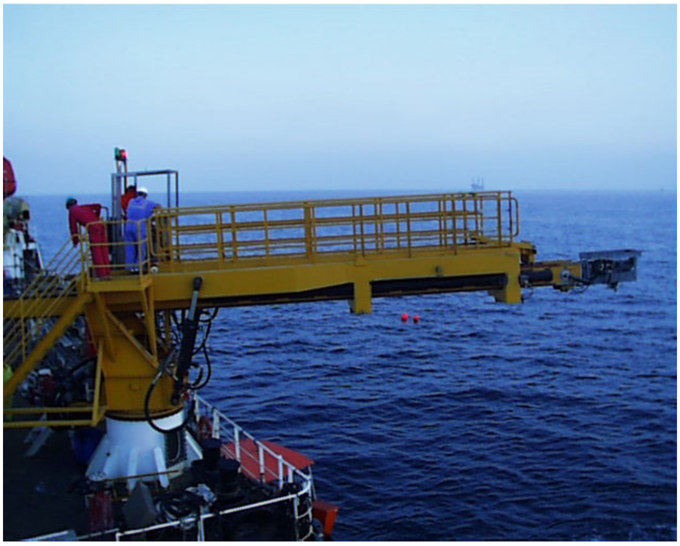

Fig. 3: Prototype of OAS gangway, tested in the Middle East (Photo: Fabricom)

TURBINE DEVELOPMENT

Offshore Experience

Today, four manufacturers have experience of installing and operating their wind turbines in the offshore environment – Bonus, GE Wind, NEG Micon and Vestas – with the number of manufacturers and the sizes of turbines likely to increase in coming years. The first one to extend the list was Nordex, who provided one turbine for the small wind farm near Frederikshavn, where three competing wind turbine models are being compared. December 2003, Vestas and NEG Micon announced the intention to combine businesses, which would give a company with unsurpassed experience with offshore wind farms.
In terms of numbers, the 2 MW class dominates the current offshore market, exemplified by three models:

- the Vestas V80, used at Horns Rev, North Hoyle and Scroby Sands
- the Bonus 2/2.3 MW, used at Middelgrunden, Samsø and Nysted
- NM72 from NEG Micon used at Yttre Stengrund.

Product Range

However, with larger turbines likely to deliver a reduced overall cost of generation, the offshore market is propelling developments rapidly towards ever-larger machines (Table 2). After using its 1.5s offshore turbine at Utgrunden, GE Wind has skipped the 2 MW class and has installed its 3.6 MW/100-meter rotor model at Airtricity's Arklow Bank development, off the east coast of the Irish Republic.

Table 2: Overview of wind turbines (>3 MW, available or prototyping)

Company	Type	Power (MW)
WinWinD	WWD-3	3.0
Vestas	V90	3.0
GE Wind Energy	3.6 offshore	3.6
NEG Micon	NM 110	4.2
Enercon	E-112	4.5
RePower	5M	5.0
Pfleiderer	Multibrid	5.0
NOK	5 MW Offshore	5.0

