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Demand and Requirements of the Offshore Wind Industry concerning Ports worldwide

Final Report

The International Association of Ports and Harbors

Technical Committee Port Planning and Development

UNICONSULT Universal Transport Consulting GmbH
April 2013

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1. INTRODUCTION

Ports worldwide have realized that the Offshore Wind Energy industry is offering an enormous value-adding potential to their development. Ports have chances of emerging as production location as well as a base or service port for wind energy as it has been already demonstrated along the North Sea coast in Northern Europe.

The events in the nuclear power plant of Fukushima in Japan in 2011 created new dynamics in the debate on the turn in energy politics and on the production of renewable energy after the decades of nuclear and fossil fuels. These dynamics can lead to a reduction in period of time that is taken to plan and realize for Offshore Wind Energy Farms (OWF) thereby leading to an increase in the number of farms worldwide. By this development new jobs and additional positive regional economic effects can be created at port locations along the world's coasts.

The North Sea ports are currently the main nodes for this new market which is rapidly growing in Northern Europe. The United Kingdom (U.K.) is Europe's leader in Offshore Wind Energy as regards to the installed Megawatt (MW) capacities. Germany will be the second largest Offshore Wind Energy market regarding installed Megawatt (MW) capacities in the future. Currently studies indicate that up to 69 OWF are going to be installed along the whole German Bight. Plans are underway to install 25-30 Gigawatt (GW) of wind power in this region by the year 2030. The construction of the first commercial OWF in the German Exclusive Economic Zone (EEZ) has already begun (such as the installation of the OWF "BARD Offshore 1" with 80 Offshore Wind Energy Plants (OWEP) to be installed until end of 2013). At the same time several more European countries are planning to establish the Offshore Wind Energy sector within their waters (e. g. the United Kingdom with installation of around 32 GW until 2023). Furthermore the Offshore Wind Energy industry is heading the worldwide market, whereby the import and export of Offshore as well as Onshore Wind Energy plants and components will be an important factor for the worldwide industry especially in Europe, Asia and America.[1]

Therefore many ports not only in Europe but also in different continents all over the world where the Offshore Wind Energy is emerging are faced with the requirements and demands of the Offshore Wind Energy industry. Due to the large number of processes which are related to fabrication, construction, installation, grid connection, operation and maintenance of OWF and OWEP, there are many different possible functions that can be taken over by ports in the offshore-related supply chain leading to different requirement profiles. For instance in terms of production, the requirements are determined by the components. In the field of storage they are related to the production depth of pre-installation. Transport and handling also need to be taken into

[1] The China wind energy development roadmap 2050 predicts an installed capacity of 1 Terrawatt (TW) of wind power in China in the year 2050. The scenario expects a total installed capacity of 200 GW of wind power in the year 2020, whereof 30 GW should be distributed by near offshore wind parks. It is planned to double the total installed capacity to the amount of 400 GW of wind power in the period from 2020 to 2030 (335 GW onshore, 60 GW near offshore, 5 GW far offshore). See China Wind Energy Development Roadmap 2050 (2011), pp. 23. For the situation in the USA see the study "Large-Scale Offshore Wind Power in the United States – Assessment of opportunities and barriers" (2010), pp. 121.

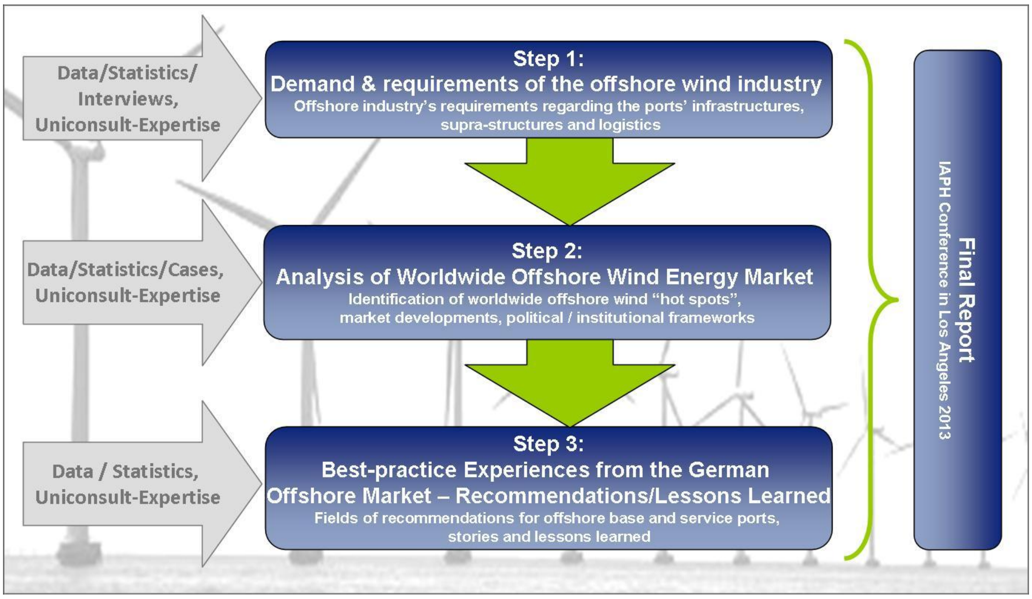
consideration. Furthermore there is also value-added potential in the formation of clusters, e. g. in regards of service, research or eco-monitoring.

