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Rare materials - can we compete for them on the global market?

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

SOUTH BALTIC OFF.E.R

South Baltic PROGRAMME

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

April 2013

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Editors: Andrzej Tonderski, Aleksandra Jędrzejewska

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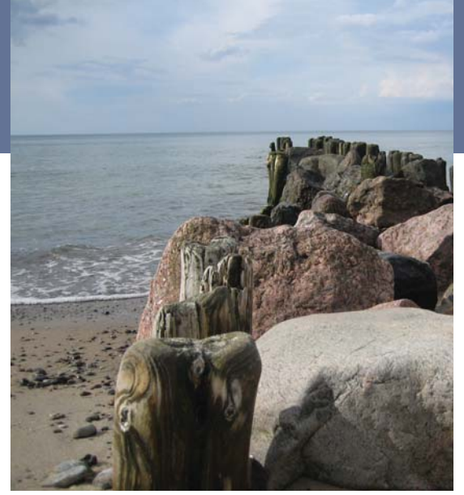

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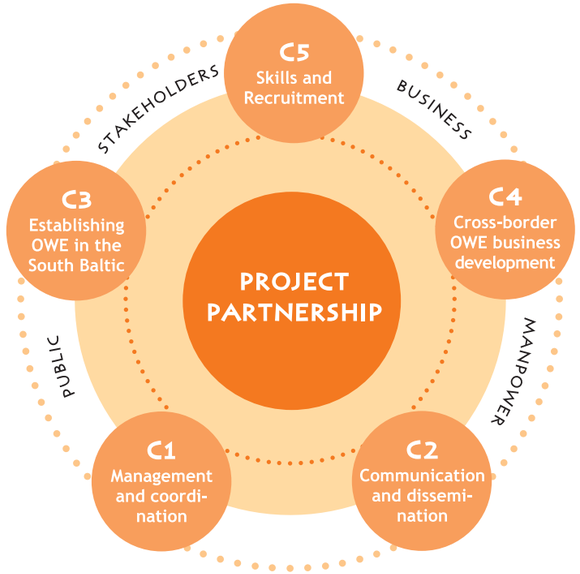
FOREWORD

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:

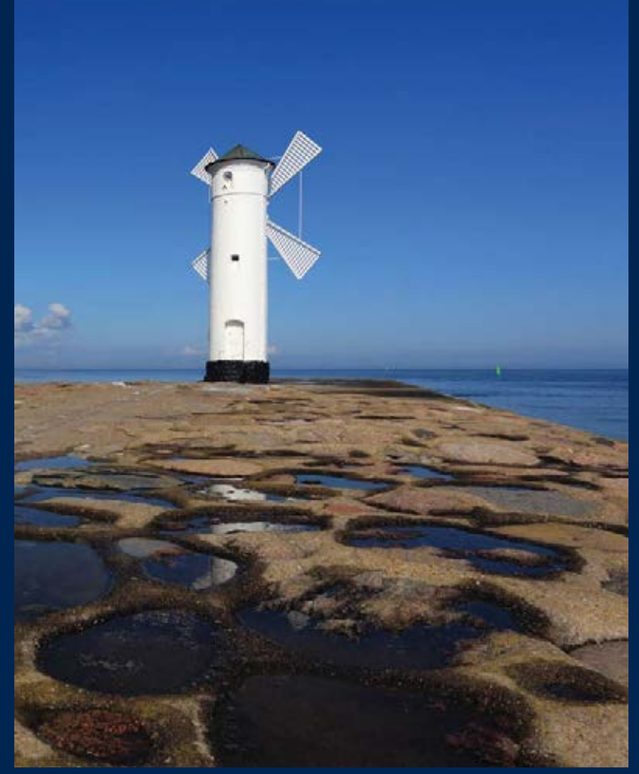


Increased cross-border cooperation between businesses, universities and research institutions significantly fosters the region's competitiveness and innovative capacity. This also enables the region to meet the rising demand for skilled workers in the Offshore Wind Industry in the future.

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 Balitc Region benefits.

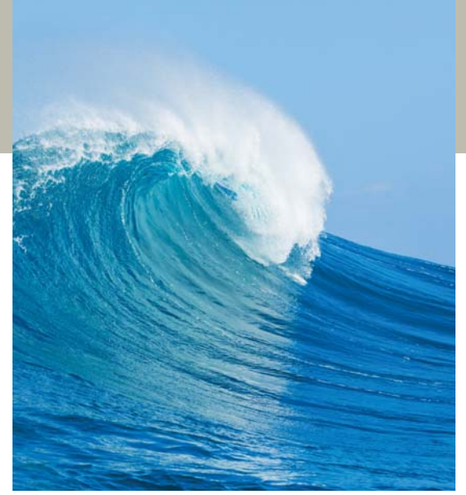
The implementation of the South Baltic OFF.E.R project has thus enabled the region to significantly benefit from the rapidly growing Offshore Wind Industry, and has thus contributed to a sustainable economic growth within the region. The long lasting networks established within the project have also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

ROSTOCK BUSINESS	Rostock Business and Technology Development, DE	KARLSKRONA KOMMUN	Municipality of Karlskrona, SE
STIFTUNG OFFSHORE WINDENERGIE	German Offshore Wind Energy Foundation, DE		Klaipeda University Coastal Reaserch and Planning Institute, LT
GULDBORGSUND	Guldborgsund Municipality, DK	SSI Strateginės savivaldos institutas	Public Institution Strategic Self-Management Institute, LT
DTU	DTU Wind Energy, DK	PTMEW	Polish Offshore Wind Energy Society, PL
SÖLVESBORG	Municipality of Sölvesborg, SE	POMCERT	University of Gdańsk POMCERT, PL



A. DEVELOPMENT OF THE OFFSHORE WIND ENERGY SECTOR

- CLEAN, SAFE AND SECURE - OFFSHORE WIND ENERGY ADVANTAGES
- DEVELOPMENT OF OFFSHORE WIND ENERGY – A GLOBAL PERSPECTIVE
- OFFSHORE WIND ENERGY IN THE EU STRATEGY FOR THE BALTIC SEA REGION
- AMERICAN STRATEGY FOR THE DEVELOPMENT OF OFFSHORE WIND ENERGY
- INFRASTRUCTURE - DOES THE REGION HAVE SUFFICIENT INFRASTRUCTURE?
- POLITICAL SUPPORT NEEDED FOR DEVELOPMENT OF OFFSHORE WIND ENERGY
- WIND ENERGY ORGANIZATIONS
- SHARING REGIONAL EXPERIENCE IN OFFSHORE WIND ENERGY DEVELOPMENT
- FUTURE WIND ENERGY



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 & Jędrzejewska 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

government supported public-private framework for spurring development of the offshore wind power through the Offshore Wind Innovation and Demonstration Initiative (OSWInD). This is described by Samotyj & Jędrzejewska in the article '*Strategy for the development of offshore wind energy in USA*'.

Anne-Bénédicte Genachte (EWEA) gives several recommendations on how political support could ensure and stimulate a better and faster development of the OWE in the article '*Political support needed for 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 experience 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*'.

MYTH Wind farms are noisy.

FACT The evolution of wind farm technology over the past decade has rendered mechanical noise from turbines almost undetectable with the main sound being the aerodynamic swoosh of the blades passing the tower. There are strict guidelines on wind turbines and noise emissions to ensure the protection of residential amenity.

Source: www.environmentalenergies.co.uk/wind-turbines-faqs

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DEVELOPMENT OF OFFSHORE WIND ENERGY – A GLOBAL PERSPECTIVE

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 Arrey (power generating from 2013), which explains small deviation from the numbers in Table 1. The second country with 921 MW installed capacity is Denmark, third is China with 559 MW, 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.

Offshore wind energy is the fastest growing energy sector. Europe's offshore wind potential is enormous and could meet Europe's electricity demand seven times over (estimated by European Environment Agency's), and the United States' electricity demand four times over. It is assumed that the installed capacity will amount to 40 GW by 2020, and to 150 GW by 2030. This will meet 14% of the European Union electricity demand, or 562 TWh, and prevent 87 million tons of CO_2 emissions.

In Europe, more than one offshore wind turbine was installed per working day in 2012.

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

Country	UK	Denmark	Belgium	Germany	Netherlands	Sweden	Finland	Ireland	Norway	Portugal	China	Japan	South Korea	Vietnam	US	Total
No. of farms	18	13	3	6	4	6	3	1	2	1	15	5	2	1	1	**81**
No. of turbines	796	416	91	68	124	75	11	7	2	1	255	17	12	10	5	**1890**
Capacity installed	2679.2	921	379.5	280.3	246.8	163.7	32.3	25.2	2.32	2	559	25.43	35	16	0.15	**5 358.98**

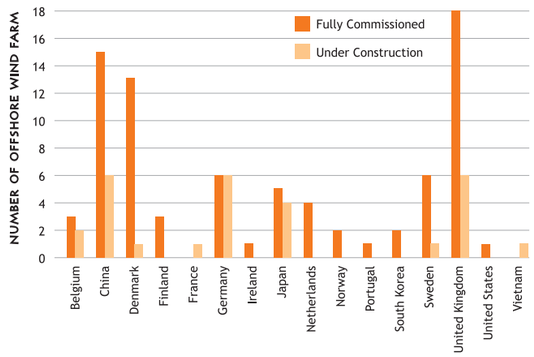

Figure 1. Fully commissioned and under construction offshore wind farms [4Coffshore.com, as of 31.12.2012]

In the end of 2012, a total of 1662 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).

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OFFSHORE WIND ENERGY IN THE EU STRATEGY FOR 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,

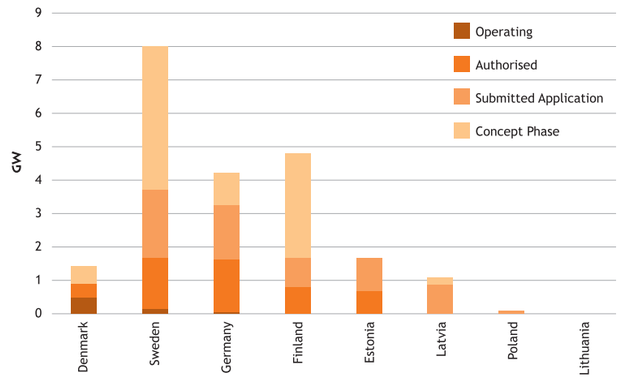

Figure 2. Offshore Wind Energy development in the Baltic Sea Region [Proba & Wójcik, 2011]

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

CO_2 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 Euro zone 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 rate. The BSR states shall engage investments to deliver equipment such as rotor blades, cables, foundations and also to provide offshore services [El Bassam 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].