In August 2002, three months after the construction of GE Wind's prototype 3.6 MW turbine, Enercon took the size record, with its E-112 prototype at Magdeburg, Germany. This 4.5 MW, direct drive turbine has a rotor diameter of 112.8 meters and a 10-meter synchronous ring generator. The on-site assembly of the generator provides an insight into the likely future difficulties for offshore installation. The first such installation is planned in Wilhelmshaven, Germany, when two further prototypes will be built, one at 550 meters off the coast. The enormous blades for this turbine were made in a small series of seven by Abeking & Rasmussen Rotec GmbH.
Back in 2001, Vestas' intention to develop a 3 MW turbine seemed to be out of line with announcements of much larger machines from its competitors. However, with several prototypes of the V90 installed and series production planned for 2004, Vestas has preserved its good position among suppliers of the multi-megawatt class. Vestas' engineers have succeeded in limiting the mass increase for the V90's rotor and nacelle to only 3%, compared with the 2 MW V80, achieved partly by using a very compact design. Compact designs have a reputation for poorer maintainability, so the V90's performance is being closely watched in this regard.
NEG Micon introduced a similar-sized turbine, the 2.75 MW NM72, with the first prototype being commissioned in 2002. With the NM72, NEG Micon has also made the switch to variable speed and pitch control, the currently prevailing concept for load and power control. The NM72 is a spin-off of the DOWEC project, pursuing the best concepts for large-scale offshore wind turbines and farms.
A smaller new turbine is the 2.3 MW N90, designed for low wind speeds, which was introduced by Nordex in April 2003, followed by the offshore version in Frederikshavn in May. In 2002, ABB and Lagerwey produced their 2 MW LW72 Zephyros, a direct drive with a medium-voltage (4000 V) permanent magnet generator. The newly founded company Zephyros bv markets the turbine for offshore applications, for which it has been specifically designed.

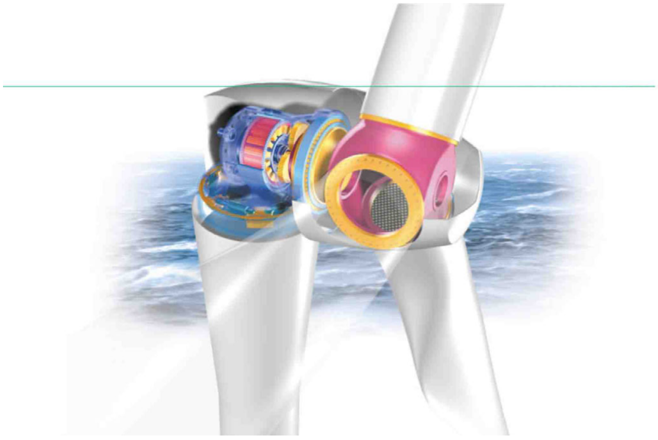

Fig. 4: Multibrid technology ® for offshore operation (Image: Pfleiderer Wind Energy)

Planned Developments

Several other companies have announced the development of large turbines suitable for offshore applications that have not yet reached the prototype stage. In 2001, the German companies Nordex, Pro+pro Energiesysteme and Jacobs founded the Norddeutsche Offshore Konsortium (NOK), with the intention of developing a 5 MW offshore turbine with a rotor diameter of around 110 meters. REpower is also working on a 5 MW turbine, the 5M, with a rotor diameter of 125 meters and installation of a prototype planned for 2004.

The prototype of the long-awaited 5 MW Multibrid, designed by Aerodyn and developed by Pfleiderer Wind Energy, is due between conception and publication of this article. A 3 MW prototype of the same concept, the WWD-3, is made under licence by WinWinD Oy, and is due to be installed in Finland in the same period. Whether this design will make a breakthrough in the offshore market will depend on the (perceived) reliability and maintainability of the compact design. The Multibrid concept includes a compact, single-stage gearbox, a medium-speed generator and an integrated main bearing support.
ScanWind and DeWind are also working on turbines in the 3 MW range, but ScanWind received a setback with the cancellation of the ABB Windformer design.

Trends In Design Concepts

The development of wind turbine design concepts has mainly followed an evolutionary process, with only a few concepts surviving out of the enormous diversity that existed in the early days of modern wind turbines (Fig. 5). Currently, the most widespread control concept is that of a variable speed rotor with full-span pitch regulation. This concept is combined with both direct drive and geared drive trains, the latter dominating the wind turbine market, with a share of approximately 85%. The compact drive train system used in the 500–750 kW range has been abandoned by many manufacturers for their larger machines, in favour of the staged drive train with a single main bearing, a long main shaft and a separately aligned gearbox. Versatility, maintainability, logistical advantages and independence of specific suppliers are among the reasons for this development.
However, with the Multibrid concept and the Vestas V90, the much more integrated drive train is (re-) introduced, particularly to solve the problem of excessive weight increase. The transition from megawatt to multi-megawatt capacity also results in a larger logistical impact on the design, as masses and dimensions reach the limit for transportation by road. This problem is visible in the blade design, which shows a trend towards slender blades with relatively small inboard sections.