With respect to the worldwide development of the Offshore Wind Energy sector the main **goal** of the present study is to offer an overview on the corresponding requirements towards the ports' infrastructures, supra-structures and logistics. Therefore the following questions are answered by the study:

- What are the demands and requirements towards port infrastructures, supra-structures and logistics regarding fabrication, installation, service and operation of Offshore Wind Energy farms and plants?
- Where are the major international markets of the Offshore Wind Energy industry and therefore the most important Offshore Wind Farms located worldwide and which are the most relevant current and future developments including political/institutional regulations?
- Which experiences from the German Offshore Wind Energy market can be made available to the ports worldwide, leading to first best-practice recommendations with regard to the ports' fields of offshore-related actions (e. g. infrastructure, strategy and cooperation, etc.) from a base port or a service port perspective?

In order to respond to the above listed questions and to achieve the mentioned goals the study has been conceptualized in the three methodological steps displayed in the figure below.

Figure 1 Systematic Approach



Source: UNICONSULT (2012)

In step 1, primary data sources will be used and will be obtained through interviewing major market players and secondary data will also be used to identify the Offshore Wind Energy industry's requirements towards ports. In a second step the study will further utilize both primary and secondary data sources to analyze the worldwide Offshore Wind Energy market developments. In step 3, case studies have been used to document best practices in Europe which will further assist in drawing recommendations for ports to position themselves as base or service port.

2. REQUIREMENTS OF THE OFFSHORE WIND INDUSTRY CONCERNING PORTS

In this chapter the possible functions of ports in the Offshore Wind Energy industry (i. a. base and service ports' functions) will be explained together with the factors relating to the corresponding industry's requirements towards the ports such as nautical needs, demand for land, infrastructure needs and services, accessibility requirements and hinterland connectivity. This will provide ports worldwide with an overview of requirements that they have to fulfill in order to benefit from the potentials of this industry.

Prior to the identification of the industry's requirements towards ports an introduction into the Offshore Wind Energy related maritime logistics will be given stemming from the major worldwide Offshore Wind Energy market Europe with regard to installed capacities and plants. This includes the current market situation, technology development and logistics needs in terms of construction and operations, services and maintenance.

As mentioned above the Offshore Wind Energy industry is offering large potential for ports worldwide in terms of creation of new jobs and enhancing regional economic development. Ports can serve the industry not only as handling and transshipment node but also as high quality industrial location, such as for producers of Offshore Wind Energy Plant components.

2.1 Maritime Logistics

2.1.1 Status Quo in Europe

In general there are two major different tasks to be fulfilled by the Offshore Wind Energy industry:

- The installation of Offshore Wind Energy plants (OWEP),
- The operation and service including maintenance and repair of OWEP and OWF.

These two tasks lead to different requirements in terms of the maritime logistics and the need with regard to suitable transport, installation and handling equipment.

<u>Market Situation</u>

Although first commercial Offshore Wind Farms are already installed in the North Sea, Irish Sea, and Baltic Sea, the European Offshore Wind Energy industry is still in between the industry life cycle phases of introduction and growth. During 2012, work was carried out on 18 Offshore Wind Farms in Europe (see the following table): four utility-scale wind farms were completed. Works went on and several wind turbines were erected and connected in five further wind farms. Works have started but no turbines are yet connected in nine other wind farms. Additionally, preparatory work has begun at five more sites: Belwind Phase 2 and 3 (Belgium), Vertiwind (France), and Dan Tysk, EnBW Baltic 2 (Germany) as well as West of Duddon Sands (U.K.).[2]

[2] European Wind Energy Association (EWEA) (2013), p. 5, “The European offshore wind industry – key trends and statistics 2012”. Please see also chapter 3 of the present study.