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].

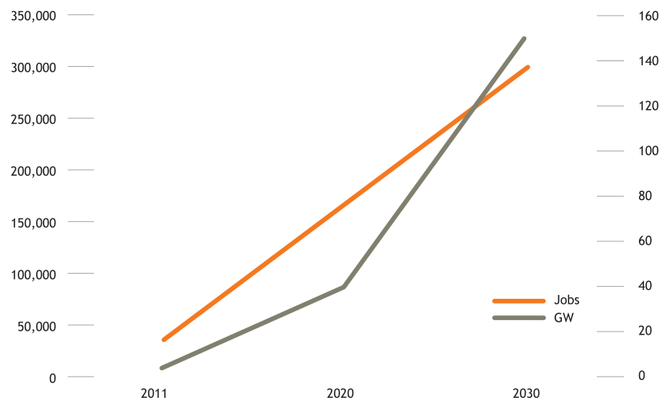

Figure 3. Offshore Wind Energy growth and jobs forecast in the European Union [Rowe, 2012]

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 CO_2 emissions, and by 2020 the industry may have avoided 102.1 Mt of CO_2 from electricity production in conventional power plants [Azau and Arapogianni, 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 conserved 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 co-operation 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].

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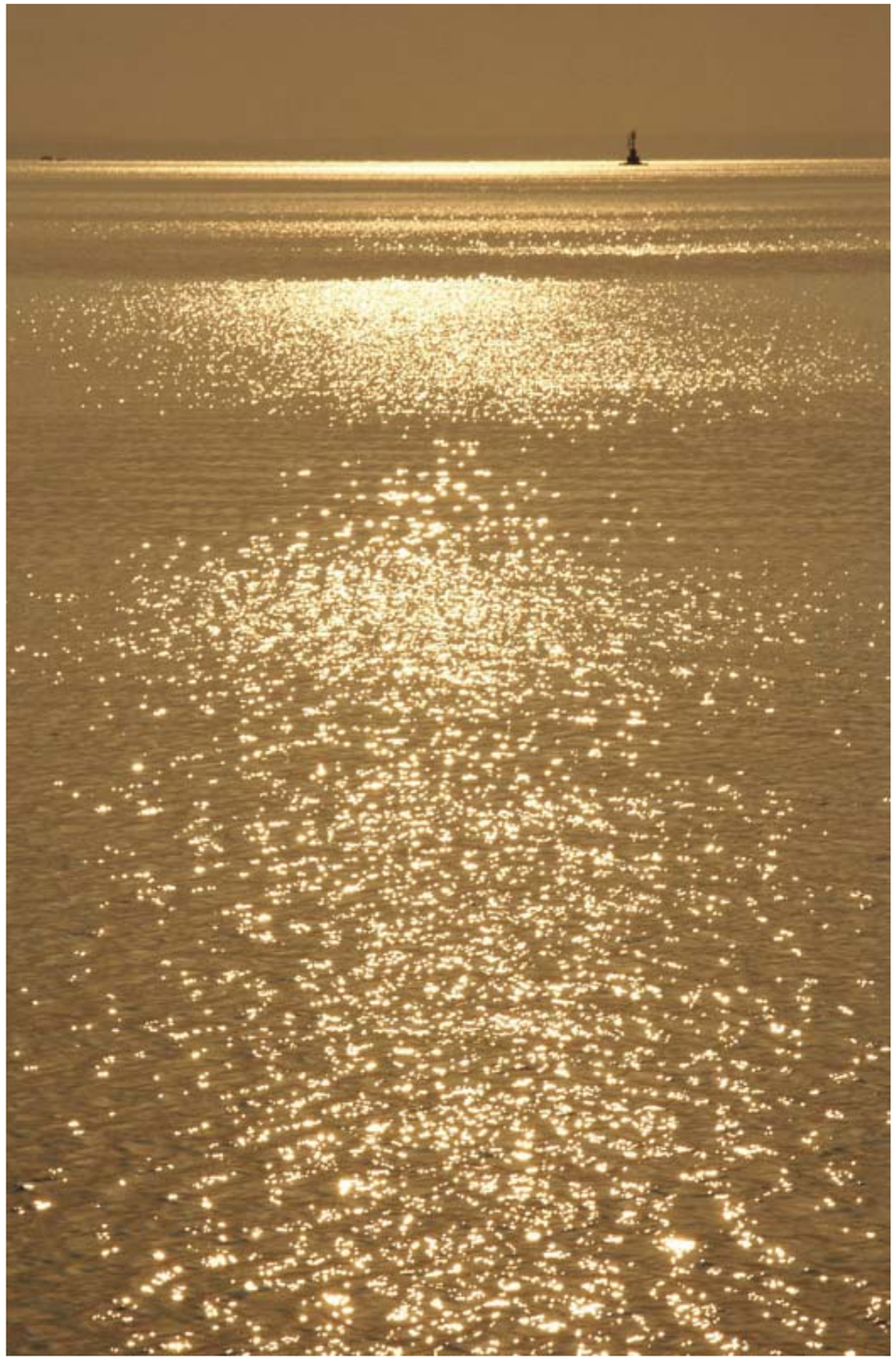

AMERICAN STRATEGY FOR THE DEVELOPMENT OF OFFSHORE WIND ENERGY

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 outfitted 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

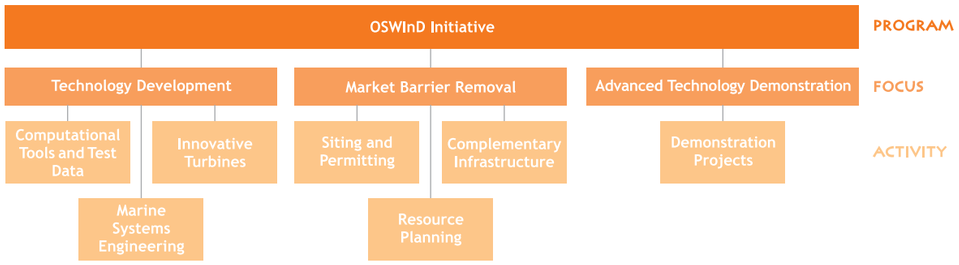

Figure 4. Structure of OSWInD focus areas and activities.

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 those 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].

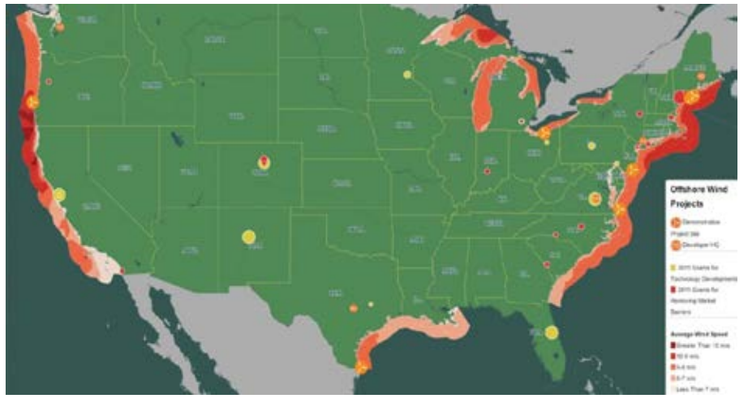

Figure 5. Offshore wind power projects supported by the Energy Department in 2012 [data from the Energy Department and the National Renewable Energy Laboratory]

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IMPORTANCE OF REGIONAL INFRASTRUCTURE FOR OFFSHORE WIND DEVELOPMENT

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 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.

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POLITICAL SUPPORT NEEDED FOR DEVELOPMENT OF OFFSHORE WIND ENERGY

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 different 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 developed. 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 planning 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 developed 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 development, similar to the ones in place for the automotive 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 forward 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.

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WIND ENERGY ORGANIZATIONS

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 functional organizations. The World Wind Energy Association (WWEA), founded 2001 in Denmark, is an international 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 organization 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, including manufacturers with a leading share of the world wind power market, component suppliers, research institutes, national wind and other renewables associations, developers, contractors, electricity providers, finance companies, insurance companies, and consultants [EWEA, 2012].

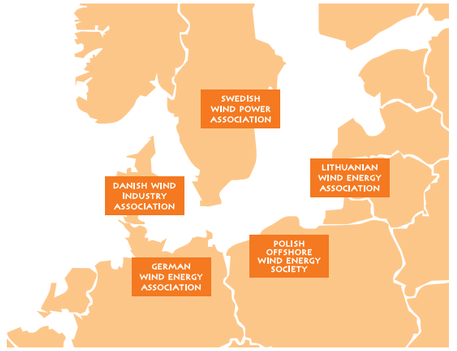

Figure 7. Key wind energy associations in the South Baltic Sea Region

In the South Baltic Region, there are also national key organizations (Fig. 7). The Polish Wind Energy Association (PWEA) is a non-governmental organization supporting and promoting the development of wind energy from 1999. It brings together the most important companies in the wind energy market in Poland, as well as investors and producers of turbines and power components, both from Poland and other countries.

Another important Polish organization is the Polish Offshore Wind Energy Society (PTMEW). This society was registered in 1997 as one of the first organizations that promote the development of offshore wind energy. Its main goal is to support the offshore wind energy sector in Poland and to promote an economic development that is favourable for offshore wind energy, using innovative technologies and respecting the need for environmental protection.

The Lithuanian Wind Energy Association (LWEA) was established on October 2, 2002. It is attempting to assure the most favourable conditions for the development of wind energy projects, including fair legislation and an attractive business environment. Some of the major objectives are to strive for decentralization of the national energy market, to achieve energy independence through the development of wind energy and to pursue the implementation of the EU's renewable energy policy.

The Swedish Wind Power Association is a collective trade organization for private persons, wind turbine owners and wind power developers. The association has approximately 2,000 members and is active both in Sweden and internationally. It promotes the development of wind power through mediating knowledge, promoting technical development, creating reasonable economic and financial conditions, and collaborating with authorities, organizations and the industry.

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.