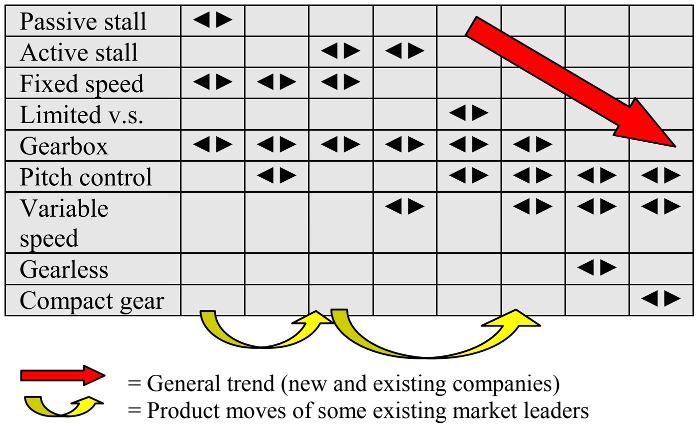

Fig.5: Diagram with concept development

SUPPORT STRUCTURES

Applied Concepts

The first offshore wind turbine was located on a tripod with three vertical piles supporting a three-point platform several meters above sea level. This concept originated from the jacket-focused offshore industry, but was immediately replaced by gravity bases and monopiles with tubular towers for the next wind farms. The prevalence of gravity base foundations for wind turbines in the Baltic Sea demonstrates their suitability for benign and shallow waters with drifting ice in winter. To minimize floating crane operations, the Nysted wind farm initiated a novel direction for gravity base structures. The concept of solid concrete used so far, was replaced with a lightweight concrete structure with six compartments that were ballasted with granite boulders and sand after installation.
For more exposed sites the monopile has proven to be the preferred option. The application of monopiles has been stretched to deeper waters and larger turbines than anticipated possible, exemplified by the monopiles for the 3.6 MW turbines in 26 meters water depth at Arklow Bank. Several years ago, the design, procurement and installation of these monopiles, with a diameter of 5.1 meter, was not considered feasible and cost-effective for a wind farm consisting of a multiple of these structures. The extensive use of monopiles for offshore wind turbines is stimulating the oil and gas industry to contemplate its use for marginal fields in shallow water.
As stated in the introduction, the range of applied support structure concepts is completed with the mono-bucket foundation at Frederikshavn (Fig. 6). Installation of a monopile with the same turbine type in the same wind farm permits project owner ELSAM to compare the performance of these foundation types.

Fig. 6: Monobucket at Frederikshavn
(Picture: MBD Offshore Power A/S - Elsam)

Future Concepts

Despite the success of the monopile, and its projected use in many future projects, other concepts are continuously being proposed in desktop studies, as well as in implementation proposals. These concepts are particularly developed to facilitate the use of even larger turbines and installations in even deeper waters. Danish consultancy company Rambøll designed several tripod concepts, one of which was offered in a tender for the Dutch near shore wind farm (NSW) by the consortium headed by Siemens. The Butendiek wind farm, to be built with turbines at the 3 MW scale in water of 20 meters in depth, retains the option of building with tripods or lattice structures, although the monopile still appears to be the cheapest feasible choice. However, lack of knowledge of pile behaviour when diameters exceed 5 meters and wall thicknesses are between 70 and 100 millimeters, as well as the difficulties of handling and obtaining the right equipment are arguments put forward by the developers against its further use. Many of the wind farms planned in the German exclusive economic zone of the North Sea are far from shore and in water depths of around 40 meters. Considering that these conditions require wind turbines of around 5 MW to develop a commercially attractive wind farm, these projects will require and demonstrate a further progress in support structure technology.
The suggested and developed support structures for offshore wind turbines emphasize that offshore wind energy technology goes beyond simply combining offshore technology and wind energy. The monobucket foundation tested at Frederikshavn is an unprecedented foundation type, as are certain single- and multiple-turbine floating structures. Other concepts on the drawing board include suction bucket tripods, guyed structures and self-installing gravity bases and towers.