The average capacity rating of the 293 offshore wind turbines connected to the grid in 2012 was 4 MW, 11 % bigger than in 2011. The continued dominance of Siemens' 3.6 MW turbine explains why the average capacity of turbines remains around the 4 MW mark. The average capacity of the 18 wind farms being constructed during 2012 was 285.6 MW, 43 % more than in 2011. This confirms the sector's trend towards larger turbines and bigger wind farm projects.

So the present study defines the Offshore Wind Energy industry's requirements towards ports based on the already available experiences with the average 4 MW turbines as **minimum needs**. Of course the study also integrates those perspectives on logistics as well as on port infrastructure and supra-structure arising from larger capacities of turbines and therefore larger scales of Offshore Wind Energy plant (OWEP) components. The development towards lager scale OWEP (larger turbines in combination with larger rotor-blades with larger diameters) is strongly connected with OWF installations far offshore, i. e. in larger distances to the shores: as those OWF installations lead to higher logistics and operational costs they have to generate higher volumes of electricity and revenues per OWEP.

Table 1 Status Quo of Works at European Offshore Wind Farms in 2012

Offshore Wind Farm name	Country (EEZ)	Status quo of works
Ormonde	United Kingdom	Fully grid connected
Walney 2	United Kingdom	Fully grid connected
Greater Gabbard	United Kingdom	Fully grid connected
Sheringham Shoal	United Kingdom	Fully grid connected
Thornton Bank (phase 2 and 3)	Belgium	Partially completed
Lincs	United Kingdom	Partially completed
London Array	United Kingdom	Partially completed
Anholt	Denmark	Partially completed
BARD Offshore 1	Germany	Partially completed
Global Tech 1	Germany	Foundations installed
Nordsee Ost	Germany	Foundations installed
Meerwind Süd/Ost	Germany	Foundations installed
Riffgat	Germany	Foundations installed
Borkum West II	Germany	Foundations installed
Teesside	United Kingdom	Foundations installed
Gwynt y Mor	United Kingdom	Foundations installed
Gunfleet Sands 3 Demonstration	United Kingdom	Foundations installed
Kårehamn	Sweden	Foundations installed

Source: European Wind Energy Association (EWEA) (2013), p. 5

The current assessment of the numbers of OWF-projects in the North Sea – the region with the highest market potential in Europe – on planned, approved OWF and on

OWF in the status of approval procedure in the German, Danish, Dutch, Belgium and the United Kingdom's Exclusive Economic Zones (EEZ) shows the following situation:[3]

- At the moment for approximately 75 % of all OWF that are planned, approved or in the status of approval procedure, it is unknown when their installation will actually start. However, the year of installation of an OWEP is of great importance because it determines different actions during its life-cycle like maintenance, repowering or replacements generating market potential for ports (see also chapter 2.1.2).
- In total there are 283 OWF-projects (including expansion projects) operating, under construction, in the approval procedure, approved or still planned. Taking an average of 5 MW per OWEP there are 15,307 OWEP in total in the North Sea in a distance lower than approximately 200 nm away from the major already operating base ports along the Belgium, Dutch, German and Danish coast in the Danish, Dutch and German EEZ, 11,307 OWEP in a distance of 200-400 nm in the Dutch, Belgium and U.K. EEZ and another 1,040 OWEP in a distance larger than 400 nm located in the U.K. EEZ near to Scotland.

This leads to significant market potentials of the already established offshore base ports of Esbjerg (Denmark), Cuxhaven, Bremerhaven, Emden (all located in Germany)[4], Eemshaven, Vlissingen (both Netherlands), Oostende (Belgium), Hull, and Grimsby-Immingham (both U.K.).

Technology Situation

In the next 5-8 years it is expected that the average Offshore Wind Farm (OWF) size will further increase. While it has been on average 200 MW in 2011, 286 MW in 2012, projects currently under construction already have an average size of about 300 MW. Developers plan for the U.K. offshore wind "round 3" with project sizes of up to 555 MW. This trend is supported by technological advance in the field of Offshore Wind turbines. As already stated, today, the average capacity of all installed Offshore Wind Energy plants (OWEP) is 4 MW. There are already 5 MW turbines available and it is expected that turbines with a 10 MW capacity will be built in the future. Meanwhile the market leader Siemens has started to bring its new 6.0 MW wind turbine on the market (first turbine was installed in the Dong-Offshore Wind Farm Gunfleets Sands at the end of January 2013).[5]

Following the installation phase the repowering of Offshore Wind Farms will be another important market segment in the future. Due to a lack of experiences with lifetimes of OWEP-turbines only assumptions can be made about the exact start of this

[3] Based on available market data from UNICONSULT, dena („Deutsche Energie-Agentur GmbH") and the British Department of Energy and Climate Change (DECC) and further publicly available sources as i. a. http://www.4coffshore.com/; http://www.offshorewindenergy.org/.