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SHARING REGIONAL EXPERIENCE IN OFFSHORE WIND ENERGY DEVELOPMENT

The South Baltic region is playing a very important role for wind power development in Europe and worldwide. The development of the wind power market in Europe started in 1891 when Poul la Cour (Denmark) invented his wind turbine. The German industrial experience was later used to meet the technological requirements of this new energy sector, which has been constantly growing in the last three decades. The European Community has played an important role for regional offshore wind energy development via projects financed by regional funding mechanisms such as the INTERREG research and development, and the Leonardo da Vinci Life-long learning programs.

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

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 Gdansk, 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 Gdansk. 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 Riso DTU National Laboratory for Su-

Figure 8. Project „POWER" team in September 2007 HUSUMwind energy trade fair

stainable Energy (Denmark), as well as by the Strategic Self-Management Institute and the Klaipeda University Coastal Research and Planning Institute (Lithuania), and the University of Gdansk (Poland). The business development team is composed of the Leading Beneficiary of the project, i.e. the Rostock Business and Technology Development GmbH, the German Offshore Wind Energy Foundation, the REM Consult (Germany), and the Polish Wind Energy Society. Regional administrations are represented by the Municipalities of Guldborgsund (Denmark), Sölvesborg and Karlskrona (Sweden). This consortium has created opportunities for knowledge and experience exchange, including scientific knowledge, practical technical skills and new ideas for OWE related tourism development.

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 benefitted 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 9. Partners of 'SB-OFF.E.R.' and 'RES-Chains' in opening of project WEBSR2 Wind Energy Info Point in Klaipeda (April 2012)

experts. Examples of such events are an OWE road show, crush courses in summer schools, and expert lectures during cross-border meetings in Denmark, Germany, Poland and Lithuania.

The project has identified a need for modern learning programs at the Universities and high schools to provide expertise for the growing OWE industry. In order to cover the gap, the Lithuanian Strategic Self-Management Institute has used the experience from other projects, i.e. Leonardo da Vinci Lifelong learning, and the Transfer of Innovations Programme projects e-WindTech, EMPRES, ELOMPRES and ALPER. Together with partners from Spain, Greece, Portuguese, Poland, Hungary, Turkey and Germany, Master degree courses on offshore wind energy have been created and are adopted as part of the curriculum at the Maritime Institute of Klaipeda University.

In conclusion, we can say that offshore wind power is as 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.

MYTH **Wind farms are dangerous to humans.**

FACT Wind energy is a benign technology with no associated emissions, harmful pollutants or waste products. In over 25 years and with more than 68,000 turbines installed around the world, no member of the public has ever been harmed by wind turbines. In response to recent unscientific accusations that wind turbines emit infrasound and cause associated health problems, Dr Geoff Leventhall, Consultant in Noise Vibration and Acoustics and author of the Defra Report on Low Frequency Noise and its Effects 16, says: 'I can state quite categorically that there is no significant infrasound from current designs of wind turbines. To say that there is an infrasound problem is one of the hares which objectors to wind farms like to run. There will not be any effects from infrasound from the turbines.'

Source: www.communitywind.ca/13701/20501.html

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FUTURE WIND ENERGY

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.

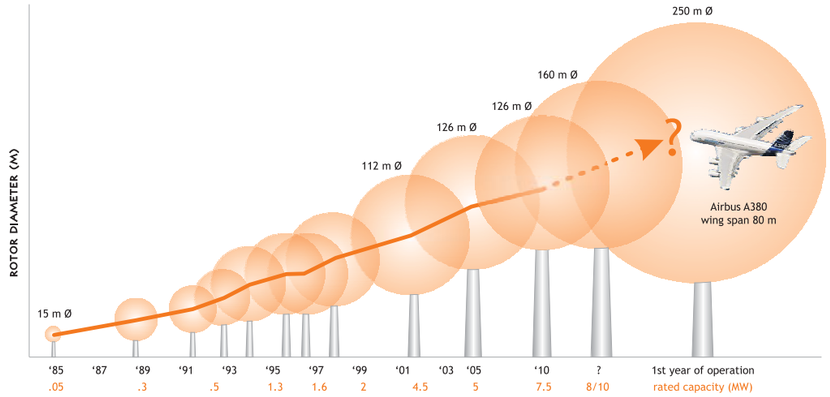

Figure 10. Scaling up of wind turbines [UpWind Final report March 2011]

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

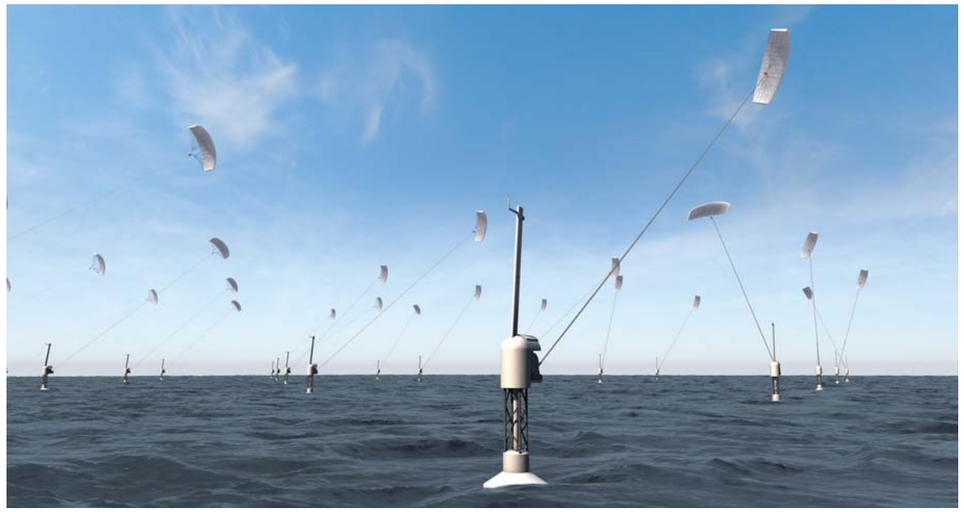

Figure 12. SkySails HAWE system

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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

CHALLENGES AND OPPORTUNITIES IN THE SOUTH BALTIC REGION

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.

MYTH

Wind farms won't help to combat climate change.

FACT

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 CO_2. Just one modern wind turbine will save over 4,000 tons of CO_2 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 Skrzypiński 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.

MYTH

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

FACT

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.ca/13701/20501.html

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SAFETY – HOW CAN THE SAFETY & HEALTH OF OFFSHORE WIND ENERGY BE IMPROVED

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, and formulate a plan 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 huge sums of money 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 deployed in remote locations 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. possibility 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/grease 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 arise from damage repairs or replacements, salvage costs, litigations, 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 focused 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 outside 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[1] 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/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 available, giving the opportunity of a few to raise their profile, but the details never seem to be released. The perception of 'not wanting to air our dirty washing in public' hampers others, faced with similar problems, from understanding all the issues encountered by those who have already experienced them. The 'wheel is re-invented' each time so we don't gain the benefit of best practice. It is important to collate all hazard incidents and near miss data on projects. We need to establish a common basis to enable us to learn from a wider industry knowledge pool rather than from individual projects. Whilst some sharing of incidents is provided through the G9 Group and others recorded on the Renewables UK members forum, the RISE initiative must be promoted and utilised as a valuable resource to move us forward. Similarly, performance management and benchmarking will enable us to learn how we can better measure our performance, identify areas of weaknesses, and more effectively drive improvements on both our individual projects and across the industry sector, as proven with the 'Constructing Excellence' initiative in the UK for general building projects.

Competence &Training

Competence — when considered as a combination of base line training & qualifications, relevant experience and an attitude of keeping up to date with industry developments — is sometimes difficult to evidence in a new and emerging sector. This is particularly true when innovation is continuous as in offshore wind, so we need to carefully evaluate individual competences based upon the support that is provided from the employer. These qualities will foster respect for the dangers involved, drive standards improvements and the tenacity to prove capability over time. Common standards for training to suit the particular needs in offshore wind are being developed by industry stakeholders, including Renewables UK and European Wind Energy Association (EWEA), with support from leading training organisations. However, they need to be applied in a consistent way to avoid the plethora of different skills cards accepted by some and not others. This work needs to continue to promote a consistent standard throughout the industry to ensure that a constant supply of new entrants can develop their skills and share knowledge with experienced operatives, to ensure business continuity with a skilled workforce.

Construction/Marine Interfaces

Whenever measurement of performance is undertaken you need to ensure that the base line for comparison is consistent each time. The nature of the work in offshore wind involves many different functions from supply chain logistics, port operations, vessel sailing to construction activities, which create difficulties in establishing a consistent approach. The process of recording incidents between the marine and construction activities can sometimes be obscure and ambiguous, depending upon the party and role of the person recording the incidents. For example, a near miss arising from an incident during anchor handling is a marine incident, whereas a dropped tool during disconnection of a TP following lifting operations is a construction incident. But what about scour around a spud can of a jack-up leg or a failed hydraulic arm on 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 those interfaces may be simple every day functions, which are well understood and practiced by those involved. Others may be compounded by the specialist nature of the activities involved or circumstances arising that had not been foreseen by the principal party who normally carry them out. Such circumstances, irrespective if 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 power will always stretch 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 test our understanding until we can gain the benefit of experience in use.

Vessel Procurement & Capability

Ever increasing demands on the availability of a limited number of heavy lifts and other specialist vessels and equipment dictate increasing procurement costs and the contract conditions for programs etc. Whilst it is recognised that some operators are investing for the future and commissioning new vessels with specific capabilities for offshore wind, it will take some time before those vessels will be readily available. Furthermore, even though they are being designed based on the technology and systems that we are aware of now, future proofing is difficult to anticipate. As a result we are finding that more and more vessels are being adapted to fill a gap in the market, or to suit a particular niche function in offshore renewable energy projects. Whilst these vessels are generally meeting the criteria for certification and registration, there are undoubtedly some compromises which have been made with respect to the functions they are to carry out or those that are not fully understood until they are actually put to work. This has resulted in a number of incidents, e.g. failed twist lock anchors fitted for use when securing containers when used as part of a configuration for cable pulling installations, or anchor lines used for vessel movement during cable laying which become damaged as the spooling arrangement hasn't been designed for the actual angles of line in use. Is it any wonder that incidents which result in a near miss, damage and potential injury, occur when these issues are foreseeable by experienced people? Although these two incidents didn't result in any injuries, they could all too easily have killed or seriously injured someone. There is no doubt that we need to maximise the opportunities using existing equipment to give sufficient flexibility to provide cost effective solutions, but we do need to fully understand how it is to be used as part of any adaptation, and ensure that it is not misused or abused in service.