POLICY AND MARKET

Global market

According to a study undertaken by consultants Douglas-Westwood, the global market for offshore renewables will be worth €12 billion by 2007, consisting mainly of offshore wind energy in Europe. The study forecasts that in five years the annual worldwide installation rate could exceed 900 MW, with 3914 MW already installed. By then, the leading countries would be Germany and the UK.

Denmark

For a long time, Denmark has been at the forefront of wind energy implementation. However, that appears likely to change now, with the present Danish Government removing the certainty and clarity that encouraged developers to invest time and risk money. The country's minimum price scheme for wind-generated electricity was abandoned in 1999, and the green certificate trading that was to replace it has still not been implemented. The only substantial support remaining is for operators of plants that were installed before 2000, and which have not reached a state-determined number of full-load hours. Horns Rev and Nysted are the only two large-scale offshore wind farms that remain from the previous government's original plan for five such projects. The budget supporting renewable energy projects has also been reduced, from €34 million in 2001 to €5.4 million today; the Danish Government is planning to meet its Kyoto Protocol obligation by buying CO_2 certificates from abroad. After construction of the Nysted wind farm, financed under the previous renewable energy policy, there was the danger that offshore wind energy in Denmark at the commercial scale might have come to a halt. Fortunately, that now appears unlikely, no doubt because of the wind energy industry's importance in that country. However, the Government's intention to put the remaining three offshore wind farms planned by the previous government up for free competition in an international tender has recently shifted to other sites, with less impact on shipping but also less favourable conditions for construction of offshore wind farms.

United Kingdom

Quite deservedly, it is the UK that has drawn much recent attention in offshore wind, with a supportive government strategy and a streamlined permitting process. The awareness that the steep reductions of CO_2 emissions resulting from the UK's 'dash for gas' were coming to an end led the UK Government to search for a new way to make a similarly significant impact, and offshore wind energy appeared to offer an answer. The fact that a decline in offshore oil and gas activity in the North Sea is expected means that an important industry is providing essential stimulus to wind energy. In 2001, an invitation from the Crown Estate (owner of the UK's territorial waters) was met by an unexpectedly good response, with 18 applications in English and Welsh waters. Anticipating that the onshore story of planning difficulties would be repeated, all 18 were offered leases for a 30-turbine wind farm. The prognosis turned out to be unduly pessimistic, however, and it now appears that at most only one or two will fail to be built by the deadline in 2006, although not all projects are still being developed by the original applicants. So far, all of the wind farms with construction permits have also received a capital grant, typically amounting to £10 million (US$16 million). Preliminary leases have also been granted for a 150–250 MW farm at Tunes Plateau off Northern Ireland, and for a 30 turbine extension of one of the windfarms in to Scottish waters.
In November 2002, the UK Department of Trade and Industry published the consultative report Future Offshore – A Strategic Framework for the Offshore Industry, recommending that the next round of offshore wind farms should be concentrated in three strategic zones – the North-West, between the Welsh and Scottish coasts, the Greater Wash and the Thames Estuary, the second and third being on the North Sea coast (Fig. 7). In these zones future, larger offshore projects can share resources and benefit from economies of scale. The second round of bids for projects closed in October 2003, and at the time of writing, awards of licenses with a total capacity of 4000–6000 MW were expected. The second round is due to be built between 2005 and 2015 and around 70 projects from 29 consortia were registered.

