OFFSHORE WIND ENERGY
IN THE SOUTH BALTIC REGION
- CHALLENGES & OPPORTUNITIES

Part-financed by the European Union
(European Regional Development Fund)
Contents

A. Development of the Offshore Wind Energy Sector

1. Clean, safe and secure - offshore wind energy advantages
2. Development of offshore wind energy: a global perspective
3. Offshore wind energy in the EU Strategy for the Baltic Sea Region
4. American strategy for the development of offshore wind energy
5. Importance of regional infrastructure for offshore wind development
6. Political support needed for development of offshore wind energy
7. Wind energy organizations
8. Sharing regional experience in offshore wind energy development
9. Future wind energy

B. Regional Challenges and Opportunities in Offshore Wind Energy

31. Challenges and opportunities in the South Baltic Region
32. Safety - how can the safety & health of offshore wind energy be improved
33. Efficiency - how can costs of offshore wind energy be reduced?
34. Spatial planning – how can this facilitate the offshore wind energy development?
35. Economics – do subsidies help developing offshore wind energy?
36. Human resources – do we have a skilled workforce?
37. Rare materials – can we compete for them on the global market?
38. Grids & networks – it's more than just turbines
39. Construction - offshore wind farm design

C. Regional Outlook on Offshore Wind Energy

53. Wind - potential in the South Baltic Region
54. Offshore wind energy in Denmark
55. Offshore wind energy in Germany
56. Offshore wind energy in Lithuania
57. Offshore wind energy in Poland
58. Offshore wind energy in Sweden
59. South Baltic Region outlook

D. Regional Initiatives for Sustainable Offshore Wind Energy

71. Lessons learnt
72. From vision to real actions
73. Fascination offshore - a wind energy exhibition
74. How can offshore wind energy support development of other economy sectors?
75. How offshore wind farms changed the tourism industry
76. How to deal with the public in relation to offshore wind energy investments?
77. Exhibition about offshore wind energy
78. Experimental promotion of offshore wind energy
79. Events in Karlskrona about offshore wind energy
80. Knowledge toolbox - offshore wind energy
81. Useful links
82. Tables
83. Figures
84. List of acronyms
85. References
Dear Reader,

ten partners from Denmark, Germany, Poland, Lithuania and Sweden with associated organisations have participated in the project ‘South Baltic OFF.E.R’, which was supported by the South Baltic Programme and had six objectives:

- Quicker and more elaborate development of new offshore wind parks,
- A cleaner and more secure energy supply for the South Baltic Region,
- More and better jobs in the South Baltic Offshore Wind Industry,
- Increased competitiveness of the South Baltic Offshore Wind Industry and a strengthened position in the European market,
- Public perception of the South Baltic as one of Europe’s premier renewable energy regions,
- Lasting cross-border relationships, strengthening the social cohesion in the region.

The project has developed standard-setting approaches in order to increase efficiency and to speed up the development of a highly competitive offshore wind industry in the South Baltic Region. It was carried out in five Components:
Increased cross-border cooperation between businesses, universities and research institutions significantly fosters the region’s competitiveness and innovative capacity. This also enables the region to meet the rising demand for skilled workers in the Offshore Wind Industry in the future.

In some of the regions (DE, DK, SE), offshore wind farms are already operating, but even here the industry is immature. Other regions (PL, LT) are still in an early stage of Offshore Wind Energy development, and are benefitting from the transfer of know-how from the more experienced partners and associated organisations. An emerging Offshore Wind Industry in Poland and Lithuania will in turn create new business opportunities, and perspectives to create new networks and cooperative structures for actors from Germany, Denmark and Sweden. The result is a win-win situation from which the South Baltic Region benefits.

The implementation of the South Baltic OFF.E.R project has thus enabled the region to significantly benefit from the rapidly growing Offshore Wind Industry, and has thus contributed to a sustainable economic growth within the region. The long lasting networks established within the project have also contributed to an improved cohesion of the region, and created a feeling of common identity among the actors.

In some of the regions (DE, DK, SE), offshore wind farms are already operating, but even here the industry is immature. Other regions (PL, LT) are still in an early stage of Offshore Wind Energy development, and are benefitting from the transfer of know-how from the more experienced partners and associated organisations. An emerging Offshore Wind Industry in Poland and Lithuania will in turn create new business opportunities, and perspectives to create new networks and cooperative structures for actors from Germany, Denmark and Sweden. The result is a win-win situation from which the South Baltic Region benefits.

The implementation of the South Baltic OFF.E.R project has thus enabled the region to significantly benefit from the rapidly growing Offshore Wind Industry, and has thus contributed to a sustainable economic growth within the region. The long lasting networks established within the project have also contributed to an improved cohesion of the region, and created a feeling of common identity among the actors.
CLEAN, SAFE AND SECURE - OFFSHORE WIND ENERGY ADVANTAGES

The offshore wind blows clean, safe and secure energy.

This chapter is about offshore wind energy (OWE) and how it may develop over the next years to grow from demonstration scale to a mature industry.

It all started decades ago, already in the seventies, when Europe was hit by an energy crisis and people started looking for energy offshore. The first studies were conducted by big offshore oil and gas companies, as they had experience with offshore techniques. They installed offshore wind turbines by deploying onshore wind mills at sea, to generate electricity in their own backyards rather than depend on fossil fuel imports from abroad. However, only after two more decades, in the 1990’s, the first offshore wind turbines were constructed in very shallow waters of Denmark and Sweden in Vindeby (DK), Middelgrunden (DK,) and Bockstigen (SE). The first commercial large offshore farm was built in 2002 at Horns Reef (80 turbines) in the North Sea. At present (end of 2012), there are over 1.600 turbines in Europe with 5 GW of installed power (EWEA, 2013). In 2020, there will be about 10.000 turbines with a combined installed power of about 40 GW.

Offshore wind energy is renewable and CLEAN
Global warming is generally related to emissions of GHG, in particular carbon dioxide. Offshore wind provides a clean and dependable source of renewable energy. Each MW of wind power capacity would theoretically eliminate almost 2.000 tons of carbon dioxide emissions annually if replacing electricity generated in coal power plants.

Offshore wind energy is SECURE
As the supplies of traditional fossil fuels start to run out, or become uncertain, the offshore wind can improve Europe’s energy security as it is a renewable energy source. It also reduces the need to rely on expensive imports of fossil fuels.

Offshore wind energy is SAFE
If the quality assurance procedures are not followed (in attempts to save time & money), major failures can occur, which increase both the technological and financial risks of the installations. Safety is an extremely important issue in the offshore environment, as there are more risks and it is more difficult to get help if an accident occurs. For more than forty years, the offshore wind industry has benefited from the extensive technical experience of the offshore oil and gas industry. Work systems have been developed and methods to ensure that these systems are systematically reviewed and updated have been established.

The potential of offshore wind energy has been acknowledged worldwide, and Tonderski & Jędrejewska present the current development and plans for the future in the article ‘Development of offshore wind energy — a global perspective’. This article also shows, that Europe is a world leader in offshore wind energy, with a total installed capacity of almost 5 GW by the end of 2012. A more focused analysis of the OWE development in the Baltic Sea Region is presented in the article ‘Offshore wind energy in the EU Strategy for the Baltic Sea Region’ by Maegaard & Rathinavelu. They state that the key development area is located in the South Baltic Region (SBR), which is also the main target area for the SB OFF.E.R project, which has initiated and produced the current report.

In the US, one offshore wind farm has been built to date, but the large potential capacity (52 GW), and the prospects for stimulating both economic development and employment have led to a US
A. Development of the offshore wind energy sector

by Paulauskas in the article ‘Sharing regional experiences and exchanging good practices. There are several international projects are described by Zemsta & Jędrzejewska in the article ‘Future offshore wind energy’.

Anne-Bénédicte Genachte (EWEA) gives several recommendations on how political support could ensure and stimulate a better and faster development of offshore wind energy. Except from a strong political support, there is need for national and transnational cooperation and support to the OWE industry. There are several organizations in the SBR and worldwide that work hard to stimulate OWE development by sharing experiences and exchanging good practices. They are presented by Zemsta & Jędrzejewska in the article ‘Wind energy organizations’. In addition, several international projects are described by Paulauskas in the article ‘Sharing regional experiences in offshore wind energy development’ as good examples of how to support the OWE development through transnational cooperation. Finally, a technological outlook on future wind energy is presented by Skrzypiński & Clausen in the article ‘Future offshore wind energy’.

OFFSHORE WIND ENERGY IN THE SOUTH BALTIC REGION – CHALLENGES & OPPORTUNITIES

By the end of 2012, some 5358 MW of offshore wind power has been installed globally, representing more than 2% of the total wind power capacity installed (Table 1). More than 90% of this is installed off Northern Europe, in the North, Irish and Baltic Seas, and in the English Channel. There were 81 operational offshore wind farms in the world, 18 of them belong to the United Kingdom, 13 to Denmark and 15 to China (Table 1). Additionally, some 30 farms are under construction, 6 of them in China, 6 in Germany and 6 in United Kingdom. There are also great expectations on major OWE developments elsewhere. Governments and companies in the United States, Japan, Korea, Canada, Taiwan, and recently India, have shown enthusiasm for developing offshore wind energy in their waters. According to optimistic projections, 80 GW could be installed worldwide by 2020.

The UK has been the world leader in offshore wind since 2008, with as much capacity installed as the rest of the world combined. By the end of 2012, there were 870 turbines installed in 20 generating power farms, which was equal to a total offshore capacity of 2,948 MW (EWEA, 2013). This reference includes two farms: Lincs and London Array (power generating from 2013), which explains small deviation from the numbers in Table 1. The second country with 921 MW installed capacity is Denmark, followed by Belgium, Germany, the Netherlands, Sweden, Finland and Ireland. New technologies are continuously tested and released on the market, as there is an ever-increasing demand for electricity. Good examples are found in Norway and Portugal, where full-scale floating turbines have been installed.

Table 1. Offshore wind farms in the world [4Coffshore.com, as of 31.12.2012]

<table>
<thead>
<tr>
<th>Country</th>
<th>UK</th>
<th>Denmark</th>
<th>Belgium</th>
<th>Germany</th>
<th>Ireland</th>
<th>United States</th>
<th>Japan</th>
<th>China</th>
<th>Taiwan</th>
<th>Indonesia</th>
<th>India</th>
<th>South Korea</th>
<th>Vietnam</th>
<th>US</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of farms</td>
<td>18</td>
<td>13</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>81</td>
</tr>
<tr>
<td>No. of turbines</td>
<td>798</td>
<td>416</td>
<td>34</td>
<td>60</td>
<td>124</td>
<td>75</td>
<td>34</td>
<td>2</td>
<td>1</td>
<td>205</td>
<td>17</td>
<td>18</td>
<td>10</td>
<td>5</td>
<td>1890</td>
</tr>
<tr>
<td>Capacity installed</td>
<td>2297.9</td>
<td>394</td>
<td>379</td>
<td>5</td>
<td>280.3</td>
<td>243.8</td>
<td>138.7</td>
<td>33</td>
<td>25</td>
<td>2</td>
<td>255</td>
<td>25.43</td>
<td>35</td>
<td>18</td>
<td>0.15</td>
</tr>
</tbody>
</table>
A. Development of the offshore wind energy sector

In the end of 2012, a total of 1642 turbines were installed in 55 offshore wind farms in ten European countries, reaching a total capacity of 4995 MW (EWEA, 2013). During 2012, 293 wind turbines were installed with a total capacity of 1,165 MW, which is a 33% increase from 2011 when 874 MW were installed.

EWEA forecasts further growth in the EU offshore wind power capacity, with an additional 14 offshore wind power projects under construction for 2013 and 2014. This will add another 3,300 MW, bringing the total capacity to 8,300 MW. These farms represent investments of some €4 billion, which has contributed to growth in employment opportunities and government tax revenues, as well as spurred innovations and enhanced technological reductions in carbon dioxide and other greenhouse gas emissions from power generation.

However, despite this development the EU target for offshore wind energy of 5,829 MW installed capacity by 2012 was not met. The main reason is a poor grid interconnection, and the grid development is also lagging behind the target (only a few new additions in Germany and France were reported). In addition, there are uncertainties in the policy for renewable energy in EU, market reforms and regulations.

Europe is a world leader in offshore wind energy, and could create an even faster expansion rate if governments gave greater certainty to investors, and reduced the grid interconnectivity challenges. According to Justin Wilhes (EWEA), offshore wind industry is ‘being hit by political and regulatory instability, the economic crisis, the higher cost of capital and austerity’.

The UK led the development in 2012 with 30 turbines connected (60% of the installed capacity) followed by Denmark (13 turbines and 18% capacity), Belgium (30 turbines and 8% capacity) and Germany (16 turbines and 6% capacity).

Offshore Wind Energy in the Baltic Sea Region

Potential for prosperity
The most common wind turbines in operation generate power from three-blade, horizontal axis wind turbines with the nacelle mounted on towers that can be cylindrical concrete, steel plate or lattice towers. This modern wind turbine concept has emerged since 1976 and has become the industrial standard. The concept is basically the same whether used for onshore or offshore applications [Maegaard et al., 2013].

In the first half of 2012, the installed capacity of EU’s offshore wind energy (OWE) was 4.3 GW. Predictions suggest that by 2020, 40 GW will be installed, which would contribute to 4% of the EU electricity demand or 148 TWh production [Offshore Wind: Key Facts, 2012]. In a recent study of the Baltic Sea Region Energy Co-operation (BASREC) it is estimated that the Baltic Sea region (BSR) has a potential for 40 GW of OWE. In this estimate, Finland has the greatest potential (18.3 GW), followed by Denmark (9.2 GW), Sweden (4.5 GW) and Estonia (3.1 GW). The study also states that with the present grid infrastructure and existing plans, about 4.3 GW of OWE is both economically and technically feasible [Soderlund, June 2012]. This prospect not only suggests an opportunity to foster a stronger economy, but also to bring a higher environmental sustainability to the region. Moreover, it also brings in possibilities to mitigate climate change, fortify transnational co-operation and create new job opportunities [Ridlington and Kerth, 2012], [POWER creates a North Sea competence network for offshore wind energy, 2007].

BSR OWE Experience
It is apparent that most of the OWE farms are installed in the North Sea Region (NSR). Nonetheless, Finland has the greatest potential (18.3 GW), followed by Denmark (9.2 GW), Sweden (4.5 GW) and Estonia (3.1 GW). The study also states that with the present grid infrastructure and existing plans, about 4.3 GW of OWE is both economically and technically feasible [Soderlund, June 2012]. This prospect not only suggests an opportunity to foster a stronger economy, but also to bring a higher environmental sustainability to the region. Moreover, it also brings in possibilities to mitigate climate change, fortify transnational co-operation and create new job opportunities [Ridlington and Kerth, 2012], [POWER creates a North Sea competence network for offshore wind energy, 2007].
in the end of 2011, the operating OWE farms in the BSR had a combined installed capacity of 750 MW. Denmark had 487 MW, followed by Sweden (163 MW), Germany (50 MW) and Finland (32 MW). The experience gained by those projects has shaped a realistic approach to exploit the potential to its maximum. Even more, in the BSR there are nearly 5 GW of authorized projects, and a further 6.5 GW projects are waiting for consent (Fig. 2). Besides this, another 10 GW is already in the concept phase [Proba & Wójcik, 2011]. Cross border cooperation, such as BASREC and the EU Strategy for the Baltic Sea Region, provides a basis for efficient maritime spatial planning in the Baltic basin. Such co-operation is vital for the future development of OWE farms in the BSR.

Powering the Baltic Sea regional economy
CO2 emission reduction, climate protection, increased manufacturing and employment opportunities, and decreased dependence on fuel imports are all factors that associate the OWE industry with a positive pathway for economic development [Offshore Wind: Key Facts, 2012], [Ridlington and Kerth, 2012]. The Baltic Sea Report by Swedbank indicates that the export performance of the Eurozone has slowed down the gross domestic product (GDP) growth rate in the BSR [Baltic Sea Report, 2012]. Nevertheless, the OWE industry provides a unique economic leverage to increase growth (GDP) and decreased dependence on fuel imports are all factors that associate the OWE industry with a positive pathway for economic development [Wilkes et al., 2012].

The creation of new jobs in engineering, manufacturing, and construction, as well as in operation and maintenance of the OWE industry are acknowledged in the North Sea Region (NSR). With the current rate of unemployment in the BSR, OWE investments would render employment benefits [Wiersma and Grassin, 2011]. Currently, the OWE industry employs 35,000 people globally (96% of this is in the EU) and it is envisioned that this will grow to 170,000 jobs by 2020, and 300,000 jobs by 2030 (Fig. 3) [European Commission, 2012]. Personnel with transnational offshore experience can contribute to the future labour market. Investments in OWE may pave way for growth in other, related, businesses as well, such as tourism and aquaculture. These new prospective markets may in turn also allow for new job opportunities in small and medium enterprises. It is noteworthy that between 2007 and 2010, despite a 9.6% unemployment rate in the EU, the employment rate increased by 30% in the wind sector [Wilkes et al., 2012].

In 2011 alone, the industry represented £2.8 billion in annual investments, and forecasts predict £9 billion of cumulative investments between 2011 and 2020 [Offshore Wind: Key Facts, 2012]. This growth trend would be reflected in a growing contribution by the wind industry to the EU’s economy and GDP. Hence, OWE investments in the BSR would certainly have a positive effect on its economy. It is interesting to note that the wind industry is already accounting for 0.3% of the current GDP in the EU [Wilkes et al., 2012].