Leadership

As with all these scenario judging the right level of effort to ascertain what is reasonably foreseeable is difficult, but experience has taught us that there is always opportunity for improvement.

Where a change in the health & safety culture is sought, it can only be achieved with a well-considered plan, clear objectives and strong leadership to drive the change in perceptions and expectations among the whole team, including the supply chain and other stakeholders. Whilst any interventions will add cost to a project, the eventual deliverables will derive tangible cost savings from reduced lost time due to incidents and the avoided associated costs, but also through less tangible additional costs not incurred, e.g. prosecutions and fines. There may also be cost benefits arising from improved reputation and preferred stakeholders. [Koster et al., 2010]

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EFFICIENCY - HOW CAN COSTS OF OFFSHORE WIND ENERGY BE REDUCED?

Rhythm and flow

In manufacturing, 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 halves this again. The 3.6 MW Siemens turbine uses 260 t of steel in the tower onshore. In the UK Walney offshore wind farm it uses 1160 t of steel in the tower, monopile and connecting piece that require a costly series of installation processes. Moving to guyed towers in steel would reduce 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 downwind 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.

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SPATIAL PLANNING – HOW CAN THIS FACILITATE THE OFFSHORE WIND ENERGY DEVELOPMENT?

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 renewables zoning is in progress, but is far from finalised, while in Sweden, the Coherent Swedish Maritime Policy adopted in March 2009 has been the legal basis for renewable energy development in both its territorial sea and its EEZ. In the South Baltic Sea, most of the countries do not have a comprehensive MSP as a legal framework. Apart from Germany with its integrated MSP policy, and Poland, where legislation (Act on Maritime Areas of Poland and Maritime Administration) has allowed maritime spatial planning since 2003, there is no integrated spatial planning in the region. Since 2012, Lithuania is preparing marine solutions by extending the National General Plan to the sea. This is an essential step for MSP to be officially launched in the coming years. The newly established Swedish Agency for Marine and Water Management is in charge of drafting a program and plan. The Agency leads work on MSP with support from government county offices, government agencies and municipalities. A maritime spatial plan should be elaborated for each of the three areas: the Gulf of Bothnia, the Baltic Sea, and the Skagerrak and Kattegatt.

National MSP is a pre-condition for successful transnational cooperation on marine planning and should be promoted. An established coordination of a number of aspects related to MSP is a key principle to foster a sustainable development 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.

MYTH

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

FACT

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

Source: http://oceana.org/en/our-work/climate-energy/clean-energy/learn-act/renewable-energy-myth-vs-fact

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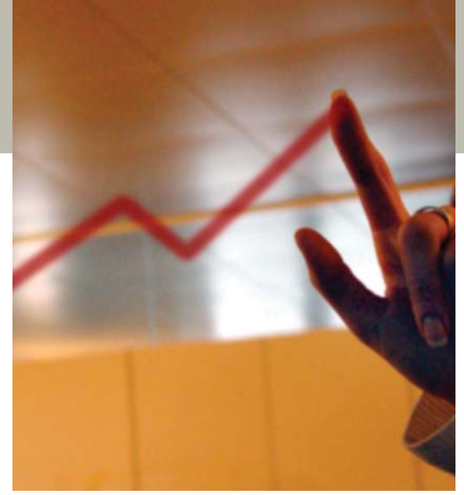
ECONOMICS – DO SUBSIDIES HELP DEVELOPING OFFSHORE WIND ENERGY?



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 CO_2 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 investment but the operational phase. This can be achieved either by fixing the monetary support level (e.g. €/MWh) or the desired quantity (e.g. MWh/year; Figure 13). In the first case, the guaranteed income level per MWh produced (feed-in tariff), or an add-on on top of the power market price (price premium) can be granted. This is current practice e.g. in Germany (see chapter D). In the second case of setting a fixed quantity target, both a micro and a macro solution exist. The micro solution is that the government decides on the capacity which is to be erected at a specific site and holds a tendering procedure, e.g. granting the tender to the cheapest offer. This tool is used in e.g. France and Denmark (chapter D). At a macro level, the government can decide the total generation quantity that should be supplied by offshore wind or renewables in general. In this case, a certain number of tradable certificates is issued per unit of OWE generation. Such a tradable green certificate scheme is applied in e.g. the United Kingdom. A sufficiently large market and related liquidity are important prerequisites for this tool.

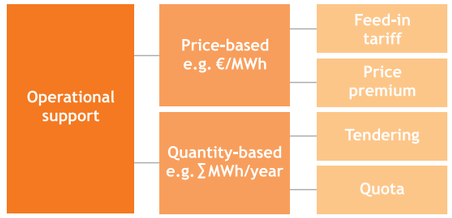


Figure 13. Overview of operational support schemes

MYTH

Wind power is expensive.

FACT

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.

Source: http://oceana.org/en/our-work/climate-energy/clean-energy/learn-act/renewable-energy-myth-vs-fact

Figure 14. The Middelgrunden offshore wind park close to Copenhagen [© Sascha Schröder]

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.

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HUMAN RESOURCES – DO WE HAVE A SKILLED WORK FORCE?

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 heterogenic. 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

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.

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RARE MATERIALS – CAN WE COMPETE FOR THEM ON THE GLOBAL MARKET?

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

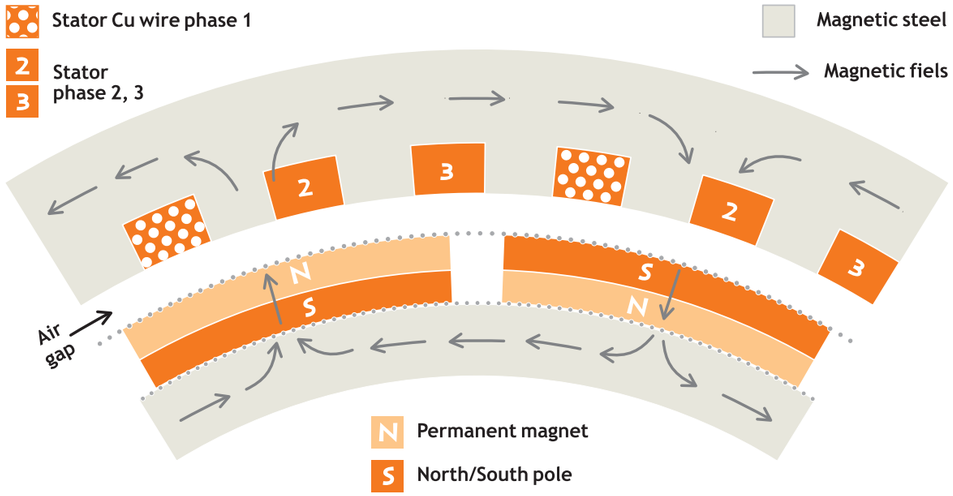

Figure 17. The basic principles of a permanent magnet direct drive generator showing the cross section of one of many pole-pairs on a large diameter ring. The two magnets are mounted on the rotor steel laminates, which are providing a magnetic flux path from the north to the south pole of the magnets. 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.]

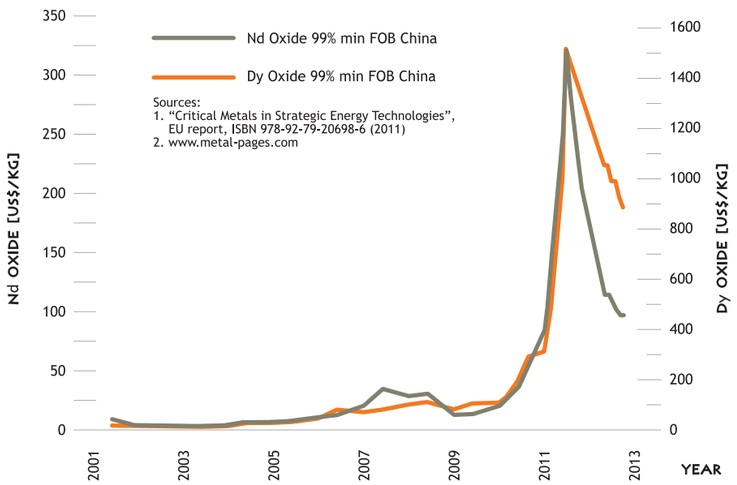

Figure 18. Price development of the raw oxide materials of Nd and Dy elements during the last decade illustrating the peak in the summer of 2011 [Reproduced from Moss et al., 2011 and supplemented by the metal pages]

PM magnets in order to raise the operation temperature from 80°C to 120°C by adding a few percent of Dy. This latter is the operation temperature of direct drive generators, which therefore depend on both Nd and Dy.

Europe has currently very little commercial mining activity of these materials. There are however new initiatives on opening mines and especially Greenland has attracted attention, since there are several deposits containing the rare earth elements. The potential of the Tanbreez deposits is analysed within the consortium REEgain [REEgain innovation consortium] and it is interesting to note that it will be able to supply in the order of 1300 and 280 tons/year of Nd and Dy oxide respectively. This will be enough to provide magnets for 2000 direct drive wind turbines of 3 MW rating per year, and will make the EU offshore target within reach. However, the development of mines is expensive and it remains to be seen at what price the Greenland rare earth elements can be produced.

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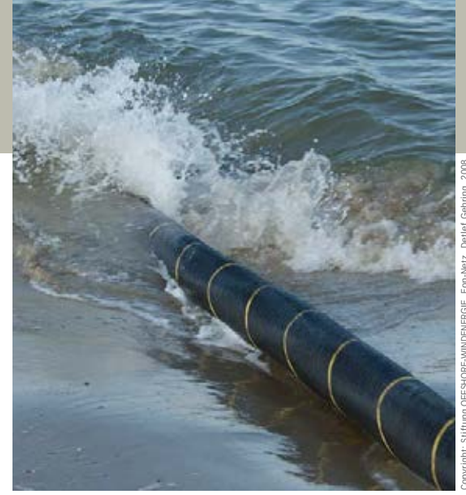
GRIDS & NETWORKS – IT'S MORE THAN JUST TURBINES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The grid connection of offshore wind farms is a critical and challenging factor. Electricity generated at sea must be fed into the transmission network and transported to consumers. This requires submarine 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 Flag project in the Baltic Sea may serve as an interconnector between Germany, Sweden and Denmark in the future.