[4] Furthermore there are activities along the German coasts to develop offshore base ports in Brunsbüttel, Rysumer Nacken near Emden, Wilhelmshaven and to build a dedicated offshore terminal in Bremerhaven (OTB).

[5] In 2012 the prototype of the 7 MW Samsung turbines was entering the market.

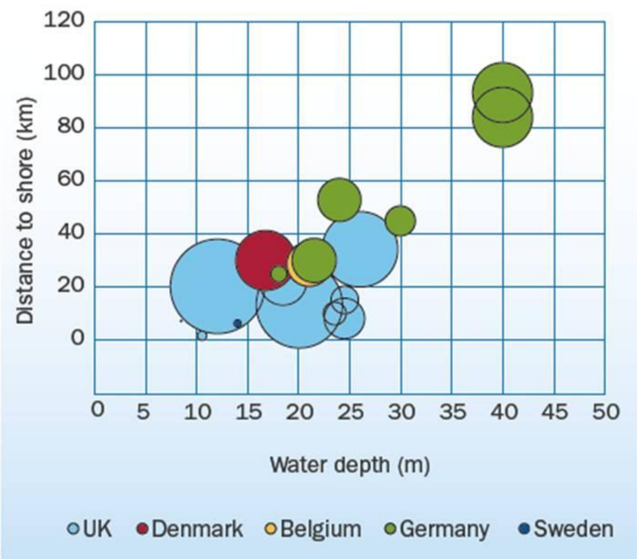
period, approximately beginning at 2030. Nowadays the industry estimates the lifetime of offshore turbines between 15 and 25 years.[6]

Based on current market and expert knowledge, repowering will not only mean to replace the wind turbine itself, but also all other components including the foundations, as the future larger turbine types will require different OWEP specifications. Furthermore, the distances between the wind turbines in an OWF need to be increased due to larger diameters of the rotors. The result will be not just the replacement of the offshore wind turbine, but a new planning of the whole Offshore Wind Farm.

At the moment Offshore Wind Farm installation projects have their own tailor-made logistics concepts leading to still not realized high standardization and logistics optimization potentials. A variety of logistics concepts is implemented when installing an OWF depending on the individual strategies of the OWF-developing company, component manufacturers or the companies which will operate the OWF. Therefore the number of standardized processes in the offshore maritime logistics is rather low, yet.

Furthermore the maritime offshore logistics differs also depending on geographical location of the OWF whether in deeper waters (far offshore) or in shallow waters (near shore) as well as on the types of OWEP-components (e. g. foundations) used for installation. The average water depth of European Offshore Wind Farms where work was carried out in 2012 was 22 m, slightly lower than in 2011 (see the following figure). The average distance to the shore for those projects was 29 km, almost 24 % more than in 2011 (23.4 km).

Figure 2 Water Depth, Distance to Shore and Size of OWF under Construction in 2012



Source: European Wind Energy Association (EWEA) (2013), p. 10

Due to legislature and regulatory reasons the OWF in the German EEZ are far-offshore projects. As displayed in the figure above especially the German OWF are

[6] Based on expert interviews with market players the present study will calculate with an average lifecycle for each OWEP of 20 years.

on average positioned approximately in 50 km distance to the coasts and in 20-25 m water depth.

Depending on the depths of water different technologies for OWEP foundations have to be applied. The following figure gives an overview on the developments of OWEP foundations. With the anchorage of wind energy plants on the seabed, different fundament types can be employed. Their possible areas of employment are dependent on factors like the weight of the OWEP (mass of the housing), water depth, the dynamic load spreading as well as conditions and the consistency of the seabed. With regard to the limited transport possibilities of foundations and foundation components which can weigh more than 1,000 tons, the technical infrastructure for the production as well as the production location is important when choosing suitable foundations for an OWF.[7]

The foundation type which is mainly used in Europe at the moment are tripods (suitable for water depths of 20 to 80 m and employable in relatively flat seabed in particular), monopiles (the area of employment is restricted to relatively low water depths of up to 20 m), and jackets (they can be used also with relatively big water depths).

Figure 3 Developments in the Offshore Foundation Technologies

Source: Stiftung Offshore Wind Energy (2012)

With regard to the service, operation and maintenance of OWF the maritime logistics is still in its infancy even though there are shipping company owners, e. g. A2SEA A/S, which are already starting to provide offshore service logistics solutions. They are developing and managing vessel pools for services of OWEP (each pool consisting of one or more vessels which can be shared between different sites and/or wind farm owners). In terms of fabrication and installation the industry has begun sharing the technology and logistics experiences stemming from the offshore oil and gas industry (e. g. using jack-up platforms, floating cranes, heavy lift platforms and pontoons) – especially in the United Kingdom.