Saving Baltic marine environment
Just like onshore, the offshore wind farms do not emit greenhouse gases (GHG). In addition, they replace part of the fossil fuel mix in the electricity generation on the spot markets, gaining from the merit-order effect. Lowering the carbon emissions will have positive effects on both the domestic and global climate change. In 2011, the European OWE avoided 9.8 million tonnes (Mt) of CO2 emissions, and by 2020 the industry may have avoided 102.1 Mt of CO2 from electricity production in conventional power plants [Azau and Arapogiannis, 2011] [Maegaard, 2012].

It is evident that the Baltic marine environment is adversely affected by hazardous emissions from conventional power plants in the region [Korpinen and Laamanen, 2010]. Development of OWE farms in the area would reduce emissions and consequently also the spread of toxic substances in the sea. This would contribute to make the fish safer for consumption and would also improve the air quality in the surroundings [Ridlington and Kerth, 2012]. OWE plants do not need any fresh cooling water unlike the conventional power plants, except those located by the sea which use salt water for cooling [Snyder and Kaiser, 2009]. The preserved freshwater may instead be available for agriculture and aquaculture. Moreover, the BSR’s energy imports could be substantially reduced, as wind energy ensures a long term and sustainable energy supply. Basically, OWE is one of the technologies applicable for large scale power generation, in order to decrease the power production based on uranium, coal, oil and gas in the Baltic Sea region [Maegaard, 2010].

Transnational Relationships
Experience from NSR projects shows that cross-border cooperation of MSP could deliver real cost reductions. Planning, erection, maintenance and decommissioning of OWE farms are then done within Exclusive Economic Zones, which is a transnational activity. Therefore, a cross border co-operation aiming at sharing knowledge, skill development and experience is crucial for further development of OWE in the BSR. One of the key aims of transnational cooperation is to provide corridors for regional energy market integration. One such initiative is the Kriegers Flak, a tri-national co-operation between Germany, Denmark and Sweden, which is now in the pipeline. This OWE grid infrastructure will enable the participating member states to trade their electricity from different energy sources. Other Baltic Sea region offshore installations could have the same corridor effect. Moreover, transnational co-operation is not only an effective way of employing projects, but it also fosters relationships and cooperation among the EU member states in a region [POWER creates a North Sea competence network for offshore wind energy, 2007], [Thynell and Tonderski, 2011].

Offshore wind – a key component in EU’s strategy for the Baltic Sea region
Offshore wind power is a positive step towards the EU goals of competitiveness, energy security and reduction of greenhouse gas emissions. However, there is a long road ahead to achieve an OWE regional market integration in the BSR. But all efforts in developing OWE can be well conceived of as supports for EU’s intent to increase environmental sustainability, prosperity, accessibility, attractiveness, safety and security in the Baltic Sea Region [El Bassam, et al., 2004].
AMERICAN STRATEGY FOR THE DEVELOPMENT OF OFFSHORE WIND ENERGY

The potential for offshore wind resources is vast with data suggesting over 4,000,000 MW [A National Offshore Wind Strategy, 2011] available in state and federal waters along the coasts of the United States and the Great Lakes. This is around four times more than the total generating capacity of all U.S. electric power plants. The aim of the National Offshore Wind Strategy is to achieve 10 GW by 2020 at a cost of energy of $0.10 per kWh, and 54 GW by 2030 at a cost of energy of $0.07 per kWh.

The U.S. Department of Energy (DOE), Office of Energy Efficiency and the Renewable Energy, Wind & Water Power Programme are working with an agency responsible for reviewing and approving offshore wind projects in federal waters. The U.S. Department of the Interior, the Bureau of Ocean Energy Management, Regulation, and Enforcement issued on 7th February 2011 ‘A National Offshore Wind Strategy—Creating an Offshore Wind Energy Industry in the United States’, to establish the actions it will pursue to support the development of a world-class offshore wind industry in the United States. This will be led by the Offshore Wind Innovation and Demonstration (OSWinD) initiative. This initiative programme has three main focus areas: Advanced Technology Demonstration, Technology Development, and Market Barrier Removal (Fig. 4).

The projects described below have been allocated over $200 million dollars in the form of grants, with $168 million of this going towards Advanced Technology Demonstration (Fig. 5). The programme choose seven technology demonstration partnerships, which will receive up to $4 million to complete the site evaluation and planning phases of their projects. The seven selected projects are:

- Baryonyx Corporation plans to install three 6 MW direct-drive wind turbines in state waters near Port Isabel, Texas.
- Fishermen’s Atlantic City Windfarm plans to install up to six direct-drive turbines in state waters three miles off the coast of Atlantic City, New Jersey.
- Lake Erie Development Corporation plans to install nine 3 MW direct-drive wind turbines. The project will be installed on Lake Erie, seven miles off the coast of Cleveland.
- Principle Power (Seattle, Washington) plans to install five semi-submersible floating foundations out fitted with 6 MW direct-drive offshore wind turbines. The project will be sited in deep water 10 to 15 miles from Coos Bay, Oregon.
- Statoil North America of Stamford, Connecticut, plans to deploy four 3 MW wind turbines on floating spar buoy structures in the Gulf of Maine off Boothbay Harbor at a water depth of approximately 460 feet.
- The University of Maine plans to install a pilot Figure 4. Structure of OWSiND focus areas and activities.
A. Development of the offshore wind energy sector

importance of regional infrastructure for offshore wind development

Aleksandra Jędrzejewska
Gdańsk University – POMCERT
e-mail: aj@pomcert.pl

Marek Samotyj
Electric Power Research Institute (EPRI)
e-mail: msamotyj@epri.com

Floating offshore wind farm with two 6 MW direct-drive turbines on concrete semi-submersible foundations near Monhegan Island.

Dominion Virginia Power of Richmond plans to design, develop, and install two 6 MW direct-drive turbines off the coast of Virginia Beach.

After completion of these phases, the DOE Wind Programme will select up to three of these projects to advance the study and achieve commercial operation by 2017.

About $42 million have been allocated to 42 projects defined under the two categories Technology Development and Market Barrier Removal. The Technology Development component awarded 19 projects in 2011 to i) research and develop innovative rotor and control system designs for advanced components and integrated systems to reduce capital costs of these systems by up to 50%; ii) advance the current state-of-art modelling and analysis tools for the design performance assessment, system modelling, and cost assessment of offshore wind systems; and iii) to develop conceptual designs and assessment of offshore wind plant systems that enhance energy capture, improve performance and reliability, and reduce the cost of energy. The Market Barrier Removal programme invested in 23 projects to remove barriers that limit deployment of offshore wind in the nation’s coastal and Great Lakes regions.

The U.S. Department of Energy (DOE) estimates that by 2030 the U.S. could create more than 43,000 permanent and maintenance jobs, which would equal approximately 20.7 direct jobs per annual megawatt [A National Offshore Wind Strategy, 2011].

The Atlantic Wind Connection: The United States Super Grid for Offshore Wind Power Transmission

The US Mid-Atlantic region is home to one of the most powerful offshore wind resources in the world. Just 15 to 20 miles offshore there is enough wind energy to supply millions of homes with clean, renewable power. The area is also home to major population centers, with an ever-increasing appetite for energy. Geographically, it is perfect for offshore wind, with a gently sloping continental shelf and shallow waters – only 100 to 150 feet deep, as far as 15 to 20 miles offshore. The seafloor is typically comprised of sand and gravel sediments, making for simpler civil marine construction using current, field-proven techniques.

Now, how to bring all that power to shore in the most efficient manner? The generation and collection of offshore wind power has matured well in Europe over the last 20 years. Turbine manufacturers are building ever larger generators, foundations are being designed for deeper waters, and the submarine cable industry has expanded with new factories to meet the demand. The missing link is an efficient and flexible power transmission system to transfer the available power to the right place at the right time. This is where the Atlantic Wind Connection (AWC) project comes in.

The Atlantic Wind Connection (AWC) Project is an offshore backbone electrical transmission system proposed off the Mid-Atlantic coast between Northern NJ and Virginia (Fig. 6). The system will consist of an HVDC submarine cable system interconnecting a series of offshore converter hubs. Each hub will consist of an offshore foundation housing an HVDC converter station on its deck. At each hub location utility scale offshore wind farms will interconnect to the AWC offshore grid. The alternating current (AC) power generated by the wind farms will be converted to high voltage direct current (HVDC) and transmitted to shore via submarine cable connections.

On shore, the AWC HVDC system will follow an underground route to a strategic point of interconnection on the terrestrial grid where a land-based HVDC converter station will convert the DC power back to AC.

Figure 5. Offshore wind power projects supported by the Energy Department in 2012 [data from the Energy Department and the National Renewable Energy Laboratory]

Figure 6. Atlantic Wind Connection project configuration
for distribution on the grid. The AWC Project will allow up to 6,000 megawatts (MW) of offshore wind turbine capacity to connect to the regional, high-voltage terrestrial grid. The first phase of the project, the New Jersey Energy Link, is slated to start construction off the coast of New Jersey in 2016, and be fully operational for connections by wind farms in 2019.

The Bureau of Ocean Energy Management (BOEM), part of the US Department of Interior (DOI) is the federal government regulator for all renewable energy project developments planned for the US Outer Continental Shelf (OCS). BOEM has issued rules that govern the use of OCS submerged lands for renewable energy development. BOEM’s ‘Final Renewable Rule’ states the requirements wind developers and transmission line developers must follow to obtain a submerged lands lease to build a wind farm or a ROW to build transmission. BOEM is the lead federal regulatory agency for permitting leases (for wind farms) or grants (for transmission systems) on the OCS.

Numerous additional federal agencies in addition to BOEM must also be consulted in the AWC permitting process and, in many cases, permits must be obtained from them, as well. The US Army Corps of Engineers, the US Coast Guard, US Fish and Wildlife Service, the US Environmental Protection Agency, as well as several others must review AWC project applications to determine what impacts the project may have on the environment, navigation safety, or other aspects of the existing marine and terrestrial environments.

Each of the coastal states also has jurisdiction over their adjacent coastal waters, usually to three nautical miles from the shore. The permitting processes for each state varies, but in order to site a transmission line like the AWC that will ultimately run through state waters and make landfall on a particular state’s shores, AWC will need to obtain several permits from state regulators. Those permits include ones which confer the rights to the states’ submerged lands, as well as environmental permits which confirm that the AWC will meet the environmental protection standards set by each state.

The Atlantic Wind Connection submitted an application to BOEM for access to the offshore right-of-way in March of 2011, the first step in obtaining a grant to construct a transmission system on the OCS. This application presented a proposed cable route to BOEM as a first step in obtaining the grant for the right-of-way and initiated the official permitting process with BOEM. In their review of the application, BOEM wanted to determine if there was any competition for the area which AWC requested for the project, as well as understand the potential impact granting the right-of-way could have on the environment, existing marine uses and stakeholders. In May of 2012, BOEM granted a Determination of No Competitive Interest (DNCI) for the right-of-way, which confirmed that no other offshore transmission developers had a competitive interest in the route AWC proposed.

The next step in the permitting process is for the AWC team to prepare a General Activities Plan for BOEM to review and generate an Environmental Impact Statement under the United States National Environmental Policy Act of 1969, also known as NEPA. Once BOEM completes its NEPA analysis, it will determine whether or not the AWC will have significant environmental effects. Then a Record of Decision (ROD) will be issued by the Secretary of Department of the Interior. The ROD, in conjunction with the permits issued by the additional federal and state agencies, will enable AWC to move forward in the final steps of the BOEM permitting process and move ahead to financing the construction of the project.

Europe is the world-leader in offshore wind technology giving the continent a valuable competitive edge, offshore wind power reduces our dependence on imported fossil fuels boosting our energy security and it helps drive down carbon emissions from the electricity-producing sector as well as creating long-lasting employment opportunities. But, as a young industry, offshore wind needs political support in order to help it reach its full potential. Europe currently has a target for 20% renewable energy by 2020, and offshore wind will provide a meaningful contribution to it. By 2020, EWEA estimates that there will be 43 GW of offshore wind capacity which will meet 4% of the EU’s electricity demand, a level that could rise to 14% from 150 GW by 2030. But to reach that level the sector needs policy certainty through extended targets for 2030. EWEA is calling on the EU to set a new renewable energy target soon and the European Renewable Energy Council has recommended a target of 45%.

On a national level, offshore wind also needs political certainty through stable, long-term support schemes that afford investors the clarity they need to carry out the necessary investment. Moreover, the authorities responsible for offshore wind power need to make sure that permitting and licensing of offshore wind farms is a smooth process not burdened by over-complex and unduly long procedures. In addition to targets, stable support schemes and quick, non-complex planning procedures, offshore wind power needs to operate in a well-planned maritime setting. Proper maritime spatial planning, one that maps the use of the sea for all its diverse users and sets suitable zones for the development of offshore wind, is now needed to provide investors with certainty and to help reduce the costs of offshore through optimum integration of the projects in the marine environment. Furthermore, it is necessary that the EU’s sea states cooperate on
spatial planning so that the cross-border projects such as the North Sea offshore grid can be deve-
loped. As a newcomer to maritime space, offshore wind is driving this process, but proper maritime spatial planning will be to the benefit of all sea users. EWEA urges the European Commission to put a European framework for maritime spatial plan-
ning in place without any further delays.

Offshore wind power will not be able to reach its full potential without the development of an offshore electricity grid that delivers the power produced at sea to the demand centres on land. Research has shown that if an offshore grid is deve-
loped in clusters that connect offshore wind farms together, as opposed to each wind farm having its own radial connection to the land, some €14 billion in grid costs can be saved up to 2030.

Lastly, Europe needs new industrial investment and development and, although the offshore sector is a highly promising one, it is not supported by any European industrial strategy to guide its develop-
ment, similar to the ones in place for the auto-
motive and shipbuilding sectors. EWEA urges the European Commission to recognize the strategic importance of the European offshore wind industry by developing an industrial strategy to drive for-
ward its development.

With the policy support outlined above, offshore wind power can reach its full potential, meeting 14% of the EU’s electricity demand by 2030 and creating 300,000 jobs by 2030.

The rapidly developing offshore wind energy sector needs support in regions where it already exists, but also in countries like Poland or Lithuania where it is expected that offshore wind farms will be built. It is necessary to create organizations that support both the development of new offshore technologies and public education about wind energy opportunities, including offshore. There are already a few func-
tional organizations. The World Wind Energy Association (WWEA), founded 2001 in Denmark, is an interna-
tional non-profit association representing the wind power sector worldwide. Members come from 100 different countries, and include the leading national and regional wind energy associations. The organiza-
tion works for promotion and worldwide deployment of wind energy technology, and advocates a future energy system based on renewable energy.

A well-known organization in Europe is The European Wind Energy Associations (EWEA), an association based in Brussels, founded in 1982 and focusing on promoting the use of wind power in Europe. It has over 700 members from nearly 60 countries, includ-
ing manufacturers with a leading share of the world wind power market, component suppliers, research institutes, national wind and other rene-
wables associations, developers, contractors, elec-
tricity providers, finance companies, insurance com-
panies, and consultants [EWEA, 2012].

The rapidly developing offshore wind energy sector needs support in regions where it already exists, but also in countries like Poland or Lithuania where it is expected that offshore wind farms will be built. It is necessary to create organizations that support both the development of new offshore technologies and public education about wind energy opportunities, including offshore. There are already a few func-
tional organizations. The World Wind Energy Association (WWEA), founded 2001 in Denmark, is an interna-
tional non-profit association representing the wind power sector worldwide. Members come from 100 different countries, and include the leading national and regional wind energy associations. The organiza-
tion works for promotion and worldwide deployment of wind energy technology, and advocates a future energy system based on renewable energy.

A well-known organization in Europe is The European Wind Energy Associations (EWEA), an association based in Brussels, founded in 1982 and focusing on promoting the use of wind power in Europe. It has over 700 members from nearly 60 countries, includ-
ing manufacturers with a leading share of the world wind power market, component suppliers, research institutes, national wind and other rene-
wables associations, developers, contractors, elec-
tricity providers, finance companies, insurance com-
panies, and consultants [EWEA, 2012].
The Danish Wind Industry Association (DWIA) is an interest and industry association with more than 240 members across Denmark. DWIA’s members consist of wind turbine manufacturers, energy companies and a wide range of companies that provide components, services and consultancy. DWIA manages the interests of the members and creates a framework for the various fora, in which members can utilize the potential in knowledge sharing and experience exchange with players within and outside the industry. Furthermore, DWIA promotes the member interests on both the national and international political stage.

The German Wind Energy Association (BWE) is the largest renewable energy association in the world with about 20,000 members. They include wind turbine manufacturers, operators and their shareholders, planning offices, financial institutes, scientists, engineers, technicians and lawyers, but also early conservationists, schoolchildren and students. Its strength lies in its structure, as it represents a concentration of know-how and experience from the entire sector. This great pool of knowledge makes the BWE the prime discussion partner for politics, commerce, science and the media.

There are many more wind energy organizations around the world, e.g. the British Wind Energy Association (renewableUK), the American Wind Energy Association (AWEA), the Canadian Wind Energy Association (CWEA), the Irish Wind Energy Association (IWEA) and the Spanish Wind Energy Association (SWEA). They are all the voice of the wind energy sectors in the specific countries. Through such organizations, the offshore wind energy industry grows faster and is better understood by people.

Sharing of regional experience in offshore wind energy development started during the INTERREG III funding period 2000-2006. Two POWER projects were simultaneously launched, the North Sea POWER (Pushing Offshore Wind Energy Regions) and the South-Eastern Baltic POWER (Perspectives of offshore wind power development in marine areas of Poland, Lithuania and Kaliningrad region, Russia). Their aim was to discover opportunities for the new offshore wind energy sector in the respective regions. The North Sea project developed further into the POWER cluster project. The main achievements of both projects were incorporated into the South Baltic Programme project ‘SB-OFF.E.R – South Baltic Offshore wind energy regions’ (2010-2013). This project strives to foster a rapid development of the offshore wind energy market in the South Baltic Region, and Europe in general.