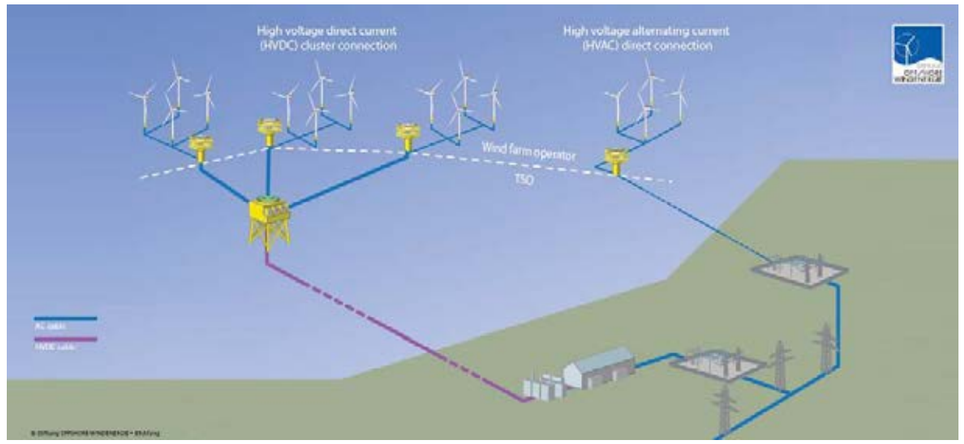

Figure 19. Grid connection of offshore wind farms

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.

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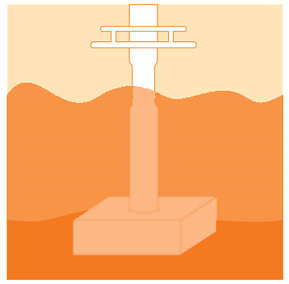
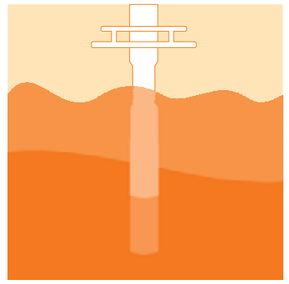
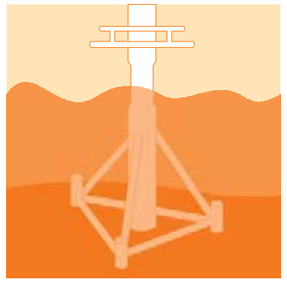
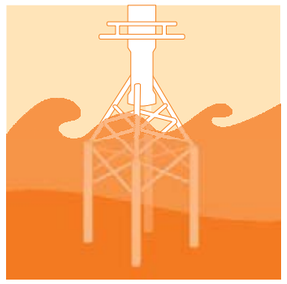
CONSTRUCTION – OFFSHORE WIND FARM DESIGN

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. There are two reasons for doing a wind resource assessment. The first is to estimate the power production and verify whether it is beneficial to erect the turbines at the location. If it is, the second reason is to select the appropriate turbine class depending on the wind characteristics. These classes are described in the IEC61400-1 International Standard by the International Electrotechnical Commission. The same wind-assessment procedure applies also

Table 2. Selection of turbine foundations for offshore application

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

Visualization	Name and description
	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

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.

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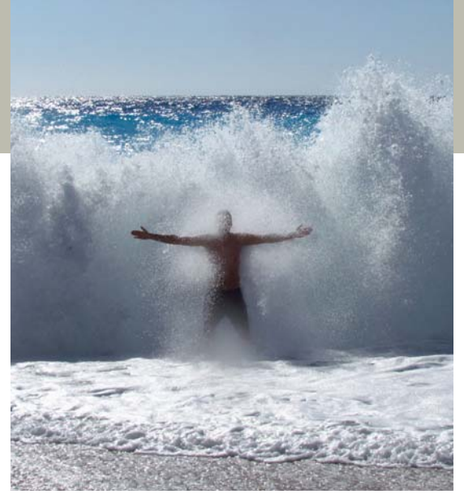
C. REGIONAL OUTLOOK ON OFFSHORE WIND ENERGY

- WIND - POTENTIAL IN THE SOUTH BALTIC REGION
- OFFSHORE WIND ENERGY IN DENMARK
- OFFSHORE WIND ENERGY IN GERMANY
- OFFSHORE WIND ENERGY IN LITHUANIA
- OFFSHORE WIND ENERGY IN POLAND
- OFFSHORE WIND ENERGY IN SWEDEN
- SOUTH BALTIC REGION OUTLOOK

WIND – POTENTIAL IN THE SOUTH BALTIC REGION



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.

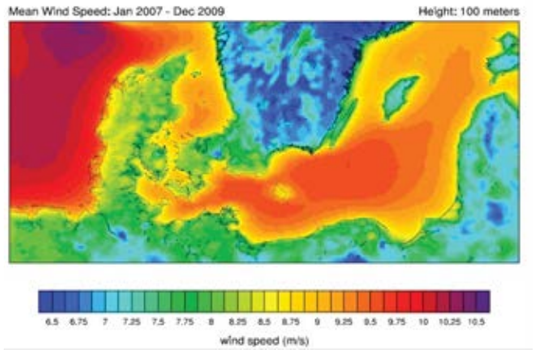


Figure 20. Mean wind speed at 100 m for the South Baltic Sea Region during the period January 2007 to December 2009

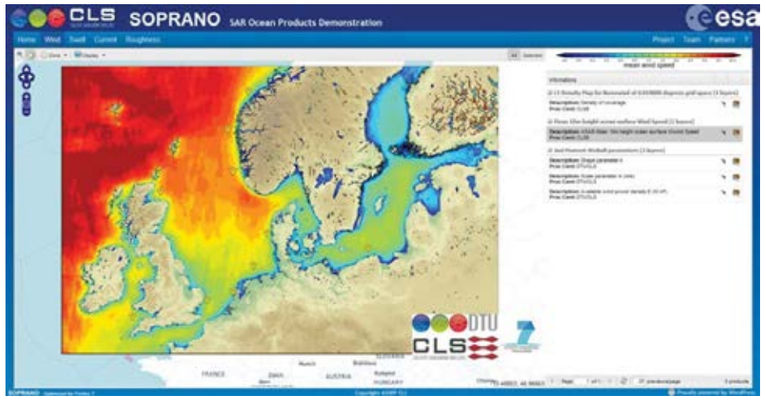


Figure 21. Mean wind speed at 10 m height above sea level based on Envisat ASAR wind maps for the seas of Northern Europe [Courtesy: Merete Badger, DTU Wind Energy and Alexis Mouche, CLS, France]

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 shown in Fig. 22 is from 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 in the Baltic Sea is listed for many existing and potential wind farm sites.

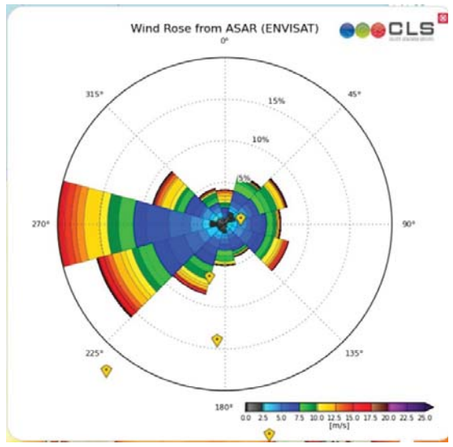


Figure 22. Wind rose based on Envisat ASAR from one location in the Baltic Sea [Courtesy: Merete Badger, DTU Wind Energy and Alexis Mouche, CLS, France]

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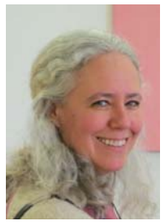

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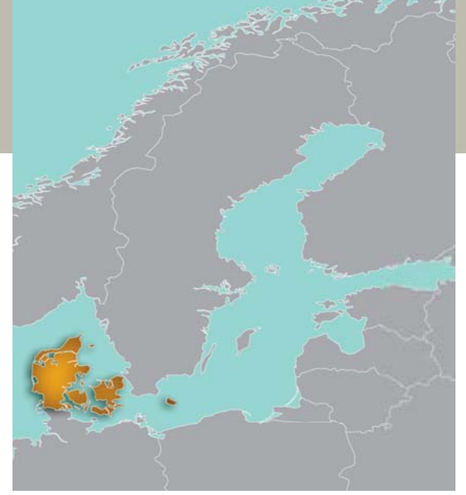
OFFSHORE WIND ENERGY IN DENMARK



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

There are currently 14 offshore wind farms in Denmark (Table 3 and Fig. 23), and a closer description of a few selected ones can serve to illustrate some of the technical progress made.

Vindeby (1991): The wind farm consists of eleven 450 kW stall controlled wind turbines, and is located approximately 2 km from the coastline. The 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.

Middelgrunden (2001): When commissioned, it was the 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.

Horns Rev and Nysted/Rødsand (2002–2010): Horns Rev I (160 MW) and Nysted (165 MW) were established in 2002 and 2003 respectively. The slightly bigger Horns Rev II (209 MW) and Rødsand II (207 MW), 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.

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 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.