In the past 2-3 years more and more innovative vessel technologies have been developed for the installation of OWF so that the competitive situation between the Offshore Wind Energy industry and the offshore oil and gas industry in terms of vessel capacities is slowly declining. This can avoid capacity bottlenecks when Offshore

7 http://www.offshore-windenergie.net/en/technology/fundaments.

Wind Farm installation will reach the status of serial production in the forthcoming years.

During 2012 a number of new installation vessels were delivered including the “Northwind Installer” by NorWind, “Pacific Orca” by Swire Blue Ocean, “Hydra” and “Zaratan” by Seajacks, “Seafox 5” by the Seafox Group, “Friedrich Ernestine” by RWE Innogy, and the “Innovation” by HGO InfraSea Solutions.[8] The latter is shown in the following picture. At the moment it is one of the largest installation vessels with 147.50 m length hull overall, 42 m breadth hull, 11 m depth hull. When jacking-up, the vessel can operate in a water depth of 50.00 m up to 65.00 m (with leg extension) and in weather conditions with significant wave heights up to 2.00 m and wind speed of 18 m/s for crane operation.

Those new generation installation vessels feature innovative technologies. They are capable of operating in deeper waters (up to 75 m) and in harsher sea conditions (higher waves). Moreover, they can carry a larger number of foundations and turbines and are equipped with stronger cranes capable of lifting and installing wind farm components with enhanced precision. Those purpose-built vessels reduce the number of trips from ports to Offshore Wind Farm sites which are required during the installation process and they increase the “weather window” during which the offshore work can be carried out. Ultimately, this increased efficiency will be an important driver in reducing Offshore Wind Farm installation costs in the future.

Figure 4 HGO InfraSea Solutions Installation Vessel „Innovation“

Source: HGO InfraSea Solutions GmbH & Co. KG (2013)

Indeed the primary goal of future optimization in the Offshore Wind Energy technologies for the purpose of installation, service, operations and maintenance is to reduce maritime logistics costs and to expand the timeframes for installation and service operation.

8 See EWEA (2013), p. 10.

Furthermore the companies constructing and installing OWF are pursuing the goal to keep themselves independent from any potential capacity bottlenecks in terms of installation vessels (see the mentioned competition on maritime equipments with the oil and gas industry above). Therefore many of them are ordering own vessels. Those vessels can then be equipped and designed tailor-made to the requirements of the buyers and can be used flexible and for own purposes. For the logistics demand of its Offshore Wind Farms e. g. RWE Innogy operates two special installation vessels. The “Victoria Mathias” and the “Friedrich-Ernestine” were set off for Europe in December 2012. They will overcome one of the most important supply bottlenecks which RWE Innogy faces at the moment in the construction and installation of Offshore Wind Farms.[9] Ship owners of special Offshore Wind Energy vessels (e. g. A2SEA A/S) are expanding their fleets of installation and service/crew vessels to serve the increasing demand regarding construction of Offshore Wind Farms in Europe. In the field of service and maintenance more and more special vessels are going to be developed to optimize OWF service logistics in the area of quick response services for critical smaller spare parts as well as for heavy maintenance purposes.

With regard to the still missing long-term experiences with the construction of OWF and the corresponding technologies, no standardized logistics concepts for the installation and service/maintenance of OWF currently exist. Therefore it is important for ports worldwide to know the already used and the currently discussed construction, installation and service operation concepts as they lead to different requirements towards the infrastructure and logistics (see chapter 2.2). The following chapters will focus the fields of construction, service, operations, and maintenance of OWF and will describe corresponding current and future offshore logistics concepts. The resulting requirement profiles regarding ports will be elaborated in chapter 2.2.

2.1.2 Construction

In the first construction phase of an OWF the foundations are piled before in the second phase the Offshore Wind Energy Plant (OWEP) is installed. The OWEP components (foundations, tower segments, turbines, nacelles, and blades) are pre-stored and pre-stowed in the base port. The OWEP components either are manufactured in the production plants located at the base port or are transported seaward or landward from other production locations to the base port: foundations have to be shipped seaward due to their heavy weights, whereas blades, nacelles, turbines, and tower segments can be transported landward. In the base ports the ship’s own handling equipment is generally used for the sea side handling of OWEP components. Therefore installation vessels or heavy-lift platforms have to be jacked up in the port.[10] However, the OWEP components have to be placed in the reach of the boom of the handling equipment. This is why the handling of pre-assembled rotor blades or stars with a diameter of 130-160 m (Siemens’ new 6.0 MW turbine has a rotor diameter of 154 m) makes water-side handling processes difficult so that the loading of those OWEP components will be done more and more shore-side. The future larger scale

[9] See http://www.rwe.com/web/cms/en/1299546/rwe-innogy/technologies/offshore-logistic/installation-vessel/news-archive/archive-2012/.