The 2004-2006 Neighbourhood Programme offered different perspectives on the offshore wind energy development in the marine areas of Poland, Lithuania and the Kaliningrad region (Russia) were investigated during 2006-2008. This POWER project was initiated by researchers from the Polish Maritime Institute in Gdańsk, and coordinated by the Klaipeda University Coastal Research and Planning Institute (CORPI). Russia was represented by the Institute of Oceanology of the Atlantic Branch of the Russian Academy of Sciences. The project was structured to facilitate cooperation between the scientific community, developers and local administrations. The joint experience of wind power developers was represented by the Strategic Self-Management Institute in Lithuania and the Polish Wind Society in Gdańsk. Administrative competence was provided by regional development authorities, i.e. the Maritime office in Gdynia and the Klaipeda County Governor’s Administration.

This advanced Triple Helix junction project structure created conditions for the complex decisions needed for offshore wind energy development in the region. In the preliminary phase, environmental requirements were identified, conflicts recognized and grid connection opportunities evaluated. During the optimization phase, locations of potential offshore wind farms were pre-selected taking into account results from public communication, economic feasibility studies and promotion strategies. Based on pilot projects deployed in the marine waters of Poland, Lithuania and the Kaliningrad region, a set of legislative and political recommendations were developed that could promote electricity production by offshore wind energy parks.

South Baltic Programme 2007-2013
The project ‘SB-OFF.E.R – South Baltic Offshore wind Energy Regions’, which was initiated within the framework of the South Baltic cross-border cooperation programme 2007–2013, has created favourable opportunities to share regional experience in the offshore wind energy development sector. This project joins researchers, businessmen and regional administration bodies.

The scientific community is represented by one of the worldwide leaders in wind power development, i.e. the Risø DTU National Laboratory for Su-
A. Development of the offshore wind energy sector

Denmark has the most significant achievements in offshore wind power parks design and construction. Hence, a visit to the Nysted Offshore wind power park and the associated information point was very useful for the project partners and OWE developers from partner countries. Danish, Swedish, Polish and Lithuanian partners benefited from sharing the experiences of the Bremerhaven port on how to produce, transport, and technically maintain offshore wind power facilities, as well as provide training for OWE workers. The Swedish projects illustrated advanced technologies such as floating OWE stations, and the large Lillgrund OWE park, and were among those that had a big influence on developers, and were also important for promotion and dissemination of modern OWE ideas in the partner countries.

Parallel South Baltic Programme projects
The success of wind power development is closely linked to a friendly legislative environment, power storage and balancing opportunities, and efficient promotion of wind power. Those were the target areas set in the South Baltic Programme project “WEBSR2 – Wind energy in Baltic Sea region – extension” (2010–2013). The city of Rostock municipality, the Regional Planning Association Central Mecklenburg/Rostock, the Energy Agency for Southeast Sweden together with the Polish and Lithuanian Wind energy associations represented the administrative and professional sides of wind energy development in the region. The scientific tasks were executed by the Strategic Self-Management Institute, the Lithuanian Energy Institute, the Klaipeda University, the Hydrogen Technology Initiative Mecklenburg-West Pomerania, and the Automotive and Electro-technical Institute in Gdansk.

Participation in meetings and events of parallel projects was encouraged, and exchange of dissemination materials, reports and recommendations were a common practice in the project. An example is that the WEBSR2 projects achievements in the field of energy storage were presented in the cross-border event of SB-OFF.E.R. in Vilnius in 2011. The project results were reported in the WEBSR2 project meetings in April 2012 in Klaipeda, and in the final conference in October 2012 in Gdansk.

Another cross-border co-operation programme project is the ‘Sustainable RES–CHAINS in South Baltic Region’ (2011–2013), which has become a real tool for sharing scientific, technical, administrative and business experience between partners in Denmark, Sweden, Germany, Poland and Lithuania. The activities include comparisons of RES facilities and energy production, case studies, study trips, competitions between schoolboys in partner countries, and have given ample possibilities to share experiences in RES development, including offshore wind energy.

The projects partners have agreed to disseminate achievements of all parallel projects during a period of five years after the project termination through the WEBSR2 Wind Energy Info Points established by the project in Sweden, Germany, Poland and Lithuania.

Exchange of experience with European partners
The activities in the fifth component of the SB-OFF.E.R. project have been targeted towards developing skills and fostering recruitment in OWE related businesses. A range of different events have been arranged with participation from DTU, local lecturers and

Figure 8. Project ‘POWER’ team in September 2007 HUSUM wind energy trade fair

Figure 9. Partners of ‘SB-OFF.E.R.’ and ‘RES-Chains’ in opening of project WEBSR2 Wind Energy Info Point in Klaipeda (April 2012)
Offshore wind energy have been created and are adopted as part of the curriculum at the Maritime Institute of Klaipeda University. Together with partners from Spain, Greece, Portugal, Poland, Hungary, Turkey and Germany, Master degree courses on offshore wind energy have been created and adopted as part of the curriculum at the Maritime Institute of Klaipeda University.

In conclusion, we can say that offshore wind power is a very innovative field, which has brought together scientific research, business development and administrative facilities in large regions of the North Sea, South Baltic and overall Europe, with the purpose of exchanging best knowledge and practice to develop offshore wind energy competence for successful implementation in the EU. For this to succeed, better wind conditions, a strong maritime industry, and focused innovative facilities are the most important factors to maintain the EU as one of the leading regions for offshore wind energy worldwide.

Although the offshore market is only 2% (2012) of the global wind energy market, it is often regarded as the technology driver for the industry. First of all, offshore conditions are very demanding and access to the turbines is challenging, which calls for the development of highly reliable and autonomous wind turbines. Furthermore, the high costs for the foundations and grid connections, compared to land installations, drive the size of the turbines upwards in an effort to reduce the cost of electricity.

In the UpWind project (www.upwind.eu, EU-FP6, 2005–10, 46 partners), the design limits of today’s wind turbine technology is challenged by up-scaling to a 20 MW wind turbine. Such a wind turbine would have a rotor diameter of 250 m and a hub height of 150 m. In Fig. 10 the rotor size of this turbine is compared to an Airbus A380 airplane.

The new EU-FP7 project INNWIND.EU (2012–2017; 26 partners) is addressing the design of a beyond-state-of-the-art 10–20 MW offshore wind turbine, focusing on three critical components: i) a new lightweight rotor, ii) a super conducting low-weight, direct drive generator and iii) a standard mass-produced integrated tower and substructure. As for the UpWind project, the consortium comprises leading industrial partners and research institutions led by DTU Wind Energy in Denmark.

**Floating wind energy**

In countries with deep water close to the coast, e.g. Norway, bottom-mounted offshore wind energy is not feasible and development of floating concepts has started. Today, two principles are being tested at a prototype stage: Hywind (Statoil, Siemens; Fig. 11) and WindFloat (EDP, Energies de Portugal, Vestas, Repsol). While Hywind is designed for large water depths in the range of 100–700 m, WindFloat is intended for the transition between traditional bottom-mounted wind and deep water.

**High Altitude Wind Energy**

High Altitude Wind Energy (HAWE) is a concept that aims at harvesting energy at high altitudes by means of kites, gas-filled structures, gliders or hovering turbines. The energy resources at high altitudes are “very promising”, according to GL Garrad Hassan, as high-altitude wind is more stable and has a higher velocity.
A. Development of the offshore wind energy sector

Over 22 firms develop such concepts, where one is to use large automated kites attached to drums (Fig. 12). The kite pulls a rope from the drum, thus generating electricity. After the rope has extended to its full length, the kite is flown into a position where its pulling force is low. Then, a motor reels in the rope on the drum using a relatively low amount of energy, and the process repeats.

Another concept, included in HAWE, is Airborne Wind Turbines, where the turbine is tethered to the ground, with the generator either on the ground or aloft. One of the main advantages of all HAWE techniques is that the whole system may float and can therefore be deployed in deep water.

Figure 11. Hywind floating wind turbine by Statoil

Figure 12. SkySails HAWE system

B. REGIONAL CHALLENGES AND OPPORTUNITIES IN OFFSHORE WIND ENERGY

- CHALLENGES AND OPPORTUNITIES IN THE SOUTH BALTIC REGION
- SAFETY - HOW CAN THE SAFETY AND HEALTH OF OFFSHORE WIND ENERGY BE INCREASED?
- EFFICIENCY - HOW CAN COSTS OF OFFSHORE WIND ENERGY BE REDUCED?
- SPATIAL PLANNING - HOW CAN THIS FACILITATE THE OFFSHORE WIND ENERGY DEVELOPMENT?
- ECONOMICS - DO SUBSIDIES HELP DEVELOPING OFFSHORE WIND ENERGY?
- HUMAN RESOURCES - DO WE HAVE A SKILLED WORK FORCE?
- RARE MATERIALS - CAN WE COMPETE FOR THEM ON THE GLOBAL MARKET?
- GRIDS & NETWORKS - IT’S MORE THAN JUST TURBINES
- CONSTRUCTION - OFFSHORE WIND FARM DESIGN

Niels-Erik Clausen
Technical University of Denmark
e-mail: necl@dtu.dk

Witold Skrzypinski
Technical University of Denmark
e-mail: wisk@dtu.dk
There are many challenges to overcome in order to make offshore wind energy available on a large scale. In this chapter, some of the important challenges in the South Baltic Region (SBR) are presented, and the possibility to turn them into opportunities for the region is discussed.

Development of renewable energy often requires subsidies or other financial support in the early stages. Schroeder gives a brief account on how offshore wind energy can be supported in the article ‘Do subsidies help developing OWE?’.

Other main ingredients in the current discussion about Offshore Wind Energy are cost, efficiency and the respective potentials. As Platts states, lightweight, agile rotors on taller, lightweight composites guyed towers give a route to energy-efficient, cost effective, long term electricity generation (the article ‘How can cost of OWE be reduced?’).

In addition, certain elements of wind turbines are dependent on the global market development. For instance, the availability of rare materials (essential in turbines) is largely controlled by one country, which can cause turbulence in both availability and prices. This is illustrated in the analysis ‘Can we compete for rare materials on global market?’ by Abrahamson.

Safety is a challenge that has been carefully addressed in the OWE sector, and has become a strength of the industry. That development is comprehensively described by Lawson in the article ‘How can safety of OWE be increased?’, where he emphasizes experience and track record, emergency response, sharing and shaping, competence and training, construction and marine interfaces, technology advancement, vessel capability, as well as the role of leadership.

There is still a lot to improve in the area of spatial planning for OWE development. In the article ‘How can spatial planning facilitate the OWE development?’ Blažauskas describes benefits that could result from the implementation of integrated maritime spatial planning in the South Baltic Region.

To enjoy the benefits of OWE development, countries with coastal areas need an adequate and skilled work force. Carstensen analyses the availability of the educated work force in the region (the article ‘Do we have skilled work force?’), and comes to the conclusion that there is still a lot to do in this field in order to facilitate development of the OWE industry.

Wind farms won’t help to combat climate change.

Wind power is a clean, renewable source of energy which produces no greenhouse gas emissions or waste products. Power stations are the largest contributor to carbon emissions. We need to switch to forms of energy that do not produce CO2. Just one modern wind turbine will save over 4,000 tons of CO2 emissions annually.

Source: www.communitywind.ca/13701/20501.html
Construction and technological challenges have been addressed by both science and industry. Offshore wind exploration is not only about the turbines. It is equally important to have access to electric grids and networks, which require large infrastructure investments. This issue is professionally addressed by Wagner et al. in the article ‘Grids and Networks: – it’s more than just turbines’. Another challenge related to the construction of wind turbines is thoroughly described by Skrzypinski in the article ‘Offshore wind farm design’.

In summary, a number of major challenges for offshore wind development are addressed and analysed in this chapter. In future projects aimed at promoting offshore wind energy, the scope of the indicated challenges remain quite broad. Even those issues that have been at the centre of our attention for quite a while still remain unsolved.

Wind farms are inefficient, they are only operational 30% of the time.

A modern wind turbine produces electricity 70-85% of the time, but it generates different outputs dependent on wind speed. Over the course of a year, it will generate about 30% of the theoretical maximum output. This is known as its load factor. The load factor of conventional power stations is on average 50%. A modern wind turbine will generate enough to meet the electricity demands of more than a thousand homes over the course of a year.

Source: www.communitywind.org/2015/03.html

As with any review of performance we need to establish the current position and it is at this point that we encounter the first difficulty in addressing the issue of where improvement is needed. Depending upon which role you play in the industry – whether you are a developer, a vessel contractor, a turbine manufacturer, or an operator – this will influence your perception of the current situation. Clearly, if you are a developer with responsibility for the procurement of a project you are more likely to have a holistic view on all aspects of the industry, but health & safety may not be your core expertise. There will, however, be different perceptions of those issues depending on the actual role undertaken, and it is likely that health and safety managers will have a more robust understanding of the issues and scope for improvement. Another influence will be your background experience, whether it is in Oil & Gas or Maritime with a deep understanding of the offshore marine environment, electrical supply and distribution with familiarity with the grid network challenges, or in manufacturing and engineering with the constant challenge of technology advancement.

No matter what your individual role or part played in offshore wind development, we all acknowledge that there is always scope for improvement. This is where we start to explore the areas that may provide us with these opportunities.

Before we consider the opportunities for improvement, we must also take into account the barriers that influence any change in the culture that we may wish to introduce. Firstly, the legislation applicable in the country in which the development is to take place. If the project is undertaken within the European Union, the legislation applicable in one country is based upon a common EU directive. If you are working outside your immediate knowledge of the particular rules and regulations in that country, it is important to secure local competent advice. There are many other factors which influence our attitude to health & safety, such as our past involvement, our specialisms and experiences with other members of the project development team.

Experience and Track Record

The Offshore Wind sector is a new one that we are still trying to understand. Despite leaps in technology and practice we still have much to learn. We hear a lot about the knowledge and experience of those working in the Oil & Gas sector, given their involvement in building offshore installations, laying sub-marine pipes and working in a marine environment, but do they have all the answers? If they did, there wouldn’t be the number of incidents recorded today. They have, however, taken an active role in the OWE sector, be it from the perspective of a commercial opportunity, a developer on behalf of an operator, or a contractor facilitating projects. The same can be said for the turbine manufacturers, who have extensive experience of producing and operating turbines onshore, as well as of research and development of turbines intended for the harsher offshore environment. Similarly, the heavy engineering industry can claim experience of offshore installation design and construction, and the power generating organisations are familiar with distribution and network systems. The fact is that they can all bring valuable experiences to the table, and we need to harness that in a constructive and proactive way. The best way to address this is through ownership and accountability for a project as a whole for its entire lifespan; including engineering, execution, use, repair and maintenance as well as subsequent decommissioning & removal. Each partner should be taking responsibility for all elements, whilst providing a transparent process for cooperation and coordination of information to achieve health, safety and environmental best practice.
What is best practice? Another challenge for the offshore wind sector is to develop and dictate its aspirations for performance measurement and benchmarking. The broader the depth of practical knowledge, the more accurately we can predict outcomes and drive practical guidance.

**Health & Welfare**

The constraints imposed by unpredictable weather, and the work involved, mean that the nature of offshore work is very often a 24/7 operation with unsociable working patterns, often involving night shifts and prolonged periods at sea away from home. This can have a psychological effect on the workforce in addition to the physical demands of the work in a harsh environment. The nature of offshore work, and that associated with turbine maintenance, means that it is generally undertaken by a younger generation better suited to meet the physical demands of the work, where physical fitness and peak health is a pre-requisite.

The more experienced operatives, whilst retaining a minimum fitness level, move to a supervisory level but still maintain an active involvement ‘at the sharp end’. People with lower fitness levels or more complex health conditions, such as diabetes, must accept that their conditions induce unnecessary additional risks associated with the tasks undertaken, and are therefore limited to the shore based functions.

When it comes to welfare facilities, most vessels are equipped with sleeping quarters, a restaurant, showers, and toilets. Hence, suitable facilities are provided for longer and more complex tasks. However, a lot of the work activities involve small teams working in isolation to undertake relatively short duration tasks, and therefore the welfare facilities are often provided by the personnel transport vessels (PTVs) or the emergency facilities within an offshore substation. In either case, these facilities are basic and don’t always cater for the welfare needs associated with the work done, i.e. a need to rest and take a basic hot meal after a few hours of work, or warm water to thoroughly wash off substances – be it oil/creosote or epoxy constituents. We need to enhance the basic provision to the workforce in these situations, and this can only be achieved by designing suitable facilities within each turbine.

**Emergency Response**

The industry hasn’t suffered any major catastrophes involving multiple fatalities or significant pollution, which would influence the way that we approach emergency response. The risk for such a major incident is relatively low given the installations, equipment and number of people involved. Our ability to foresee such an incident is limited to the higher risk activities, i.e. lifting operations, vessel collisions or turbine fires/explosions. The consequence of such incidents would not involve large numbers of people or volumes of material. Thus, the severity of the consequences is by comparison, low. The commercial impact is, however, high and arises from damage repairs or replacements, salvage costs, litigation, fines etc. on top of the other hidden costs of accidents.