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

Wind turbine	Sea name	Region	Project capacity MW	Turbine model	Number of turbines	Foundation
Avedøre Holme	Køge Bugt	Hvidovre	10.8	SWT-3.6-120 Siemens	3	Gravity- Base
Frederikshavn	Kattegat	Frederikshavn	10.6	N90/2300, Vestas V90 3MW,BONUS 82.4 2.4MW	4	Various (Mo-nopile and Bucket)
Horns Rev 1	North Sea	Blåvandshuk	160	V80-2.0 MW	80	Monopile
Horns Rev 2	North Sea	Blåvandshuk	209.3	SWT-2.3-93 Siemens	91	Monopile
Middelgrunden	Øresund	København	40	B76/2000 Bonus	20	Gravity - Base
Nysted	Baltic Sea	Nysted	165.6	B82/2300 Bonus, SWT-2.3-82	72	Gravity - Base
Poseidon	Smålandshavet	Lolland	0.03	GAIA 0.011 MW	3	Floating
Rødsand 2	Baltic Sea	Holeby	207	SWT-2.3-93 Siemens	90	Gravity - Base
Rønland	Thyboron -Harboore	Nissum Bred-ning	17.2	SWT-2.3-93 Siemens, Vestas V80-2.0 MW	8	High-Rise Pile Cap (Piled)
Samsø	Kattegat	Samsø	23	B82/2300 Bonus, SWT-2.3-82	10	Monopile
Sprogø	Storebælt	Korsør	21	V90-3.0 MW Offshore Vestas	7	Gravity - Base
Tunø Knob	Kattegat	Odder	5	V39-500kW Vestas	10	Gravity - Base
Vindeby	Smålandshavet	Ravnsborg	4,95	B35/450 Bonus	11	Gravity - Base
Anholt (under construction 2013)	Kattegat	Nørre Djurs	399.6	SWT-3.6-120 Siemens	111	Monopile

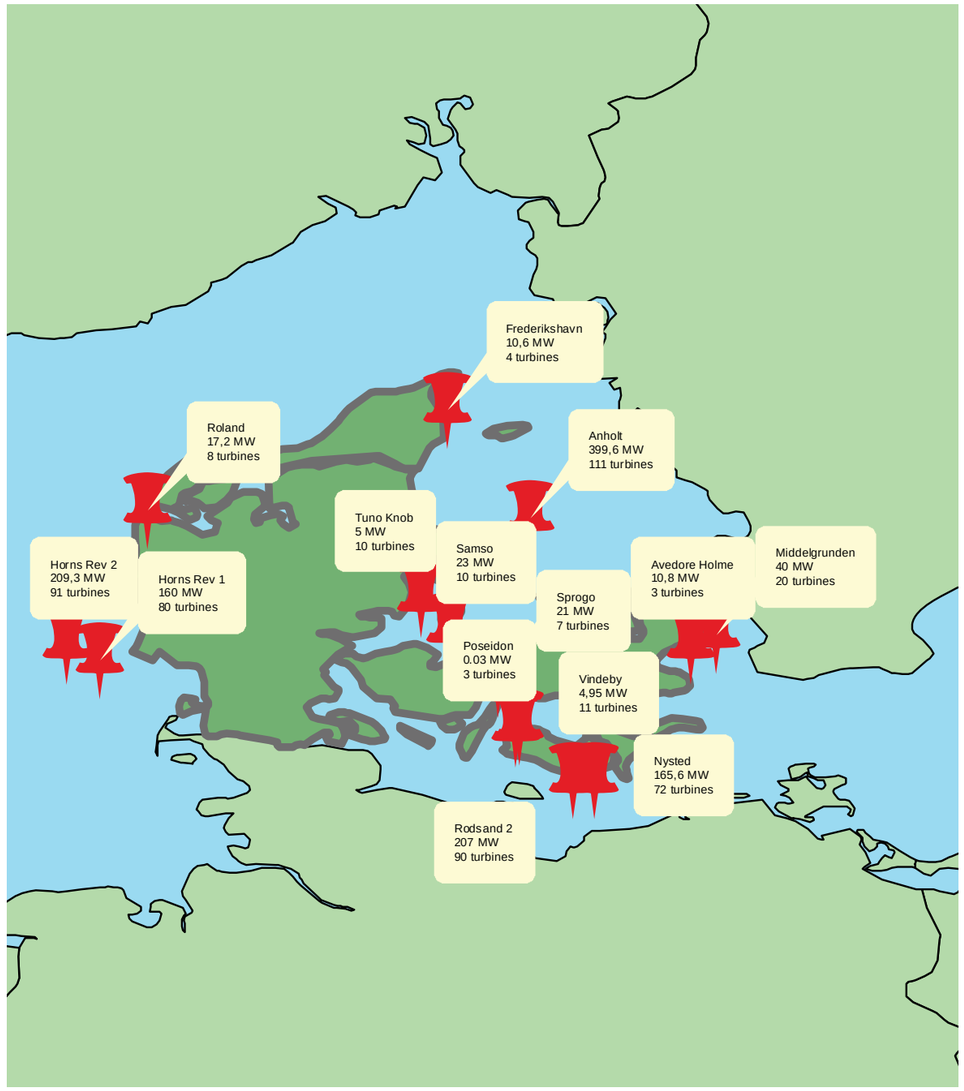


Figure 23. Location of wind farms in Denmark [© POMCERT]

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 18 TWh annually, equivalent to more than half of the current Danish electricity consumption. The sites are prioritized according to public interests, such as the need for grid transmission, navigation, nature, landscape, raw material extraction, and the anticipated costs of establishing and operating the offshore wind farms. The cross-ministry committee has focused on a planned and coordinated development of offshore wind farms and transmission grids. The sites have been chosen based on a strategic environmental assessment in order to minimize conflicts with nature conservation and other environmental interests. Through its Offshore Wind Turbine Action Plan of September 2008, the Danish Energy Authority updated the mapping in light of the Energy Policy Agreement of 21 February 2008. The good wind conditions at the chosen sites will allow the offshore wind farms to 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.

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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 OFFSHORE-WINDENERGIE (the German Offshore Wind Energy Foundation) acquired the project rights of 'Borkum West' from the developer ProkonNord, 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 practicality 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 4. Characteristics of offshore wind farms in Germany [www.offshore-windenergie.net], status: 31.12.2012.

Wind turbine	Sea name	Region	Project capacity MW	Turbine model	Number of turbines	Foundation
ENOVA Offshore Ems-Emden	North Sea	Niedersachsen	4.5	E112/4500 Enercon	1	Monopile
Hooksiel	North Sea	Niedersachsen	5	Bard 5.0	1	Tripile
alpha ventus	North Sea	EEZ	60	M5000-116 Areva Wind, Repower 5M	12	Tripod and Jacket
BARD Offshore I	North Sea	EEZ	400 (160 online)	Bard 5.0	80	Tripile
Baltic I	Baltic Sea	SMZ	48.3	SWT-2.3-93 Siemens	21	Monopile
Breitling/ Rostock	Baltic Sea	Mecklenburg-Vorpommern	2.5	N90/2500 HS Offshore Nordex	1	Gravity-Base

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.

Figure 24. Location of offshore wind farms in Germany, status: 31.12.2012 [© POMCERT]

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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 IIIa 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, ELOMPRES and ALPER together with partners from Spain, Greece, Portuguese, 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 WEBSR2 — 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 sources energetic in May 2011. Special article in this law was dedicated to offshore wind power. 1 January of 2013 was confirmed as date till which Government should prepare order for offshore auctions organisation, which winners will receive right to start investigations and real panning of offshore wind power parks.

Lithuanian Wind Energy Association, Strategic Self-Management Institute, Innovations company Eksponente 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 Windlift1 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 terrestrially grounded National General Plan

MYTH

Nuclear power is a better option for cutting carbon emissions.

FACT

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.

Source: http://oceana.org/en/our-work/climate-energy/clean-energy/learn-act/renewable-energy-myth-vs-fact

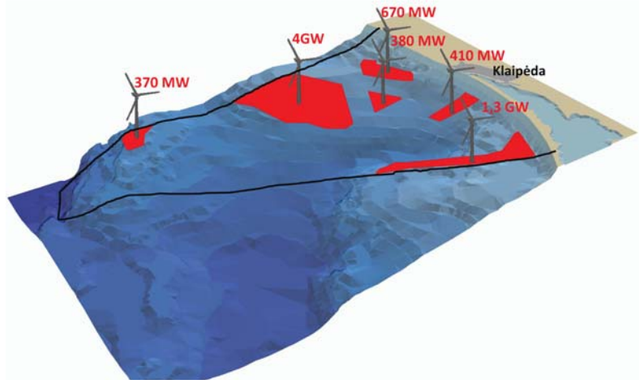

Figure 25. Potential plots for offshore wind power parks installation [CORPI]

to the maritime space in 2012. Project leaded Coastal Research and Planning Institute has built up the consortium composed of professional planners, cartographers and scientists in order to provide a professional knowledge on 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. This allows to set the specific priorities on certain marine areas where OWE development has the maximum economical profit and minimal environmental impact on the ecosystem. The finalization of the Plan is foreseen for the 1st of November, 2013.

The last evaluation of OWE potential showed that 18% of Lithuanian economic zone could be used in dept till 50 meters. In six defined territories there could be installed 1208 wind turbines of 6 MW each (Figure 25). Totally 7,2 GW of wind power could be installed here, what is 7 time more as average yearly consumption of electricity in overall Lithuania.

More as 260 MW on shore wind power is installed in Lithuania now. In coastal area capacity factor is over 31%. Going to offshore wind force is growing significant. According to Baltic Sea Wind map average wind speed in high of 100 meters in Lithuanian waters is 8,5—9,5 m/s. There we could provide capacity factor 45% and more. In heating season, when energy consumption is much higher, offshore wind energy capacity factor is growing to more as 50%. So, in winter time offshore wind energy could be used also for heating purposes. Thanks to set efficient order of RES support in Lithuania in line with wind energy is rapidly growing solar energy sector.

Taking into account seasonal energy consumption variations solar energy in summer time and offshore wind energy in winter time will help Lithuania to free from dependence of foreign suppliers of gas and reach energy independence by use local renewable energy sources. Offshore wind energy will play there the most important role.

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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.

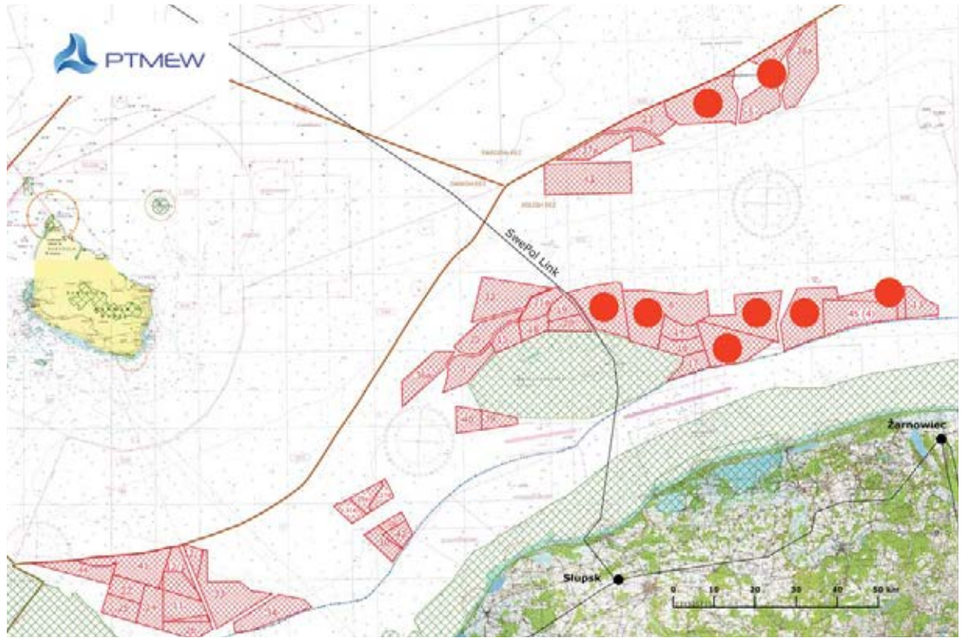

Figure 26. Submitted applications and the secured locations of the planned offshore wind farms in the Polish maritime areas, March 2013 [© PTMEW]

Since mid 2011, over 65 applications for the location decisions have been submitted by the investors and developers to the Polish Ministry of Transport, Construction and Maritime Economy. Till March 2013, the ministry has issued about 20 positive location permits, of which at least 7 have been already paid, becoming finally binding. Among the leading developers, Kulczyk Investments, PGE, ORLEN, DEME, GENERPOL and BALTEX may be mentioned, while some others are still waiting for the final decision. The ministry plans to finalize the entire permitting process till mid 2013 at the latest.