[10] At the moment there are also floating techniques discussed for loading/unloading of installation vessels which would avoid jack-up processes. However, jack-up technologies can provide more stable offshore working conditions in harsher weather conditions than floating technologies.

turbines with 6.0 up to 10.0 MW will bring Ro-Ro-loading on the agenda using self-propelled modular transporter (SPMT) systems due to cost and safety reasons. Shore-side handling of e. g. tower segments is done in general using craning and lifting equipment of heavy-cargo shippers.

For the most cost-efficient construction of OWEP it is essential to reduce the offshore works as much as possible due to the fact that labor costs offshore are up to three times higher than in the ports.[11] The conditions for accessing OWF are more difficult compared to terrestrial wind energy plant locations. Referring to representatives' knowledge from the Offshore Wind Energy market it can be realistically assumed that construction, installation and repowering actions can be carried out throughout the whole year in a restricted timeframe of approximately 170-220 days due to heavy weather conditions (high waves and strong wind). So the Offshore Wind Energy industry aims to pre-assemble OWEP components to complete modules as far as possible in the ports before installing them offshore.

The further increase of sizes of single components of new OWEP with more than 6.0 MW capacities will require larger installation vessels and/or higher frequencies of transports in between the base ports and the OWF. The increase of OWEP dimensions and weights leads to reductions of pre-assembling processes of OWEP components to complete or semi-complete OWEP in the ports. Referring to the offshore market players the larger scale OWEP will be transshipped in single components (single blades, single power sections, etc.) by the installation vessel. The assembling will then be executed in the OWF leading to higher working costs as it was mentioned above.

Based on given testimonies from the offshore market the loading, the transport and the piling of foundations requires an average construction time of 2-3 days. For the construction of an OWEP in the OWF a timeframe of approximately 2-4 days can be assumed including loading, transport and installation. Actually the offshore installation time for a 3.6 MW OWEP can be estimated to be approximately 20 hours. Those timeframes can be reduced or enlarged dependent on the dimension of pre-assembly of OWEP components.

The level of pre-assembly depends on the technical restrictions which are determined by the type of turbines (MW capacity, size and manufacturer). This influences the usability of the handling, installation and transport equipment (loading/overload capacities). For instance the 5 MW OWEP of an offshore wind manufacturer were pre-assembled to complete rotor-stars and installed offshore using craning techniques (see the following picture showing the transport of a rotor-star to the Belgium Offshore Wind Farm Thornton Bank).

[11] This information is based upon interviews with major market players of the Offshore Wind Energy industry.

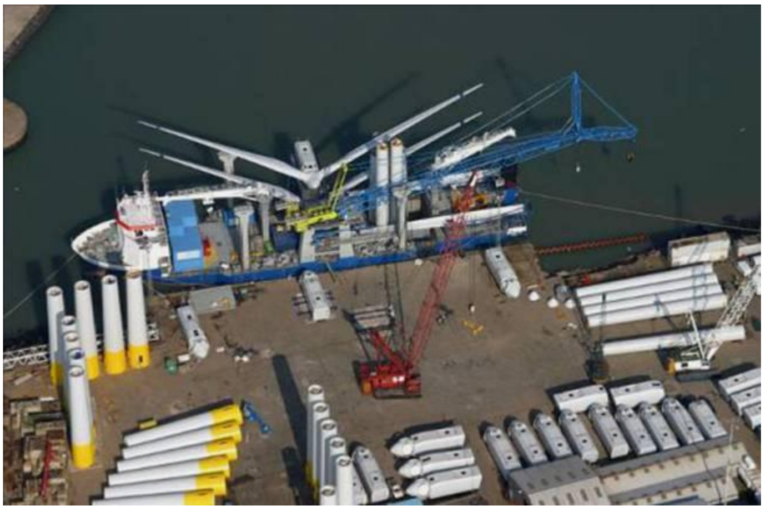
Figure 5 Jack-up Platform transporting pre-assembled Rotor Star

Source: obs/REpower Systems AG (2011)

In contrast to this logistics approach of transporting pre-assembled OWEP component parts, another option is to transport single components to the OWF and to assemble them (e. g. the blades at the before installed nacelle, see figure 8). This has been executed several times for the 3.6 MW OWEP turbines.