Our primary consideration should always be the prevention of harm to people, and as an integral consideration of welfare at work, first aid should cater for the worker. Where concentrated effort is focussed on a long duration activity, suitable first aid facilities need to be provided. This should include a competent medic based offshore within five to ten minutes of all work areas so as not to rely on other offshore emergency rescue organisations. This is not always the case, and at best the vessel master may have some medical training though not regarded as a competent medic. Short duration tasks will rely on the first aid training of other members of the team with basic first aid kits. We understand that survival rates of someone suffering sudden cardiac arrest decreases 10-12% per minute without external intervention; and that normal medical examinations will not pick up on a genetic or other heart disorder, which can affect the young and fittest athletes. As a result we should give access to Automated External Defibrillators (AEDs), which should be readily available at all work areas. These pieces of equipment do not require specialist training other than the most basic, and they incorporate verbal instructions and warnings to the operator whilst in use. They are however reliant on batteries and need to be regularly serviced.

**Sharing and Shaping**

To be able to shape the industry as we want to see it, we need to share our knowledge, draw from the lessons learnt, and invest in research and development to explore future challenges. This is one area which has significant opportunity if we are able to break down the commercial and confidentiality barriers to enable an open dialogue. We seem to be able to provide a general overview of knowledge sharing through the variety of sector specific conferences and exhibitions that is consistent with an ever increasing size of turbines, encroachment into ever deeper water and the need to reduce the cost per MW of Offshore Wind. Whether we can develop a ROV during a cable installation? The legislation and enforcement process is also different whether a vessel is in transport mode or undertaking a construction activity. Similarly, an activity in port may fall under different rules than a similar activity whilst at sea. It is therefore important to understand where these interfaces occur so that they can be appropriately managed and when incidents occur they can be recorded and properly categorised. Some of these interfaces may be simple every day functions, which are well understood and practiced by those involved. Others may be complicated by the specialist nature of the activities involved or circumstances arising that had not been foreseen by the principal party who normally carries them out. Such circumstances, irrespective of the risks have been identified and assessed or not, give rise to failures due to the unusual or unfamiliar nature of the interface that create a potential for incidents. A thorough consideration of these issues must therefore be considered by all the parties involved at the earliest opportunity.

**Technology Advancement**

The ever increasing size of turbines, encroachment into ever deeper water and the need to reduce the cost per MW of Offshore Wind means that we are constantly stretching the boundaries for new commercial opportunities, thus challenging our current understanding of the health & safety risks involved. This will also work in our favour as equipment becomes more efficient, composite materials are developed, and enhanced vessel capability becomes available. We don’t have a crystal ball that will tell us what will happen in the future, but we are aware of a number of things which are being researched and explored. The conversion of wind into electrical power has been exploited for hundreds of years and although improvements have been made in its efficiency, the matter of storage is still relatively inefficient as we explore other possibilities. Technology and progress will always work towards our understanding until we can gain the benefit of experience in use.
Vessel Procurement & Capability

Efficiency comes from rhythm and flow. Vestas manufactures 2,500 of its 2–3 MW turbines a year. Globally, only 1000 wind turbines in total have been installed offshore, in small, unconnected projects with different turbines and manufacturers. Where is the rhythm and flow? The Baltic needs to be a coordinated market, with a collaboratively developed single technology stream to fill it.

Light and simple

Wind turbine technology—rotors, nacelles, control systems—is knowledge intensive. But the tower and foundations remain materials intensive, particularly offshore.

Guyed towers in steel halve the material used in the tower and foundations. Using composites halved this to 640 t, but composites would make the complete guyed tower and foundation assembly 240 t.

This makes the totally assembled wind turbine—rotor, nacelle, tower and tower foot, guy cables and screw anchors, coiled subsea cable ready for roll-out on the seabed—handle-able at sea. Seabed-mobile units can rapidly install and tighten the screw pile guy anchors when the turbine installation catamaran stands the wind turbine in place. This vessel picks the assembled turbine up from the dock, delivers it to location, installs it and returns, all in one smooth process. This is high speed manufacturing at sea.
Agile and ageless
Moving to composites for the tower and guy lines not only drops the weight, cost and intrinsic energy content of the turbine. It doubles the life of the installation. Putting critical electricity-generating infrastructure at sea with a design life of only 20 years is inadequate. Guyed towers use geometry, not brute force, to effectively transfer the loads into the seabed and fibre reinforced composites, which are corrosion-free and survive fatigue loads better than metals, will do this for 40–60 years.

Halt the development of bigger blades and instead develop agile blades that ride the turbulent gusts more smoothly and extract steady power from the wind while dodging the varying loads. At its core, wind turbine design is still very crude. Rotors are assumed to be flat discs. Blades are assumed to be radial. The analytical tools are available to allow for the bend/twist coupling that a feather uses to soften a load, and to allow for the controlled down-wind hinging of blades, to lighten the rotor and balance gust loads with centrifugal forces. Use these tools to design long life fatigue-dodging rotors. Lightweight, agile rotors on taller, lightweight composites guyed towers, give a route to energy-efficient, cost effective, long term electricity generation.

Jim Platts
University of Cambridge
e-mail: mjplatts@eng.cam.ac.uk

There are several definitions describing maritime spatial planning (MSP), but in general it is a ‘...process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process’ [Ehler, 2009]. Offshore wind energy (OWE) is one of the activities that is developing very rapidly in the Baltic Sea, and thereby also requires maritime space, and proper knowledge about how and where to allocate new installations.

Offshore renewable energy is expected to play an important role in the Baltic Sea in order to reach the EU renewable energy targets for 2020. The tendency is a dramatic increase in OWE development, and this is expected to continue growing after 2020. On the one hand offshore renewable energy is competing with traditional sea uses, but on the other hand OWE is the activity that has fostered initiation of MSP processes in many states in the Baltic Sea Region. Each new and developing activity brings a certain pressure on the marine ecosystems. With increasing pressures it becomes increasingly necessary to manage the sea space efficiently and in a coordinated way, not only nationally but also across national borders. There are certain interdependencies between MSP measures on national and transnational levels. Usually national decisions can have an impact on other countries that share the same sea. Sea uses transcend national borders and, therefore, must be discussed cooperatively. MSP approaches at the national level need to be compatible with a cross-border perspective, and vice-versa, to ensure that together they can deliver the best basis for planning and decision making.

Although there is a strong support for MSP cross-border cooperation from the European Commission, there is little or no firm guidance on how this should be achieved. Related to this, national MSP initiatives have not sufficiently integrated the international context, and the BSR countries usually do not have sufficient frameworks in place to encourage future cooperation. To change this, the European Commission has limited options: voluntary guidelines encouraging cross-border cooperation; support to individual regional projects and initiatives; establishing MSP expert working groups; or introducing an MSP Directive that creates a framework for cooperation.

In general, in the South Baltic there is not much on-going zoning for OWE, except in Germany, Denmark and Sweden. In Denmark, offshore renewable energy and marine areas: the Gulf of Bothnia, the Baltic Sea, and the Skagerrak and Kattegat.

Although there is a strong support for MSP cross-border cooperation from the European Commission, there is little or no firm guidance on how this should be achieved. Related to this, national MSP initiatives have not sufficiently integrated the international context, and the BSR countries usually do not have sufficient frameworks in place to encourage future cooperation. To change this, the European Commission has limited options: voluntary guidelines encouraging cross-border cooperation; support to individual regional projects and initiatives; establishing MSP expert working groups; or introducing an MSP Directive that creates a framework for cooperation.

In general, in the South Baltic there is not much on-going zoning for OWE, except in Germany, Denmark and Sweden. In Denmark, offshore renewable energy energ-
B. Regional challenges and opportunities in offshore wind energy

National MSP is a pre-condition for successful transnational cooperation on marine planning and OWE growth in the region. Those aspects include planning time-frames, onshore and offshore grid infrastructures, data formats and availability, research methodologies and efforts, and some management measures such as procedures for permissions. It is clear that transnational approaches to MSP can benefit offshore wind energy by adding increased efficiencies resulting from cross-border coordination. This will result in:
- reduced planning risks for developers – stakeholders involvement processes reduce the conflicts in the initial stage of planning;
- expanded opportunities for deployment – scientifically based allocation of sea spaces for OWE park developments and for grids;
- cost savings that could arise from shared infrastructure;
- minimized environmental impacts;
- maximized economic efficiency of the installations.

Currently, Offshore Wind Energy is hardly competitive with onshore or other renewable electricity generation. This section gives a brief account of how to support OWE.

The deployment of OWE can be desirable for several reasons. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources. Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources.

Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources. Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources.

Wind power is expensive. The cost of generating electricity from wind has fallen dramatically over the past few years. Between 1990 and 2002, world wind energy capacity doubled every three years and with every doubling prices fell by 15%. Wind energy is competitive with new coal and new nuclear capacity even before any environmental costs of fossil fuel and nuclear generation are taken into account. As gas prices increase and wind power costs fall – both of which are very likely – wind becomes even more competitive, so much so that sometime after 2010 wind should challenge gas as the lowest cost power source. Furthermore, the wind is a free and widely available fuel source, therefore once the wind farm is in place, there are no fuel or waste related costs.

**Offshore wind farms won’t be able to withstand a hurricane.**

Turbines are designed to shut down in excessive wind (often 50-60 miles per hour) by ‘ feathering’ blades so they don’t catch wind, and applying breaks. Wind farms located in hurricane prone areas can be designed to withstand winds in excess of 150 mph (67.056 m/sec) – or a Category 4 hurricane.

**Operational support**

- Price-based e.g. €/MWh
- Quantity-based e.g. €/MWh/year
- Feed-in tariff
- Price premium
- Tendering
- Quota

**Figure 13. Overview of operational support schemes**

**Economics – do subsidies help developing offshore wind energy?**

Currently, Offshore Wind Energy is hardly competitive with onshore or other renewable electricity generation. This section gives a brief account of how to support OWE.

The deployment of OWE can be desirable for several reasons. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources.

Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources. Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources.

Wind power is expensive. The cost of generating electricity from wind has fallen dramatically over the past few years. Between 1990 and 2002, world wind energy capacity doubled every three years and with every doubling prices fell by 15%. Wind energy is competitive with new coal and new nuclear capacity even before any environmental costs of fossil fuel and nuclear generation are taken into account. As gas prices increase and wind power costs fall – both of which are very likely – wind becomes even more competitive, so much so that sometime after 2010 wind should challenge gas as the lowest cost power source. Furthermore, the wind is a free and widely available fuel source, therefore once the wind farm is in place, there are no fuel or waste related costs.

**Operational support**

- Price-based e.g. €/MWh
- Quantity-based e.g. €/MWh/year
- Feed-in tariff
- Price premium
- Tendering
- Quota

**Figure 13. Overview of operational support schemes**

**Economics – do subsidies help developing offshore wind energy?**

Currently, Offshore Wind Energy is hardly competitive with onshore or other renewable electricity generation. This section gives a brief account of how to support OWE.

The deployment of OWE can be desirable for several reasons. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources.

Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources. The main ones are reduced CO2 emissions in comparison with conventional power generation, technology development, increased independence from fossil-fuel imports, and positive economic effects for coastal regions, e.g. by employment effects. These goals need to be weighed together with other targets, e.g. cost-efficient deployment of a country’s renewable resources. Support for OWE can be reached by different measures. It is common practice not to encourage the deployment of a country’s renewable resources.

Wind power is expensive. The cost of generating electricity from wind has fallen dramatically over the past few years. Between 1990 and 2002, world wind energy capacity doubled every three years and with every doubling prices fell by 15%. Wind energy is competitive with new coal and new nuclear capacity even before any environmental costs of fossil fuel and nuclear generation are taken into account. As gas prices increase and wind power costs fall – both of which are very likely – wind becomes even more competitive, so much so that sometime after 2010 wind should challenge gas as the lowest cost power source. Furthermore, the wind is a free and widely available fuel source, therefore once the wind farm is in place, there are no fuel or waste related costs.
B. Regional challenges and opportunities in offshore wind energy

As described, a number of different support mechanisms are applied in different European countries. For all of them, it is important for OWE that there are specific regulations: a feed-in tariff for offshore wind energy needs to be set higher than for onshore wind. Similarly, the number of tradable certificates issued per MWh might be higher for offshore than for onshore electricity generation. This general technology differentiation can be extended to other factors within the offshore wind energy. For example, policymakers choose if they want one general support level for all offshore wind sites or if they prefer to differentiate according to e.g. distance to shore, water depth or the use of specific technologies.

Also grid access conditions impact the economics of single projects, and support levels should reflect the national regulations. Finally, cooperative projects between several countries, possibly with a combined support mechanism for OWE, may be a promising option for a least-cost resource deployment in the future.

As described, a number of different support mechanisms are applied in different European countries. For all of them, it is important for OWE that there are specific regulations: a feed-in tariff for offshore wind energy needs to be set higher than for onshore wind. Similarly, the number of tradable certificates issued per MWh might be higher for offshore than for onshore electricity generation. This general technology differentiation can be extended to other factors within the offshore wind energy. For example, policymakers choose if they want one general support level for all offshore wind sites or if they prefer to differentiate according to e.g. distance to shore, water depth or the use of specific technologies.

Also grid access conditions impact the economics of single projects, and support levels should reflect the national regulations. Finally, cooperative projects between several countries, possibly with a combined support mechanism for OWE, may be a promising option for a least-cost resource deployment in the future.

The offshore wind industry is a growing economy that is meant to provide the most important sustainable energy source in the future. To explore the offshore wind resources, the countries with coastal areas need a skilled work force. Up to now the number of wind turbines reaping the sea wind is quite small. In contrast to the short installation phase, which is done by international crews, the operation phase demands a local work force over many years. Having a look at the persons now working in the offshore wind business, it is obvious that the background of these persons is quite heterogeneous. Nearly none has completed an offshore wind technician program as a proper education. Some employees might have onshore wind experience that has been added to offshore skills adapted from the oil and gas business. The people that now spend their daily work on offshore wind turbines must be seen as prototypes of the personnel that are needed in the future.

The South Baltic Region has a maritime industry tradition. In spite of this, it cannot be expected that a skilled work force that suits all the needs of the offshore wind sector is available. Is there a work force that can be developed to fit the needs? Provided that a work force is available, which educational level does it have? An ‘offshore service technician’ is not a job just anybody is able to do. First, there are physical and psychological restrictions. This is of course no matter of gender, but working at heights and working without visible contact to the shore is two reducing factors.

Just as other renewable energies, offshore wind is not that well known publicly. So, the possibility to make a career in the wind sector in general is more or less unknown. Promotion of the possible careers within the business should be the first move to raise public interest, followed by the development of qualification programs that fit the needs of the branch. As shown in Fig. 15, the available work force has to be developed in steps. Starting with mechanical and electrical engineers without wind knowledge the ‘wind technician’ will be the next level. Onshore experience with added specific

**Figure 15. Possible development of the available work force in the offshore wind industry**

Sascha T. Schröder
DTU Management Engineering
e-mail: sas@dtu.dk

---

**Figure 14. The Middelgrunden offshore wind park close to Copenhagen (© Sascha Schröder).**
B. Regional challenges and opportunities in offshore wind energy

The EU target of 100 GW offshore wind power in 2030 indicates a 10 fold expansion, and that the offshore turbine technology will be different from the onshore turbines. The main difference will be the size, because of less environmental restriction at offshore sites, but also the reliability must be much higher because repairs are expensive. This has caused a trend towards replacement of gearboxes and DFIG generators with direct drive generators based on permanent magnets. The number of moving parts is thereby reduced (Fig. 17), but magnets will be needed in large quantities — in the order of 700 kg/MW [Jensen et al., 2011]. Thus, if all new offshore turbines in the EU should be of the PM direct drive type, the need will be in the order of 70,000 tons of magnets by 2030.

Strong permanent magnets of the composition R2Fe14B are based on the rare earth elements (R = Nd, Pr & Dy) and the supply of these materials to the European industry might become a challenge, since the production is currently dominated by China. Market distortions caused the price of these elements to increase by a factor of 10 in the summer of 2011 (Fig. 18). Several industries are considering reducing the use of these magnets in order to avoid the dependence on Chinese exports. Even though the price bubble shown in Fig. 18 has burst, it is interesting to see that the price of both the Nd and Dy raw materials have not dropped to the levels before the peak. Especially the Dy price is still quite high, because this element is 10 times as abandoned as Nd. The element is needed in the

Figure 16. Offshore safety training

Offshore training (Fig. 16) will qualify a person as an ‘offshore wind technician’.

Qualification is a continuous process. Qualified offshore service technicians will not stay their whole career on the turbines. It is expected that the average career of an offshore service technician will not be longer than ten to fifteen years, due to physical and individual issues. The time span of working offshore depends on the working conditions in the job. For land based technicians, the career could be longer than fifteen years, but for employees staying offshore over weeks it is not expected that such a job is done more than ten years on average. A steady replacement is thus needed.

The Offshore Wind branch offers financially attractive career opportunities for numerous employees in the south Baltic region. A work force trained on a certain level is available — but these human resources need to be developed.

Figure 17. The basic principles of a permanent magnet direct drive generator showing the cross section of one of many polepairs on a large diameter ring. The two magnets are mounted on the rotor steel laminates, which are providing a magnetic flux path from the north to the south pole of the magnets. A similar flux path is established above the two magnets on the stator side, where the magnetic flux is passing through a set of coil windings collecting the induced voltage into 3 phases [Reproduced from Abrahamsen et al., 2012]
B. Regional challenges and opportunities in offshore wind energy

The grid connection of offshore wind farms is a critical and challenging factor. Electricity generated at sea must be fed into the transmission network and transported to consumers. This requires submarine cables able to transmit vast amounts of power over distances of 100 km and more.

Technology

Offshore wind farms located nearshore (mainly in Denmark, Sweden and the German Baltic Sea) are connected to the mainland via high voltage alternating current (HVAC) cables. However, for longer distances and high wind farm capacities, high transmission losses arise from the use of AC technology. Therefore, most German offshore wind farms in the North Sea are connected via high voltage direct current (HVDC) technology.