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.

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.

Offshore wind industry 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.

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OFFSHORE WIND ENERGY IN SWEDEN

In 2003, Sweden decided to increase the use of renewable energy by 10 TWh from the 2002 level by 2010. In June 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 Vindkompaniet, 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 power output, the flicker and the reactive power consumption depending on online measurements of the actual grid state. All those 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

Table 5. Characteristics of wind farms in Sweden [Svensk Vindenergi]

Wind turbine	Sea name	Region	Project capacity MW	Turbine model	Number of turbines	Foundation
Bockstigen	Baltic Sea	Gotland Kommun	2.5	Wind World 550 kW	5	Monopile
Lillgrund	Öresund	Malmo Kommun	110	SWT-2.3-93 Siemens	48	Gravity - Base
Utgrunden I	Baltic Sea	Morbylanga Kommun	10	Enron Wind70/1500	7	Monopile
Gässlingegrund	Vänern Lake	Karlstad Kommun	30	WWD-3-100, Dynawind	10	Gravity - Base
Yttre Stengrund	Baltic Sea	Karlskrona Kommun	10	NM 72/2000 (NEG Micon)	5	Monopile
Risholmen Arendal	Göteborg	Goteborg Kommun	4	GE 4.1- 113GE Energy	1	Concrete foundation
"Kårehamn (under construction 2013)"	NÖ Öland	Borgholm Kommun	48	V112-3.0 MW Offshore (Vestas)	16	Gravity - Base

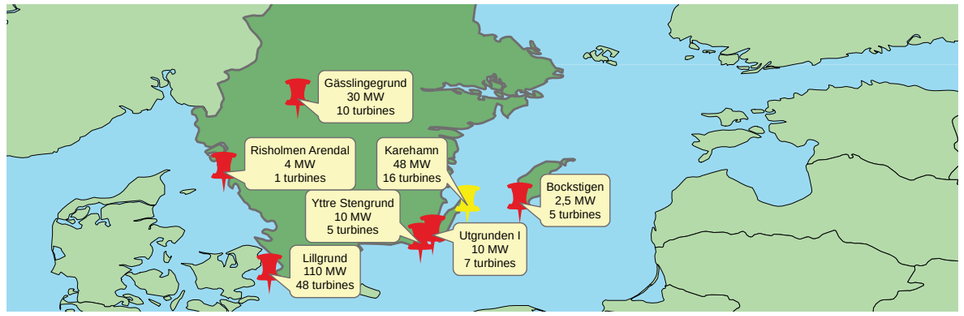

Figure 27. Location of wind farms in Sweden [© POMCERT]

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, Lillgrund 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 Kalmarsund sound, 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 Gässlingegrund, 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 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 Kalmarsund, 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.

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SOUTH BALTIC REGION OUTLOOK

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 6. Total Offshore Wind Capacity (MW) installed until 31.12.2012

Year	Total Offshore Capacity [MW]				
	Denmark	Germany	Sweden	Lithuania	Poland
2000	49.95	0	2.75	0	0
2008	426.35	12	133.65	0	0
2010	863.65	72	163.65	0	0
2012	874.48	280.3	167.65	0	0
2015	1274.1	4000	215.65		0
2020	1450	10000			1000
2025					5000
2030		25000			10000

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

Table 7. Number of Offshore Wind Turbines in the South Baltic Region

Year	Offshore Wind Turbines Number				
	Denmark	Germany	Sweden	Lithuania	Poland
2000	41	0	5	0	0
2008	215	3	65	0	0
2010	403	15	75	0	0
2012	409	68	76	0	0
2015	520	394	92	0	0

The majority of the turbines installed in the South Baltic region (Fig. 28) have been provided by Siemens, which is the dominating company in all the three active countries (Table 8). Nordex has installed one turbine in Denmark and one in Germany. 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 8. Number of turbines produced by different manufacturers sorted by countries (2012 cumulated)

Manufacturer of offshore wind turbines	Denmark	Germany	Sweden
Siemens	303	21	48
Vestas	103		
Nordex	1	1	
Enercon		1	
Multibird/AREVA		6	
Repower		6	
BARD		81	
Wind World (A/S)			5
Enron			7
NEG Micon			5
Dynawind			10
GE Energy			1
GAIA WIND	3		

MYTH

Building a wind farm takes more energy than it ever makes.

FACT

A wind turbine produces enough clean electricity in 3 to 5 months to offset all of the greenhouse gas emissions emitted in its manufacture – and it will produce clean electricity for another 20-25 years. This compares favorably with coal or nuclear power stations, which take about six months. A modern wind turbine is designed to operate for more than 20 years and at the end of its working life, the area can be restored at low financial and environmental costs.

Source: www.communitywind.ca/13701/20501.html

Figure 28. Location of wind farms in the South Baltic Region

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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

LESSONS LEARNT

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

Figure 29. OWE vessel in Lithuania, Western Shipyard

Figure 30. Crash course in Gdańsk, 26 October, 2012

and present a huge amount of important educational material on offshore wind energy in one place with user-friendly search possibilities, a special internet service has been designed, created and described by Miszewska & Tonderski in the article '*Knowledge toolbox — offshore wind energy*'.

But offshore wind energy also has a significant impact on other sectors of the economy. As described in previous chapters, there is a significant impact on industrial development, employment, innovation, etc. There are many initiatives where new clusters and associations have been created to support economic development of the OWE industry. The examples presented by Proba show the impact of OWE on other sectors of the German economy (the article '*How can OWE support development of other economy sectors*?'). Another example, presented by Wagner et al. highlights the impact of offshore wind farms on the tourism industry (the article 'Offshore wind farms change the tourism industry').

Many of the selected examples presented here could be duplicated, replicated and adapted in other regions, to foster the development of a sustainable offshore wind energy sector.

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FROM VISION TO REAL ACTIONS

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.

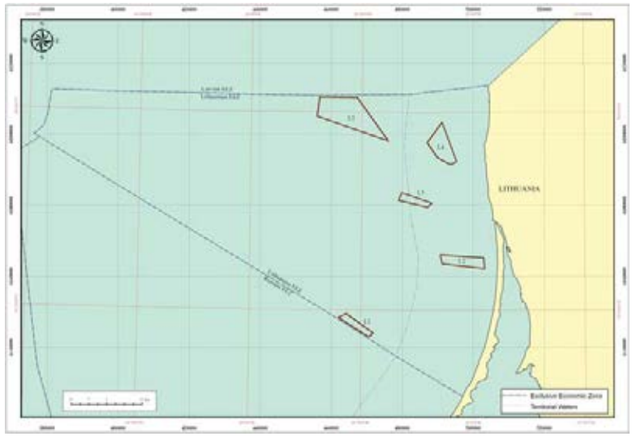

Figure 31. Areas identified for OWE development in the year 2008

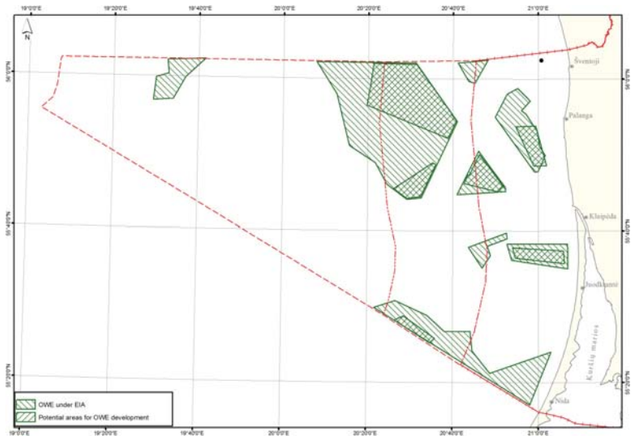

Figure 32. Identified areas for OWE development and projects under EIA in 2012

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 Windlift1 (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 cauterize the maritime affairs. Preparation of training concepts/programs, summer schools, manuals and guidelines are key tools to fill this gap.

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FASCINATION OFFSHORE - A WIND ENERGY EXHIBITION

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

Figure 33. Touring boat exhibition [German Offshore Wind Energy Foundation]

Figure 34. Exhibition [German Offshore Wind Energy Foundation]

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.

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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

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

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 manufactures 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 produces 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.

Figure 36. Demonstration wind energy plant with 'offshore-comparable" conditions in Rostock harbour (Breitling wind energy plant)

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HOW OFFSHORE WIND FARMS CHANGED THE TOURISM INDUSTRY

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 edutainment 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

Table 9. Tourism and offshore wind energy – impacts [German Offshore Wind Energy Foundation closely following Hilligweg & Kull, 2005; ARCADIS, 2010]

Tourism and Offshore Wind Energy	
Fears and Prejudices 'damage to image due to disturbing emotions'	Benefits 'better image due to the value of experiencing entertainment and prosperity of the region'
Impacts on the landscape	Fascination with technology
Land use	Event character
Noise and shadow flickering[1]	Contribution to active environmental protection
Risk of ship collisions[2]	General attractiveness of region

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

information centre informing about offshore and onshore wind energy. An alternative could be provided by nearshore demonstration turbines together with information boards. In addition, offshore wind farms could offer excellent diving and sailing areas. Offshore restaurants and merchandising products could also be opportunities for the tourism industry.

No matter which attractions concerning offshore wind energy the region might offer, incorporation into regional information material (e.g. tourism guides) is crucial.