According to the dimensions and weights of single components and modules the logistics and assembly concepts are varying. An intermediate type of transport of OWEP components is the so-called “bunny ears”-transport, describing the transport of the nacelle together with two assembled blades (see the following figure). However, this concept seems not to be feasible for future larger scale OWEP and their components.

Figure 6 Assembling of an OWEP and Transport of “Bunny Ears”

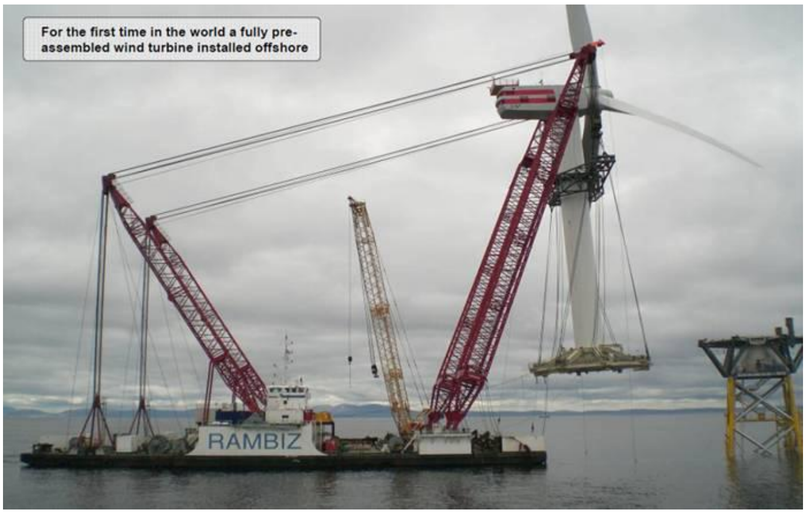


Source: EnBW Renewables GmbH (2009)

Independent from the above illustrated assembly and transport options installation vessels in general are able to ship tower segments, rotors, turbines and blades for at least one complete OWEP. The current and future generation of installation vessels will be able to transport components for up to 5-8 OWEP (foundations not included).

In contrast to the transport of single OWEP components or modules it is also possible – subject to the general technical set-up in a port – that an OWEP is totally assembled in the port (tower segments, nacelle and rotor blades) so that complete OWEP are loaded and shipped to the OWF for installation on the corresponding pre-piled foundations (see the following figure). However, this is especially feasible for smaller OWEP with lower capacities.

Figure 7 Installation of a completely assembled OWEP



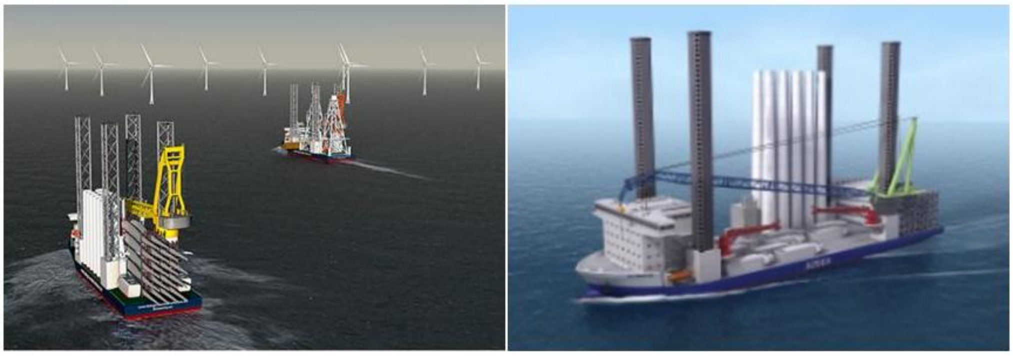
Source: REpower Systems AG (2009)

In terms of handling, transportation and installation two different approaches can be identified:

1. All construction tasks are executed using the same equipment, i. e. the installation vessels or jack-up platforms use their ship-own craning and lifting equipment for handling the OWEP and foundations in the port. After that, the OWEP are transported to the OWF and installed offshore using those vessels and platforms.
2. In a “feeder-system” the installation vessels or jack-up platforms are positioned directly in the OWF. The OWEP (components) are transported to the OWF with the help of pontoons. Hence, OWEP and foundations are handled by landside craning and lifting equipment (heavy-lift cranes). This concept has been applied especially for the setting, i. e. piling and ramming, of foundations using floating cranes. In this concept the offshore technologies which are stationed in the OWF have to be frequently delivered with OWEP components by pontoons to reach cost-efficiency.