In general, each offshore wind farm has its own transformer platform, to which wind energy turbines are connected in groups and where the voltage is transformed to a higher level for transmission. For AC connections, the power then goes directly to the next grid node on land (Fig. 19). With most DC connections, power from several neighbouring wind farms is then usually collected in an additional converter platform at sea (so-called cluster connections). From there the electricity is transmitted via a sea cable, with high level capacities of up to 900 MW, to the mainland. Cluster connections are more efficient and have a reduced impact on nature.

In addition to separate national grid connection solutions, it is possible to combine the grid connection of offshore wind farms with cross-border transmission capacities (interconnector solutions). Planning for transnational clustering and a coordinated development of European grid infrastructure projects, e.g. NSCOGI, promotes flexible and harmonized technical standards with respect to technology and technical choices. This may help to improve the economics and security of the supply, as well as strengthen the European electricity market. The Kriegers Flak project in the Baltic Sea may serve as an interconnector between Germany, Sweden and Denmark in the future.
CONSTRUCTION – OFFSHORE WIND FARM DESIGN

The present section will present a brief overview of two of many aspects to consider when designing an offshore wind farm. The first is the wind resource assessment and the second is the choice of an appropriate foundation for offshore turbines. To assess the wind resource at a particular location, a wind atlas or a meteorological computer model is used. If the preliminary assessment brings satisfactory results, a meteorological mast or a laser device called LiDAR is erected at the location to gather wind measurements for at least a period of six, and preferably twelve, months.

Table 2. Selection of turbine foundations for offshore application

<table>
<thead>
<tr>
<th>Visualization</th>
<th>Name and description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAVITY BASE</td>
<td>• Heavy displacement structure</td>
</tr>
<tr>
<td></td>
<td>• Usually made of concrete</td>
</tr>
<tr>
<td></td>
<td>• Stands on the seabed</td>
</tr>
<tr>
<td></td>
<td>• 15-25 m diameter base</td>
</tr>
<tr>
<td></td>
<td>• Semi-hard to uniform seabed</td>
</tr>
<tr>
<td></td>
<td>• Water depth up to approximately 10 m</td>
</tr>
<tr>
<td></td>
<td>• Filled with stones or other ballast</td>
</tr>
<tr>
<td></td>
<td>• Weight from 1500 to 4500 tons</td>
</tr>
<tr>
<td></td>
<td>• Seabed must be prepared by dredging and backfilling material</td>
</tr>
<tr>
<td>MONOPILE</td>
<td>• 4-8 m diameter steel tube</td>
</tr>
<tr>
<td></td>
<td>• Driven into the seabed using a hydraulic hammer</td>
</tr>
<tr>
<td></td>
<td>• Stands upright because of the friction of the sealed on its sides</td>
</tr>
<tr>
<td></td>
<td>• Applicable at hard to semi-hard seabed conditions</td>
</tr>
<tr>
<td></td>
<td>• Water depth up to approximately 35 m</td>
</tr>
</tbody>
</table>

Current German Situation – intensive discussions in 2012/13

Since December 2006, the German transmission systems operators (North Sea: TenneT TSO GmbH; Baltic Sea: 50 Hertz Transmission GmbH) had been legally obligated to connect offshore wind farms to the mainland grid in time in their respective areas of control, and to cover the costs for this connection (Energy Industry Law, § 17 (2)). Connection lines for clusters of offshore projects are being planned but will require additional time. Up to now, three connections have been completed; two of these are employing conventional HVAC technology (alpha ventus and Baltic I), and one has been built with HVDC (BARD Offshore1).

In 2012, the debate concerning offshore grid connection and the associated liability issues regarding delays or interruptions was the central topic for the German offshore sector, and this will continue to be relevant in 2013. TenneT TSO, the TSO in charge of the German North Sea, did not award any new contracts for grid connections in Germany between the end of 2011 and 2012.

The unresolved questions relating to the expansion of the grid then resulted in a climate of uncertainty which pervaded the entire sector. Suppliers, ports, shipyards and the entire maritime economy are all in need of follow-up contracts, since further investment in the construction of wind farms has been placed on hold until the legal issues surrounding offshore grid connection in general, and liability questions regarding delays and disruptions of grid connection in particular, have been clarified.

System change: On route to an offshore grid plan

Following the adoption of the Third Act Revising the Legislation Governing the Energy Sector (EnWG-E) in December 2012, a new grid connection regime for offshore wind farms in Germany came into effect on December 28th, 2012.

This is a significant milestone in the evolution of the legal framework governing the creation of a new electricity infrastructure in the North Sea and the Baltic Sea. The new legislation covers the development of a comprehensive offshore grid development plan (ONEP), a binding set of roadmaps for their realisation, and a variety of damage mitigation strategies which are intended to pave the way for an economically efficient expansion of the grid. The offshore grid development plan was prepared by the transmission grid operators in the first quarter of 2013. It was officially released by the Federal Network Agency on March 3rd, and is open for public consultation until mid-April 2013.

The new legal framework must now be swiftly filled with substance in order to prevent any further delays in the future development of offshore wind energy in Germany. In addition, the transition phase must be implemented prudently, since the ‘old’ system will still apply to those wind farms where construction is starting in 2013. An early priority for the transmission grid operator is to commission the outstanding grid connections in the North Sea (BorWin3 and 4) as soon as possible. In February 2013, the contract for cluster DolWin3 was already signed between TenneT and ALSTOM.

It is essential to fill this new framework with substance and to implement the system change rapidly and efficiently. If this succeeds, Germany will have placed an important milestone, also on the international level.
to onshore wind farms. Regarding wind characteristics, generally larger wind speeds and smaller ambient turbulence levels are observed offshore than onshore.

The second subject covered in this section is an overview of turbine foundations for offshore application (http://offshorewind.net/). Four different foundation types are presented: gravity base, monopile, tripod and jacket (Table 2). Three of these—gravity base, monopile and tripod—are used at most offshore wind farms, and the monopile type is the most common. Other foundation types exist, although they are used less commonly.

### Table 2: Visualization and description of foundation types

<table>
<thead>
<tr>
<th>Visualization</th>
<th>Name and description</th>
</tr>
</thead>
</table>
| **TRIPOD**    | • Single steel tube above the water surface  
                • Under water – three-legged foundation  
                • Each leg ends in a pile sleeve  
                • From each pile sleeve an anchor pile is driven into the seabed  
                • Great stability  
                • Reliable at depths up to 50 m  
                • Expensive to produce, takes long to install |
| **JACKET**    | • Lattice-type structure  
                • Low weight  
                • Efficient use of material  
                • Applicable at the largest water depths among all foundations  
                • Each leg ends in a pile sleeve  
                • From each pile sleeve an anchor pile is driven into the seabed  
                • Overall, as expensive as a tripod  
                • Expensive ice protection |
The aim of this work was to provide a wind atlas for the South Baltic Sea Region. Only a limited number of observations from meteorological masts were available, and therefore it was decided to use an atmospheric model to assess the wind climatology in this region. The Weather Research and Forecasting (WRF) mesoscale model was used and the resulting wind climatologies were compared with data from Danish and German tall meteorological masts. There was good agreement between model results and measurements, particularly at the 100 m level, which may be the hub-height for new large offshore wind farms.

A key result of the work is the map of mean wind speed at 100 m calculated with a 5 km by 5 km spatial grid spacing (Fig. 20). In the Baltic Sea, wind speeds are higher in the western part, south of Sweden and in the area east and north of the Danish island of Bornholm.

After an initial testing to find the best model configuration, the WRF model simulations were done in a nested domain with high spatial resolution for around 4 years. In addition, the long-term wind statistics for 30 years was calculated, using the NCAR-NCEP reanalysis data, to provide a basis for long-term adjustment of the results. The long-term analysis indicated that the wind climate in the South Baltic Sea is spatially highly variable over a 30-year period. However, there were no long-term observations available to validate the accuracy of this calculation.

Another task was to use observations from Earth observing satellites to estimate the mean wind speeds at 10 m above sea level. The Envisat ASAR wind speed maps have a spatial resolution of 2 km by 2 km (Fig. 21).

It is possible to view the results at the following web-site:
At http://soprano.cls.fr web-site select ‘Wind’ (upper left area) → select ‘Statistics (L3)’ in menu → select ‘Norsewind’ in right side of panel → select the map you would like to see
• Density of coverage (gives you the number of overlapping maps)
• Mean 10 m height ocean surface wind speed
• Shape parameter k (gives you Weibull k)
• Scale parameter A (gives you Weibull A)
• Available wind power density
If you click a yellow marker in the map you can see the wind rose for the location.

Figure 20. Mean wind speed at 100 m for the South Baltic Sea Region during the period January 2007 to December 2009.
The available maps include a number of overlapping Envisat ASAR images, mean wind speed maps, Weibull A and k maps, and energy density maps.

The wind rose as observed from Envisat ASAR in one location in the Baltic Sea (indicated in Fig. 21).

The WRF wind statistics are available at http://geoportal.lneg.pt//index.php?lg=en&state=Inicio. Further information about the wind atlas in the Baltic Sea is given in the reports by Peña et al., 2011, Hasager et al., 2012, Hasager et al., 2011, Karagali et al., 2012, Karagali et al., 2013a, Karagali et al., 2013b. In Hasager et al., 2011 a table of energy resource statistics based on satellite data is presented in close vicinity to Nysted, were brought online in 2009 and 2010. Those projects raised all known technical benchmarks within the field, and greatly increased the understanding of offshore windpower impacts on the environment through intensive monitoring and several research projects. In March 2012, the new Danish parliament approved an increase in the country’s goal for windpower development — 50% of the electricity supply should come from wind power by 2020. This goes beyond its commitment under the European Union targets, which is to provide 31% of electricity from renewables source. New offshore projects will play a crucial part in meeting this goal. An additional 1.5 GW offshore capacity is now planned for by the Danish Energy Agency, a government body, with active participation from other organizations, such as the transmission system operator Energinet.dk and the Danish Wind Industry Association.

Selected wind farms in Denmark:

- Middelgrunden (2001): When commissioned, it was the world’s first offshore wind farm using multi-megawatt wind turbines and was the largest offshore installation (40 MW) at the time. Half of the turbines are owned by DONG Energy (Denmark’s utility provider) and the other half is owned by a cooperative, which is a private partnership of local citizens that was formed in 1997. The wind farm has proved to be a success. With an estimated 20% higher performance during more than 20 years of operation has been good, with an estimated 20% higher output than with comparable land sites. Along with an increased understanding of wind turbine design and operation, additional knowledge has been gained about offshore wind conditions.
- Vindeby (1991): The wind farm consists of eleven 450 kW stall controlled wind turbines, and is located approximately 2 km from the coastline. Monitoring and several research projects.
- Anholt (2014): When Anholt’s 400 MW comes online, 15% of the Danish electricity supply will be based on offshore wind. Based on the experience from previous tenders for offshore wind farms in Denmark, the Danish Energy Agency has adjusted the procedure that was used in the tendering processes for Nysted II and Horns Rev II. This means that the site development of the Anholt 400 MW offshore wind farm was done by Energinet.dk before being opened for public tenders.
- Kriegers Flak: The next large offshore wind farm will be the ground-breaking 600 MW Kriegers Flak project. When completed, it will be the world’s first offshore wind farm with the grid connection replaced by a transmission line between Denmark and Germany, with a possibility for Sweden to share it as well. This project will showcase new grid solutions needed to enable energy consumers in the countries surrounding the Baltic Sea to tap into the vast energy resources of offshore wind.

In March 2012, the new Danish parliament approved an increase in the country’s goal for wind power development — 50% of the electricity supply should come from wind power by 2020. This goes beyond its commitment under the European Union targets, which is to provide 31% of electricity from renewables source. New offshore projects will play a crucial part in meeting this goal. An additional 1.5 GW offshore capacity is now planned for by the Danish Energy Agency, a government body, with active participation from other organizations, such as the transmission system operator Energinet.dk and the Danish Wind Industry Association.

Selected wind farms in Denmark:

- Middelgrunden (2001): When commissioned, it was the world’s first offshore wind farm using multi-megawatt wind turbines and was the largest offshore installation (40 MW) at the time. Half of the turbines are owned by DONG Energy (Denmark’s utility provider) and the other half is owned by a cooperative, which is a private partnership of local citizens that was formed in 1997. Records of the actual wind turbine output are publicly available through the cooperative’s website along with any information related to the planning, construction and management of the wind farm for others to learn directly from their experiences. Objectively, the wind farm seemed to be a difficult project. This was because of the site’s close proximity to Denmark’s capital, main airport and also to an important shipping lane and a bird sanctuary on the island Saltholm. However, due to the local ownership provided by the coop and excellent communication with the local community, the wind farm has proved to be a success.
- Vindeby (1991): The wind farm consists of eleven 450 kW stall controlled wind turbines, and is located approximately 2 km from the coastline. Monitoring and several research projects.
- Anholt (2014): When Anholt’s 400 MW comes online, 15% of the Danish electricity supply will be based on offshore wind. Based on the experience from previous tenders for offshore wind farms in Denmark, the Danish Energy Agency has adjusted the procedure that was used in the tendering processes for Nysted II and Horns Rev II. This means that the site development of the Anholt 400 MW offshore wind farm was done by Energinet.dk before being opened for public tenders. Kriegers Flak: The next large offshore wind farm will be the groundbreaking 600 MW Kriegers Flak project. When completed, it will be the world’s first offshore wind farm with the grid connection replaced by a transmission line between Denmark and Germany, with a possibility for Sweden to share it as well. This project will showcase new grid solutions needed to enable energy consumers in the countries surrounding the Baltic Sea to tap into the vast energy resources of offshore wind.
C. Regional outlook on offshore wind energy

Table 3. Characteristics of wind farms in Denmark [www.offshorecenter.dk/offshorewindfarms.asp]

<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Sea name</th>
<th>Region</th>
<th>Project capacity MW</th>
<th>Turbine model</th>
<th>Number of turbines</th>
<th>Foundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avedøre Holme</td>
<td>Koge Bugt</td>
<td>Hvidovre</td>
<td>10.8</td>
<td>SWT-3.6-120 Siemens</td>
<td>3</td>
<td>Gravity-Base</td>
</tr>
<tr>
<td>Frederikshavn</td>
<td>Kattegat</td>
<td>Frederikshavn</td>
<td>16.6</td>
<td>N90/2300, Vestas V90 3MW/BONUS R3, 2.4MW</td>
<td>4</td>
<td>Various (Monopile and Bucket)</td>
</tr>
<tr>
<td>Horns Rev 1</td>
<td>North Sea</td>
<td>Blavandshuk</td>
<td>160</td>
<td>V80-2.0 MW</td>
<td>8</td>
<td>Monopile</td>
</tr>
<tr>
<td>Horns Rev 2</td>
<td>North Sea</td>
<td>Blavandshuk</td>
<td>209.3</td>
<td>SWT-2.3-93 Siemens</td>
<td>9</td>
<td>Monopile</td>
</tr>
<tr>
<td>Middelgrunden</td>
<td>Øresund</td>
<td>København</td>
<td>40</td>
<td>R76/2000 Bonus</td>
<td>20</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Nysted</td>
<td>Baltic Sea</td>
<td>Nysted</td>
<td>165.6</td>
<td>B82/2300 Bonus, SWT-2.3-82</td>
<td>72</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Poseidon</td>
<td>Smålandshavet</td>
<td>Lolland</td>
<td>0.03</td>
<td>GAIA 0.011 MW</td>
<td>3</td>
<td>Floating</td>
</tr>
<tr>
<td>Rødland 2</td>
<td>Baltic Sea</td>
<td>Holeby</td>
<td>207</td>
<td>SWT-2.3-93 Siemens</td>
<td>90</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Rønland</td>
<td>Thyboron -Harboore</td>
<td>Nissum Bredning</td>
<td>17.2</td>
<td>SWT-2.3-93 Siemens, Vestas V80-2.0 MW</td>
<td>8</td>
<td>High-Rise Pile Cap (Heel)</td>
</tr>
<tr>
<td>Samsø</td>
<td>Kattegat</td>
<td>Samsø</td>
<td>23</td>
<td>B82/2300 Bonus, SWT-2.3-82</td>
<td>10</td>
<td>Monopile</td>
</tr>
<tr>
<td>Sprogø</td>
<td>Storebælt</td>
<td>Korsør</td>
<td>21</td>
<td>V90-3.0 MW Offshore Vestas</td>
<td>7</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Tune Knob</td>
<td>Kattegat</td>
<td>Odder</td>
<td>5</td>
<td>V90-3.00kW Vestas</td>
<td>10</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Vindeby</td>
<td>Smålandshavet</td>
<td>Ravnsborg</td>
<td>4.95</td>
<td>B35/450 Bonus</td>
<td>11</td>
<td>Gravity - Base</td>
</tr>
<tr>
<td>Anholt (under construction 2013)</td>
<td>Kattegat</td>
<td>Nørre Djurs</td>
<td>300.4</td>
<td>SWT-3.6-120 Siemens</td>
<td>111</td>
<td>Monopile</td>
</tr>
</tbody>
</table>

Figure 23. Location of wind farms in Denmark [© POMCERT]
C. Regional outlook on offshore wind energy

To ensure that the future development of offshore wind turbines does not clash with other major public interests, and that the development is carried out with the most appropriate socio-economic priorities, the Danish Energy Authority, in conjunction with other relevant authorities, has mapped the most suitable sites for future offshore wind farms. This mapping is a dynamic process because the framework conditions for developing offshore wind farms are continuously changing. In 2007, the Danish Energy Authority published a technical mapping report identifying 23 suitable sites, each with space for around 200 MW. These potential offshore wind farms could provide a total installed capacity of 4,600 MW. With an average wind speed of around 10 meters per second they could produce around 4,000 full-load hours a year. Designated areas are located at sea depths of 10—35 meters, and 22—45 kilometres from the coast, which means that a balance has been struck between economic considerations and the visual impact from land.