But also industrial areas/cities with manufacturing capacities related to offshore wind energy can exploit the attractiveness of this new industry. One example from Germany is the 'Tour de Wind' in Bremerhaven (Fig. 36). The Bremerhaven Economic Development Company Ltd. (BIS) offers a guided bus excursion, from March to November, which runs along 20 stations through Bremerhaven. The seaside city is a centre for offshore wind energy and attractive for companies from the wind energy sector, e.g. in the fields of research, construction and the maritime industry. The bus tour focuses on providing information on offshore wind energy and its entire supply chain. Parts of the tour are, for example, the offshore security training centre, the wind house, and the offshore-heliport. Another station is the College of Applied Sciences in Bremerhaven, which offers a Master's degree program in Wind Energy Technology. Following the success of the 'Tour de Wind', the BIS decided to plan for establishing a permanent offshore information centre. The study 'The Impact of Offshore Wind Energy on Tourism — Good Practices and Perspectives for the South Baltic Region' with further examples is now available and can be requested from the German Offshore Wind Energy Foundation.

Figure 37. Tour de Wind in Bremerhaven [© BIS Bremerhaven Touristik]

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HOW TO DEAL WITH THE PUBLIC IN RELATION TO OFFSHORE WIND ENERGY INVESTMENTS?

The term 'social acceptance' of wind energy is used here, meaning acceptance from all project stakeholders, consumers, policy makers, neighbours 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 do 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 utilise 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.

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.

MYTH **Wind farms kill birds.**

FACT The modern wind farm undergoes a series of environmental assessments before being approved. In this process, the proposed site will be monitored and bird populations evaluated. What kinds of birds are on site? What are their habits, flight patterns? Do they nest in the area or simply fly through? Questions like these are answered in an effort to better understand on-site bird populations and to mitigate their potential interactions with wind turbines. Once built, further monitoring takes place to better understand the ongoing relationship between birds and the wind farm.

A real concern for birds is noted in the 2004 study in Nature that estimated that up to a quarter of all bird species could become extinct by 2054 due to global climate change, for which wind energy is one of the solutions.

Source: www.communitywind.ca/13701/20501.html

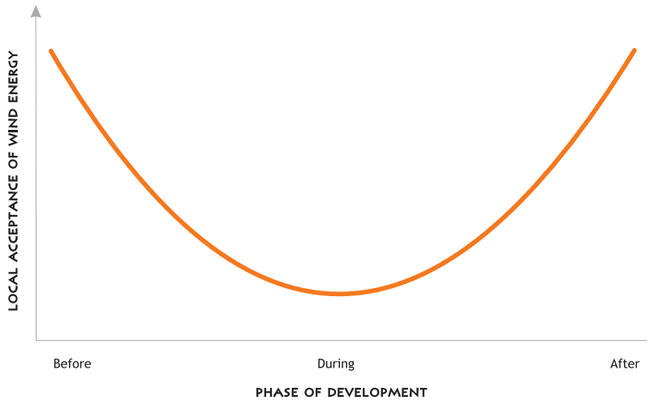

Figure 38. Community acceptance of wind power during the development of a local wind farm

In Denmark, the introduction of wind turbines on land started in the late 70'ies led by private idealistic people and cooperatives, and the general support 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 neighbours living within 4.5 km from the wind farm at cost basis, i.e. the developer should have no profit 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.

MYTH

Offshore wind farms are detrimental to commercial and recreational fishing.

FACT

Offshore wind turbines cause minimal impacts to commercial and recreational fishing, and the wind industry is working actively with the fishing industry to ensure this continues.

The proposed wind farms placed turbines far apart to allow trawlers to navigate in a relatively straight line. Research also suggests that offshore wind farms may actually improve fish stocks by providing habitat – similar to artificial reefs.

Source: http://oceana.org/en/our-work/climate-energy/clean-energy/learn-act/renewable-energy-myth-vs-fact

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EXHIBITION ABOUT OFFSHORE WIND ENERGY

In Guldborgsund Municipality there are three exhibitions 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 Nysted Offshore Wind Farm, Rødsand II and the coming wind farm at Kriegers Flak, all of which can be accessed 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 exhibition or information centres is to attract a sufficient amount of visitors. A visitor centre on offshore wind energy is not in itself able to attract a large number 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 location should be one of the first considerations.

Figure 39. Nysted Offshore Wind Farm Information and Activity Centre

Guldborgsund Municipality has given great attention to this, and have 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 driers, 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.

Figure 40. Nysted Offshore Wind Farm Information and Activity Centre

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.

MYTH

Wind farms have a negative impact on tourism.

FACT

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 25% 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_farm_myths_and_facts_briefing.pdf

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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]

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.

Figure 42. Lecture about offshore wind energy [Photo: Michalina Pączkowska]

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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.

Figure 43. The wind power plant in action

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, Svennes 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.

Figure 44. 110 students gathered in the Art hall of Karlskrona

Figure 45. Students on the way to the wind turbines. Coffee break

In total, 30 students participated in Sölvesborg on the 21th of May, and 110 students in Karlskrona on the 22th of May (Fig. 44).

At the event, the following information was also distributed:

- The possibility to work within the wind power business area.
- Information about study possibilities at Gotland University (by Skype).
- Information about study possibilities at Blekinge Institute of Technology.

The students in Karlskrona were also invited to a field trip. The field trip was to 5 GE wind turbines of 2.5 MW located in Brunsmo, about forty kilometres north of Karlskrona (Fig. 45 and 46). Arise Windpower owns the turbines, and their chief technician talked about wind energy and the possibilities to work in this field. Four teachers and 45 students participated in the study tour, and both students and teachers found this to be a very successful activity. The municipalities will develop this concept and repeat it another year.

Figure 46. Students entering the tower of the wind energy plant

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KNOWLEDGE TOOLBOX – OFFSHORE WIND ENERGY

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.

Figure 47. Main page of Offshore Knowledge Toolbox

MY DOCUMENTS LIST

Your data update in 1 files.
You have 67 documents

File / Link	Requirements not met	Quality	Download
Link: http://www.seai.ie Name: Experience from the development of Offshore Wind Projects Region: Other, Languages: English, Document type: Presentation Key words: Industry, grid, challanges Information category: Other, Year of file origin: 2008 Link: http://www.seai.ie	Not verified yet	NOT ACCEPTED	0
Link: http://img.trojmiasto.pl/download/1/Fact-Sheet.pdf Name: Heavy-lift jack-up vessel, INNOVATION = Power of Performance = Fact Sheet Region: Poland, Other, Languages: English, Document type: Document Key words: Heavy-lift jack-up vessel Information category: Technology, Year of file origin: 2011 Link: http://img.trojmiasto.pl/download/1/Fact-Sheet.pdf	• consent of the author • compliance with the specification • English abstract	NOT ACCEPTED	0
Link: http://www.youtube.com/watch?v=8iBJRciIB-8 Name: Offshore Wind Turbine - 3D Presentation Region: Other, Languages: English, Document type: Video Key words: Turbine, AREVA, principles of operation Information category: Operation and maintenance, Year of file origin: 2012 Link: http://www.youtube.com/watch?v=8iBJRciIB-0	All requirements are met	ACCEPTED	0

Figure 48. 'My documents list' which is available on user's account

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.

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USEFUL LINKS

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

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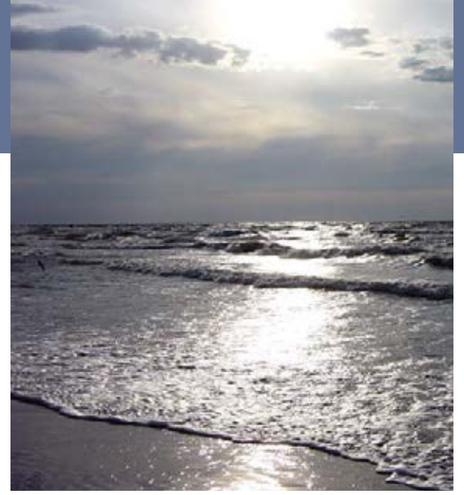
LIST OF ACRONYMS

AC	alternating current
AEDs	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
BIS	The Bremerhaven Economic Development Company Ltd.
BOEM	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
DOE	The U.S. Department of Energy
DOI	The U.S. Department of Interior
DOTI	German Offshore Test Site and Infrastructure Company
DTU	Technical University of Denmark
DWCI	Determination of No Competitive Interest
DWIA	Danish Wind Industry Association
EDP	Energies de Portugal
EEZ	Exclusive economic zone
EIA	Environmental Impact Assessment
Envisat	Environmental Satellite
EWEA	European Wind Energy Association
FP6	6. Framework Programme
FP7	7. Framework Programme
ft/s	1 foot/second (= 0.3048 meters/second)
GDP	gross domestic product
GE	General Electric
GHG	Greenhouse Gas
GW	gigawatt
HAWE	High Altitude Wind Energy
HVAC	high voltage alternating current
HVDC	high voltage direct current
IWEA	Irish Wind Energy Association
KT	knowledge toolbox
kWh	kilowatt hour
LT	Lithuania
LWEA	Lithuanian Wind Energy Association
m/s	meters/second
MSP	Maritime Spatial Planning
Mt	Megatons
MW	megawatt
MWh	megawatt hour
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NEPA	United States National Environmental Policy Act
NSCOGI	The North Seas Countries' Offshore Grid Initiative
NSR	North Sea Region
OCS	US Outer Continental Shelf
OFFSHORE-WINDENERGIE	— the German Offshore Wind Energy Foundation
OIR	Offshore Infocenter Rostock
OKT	Offshore Knowledge Toolbox
ONEP	offshore grid development plan
OSWInD	Offshore Wind Innovation and Demonstration Initiative
OWE	Offshore Wind Energy
PL	Poland
PM	Permanent magnet
POMCERT	Pomeranian Centre for Environmental Research & Technology
POWER	Pushing Offshore Wind Energy Regions
PTMEW	Polish Offshore Wind Energy Society
PTVs	Personnel Transport Vessels
PWEA	Polish Wind Energy Association
renewableUK	— British 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
SMZ	12 sea mile zone
SWEA	Spanish Wind Energy Association
t	Ton
TWh	Terawatt-hour
TP	Transition piece
UE	European Union
UK	United Kingdom
US	United States
VDMA	German Association of Machinery and Plant Manufacturers
W	Watt
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



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