Fig. 7: Strategic zones for offshore wind farm development in the UK (Image: Department of Trade and Industry (DTI) - UK)

The Netherlands

Although the Dutch government claims to support the development of offshore wind energy, implementation keeps stalling as a result of government regulations and procedures. Two long-planned projects, Q7-WP and NSW/Egmond have been delayed in construction due to a reduction in the production incentive and uncertainty surrounding the applicability of tax benefits. All applications for consents are on hold while a consent system is devised. The core of the Dutch offshore strategy is a targeted 6000 MW by 2020, for which a consent system is being developed at this moment. Offshore wind energy is one of the main means of the Netherlands to meet its obligation under the Kyoto protocol.

Belgium

In Belgium, an irregularity in the legal procedures for the Seanergy 100 MW Vlakte van Raan wind farm has enabled opponents of the project to postpone it, just a few months before construction was to begin. Belgium has also introduced a green certificate system this year, though some details still need to be formulated and the system needs to be tested. This entails a considerable political risk for offshore wind farms. As a result, electricity generator Electrabel has no further plans for offshore development in Belgium, beyond the aforementioned Seanergy project at the Vlakte van Raan. In June last year C-Power obtained a concession for a wind farm of sixty turbines at Thornton Bank, around 25 kilometers off the coast.

Germany

The delays experienced in some countries are matched by advances elsewhere, such as in Germany. The German Government is very supportive of offshore wind energy, particularly since much of the northern coastal region suffers disproportionately from the economic problems, such as unemployment. It is hoped that offshore wind energy might enliven industrial activity and create employment; one study estimated a turnover of more than €20 billion for the erection of offshore wind farms up to 2020, with an associated 22,000 jobs in manufacturing and installation and 2000 in operation and maintenance. A study carried out by DEWI, the German wind energy institute, estimates a capacity of 20,000–25,000 MW by 2030 (expected to meet 15–20% of German electricity consumption at that time), with 3000 MW installed by 2010.
Germany's Federal Economic Minister, Jürgen Trittin, is a keen supporter of renewable energies, and has announced his backing for an amendment to the German renewable energy law. The amendment proposed by German's environment Ministry end 2003 extends the commissioning deadline to 2010 and the premium payments of 9.1 €ct/kWh will now run for at least 12 years of operation with longer periods applying to projects in deep waters or far from the coast.
In May 2002, the Regional Government of Lower Saxony passed an action plan to accelerate grid connection of offshore wind farms, and identified suitable areas within the 12-mile (20-km) zone. The Lower Saxony Government also intends to expand the region's ports to assist the industry. An investment of around €300 million would be required to construct suitable production, shipping, servicing and operational facilities at Cuxhaven and Emden. The Government is willing to make large sites available to wind companies that want to establish a base at the ports, and it will also contribute to an offshore engineering training centre.

Ireland

In Ireland, the sixth Alternative Energy Requirement (AER) competition, announced in late February 2003, includes support for two further offshore wind projects at Bray and Kish Banks. The energy potential of the seas surrounding Ireland is sufficient to supply one third of the country's electricity consumption, even if waters no deeper than 20 meters are used.

France

At the time of writing, an announcement for the first round of offshore windfarms in French waters was imminent. This was expected to award licenses for a total of 500 MW of capacity distributed around the French coastline, with a maximum windfarm size of 150 MW. The deadline for commissioning will be the end of 2006. This will contributed to a national windenergy target of 2000-6000 MW by 2007. Clearly in offshore as well as onshore France is lagging behind its European neighbours and the promise of rapid development at the Global Wind Energy Conference in Paris in 2002 has not been born out by subsequent events. The approach can be characterised as being cautious, with on land windfarms limited to 12 MW and ADEME, the French environmental agency, wanting to see a pilot project no bigger than 25 MW as a first step, in order to gather experience and data. Why the lessons learnt elsewhere in the world will not be applicable is not clear.