Nearshore wind farms

A new development in Danish offshore wind energy is the planning of coast-near wind farms, i.e. located 4—10 km from the coast. The wish is to reduce the very large initial investments which are seen for regular offshore wind farms. In November 2012 the Danish government made an agreement where six sites along the Danish coast were selected for establishing wind farms with a total capacity of 500 MW. The sites were selected based on wind economy and local acceptance. Local citizens and companies will be able to invest in the wind farms. The nearshore wind farms should produce energy from 2020 at latest.

OFFSHORE WIND ENERGY IN GERMANY

According to the government’s ‘offshore strategy’ of 2002, there should be a total of 20,000 to 25,000 MW of offshore wind capacity by 2030 in the German North Sea and Baltic Sea. The annual energy yield from such installations is expected to climb to 85—100 TeraWatt-hours (TWh), which would equal 15% of the electricity consumption in Germany.

Selected wind farms in Germany

In September 2005, Stiftung O nshore-Windernergief founded (the German Offshore Wind Energy Foundation) acquired the project rights of ‘Borkum West’ from the developer Prokon Nord, with a grant provided by the Federal Ministry of the Environment. One year later, the site was leased, under the name ‘alpha ventus’, to the German Offshore Test Site and Infrastructure Company, called DOTI, as a pilot project for testing and research.

Apart from two different turbine concepts, also the foundations used in the test site are different. The Multibrid turbines have been erected on a tripod construction, whereas the REpower turbines have been installed on a jacket construction. New territory has also been entered with respect to the permitting procedures, since alpha ventus is not only the first offshore wind farm in Germany, but also located beyond the 12 sea mile zone (SMZ) in the Exclusive Economic Zone (EEZ). The project has proven the practicability of the extensive licensing requirements imposed on offshore wind farms in Germany. Thus, alpha ventus also provides a testing ground for administrative requirements, thereby paving the way for further development of wind energy far offshore, both in Germany and throughout the rest of Europe.

Today, offshore wind power plants are found in five additional locations in Germany (Table 4., and Fig. 24.), in 2010, the first two commercial offshore projects were built in German waters. Baltic 1 with 21 turbines (each with 2.3 MW rated capacity) in the Baltic Sea off Rostock, and BARD Offshore 1 with 80 turbines (each with 5 MW rated capacity) in the North Sea.


<table>
<thead>
<tr>
<th>Wind turbine</th>
<th>Sea name</th>
<th>Region</th>
<th>Project capacity MW</th>
<th>Turbine model</th>
<th>Number of turbines</th>
<th>Foundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENOVA Offshore</td>
<td>Ems-Emden</td>
<td>North Sea</td>
<td>4.5</td>
<td>E122/4500 Enercon</td>
<td>1</td>
<td>Monopile</td>
</tr>
<tr>
<td>Hooksiel</td>
<td>North Sea</td>
<td>Niedersachen</td>
<td>5</td>
<td>Bard 50</td>
<td>1</td>
<td>Tripod</td>
</tr>
<tr>
<td>alpha ventus</td>
<td>North Sea</td>
<td>EEZ</td>
<td>60</td>
<td>M5000-116 Areva</td>
<td>12</td>
<td>Tripod and Jacket</td>
</tr>
<tr>
<td>BARD Offshore 1</td>
<td>North Sea</td>
<td>EEZ</td>
<td>400 (60 online)</td>
<td>Bard 50</td>
<td>80</td>
<td>Tripod</td>
</tr>
<tr>
<td>Baltic 1</td>
<td>Baltic Sea</td>
<td>SMZ</td>
<td>48.3</td>
<td>SWT-3.6-127 Siemens</td>
<td>21</td>
<td>Monopole</td>
</tr>
<tr>
<td>Breitling/ Rostock</td>
<td>Baltic Sea</td>
<td>Mecklenburg-Vorpommern</td>
<td>2.5</td>
<td>N90/2500 HS Offshore Nordex</td>
<td>1</td>
<td>Gravity-Base</td>
</tr>
</tbody>
</table>
As a result of Germany’s plans for future offshore wind energy development, the German Association of Machinery and Plant Manufacturers (VDMA) expects that the sector will employ an additional 20,000-30,000 workers and engineers – mainly in the economically less developed coastal areas in Northern Germany. Throughout Germany, however, the expansion of offshore wind energy is seen as a huge opportunity. The wind energy supply industry is distributed all over the country, including the traditional centres of machinery and plant building industry in the southern and western parts of Germany.

**OFFSHORE WIND ENERGY IN LITHUANIA**

First attempts to enter with wind power to offshore token place in 2002. Lithuanian Wind Energy Association was established with purpose to form overall set of advanced activities in on shore and offshore. Scientific preconditions for OWE development in Lithuania were formed during implementation of INTERREG Illa project ‘POWER — Perspectives of offshore wind energy development in marine areas of Poland, Lithuania and Kaliningrad region, Russia’ in 2006-2008.

Lithuanian Strategic Self-Management Institute participating in Leonardo da Vinci Lifelong learning and Transfer off Innovations programme projects e-WindTech, EMPRES, ELOMIPRES and ALPER together with partners from Spain, Greece, Portugal, Poland, Hungary, Turkey and Germany adopted Master degree course on offshore wind energy, which is teaching in Klaipeda university Maritime Institute. South Baltic cross-border co-operation programme projects WEBGR2 – Wind energy in Baltic Sea region, RES-Chains – Renewable energy chains in South Baltic Region enabled to investigate legislative barriers and energy storage opportunities together with partners from Denmark, Sweden, Germany and Poland. Universities and high vocational schools needs of new learning programmes.

Legislative ground for OWE development was set by accepted Republic of Lithuania Law on Renewable energy/learn-act/renewable-energy/myth-vs-fact that exposes us to unnecessary risks.

While nuclear generates zero carbon emissions, it has a whole set of environment problems. Constructing nuclear power plants is very carbon-intensive, uses vast amounts of concrete for construction, and requires a long lead time of 10 years or more. Nuclear is also dependent on a non-renewable fuel source, uranium.

Based on 2006 nuclear electricity generation and current technology, there is enough fuel for 100 years. However, with the global nuclear renaissance, we’re going to run out of fuel much sooner. And there are no long-term storage facilities in the U.S. for spent fuel rods, which means nuclear waste is being stored at power plants without the adequate facilities. All these factors show that nuclear power is a carbon intensive endeavor that exposes us to unnecessary risks.

First offshore wind energy system, WindMill1 was constructed by this enterprise and is in operation now in Nordic sea. More as three developing firms are operating preliminary investigations on OWE in Lithuania. So, only time will show when real steps on OWE planning and implementation will start. Klaipeda University Costal Research and Planning Institute are able and have appropriate equipment for make environment assessment studies of offshore wind power parks.

Lithuanian Wind Energy Association, Strategic Self-Management Institute, Innovations company Ekoenergy and Klaipeda Coastal research and Planning Institute made really big work for prepare overall system of OWE activities. South Baltic programme project SB-OFF.E.R. made frame for OWE cluster activities formation. West Lithuania Ship Yard has practical experience on construction of OWE wind turbine foundations, electricity substation. First offshore wind turbine mounting ship WindMill1 was constructed by this enterprise and it is in operation now in Nordic sea. More as three developing firms are operating preliminary investigations on OWE in Lithuania. So, only time will show when real steps on OWE planning and implementation will start. Klaipeda University Costal Research and Planning Institute are able and have appropriate equipment for make environment assessment studies of offshore wind power parks.

Next and essential step unlocking the possibilities to switch from the OWE vision to the real implementation — strategic action initiated by the Ministry of Environment to extend the spatial solutions of the territorially grounded National General Plan...
OFFSHORE WIND ENERGY IN POLAND

Development of the offshore wind energy sector in Poland

In 2009, the Polish Energy Policy till 2030, defined the general goal to create conditions for the offshore wind energy development in Poland. The National Renewable Energy Action Plan assumed, that the offshore wind farms with the capacity of 500 MW should be commissioned till 2020. Despite these general guidelines, Polish legal regulations did not offer the suitable conditions for the offshore wind energy development till 2011.

In July 2011, amendment to the act on the maritime areas and maritime administration opened the possibility to develop offshore wind energy in Poland. The new law enabled to locate offshore wind farms within the entire Polish Exclusive Economic Zone, while the territorial sea waters up to 12 nm out of the coast remained excluded from this opportunity. According to the regulations, investors may apply for the location permits which are valid for 30 years and may be extended for another 20 years. The permission fee amounts to 1% of the entire project CAPEX, but is split into 4 instalments, paid accordingly to the project development stages.

Figure 25. Potential plots for offshore wind power parks installation [CORPI]
C. Regional outlook on offshore wind energy

Offshore wind energy in Poland

Besides the growing interest of large energy companies in offshore wind projects, Poland possesses a significant industrial potential for development of the offshore wind energy sector, based on the shipyard industries located along the Polish coast in Gdansk, Gdynia and Szczecin. They and their co-operating industries have competence profiles that fit the needs of the OWE sector, both in terms of constructing wind turbine elements, installation works and producing dedicated vessels for transportation and installation of the offshore wind turbines.

Until now Polish companies have been successfully supplying the European offshore wind energy market with concrete and steel foundations for turbines and transformer stations, piles, transition sections, cathodic protections, main steel constructions of transformer stations, transportation barges, and the most sophisticated products - offshore wind farm installation vessels - Thor (2010), Innovation (2012) and Vidar (under construction, expected in 2013).

Therefore, the development of offshore wind energy constitutes an attractive alternative to the traditional specializations of the Polish shipyard industry. Hence, improvement of the conditions for offshore wind investments is expected to become a catalyst for development of both the sector itself and the shipyard industry with its co-operating industries.

According to the Maritime Institute of Gdansk, the theoretical wind power potential of the Polish maritime areas enables to develop up to 20 GW. However, different exclusion zones (e.g. Natura 2000, military, navigation), reduce the potential, which could be technically accessible till 2030 down to about 10 GW. Current analyses assume, that nearly 1 GW might be installed till 2020 and even 3-5 GW till 2025.

Meantime, the subsequent project development stages are being launched, including the Environmental Impact Assessment, grid interconnection applications and the export cables permitting. Till March 2013, eight EIA procedures have been started, while at least at few sites the environmental surveys have been carried out already in 2011 and 2012. In 2012 the national transmission system operator granted the grid connections permits for 2 projects with total capacity of 2,2 GW.

In 2003, Sweden decided to increase the use of renewable energy by 10 TWh from the 2002 level by 2010. In 2006, this target was raised to 17 TWh more than in 2002 by the year 2016. In June 2010, the Swedish Parliament decided to extend the electricity certificate system until 2035, and to increase the quota obligation to adapt this to the new goal of 25 TWh renewable electricity. This will contribute to providing Sweden with a more sustainable energy system.

In June 2009, Sweden adopted a national planning framework for 30 TWh wind power by 2020. In this context, a "planning framework" means that societal planning should target 30 TWh wind power electricity, and that the planning should not obstruct an expansion of wind power on that scale. However, the planning framework itself does not actually set an expansion target for wind power.

Offshore wind farms in Sweden

There are currently five offshore wind farms in Sweden (Tab. 5 and Fig. 27). The first Swedish offshore wind farm Bockstigen is operating since March 1998 and is located 3 km from the coast of Gotland. It was built as a demonstration project by the Swedish wind farm developer Vindkompagniet, the Danish wind turbine manufacturer Wind World and the British offshore construction company Seacore, and was partly funded under the EU-THERMIE program. Bockstigen is the fourth offshore wind farm world-wide, and was aimed at demonstrating the economic viability of offshore wind power. A number of innovative concepts were employed: Drilled monopile foundations were used to save costs. A new construction method was applied, making use of a jack-up barge. A new control system for the turbines and the whole wind farm was developed, which controls the maximum output power, the flicker and the reactive power consumption depending on online measurements of the actual grid state. All these new developments were implemented successfully, and a substantial cost reduction compared to previous offshore projects could be achieved.

Lillgrund Wind Farm is located about 10 km off the coast of southern Sweden, just south of the coast.
Öresund Bridge, where average wind speeds are 8 to 10 metres per second (26 to 33 ft/s). With 48 wind turbines (Siemens SWT-2.3-93) and a capacity of 110 MW, Västergötland is Sweden’s largest offshore wind farm, and will meet the domestic electricity demand of more than 60,000 homes. The farm’s turbines have a rotor diameter of 93 metres and a total height of 115 metres.

Utgrunden 1 was built in 2000 and consists of seven wind turbines that have a capacity of 1,425 kW each. It is located in the Kalmar sun, about 12 km from Bergkvara and 8 km from the island Öland. In a deal with Dong Energy, a Danish energy company, the energy company Vattenfall acquired 523 wind turbines in Sweden, Denmark, Poland and the UK in 2006. The acquisition included Utgrunden 1, which was made by GE.

The Vänern wind park is located in the Northern part of the lake near Gasinge, 7 kilometres from the shoreline. The project is particularly remarkable because it will generate information on how to make wind turbines function optimally in large lakes. It was implemented on a turn-key basis by the Swedish company Dynawind. The turbines of the Vindpark Vänern represent WinWind’s first delivery to an inland offshore project. All ten WWD-3 wind turbines have a 100 m rotor diameter and 88 metres hub-height.

The wind farm at Yttre Stengrund was erected in 2001 and consists of five wind turbines that have a capacity of 2 MW each. It is located in the sound Kalmar sun, about 4 km from the mainland and level with the southern headland of the island Öland. Vattenfall also had plans to construct five wind turbines near this water area, but the Swedish Armed Forces did not permit the project, due to the close proximity to an artillery range.

The first offshore wind turbines installed in Swedish waters may be replaced with larger, modern machines within the next few years, according to Windpower Offshore. If repowering takes place, it will be the first in the world for a commercial offshore wind park.

The Bockstigen project is approaching the end of its profitable operation period. Built between 1996 and 1997, Bockstigen features five Wind World 550 kW turbines, which are now seriously outmoded.

Based on the 1997 endowment from the Swedish Armed Forces, Wind World designed and produced five prototypes of Wind World’s 550-kW offshore wind turbine. The first offshore wind farm in Sweden was erected in 2005 and consists of five wind turbines that have a capacity of 2 MW each. It is located in the sound Kalmar sun, about 4 km from the mainland and level with the southern headland of the island Öland. The farm’s turbines have a rotor diameter of 93 metres and a total height of 115 metres.

In 2012, the largest number of turbines have been installed in Denmark (409), followed by Sweden (76) and Germany (68) (Table 7).

In 2012, the largest number of turbines have been installed in Denmark (409), followed by Sweden (76) and Germany (68) (Table 7). The Bockstigen project is approaching the end of its profitable operation period. Built between 1996 and 1997, Bockstigen features five Wind World 550 kW turbines, which are now seriously outmoded.

Generally, the total installed offshore wind capacity has been growing since the early 1990’s (Denmark and Sweden), but the most significant development has taken place after the year 2000 (Table 6) in Denmark, Sweden and Germany. Offshore wind farms have been planned also in Poland and Lithuania, but by the end of 2012 there were not yet any turbines erected in the eastern part of the South Baltic Region.

<table>
<thead>
<tr>
<th>Year</th>
<th>Denmark</th>
<th>Germany</th>
<th>Sweden</th>
<th>Lithuania</th>
<th>Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>49.05</td>
<td>0</td>
<td>2.75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>425.56</td>
<td>12</td>
<td>133.65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>865.65</td>
<td>72</td>
<td>163.65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>874.48</td>
<td>280.3</td>
<td>167.65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>1274.83</td>
<td>4000</td>
<td>215.85</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2020</td>
<td>1450</td>
<td>10000</td>
<td>1000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2025</td>
<td>1274.1</td>
<td>5000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2030</td>
<td>25000</td>
<td>10000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>


All the other companies have provided turbines in only one country, with significant contributions by Vestas in Denmark, BARD in Germany and Wind World in Sweden.

<table>
<thead>
<tr>
<th>Manufacturer of offshore wind turbines</th>
<th>Denmark</th>
<th>Germany</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens</td>
<td>313</td>
<td>21</td>
<td>48</td>
</tr>
<tr>
<td>Vestas</td>
<td>103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norden</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Enercon</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Multibird/AREVA</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repower</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BARD</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind World (A/S)</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Enron</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>NIEG Micon</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Dynawind</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>GE Energy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Number of turbines produced by different manufacturers sorted by countries (2012 cumulative).
C. Regional outlook on offshore wind energy

D. REGIONAL INITIATIVES FOR SUSTAINABLE OFFSHORE WIND ENERGY

- Lessons learnt
- From vision to the real actions
- Fascination Offshore – a wind energy exhibition
- How can OWE support development of other economy sectors?
- How offshore wind farms changed tourism industry
- How to deal with public in relation to offshore wind energy investments?
- Exhibition about offshore wind energy
- Experimental promotion of offshore wind energy
- Events in Karlskrona about offshore wind energy
- Knowledge Toolbox – offshore wind energy
The activities of the SB.OFF.E.R project were designed to support and promote development of the offshore wind energy in the South Baltic Region. Blazauskas & Paulauskas describe the development of supporting activities among many stakeholders in Lithuania in the article ‘From vision to real actions’.

Information, demonstration and visualisation are considered as main tools to educate people about advantages and disadvantages of offshore wind energy. The example from Germany described by Wagner et al. shows the benefits of an interesting exhibition (the article ‘Fascination offshore – a wind energy exhibition’). A different approach to exhibitions as implemented in Guldborgsund, Denmark, is described by Danborg in the article ‘Exhibition about offshore wind energy’. The Swedish example presented by Sturesson shows how to reach youths with information about offshore wind energy (the article ‘Events in Karlskrona about offshore wind energy’). The Polish example follows a similar approach via an experimental platform described by Zemsta & Miszewska in the article ‘Experimental promotion of offshore wind energy’.

These activities, as well as other educational efforts (crash courses, summer schools, road shows) implemented within the SB.OFF.E.R project were all designed to increase the public awareness and acceptance for offshore wind energy (Fig. 30). The importance of public acceptance is also emphasized by Clausen in the article ‘How to deal with the public in relation to OWE investments?’. In order to collect...
The development of the wind energy market in Lithuania started already in 1993, promoted by the Norwegian electricity enterprise Nord Trondelag Electricity Board. Quite a number of installations have been developed onshore since then. The first attempts to investigate the offshore potential were made in the period 2006–2008 within the framework of the INTERREG IIIa project ‘POWER – Perspectives of offshore wind energy development in marine areas of Poland, Lithuania and Kaliningrad region, Russia’ by the Lithuanian Wind Energy Association, Strategic Self-Management Institute and Coastal Research and Planning Institute of Klaipeda University. The feasibility study showed that Lithuanian EEZ and territorial waters could accommodate more than 1 GW of wind power installations offshore at a depth from 20 to 40 m (Fig. 31).

The vision to develop wind energy offshore has been supported by a thorough analysis of the existing legislative system, existing obstacles for developments in the sea, and identification of existing maritime uses, leading to OWE targets set by the national authorities. The OWE potential has been clearly understood by the potential investors interested in the fast developing market. This has resulted in three EIA studies for locations identified by the POWER project and some additional ones. But due to the formal uncertainties and the lack of a legislative framework for new development at sea, the projects have not been finally approved and therefore no implementation has taken place to date.

The demand for renewable energy and the high pressure from investors and researchers – in line with commitments to the EU – ensured that the Law on Renewable energy sources of the Republic of Lithuania was approved in May 2011. A special article in this law is dedicated to offshore wind power. The second important undertaking by the Government of the Republic of Lithuania was to prepare a regulatory framework for OWE development, auctions and purchase fees for the electricity produced, implemented the 1st of January, 2013. This is supposed to foster full scale investigations and real planning of offshore wind power parks.
Another strategic action — and an essential step to unlock the possibilities to move the OWE vision to real implementation — was the initiative by the Ministry of Environment to extend the spatial solutions of the land based National General Plan to the maritime space in 2012. Within a project led by the Coastal Research and Planning Institute, a consortium has been built that is composed of professional planners, cartographers and scientists in order to provide a professional knowledge about the existing and planned organization of the sea space. Wind (among other marine resources) as a potential renewable resource has been mapped during the integrated planning process (Fig. 32). This facilitates the setting of specific priorities in marine areas where OWE development gives the maximum economical profit and has minimal environmental impact. It is foreseen that the plan will be finalized by the 1st of November, 2013.

The industries have also shown their readiness to meet the emerging market demands. One good example is the West Lithuania Ship Yard, a company that is already constructing wind turbine foundations and electric substations for OWE projects, which has built the offshore wind turbine mounting ship Wind-lift (currently in an operation in the North Sea). Apart from the official initiatives and the business driven activities, the scientific community is also supporting and fostering the development of the OWE market. Critical issues highlighted by the South Baltic programme project SB-OFF.E.R are the lack of professional personnel capable of meeting the extensive versatile demands of the growing market, and create business opportunities to customize the maritime affairs. Preparation of training concepts/programs, summer schools, manuals and guidelines are key tools to fill this gap.

Stiftung OFFSHORE-WINDENERGIE (the German Offshore Wind Energy Foundation) is the initiator of a unique project aimed at raising public acceptance, a ‘sailing’ exhibition called ‘Fascination Offshore’.

The exhibition was installed on the museum ship ‘MS Greundiek’ (Fig. 33). Over the summer months, starting in June 2009, the ship has called on more than 40 harbours in the North and Baltic Seas. In the years 2009–2011, almost 86.000 people visited the exhibition on board the Greundiek, including 16.000 visitors during a complementary exhibition onshore in Büsum. Additionally, the exhibition was shown as part of the ‘Open Days’ of the Federal Government in Berlin (20–21 August 2011). The Federal Environment Ministry presented itself at the Potsdamer Platz, and welcomed over 16.000 guests. The travelling exhibition, which was set up in a custom-built pavilion, contributed to this success.

The project has received financial support from the German Ministry of Environment, as well as from the EU’s INTERREG IV B North Sea Programme, as part of the ‘POWER cluster’, and from the EU’s INTERREG IV A South Baltic Programme, as part of the ‘South Baltic OFF.E.R’ project.

One successful approach of the exhibition was to plan a series of kick-off events in different harbours, where offshore-related talks were organised in cooperation with local partners such as regional wind energy networks. In this context, many companies from the offshore wind energy sector have presented themselves and discussed with politicians from local, regional, state, federal, and even EU levels. The exhibition was often combined with other events, like harbour festivals or other promotional activities. It has been used productively as the backdrop for several press conferences and panel discussions. A total of more than 35 press releases and over 170 articles in newspapers, magazines and on the internet have been published.

The exhibition space of 200 m² contained audio-visual presentations and interactive exhibits, e.g. maps of offshore wind farms, models of offshore turbines and vessels, a touch-screen terminal, as well as job descriptions and a quiz (Fig. 34). Key target groups included the inhabitants of coastal
HOW CAN OFFSHORE WIND ENERGY SUPPORT DEVELOPMENT OF OTHER ECONOMY SECTORS?

How can Offshore Wind Energy (OWE) support the development of a region like Rostock in the North East of Germany? What role can a regional development agency like Rostock Business play for this upcoming industry?

Those questions takes us to the story of OWE and regional development in Rostock. Rostock offers several site factors that are the base for all OWE activities in the city. First of all, the city is situated on the shore of the Baltic Sea. This location is the basis for a century-long tradition in the maritime industry and logistics, as well as a wide experience of people and companies dealing with all sorts of ‘offshore’ issues. As an example, Rostock is operating the biggest and deepest German universal Baltic seaport with an annual cargo turnover of about 22 million tons. Furthermore, there are three shipyards and machine builders in Rostock with about 3,000 people working in shipbuilding and heavy steel construction. Finally, there are numerous small innovative and experienced companies like Wind Projekt and WPD, offering engineering and planning competences, which guide OWE projects through the world of environmental permissions, certifications and financing.

One might ask: What is the role of Rostock Business in this context? Rostock Business was founded in 2003 as the regional development agency of the Hanseatic City of Rostock. Its task is to provide services for the marketing of Rostock as a business location. As a company devoted to the promotion of business and technology for new and existing companies, it serves as the intermediary between the business sphere and the city, the partner of local companies, and the marketer of the city both on a national and international level.

At the time when Rostock Business was founded, there were already plans to establish the Offshore Wind Farm Baltic 1 (Fig. 35). Companies like Wind Projekt, Siemens and Aker Yards were joining forces regions, tourists, the media, schools, decision-makers in politics and industry, as well as the general public. Regular updates of the exhibition reflected developments in the offshore wind industry, as well as feedback from visitors. Opinion polls among visitors have clearly indicated that the exhibition has contributed to a more positive perception of offshore wind energy.

Due to the positive feedback received on the touring exhibition, the ‘Offshore Infocenter Rostock’ (OIR), a permanent exhibition on a museum ship in Rostock harbour, was planned for 2013. The ship already houses a Shipbuilding and Maritime Museum, covering the entire spectrum of seafaring and shipbuilding traditions. The addition of an offshore exhibition, with a space of 300 m², is organized by Rostock Business in close cooperation with the German Offshore Wind Energy Foundation, Wind Energy Network e.V. and the Hanseatic City of Rostock. In terms of content, it closely follows the original touring exhibition. A greater focus, however, is placed on the Baltic Sea and the regional situation in Mecklenburg-Vorpommern. The permanent boat exhibition is financed by the project South Baltic OFF.E.R., together with Rostock Business, the Wind Energy Network, and the offshore industry. The opening of the permanent exhibition will take place in conjunction with the international conference and exhibition ‘Wind & Maritime’ and the final conference of the South Baltic OFF.E.R. project in April 2013.

Due to the positive feedback received on the touring exhibition, the ‘Offshore Infocenter Rostock’ (OIR), a permanent exhibition on a museum ship in Rostock harbour, was planned for 2013. The ship already houses a Shipbuilding and Maritime Museum, covering the entire spectrum of seafaring and shipbuilding traditions. The addition of an offshore exhibition, with a space of 300 m², is organized by Rostock Business in close cooperation with the German Offshore Wind Energy Foundation, Wind Energy Network e.V. and the Hanseatic City of Rostock. In terms of content, it closely follows the original touring exhibition. A greater focus, however, is placed on the Baltic Sea and the regional situation in Mecklenburg-Vorpommern. The permanent boat exhibition is financed by the project South Baltic OFF.E.R., together with Rostock Business, the Wind Energy Network, and the offshore industry. The opening of the permanent exhibition will take place in conjunction with the international conference and exhibition ‘Wind & Maritime’ and the final conference of the South Baltic OFF.E.R. project in April 2013.

Figure 34. Exhibition [German Offshore Wind Energy Foundation]

Figure 35. Wind park Baltic 1, the first German offshore wind park, north of the Darß / Zingst peninsula

Kerstin Wesselmann
German Offshore Wind Energy Foundation
e-mail: k.wesselmann@offshore-stiftung.de

Andreas Wagner
German Offshore Wind Energy Foundation
e-mail: a.wagner@offshore-stiftung.de

Christina Albrecht
German Offshore Wind Energy Foundation
e-mail: c.albrecht@offshore-stiftung.de

German Offshore Wind Energy Foundation
e-mail: c.albrecht@offshore-stiftung.de

Figure 34. Exhibition [German Offshore Wind Energy Foundation]
to bring this new initiative forward. They were looking for a neutral partner like Rostock Business, who would be able to organize meetings, bundle interests and design a joint marketing. As a result of this initiative, the companies formed the Wind Energy Network in 2005. It started with ten members heading forward to bring the first offshore wind energy farm into waters. In 2009, the network widened its horizons by integrating onshore companies. In 2012, about 100 companies along the entire value chain are members of the network. They represent competences in all fields of offshore and onshore wind power — from planning and consulting to building, construction and operation.

Among the members of the network are companies like Wind Consult, which is active in engineering and planning, turbine manufacturers like Nordex or e.n.o. energy, and service providers like Baltic Diver Germany. The network is still coordinated by Rostock Business, and the main activities are focused on new markets, research and development plus qualification and recruiting. A highlight was the creation of an Endowed Chair for offshore wind power at the University of Rostock. Nordex, a leading German manufacturer of windmills, was willing to donate around €1.25 million for five years for the operation of the chair. In addition, the network is regularly present at various events and trade shows throughout the year, e.g., European Offshore Wind, Husum Wind Energy, and own events like the Wind Energy Evening. In other German regions it is nowadays marketing all competences of regional companies.

Meanwhile, several companies from the Rostock area work for the OWE sector. Nordic Yards manufactures transformer stations for Siemens, EEW manufactures large steel pipes and Liebherr has decided to move its research and development department to Rostock. One of the biggest offshore ship cranes is currently built here. To stick with the superlatives, the first offshore wind mill and the first commercial offshore wind farm EnBW Baltic 1 were installed here close to the coast (Fig. 35 and 36). But the positives do not end there; the latest news show that the performance of wind energy in the Baltic Sea is even better than expected.

All what has been said above lead us to the conclusion that favourable site factors, strong companies and the support by a regional development agency and by other stakeholders bring OWE into the waters.

Aside from their impact on the local population, offshore wind farms affect tourists visiting coastal regions or islands, and also persons touring the area with their sailing or motor boats. Fears and prejudices, as well as potential benefits that the offshore wind energy might have for the tourism industry in a given region are summarized in Table 9.

Because of the potential benefits the offshore wind industry has for tourism areas, and the fact that the region has to deal with the construction of a farm, several possibilities emerge on how to incorporate the offshore wind industry in the local tourism concept.

The multitude of potential attractions include education events [Hilligweg & Kull, 2008], such as information centres, boat tours, sightseeing flights, information boards and viewing platforms with telescopes. Edutainment events should both educate and entertain. Offshore information centres are the most widespread of these attractions. Boat tours to wind farms could include presentations on offshore wind energy, which would provide information about the offshore farm itself, the offshore wind industry in general, and the benefits of offshore wind, especially with respect to climate protection. Moreover, short movies, or a quiz which evaluates the knowledge of the participants, could be presented on the ship. However, these tours depend on favourable weather conditions. Another option for wind farms at greater distances from the coast might be sightseeing flights, which have the advantages of not being as dependent on the weather and requiring less time, although this would only be an alternative for smaller groups and is more expensive.

Since windmill climbing on offshore wind farms is not possible due to safety concerns, a great opportunity could be a combined offshore and onshore wind energy tour. Such a tour could, for example, combine onshore windmill climbing with a boat tour to an offshore farm, and include a visit to an off-shore-comparable” conditions in Rostock harbour (Breiting wind energy plant).

**Table 9**

<table>
<thead>
<tr>
<th>Tourism and Offshore Wind Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fears and Prejudices</strong></td>
</tr>
<tr>
<td>Benefits ‘damage to image due to disturbing emotions’</td>
</tr>
<tr>
<td><strong>Impacts on the landscape</strong></td>
</tr>
<tr>
<td>Fascination with technology</td>
</tr>
<tr>
<td><strong>Land use</strong></td>
</tr>
<tr>
<td>Event character</td>
</tr>
<tr>
<td><strong>Noise and shadow flickering</strong></td>
</tr>
<tr>
<td>Contribution to active environmental protection</td>
</tr>
<tr>
<td><strong>Risk of ship collisions</strong></td>
</tr>
<tr>
<td>General attractiveness of region</td>
</tr>
</tbody>
</table>

[1] Influence only on ship and boat tourism in close proximity to the farm.
[2] Influence on tourism cannot be predicted with reliable methods.

**Figure 36.** Demonstration wind energy plant with “offshore-comparable” conditions in Rostock harbour (Breiting wind energy plant).
HOW TO DEAL WITH THE PUBLIC IN RELATION TO OFFSHORE WIND ENERGY INVESTMENTS?

Regardless of the level of support, it has been found that community acceptance for wind power follows a U shaped curve during the development, as illustrated schematically in Fig. 38. The extent of the decrease in acceptance in the development phase is found to be less in areas where the community already has experience of wind turbines.

The term ‘social acceptance’ of wind energy is used here, meaning acceptance from all project stakeholders, consumers, policy makers, neighbors etc.

There are a number of characteristics of the wind technology that emphasize the importance of social acceptance. First of all, wind energy plants are still small-scale compared to conventional power plants, increasing the number of siting decisions to be taken. Secondly, as wind energy conversion is characterized by a lower energy density than e.g. fossil fuels, the relative visual impact (per MWh of output) tends to be higher. This is reinforced by the fact that resource extraction in the case of fossil or nuclear fuels happens below the earth’s surface and is invisible during the everyday life of a citizen, while wind turbines harness energy in a very visible way. Thirdly, as externalities of traditional power plants are not fully recognised in the energy sector, the wind energy sector does not compete with traditional technologies on a level playing field, thereby making acceptance of it a choice between short-term costs and long-term benefits.

Many studies have been conducted over the years and support for wind energy appears to be consistently high across Europe, with more than 80% of the citizens expressing the opinion that their respective country should utilize a greater capacity of wind power. Such findings have led wind farm developers to the conclusion that due to a consistently high level of support for the technology, there would be little resistance when it comes to developments in local areas. In some cases this has proven to be untrue and local resistance to wind power developments has been picked up by the media. However, most studies are for land-based developments and few conflicts have been reported for offshore wind farms.
In Denmark, the introduction of wind turbines on land started in the late 70’s led by private ideallstic people and cooperatives, and the general sup- port for wind energy has been very high throughout the ‘80s and ‘90s. Lately, a number of conflicts in connection with land based projects have caused delays in project development. In 2009, the Danish Government introduced a new law on renewable energy in which the co-ownership by neighbours was re-introduced. It is now mandatory to offer 20% of the shares of a land based project to neigh- bours living within 4.5 km from the wind farm at cost basis, i.e. the developer should have no pro- fit for this part. Any shares not sold to the direct neighbours can be offered to all inhabitants in the municipality where the project is located.

In Guldborgsund Municipality there are three exhi- bitions or visitors centres displaying information about offshore wind farms and wind energy. Guldborgsund Municipality is situated in the south east part of Denmark on the islands Falster and Lolland, with a coastline along the South Baltic Sea. The Ny- sted Offshore Wind Farm, Rødsand II and the coming wind farm at Kriegers Flak, all of which can be ac- cessed from towns in the municipality, give reason to focus on offshore wind energy as a resource — both for energy production and for tourism.