United States

The United States Senate has passed an energy bill that includes a national Renewable Portfolio Standard, which requires 10% of the country's electricity to come from new renewable energy sources by 2020. To what extent offshore wind energy will benefit from this bill remains to be seen, as proposals for the country's first offshore wind farm have met with both legislative uncertainty and opposition. So far, government response appears to be mainly at the local government level.

PLANNED PROJECTS

Over 160 offshore wind farms are in some stage of the planning phase, of which more than 30 intend to start construction this year or in 2005 (Fig. 8).

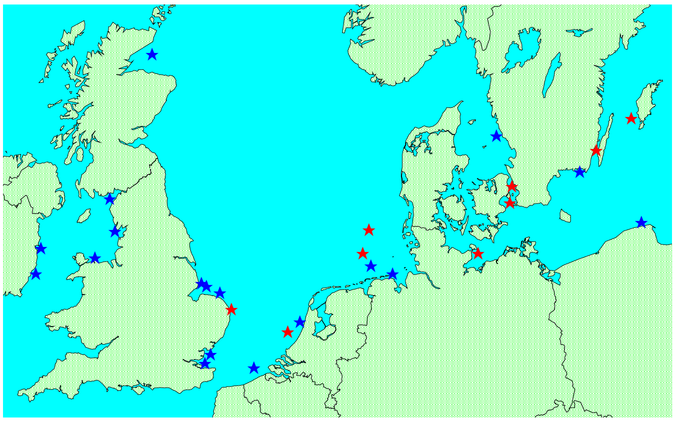

Fig. 8: Planned offshore wind farms in Europe for 2004-2005

Planning applications have been, or are being processed for all 18 first-round sites except for Southport, off the north-western coast of England, from which EnergieKontor has withdrawn, and the Teesside site in north-east England, London Electricity's second site after one off the Norfolk coast. In all, 20 projects are planned for commissioning by 2006, with a capacity totalling 1400 MW. Already eight more sites have obtained planning permission and capital grants and are in line for development: Solway Firth, Barrow, Burbo, Rhyl Flats, Kentish Flats, Gunfleet Sands, Cromer, Lynn and Inner Dowsing.
The Irish wind farm at Arklow Bank is the first phase of a development that will expand to 520 MW over two more phases (Fig. 9).

Fig. 9: Visualisation of Arklow Bank wind farm after completion (Image: Airtricity)

Construction at Lillgrund Bank in Sweden is planned for 2004 by the company Eurowind. Other active players in Sweden are the utility Vattenfall, NEG Micon, and a consortium consisting of Nordex, ABB and Göteborg Energi. In addition, the developer Airicole is, together with the French utility EDF, planning to extend its wind exploitation at the Swedish Utgrunden site, with a 75 MW farm.
In Germany, the first projects were planned for take-off in 2004, but no commissioning is expected before 2005. Two permits for projects have been granted by the Bundesamt für Schifffahrt und Hydrologie (BSH), and decisions on six North Sea projects are pending. The first project to obtain a permit is Prokon Nord's 60 MW wind farm near Borkum Island' however, this will not be built until 5 MW turbines are commercially available. The 240 MW 'Bürger-Windpark' Butendiek has also obtained a permit, and another 30 projects are at various stages of development, totalling a certainly unrealistic 60,000 MW of capacity, mostly in the North Sea. If all projects were to go ahead, the associated investment would be over €35 billion. Development of wind farms in the German section of the North Sea is complicated by the environmental protection of the shallow coastal waters – thus wind farm planning is restricted to the deeper water found at distances far from the coast. As a consequence, larger turbines are required to make projects economically viable.
As mentioned earlier, the two wind farms Q7-WP and NSW/Egmond in the Netherlands and Vlakte van Raan I in Belgium have been delayed. With the approval for the latter reversed by a recent court ruling, Belgium first offshore wind farm is likely to be C-Power's project at Thornton Bank.
Off the Atlantic coast of southern Spain, NEK Umwelttechnik and partner Umweltkontor Renewable Energy AG are planning four 'nominally separate' wind farms of 50 MW each, with Energia Hidroelectrica de Navarra (EHN) looking at possibilities for a 100-turbine wind farm nearby. However, opposition from fisherman and environmental protection groups means that progress is not certain.
Plans by US company Cape Wind to construct an offshore wind farm at Cape Cod, Massachusetts, have raised massive opposition. Possibly as a strategic decision, the company has selected GE Wind to supply its 3.6 MW turbine for the wind farm. Off the south coast of Long Island, New York, meanwhile, the Sustainable Energy Alliance (SEA) and the Long Island Power Authority (LIPA) are seeking construction approval for a 100 MW wind farm of around 33 turbines. The authorities are holding extensive community meetings, and are successfully building local support to match the political support already present. North Carolina could be the next state in line for offshore wind development as it has begun investigating the possibilities, and developers are also looking at possibilities off the Texan shore. Meanwhile, the tiny town of Hull, 35 kilometers south-east of Boston has entered the race with plans for an 18 MW offshore wind farm.