Experience from other places and countries shows that one of the main challenges concerning exhibi- tion or information centres is to attract a suf- fi cient amount of visitors. A visitor centre on offshore wind energy is not in itself able to attract a large num- ber of visitors. On the other hand, if the visitors for other reasons are passing an information centre on offshore wind energy, they will enter it. Therefore, when planning for an information centre the loca- tion should be one of the first considerations.
Guldborgsund Municipality has given great attention to this, and has placed the three centres at locations that have a good basis for visitors in general. The centre in Nysted is situated right at the harbour with the view to the Nysted Wind Farm. The new Renewable Energy Information Centre in Væggerløse is situated at the Gedser — Nykøbing Main Road next to the largest solar panel park in the eastern part of Denmark. The new Information Point in Gedser is situated on the southern-most point of Denmark, where a former naval station has been transformed to a tourist information point. All these locations attract visitors in their own right.

Nysted Offshore Wind Farm Information and Activity Centre

Nysted Offshore Wind Farm is one of the world’s largest wind farms. There are 72 wind turbines that annually generate enough power to supply 145,000 family homes with non-polluting energy. Guldborgsund Municipality and Nysted Wind Farm have together created an information and activity centre (Fig. 40) about wind energy in general and Nysted Wind Farm in particular.

The exhibition allows visitors to try various experience modules, including a miniature wind tunnel and an interactive quiz. Visitors can also study exhibition boards explaining how offshore wind turbines are made, environmental impact assessments, electricity’s path from wind turbines to hair dryers, etc. (Fig. 39). On the three PCs, visitors can see a visualising film, featuring the offshore wind farm, browse the Offshore Wind Farm website, and use a joystick to take a virtual helicopter ride through a 3D simulated version of the offshore wind farm.

The exhibition section on the general aspects of wind energy offers various activities for visitors to try. Visitors can generate power with a handle and answer questions on wind energy; children can cut and paste their own little wind turbine; and in a wind tunnel Visitors can use their hands to experience how wind feels at different wind speeds. Last, but not least, the exhibition offers a telescope from where visitors have been able to follow the offshore construction site, and, now that the farm is completed, can study the farm from a distance.

The exhibition section on construction and technology includes the Nysted and Rødsand II Offshore Wind Farms and the one coming on Kriegers Flak.

The centre will include a conference / teaching room and an audiovisual dissemination room. There will be a special target for school children and families and computer technologies will be a major tool for communication of the messages.

Information Point, Gedser Odde

When visiting the southern-most tip of Denmark, you will be able to see Nysted Offshore Wind Farm. A former naval station has been transformed to a general tourist information point, where there is a focus on issues that are relevant for the area. This includes e.g. Baltic Sea, the wind farms, migrating birds, geology and history. Special attention will be given to activate children through ‘treasure hunts’ related to all issues.

Visitors will be able to study exhibition boards explaining precise data about the turbines, capacity etc., the environmental impacts of the farms to sea and bird life, overall facts about wind energy and what impacts wind farms have on the local areas in which they are situated, e.g. creation of jobs.

Visitors Centre for Renewable Energy Sources, Væggerløse

Placed along the main-road E55 that connects Scandinavia to the Adriatic Sea, an information centre focusing on renewable energy sources is under construction spring 2013. It will be situated in connection with a large solar panel plant. There will be focus on solar energy and on renewable energy sources in general. Following this there will be a specific section on offshore wind energy, including the Nysted and Rødsand II Offshore Wind Farms and the one coming on Kriegers Flak.

The centre will include a conference / teaching room and an audiovisual dissemination room. There will be a special target for school children and families and computer technologies will be a major tool for communication of the messages.

Information Point, Gedser Odde

When visiting the southern-most tip of Denmark, you will be able to see Nysted Offshore Wind Farm. A former naval station has been transformed to a general tourist information point, where there is a focus on issues that are relevant for the area. This includes e.g. Baltic Sea, the wind farms, migrating birds, geology and history. Special attention will be given to activate children through ‘treasure hunts’ related to all issues.

Visitors will be able to study exhibition boards explaining precise data about the turbines, capacity etc., the environmental impacts of the farms to sea and bird life, overall facts about wind energy and what impacts wind farms have on the local areas in which they are situated, e.g. creation of jobs.

Guldborgsund Municipality has chosen to connect the general interest for renewable energy sources with tourism, thus promoting both knowledge and public acceptance with pleasure and tourism.

Wind farms have a negative impact on tourism.

There is no evidence to support the suggestion that wind farms impact negatively on tourism, in fact independent UK studies show the opposite is true. Wind farm developers are often asked to provide visitor centres, viewing platforms and rights of way to their sites. Whitelee wind farm received 25,000 visitors in just nine weeks in 2009. In the 2008 Moffat report to the Scottish Government on the Economic Impacts of Wind Farms on Scottish Tourism the report concluded that ‘the effects are so small that, provided planning and marketing are carried out effectively there is no reason why the two are incompatible.”

As part of the same report, a set of interviews had been conducted with 380 tourists in four case study areas about what they thought about wind farms. 75% of people that were asked had either a positive or neutral view. Only 23% said that they did not like wind farms, while 39% were positive about them. 68% said that a well-sited wind farm does not ruin the landscape, and 48% per cent said that they like to see wind farms.

Source: http://assets.wwf.org.uk/downloads/wwf_scotland__wind_farms_myths_and_facts_briefing.pdf
EXPERIMENTAL PROMOTION OF OFFSHORE WIND ENERGY

The statement that early environmental education is critical to shape children’s values and perspectives is as unquestionable as the fact that this target group requires individual educational strategies. Attempts to explain the concept of renewable energy production constitutes a particular challenge, as this idea may seem abstract not only to young people.

In the frame of the SB OFF.E.R. project, an interactive exhibit was produced in order to promote offshore wind energy among children. The model (3 metres long and 2 metres wide) consists of two offshore wind farms, each with a different blade size, which are independently connected to two housing estates (Fig. 41). Using a control panel one can set the wind speed conditions and observe the response, i.e. the rotation speed of the turbines and the amount of electrical energy supplied to the buildings.

The children are asked to conduct two experiments (Fig. 42). The first is to change the wind speed and learn that the stronger the wind, the

Figure 41. Group of children watching the wind farm model (Photo. Michalina Pączkowska)

Figure 42. Group of children watching the wind farm model (Photo. Michalina Pączkowska)
faster the turbine rotates and the more light are provided to the buildings. However, increasing the wind speed over 25 m/s makes the turbines stop working, and the children are informed that this procedure is used in real installations for security reasons. The second experiment requires that the same wind speed is set to blow on both farms. All other things held constant, the children can see that there is also another factor that influences the amount of electrical energy generated – the size of the turbine blades.

In this way, young people can learn certain things by playing with the model. The possibility to control the wind conditions and energy production nurture their imagination, and in that way makes the general idea of offshore wind energy more comprehensible. The cognitive processes are stimulated by the visual attractiveness of the exhibit, as the model is colourful, eye-catching and every detail attracts attention. Moreover, it resembles a real installation because it incorporates the two elements of nature that are indispensable when talking about wind farms at sea: real water in which the turbines are placed and wind that moves the blades.

The playful exhibit is currently placed in one of the centres for education of children and teenagers in the Tricity, and is frequently visited by families and organized groups.

EVENTS IN KARLSKRONA ABOUT OFFSHORE WIND ENERGY

Preschool
Möllebacken preschool in the municipality of Sölvesborg is a good example of how to make children interested in wind energy. Teachers have taken an interest in wind power because the preschool is located at a place where there was previously a windmill. The children have studied windmills and wind power plants. Then they have built a wind power plant from a description. A total of nine rotor blades have been attached to a bicycle wheel (Fig. 43).

During the time when the wind power plant was built, the children had a lot of questions and more studies were done to get the answers to the questions. The children also tested the wind power plant – how many revolutions per minute – they connected it to a diode that could shine, and they also charged a mobile phone battery.

The teachers at the school made a study visits to Lillgrund wind power site to learn more about offshore wind energy plants. The staff and the children also visited an onshore wind power plant owned by Eolus Vind AB. Information was given by the wind power plant technicians from Eolus Vind AB, and the children had the possibility to enter the tower. All this work was documented by photos and drawings and the children then created a small exhibition at school.

Elementary school – business contacts
At elementary school level it is important that the teachers are well informed about the modern industry of today. The teachers have the possibility and power to inspire youth to apply to technical studies at high schools, and in Blekinge this is very important since a large part of the companies are in the production industry. Within the project, 2 principals and 13 teachers attended a study trip, arranged by the Municipality of Karlskrona, with the aim to give them the tools to transfer updated information regarding the regional industry to the pupils.

The study trip was performed in cooperation with companies that in the future will need to employ young people with technical knowledge. The companies were suppliers to the wind energy sector: ABB High Voltage Cables AB, Roxtec AB, Svens Verktygsmekaniska AB and Devo Engineering. A survey was made after the study trip and all participants thought that this cooperation with companies is important and that it is important to learn how companies work with environmental issues.

High School levels
The municipality of Sölvesborg and of Karlskrona has informed students in high schools regarding the OFF.E.R. project and offshore wind energy. There was one information event in each municipality.
The Offshore Knowledge Toolbox (OKT), located on http://knowbox.org/offshore, is one of the outputs from the South Baltic OFF.E.R Project (Fig. 47). This is a tool to create non-commercial courses and trainings on offshore wind energy (OWE) of various types, both country- and topic-specific. It can be called a resource pool of documents, presentations, photos, movies and any other kind of data related to OWE. Interested stakeholders can use it according to their needs, extracting only the knowledge that is interesting for them. This approach was chosen as it enables users from the SB OFF.E.R Project partner countries, which are in quite different stages of OWE development, to retrieve any knowledge they need.

The primary target group for the OKT are lecturers, teachers and other stakeholders involved in education about OWE, that may be searching for an up-to-date source of information for their courses. However, OKT is open to the general public too, and it is expected that other groups, e.g. students and market researchers, will make use of it. The interface of the OKT and a large number of the uploaded files are in English, but some of the country-specific material (documents, reports etc.) may be in other languages, provided that they have abstracts in English.
The Offshore Knowledge Toolbox is administrated by the University of Gdańsk through POMCERT (Pomeranian Centre for Environmental Research & Technology). Material available for downloading is primarily provided by POMCERT and the other four SB OFF.E.R Project partners, but any other user that is successfully registered and has declared to be professionally or educationally involved in the OWE field gain the privilege to add files. However, it is the administrator who supervises the quality of the files and decides whether to make them available for other users or not. The quality is verified against four criteria: quality, compliance with the specification, presence of English abstract and presence of legal consent of the author (if applicable). The user who added the file can check if it is available for downloading, still waiting for verification or does not meet the requirements. If it is already verified but not accepted, the file owner can find a list of which requirements that are not met (Fig. 48).

The Offshore Knowledge Toolbox is a simple tool and this is probably its most distinguishing and beneficial feature. Thanks to the simple procedure for material addition, it is still up-to-date and this is very important as OWE is a dynamic sector. The other advantage is a quite diversified profile of the potential material providers; they are from different countries, different stages of education and different branches. Therefore, material that can be found on OKT reflects various points of view and interests, and is therefore valuable for many different users.

**USEFUL LINKS**

- www.ewea.org
- www.pwea.pl
- www.lwea.lt
- www.svensk-vindkraft.org
- www.windpower.org
- www.eesm.co.uk
- www.renewableuk.com
- www.4coffshore.com
- www.reegain.dk
- offshorewind.net
- www.wsp.lt
- www.wind-energy-network.de
- www.offshorecenter.dk
- www.seanergy2020.eu
- www.power-cluster.net
- www.4-power.eu
- www.windspeed.eu
- www.ptmew.pl

**TABLES**

| Table 1 | Offshore wind farms in the world [4coffshore.com, as of 31.12.2012] |
| Table 2 | Selection of turbine foundations for offshore application |
| Table 3 | Characteristics of wind farms in Denmark [www.offshorecenter.dk/offshorewindfarms.asp] |
| Table 5 | Characteristics of wind farms in Sweden [Svensk Vindennergie] |
| Table 6 | Total Offshore Wind Capacity (MW) installed until 31.12.2012 |
| Table 7 | Number of Offshore Wind Turbines in the South Baltic Region |
| Table 8 | Number of turbines produced by different manufacturers sorted by countries (2012 cumulated) |
| Table 9 | Tourism and offshore wind energy - impacts [German Offshore Wind Energy Foundation closely following Hilligweg & Hult, 2005; ARCADIS, 2010] |
FIGURES

Figure 1. Fully commissioned and under construction offshore wind farms [KcWindfarms.com, as of 31.12.2012]
Figure 2. Offshore Wind Energy development in the Baltic Sea Region [Proba & Wiszik, 2011]
Figure 3. Offshore Wind Energy growth and jobs forecast in the European Union [Rowe, 2012]
Figure 4. Structure of OSWHD focus areas and activities.
Figure 5. Offshore wind power projects supported by the Energy Department in 2012 [data from the Energy Department and the National Renewable Energy Laboratory]
Figure 6. Atlantic Wind Connection project configuration
Figure 7. Key wind energy associations in the South Baltic Sea Region
Figure 8. Project ‘POWER’ team in September 2007 [USU/MW wind energy trade fair]
Figure 9. Partners of ‘SB-OFF.E.R.’ and ‘RES-Chains’ in opening of project WEBSR2 Wind Energy Info Point in Klaipeda (April 2012)
Figure 10. Scaling up of wind turbines [UpWind Final report March 2011]
Figure 11. Hybrid floating wind turbine by StatOil
Figure 12. SkySails HAWE system
Figure 34. Exhibition [German Offshore Wind Energy Foundation]
Figure 35. Wind park Baltic I, the first German offshore wind park, north of the Darß / Zingst peninsula
Figure 36. Demonstration wind energy plant with ‘offshore-comparable’ conditions in Rostock harbour (Breitling wind energy plant)
Figure 37. Tour de Wind in Bremerhaven [© BS Bremerhaven To-urstik]
Figure 38. Community acceptance of wind power during the development of a local wind farm
Figure 39. Nysted Offshore Wind Farm Information and Activity Centre
Figure 40. Nysted Offshore Wind Farm Information and Activity Centre
Figure 41. Group of children watching the wind farm model [Photo: Michalina Pazgaitė]
Figure 42. Lecture about offshore wind energy [Photo: Michalina Pazgaitė]
Figure 43. The wind power plant in action
Figure 44. 110 students gathered in the Art hall of Karlskrona
Figure 45. Students on the way to the wind turbines. Coffee break
Figure 46. Students entering the tower of the wind energy plant
Figure 47. Main page of Offshore Knowledge Toolbox
Figure 48. ‘My documents list’ which is available on user’s account

LIST OF ACRONYMS

AC alternating current
ACDs Automated External Defibrillators
ASAR An Advanced Synthetic Aperture Radar
AWC Atlantic Wind Connection
AWEA American Wind Energy Association
BASREC Baltic Sea Region Energy Co-operation
BS The Bremerhaven Economic Development Company Ltd.
BDEN The Bureau of Ocean Energy Management
BWE German Wind Energy Association
CLS Collecte Localisation Satellites
CORPI Klaipeda University Coastal Research and Planning Institute
CWEA Canadian Wind Energy Association
DC Direct current
DE Germany
DFIG Doubly Fed Induction Generator
DK Denmark
DNCI Determination of No Competitive Interest
DDE The U.S. Department of Energy
DDL The U.S. Department of Interior
DOTI German Offshore Test Site and Infrastructure Company
DTU Technical University of Denmark
DNCI Determination of No Competitive Interest
DIMA Danish Wind Industry Association
EDP Energies de Portugal
EEZ Exclusive economic zone
EIA Environmental Impact Assessment
Envisat Environmental Satellite
EWEA European Wind Energy Association
FW 6. Framework Programme
FPF 7. Framework Programme
G/W 1 foot/second (~0.304 meters/second)
GDP gross domestic product
GE General Electric
GEO-ENVIRONMENTAL
GW giga watt
HAWE High Altitude Wind Energy
HMA high voltage alternating current
HVD high voltage direct current
IWEA Irish Wind Energy Association
IT knowledge toolbox
KWH kWh kilowatt hour
LT Lithuasia
UWEA Lithuanian Wind Energy Association
m/s meters/second
MSP Maritime Spatial Planning
HME HyperMarine
HWW megawatt
WWW megawatt hour
NCAF National Center for Atmospheric Research
NCEP National Centers for Environmental Prediction
NEP National Renewable Energy Laboratory
NSCOGI The North Seas Countries’ Offshore Grid Initiative
NSR North Sea Region
OCS US Outer Continental Shelf
OFFSHORE-WINDENERGY – the German Offshore Wind Energy Foundation
ORI Offshore Incoerter Rostock
OKE Offshore Knowledge Toolbox
OWEP offshore grid development plan
PMDIS Offshore Wind Innovation and Development Initiative
PWEA Polish Wind Energy Association
PtPWEA Polish Wind Energy Society
PTVs Personnel Transport Vessels
PWEA Polish Wind Energy Association
RES-Chain Sustainable RES-Chain in the South Baltic Region
ROD Record of Decision
ROV Remotely operated underwater vehicle
SB-OFF.E.R. South Baltic Offshore Wind Energy Regions
SBR South Baltic Region
SE Sweden
SIA 12 sea mile zone
SWEA Swedish Wind Energy Association
TP Transition piece
UE European Union
UK United Kingdom
US United States
VMEA German Association of Machinery and Plant Manufacturers
WEA World Wind Energy Association
WEBSR2 Wind Energy in the Baltic Sea Region – extension
WRF Weather Research and Forecasting model (Mesoscale model)
WWD-3 Water Works District 3
WWEA The World Wind Energy Association
WWEA The World Wind Energy Association

96 OFFSHORE WIND ENERGY IN THE SOUTH BAL TIC REGION – CHALLENGES & OPPORTUNITIES — FIGURES - LIST OF ACRONYMS 97
REFERENCES


- ‘POWER creates a North Sea competence network for offshore wind energy’ 2007.