CONCLUSION

Looking at projections from late 2001 of how the offshore wind energy industry would evolve, it is no surprise that not all wind farms mooted then have been built, that several have been delayed, and that construction and operation have been more difficult than anticipated. However, overall progress has been remarkably rapid and successful, due to positive collaboration between government and industry.

In particular, the governments of three countries deserve the most credit. The first and most obvious is Denmark, which drove initial developments both for small demonstration projects – as at Vindeby and Tunø Knob, which provided 'proof of concept' and some valuable operating experience – and for construction of the first full-scale wind farm at Horns Rev – which was able to confirm the construction industry's ability to meet the quality and logistical challenges.
The other governments that deserve credit for their current commitments are those of Britain and Germany. In Britain's case, the Government has provided for an open, transparent and ambitious procedure that should start delivering results, in terms of reduced greenhouse gas emissions, before the end of the decade. The competitive nature of the British market should ensure that electricity is delivered in an economic manner – which is vital if this industry is to become sustainable. In Germany's case, credit is due for the country's long-term commitment to wind energy in general, and for its willingness to fund the development of the more expensive technology necessary for the increased offshore depths and distances. This commitment on the part of both British and German Governments is exemplified by the seniority of the ministers from those countries who are scheduled to speak at wind energy events – and the fact that they do indeed usually appear as scheduled.
From the side of industry, enthusiasm and the investment of time and resources has been excellent. With regular full-capacity attendance at the numerous events, a wide knowledge base is clearly being developed, and responses to opportunities have been excellent – 18 and 29 consortia in the first and second offshore rounds in the UK, and 29 projects registered in German waters.

Looking further a field, the ‘can do’ attitude in Europe has encouraged interest outside the continent – so far, this has mainly been from a lengthening list of US states along the eastern seaboard, but Japan and Korea look like becoming longer-term candidates. On a cautionary note, however, it seems probable that substantial offshore developments will be concentrated in a limited number of countries (as with onshore wind energy): probably Britain and Germany, possibly together with the US, Ireland, Denmark and the Netherlands.
The main issues that will determine success or failure of offshore wind energy are:

- the provision of a stable framework by the authorities
- the ability of the industry to contain costs, in particular relating to cabling, installation and O&M procedures
- the ability of the manufacturers to uphold reliability of wind turbines, considering the rapid growth rate of turbine size.

With all participants acting taking these issues on board, offshore wind energy is bound to fulfill its potential for success.

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BWE – Windenergie
Erneuerbare Energien
New Energy
Renewable Energy World
Windpower Monthly
WindStats Newsletter
Wind Directions

Additional information is available on www.offshorewindenergy.org