Offshore market players and experts state that the use of jack-up technologies leads to time consuming jacking processes in the ports. Furthermore there is no common guidance for the transshipment/handling of OWEP components. In general the market favors the handling and transportation of all OWEP components with the same equipment and vessel (approach no. 1 listed above). Although the described “feeder-system” is generally attractive for constructions of OWF with larger distances to the shores the trend in the offshore industry is to use larger and faster installation vessels for handling, transport and installation of single OWEP components (see the following figure and the figures in chapter 2.1).

Figure 8 Vessel and Logistics Concepts of the Offshore Wind Energy Industry



Source: BELUGA HOCHTIEF Offshore GmbH & Co. KG and A2SEA A/S (2011)

Furthermore a trend can be observed using self-propelled installation vessels. Looking at the descriptions in chapter 2.1 the jacking systems have started to penetrate the offshore market. Jacking-up the installation vessels above sea-level enables exact fixing of the vessels for OWF construction purposes. In contrast to floating platforms this leads to stable working platforms which are able to operate more independent of harsher weather and sea conditions. In addition the capacities and dimensions of the new installation vessels are increasing. This is necessary with regard to larger dimensions of the OWEP in the future. The new installation vessels are able to operate in deeper waters (e. g. the above mentioned "Innovation" can operate in waters up to 65.00 m (with leg extension)) and will expand their maximum capacities up to 8 OWEP per installation/repowering trip.

The following figure shows alternative techniques and methods for the construction of OWEP and for service, maintenance and operations of OWF. However, from today's perspectives it is not sure whether and when such concepts will reach marketability.

The design of the maritime logistics for construction purposes of OWF is substantially dependent on the project-related location of a port and the selection-criteria of the involved manufacturing companies or OWF developers. In case they commit themselves for a base port location being also a production site then they need solid and long-term favorable quantifiable and qualitative location factors. Otherwise they commit themselves only for an individual OWF-project. In case that another base port may have better location characteristics for another OWF-project they switch the complete maritime logistics to that port.

2.1.3 Operations, Service and Maintenance

During their life-cycles the OWF with their numbers of OWEP generate different actions beginning with the installation and then followed by service, operations, maintenance, replacements/repair, and repowering. Based on market and expert statements the following assumptions can be made:

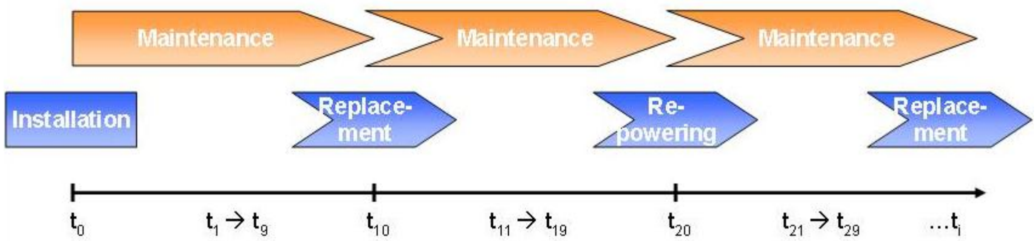
- The life-cycle of each OWEP can be assumed to be approximately 20 years on average.
- Within this life-cycle there are maintenance actions required yearly, including smaller repairs. Those maintenance actions are assumed to be carried out

regularly, i. e. each installed OWEP will be visited once a year during its lifetime.

- At halftime of the life-cycle of an OWEP the following replacements or repairs of components can be presumed:
  - 2 % of OWEP will need replacement of their tower segments.
  - 10 % of OWEP will need replacement of their turbines.
  - Each OWEP will need replacement of one blade leading to total replacement of blades at each third OWEP.
  - Replacements are accompanied by some miscellaneous parts that also need to be replaced.
- After approximately 20 year's life-cycle it can be presumed that each OWEP will be repowered leading to totally new installation of all OWEP components due to technical reasons (e. g. larger diameters of blades will require new tower segments and foundations). Based on market information it is assumed that on average the numbers of OWEP per OWF will be reduced by 20 % of the former number of plants due to higher capacities of each new plant.

The following figure shows the presumed life-cycle and the corresponding actions.

Figure 9 Life-Cycle of an OWEP leading to different Actions



Source: UNICONSULT (2012)

In the field of services for an OWF the following three types of maintenance and repair can be distinguished.

<u>Inspection and basic Maintenance Works</u>

Inspections and basic maintenance works are in general done using manual controllable tool kits. Those works generate transports of smaller scale components, spare parts and material. The OWEP are therefore equipped with service and maintenance containers. Smaller vessels have to be used to transport service crews and corresponding equipments. In case of extremely bad weather conditions helicopters should be employed. The OWEP can therefore be accessed either by using helicopter platforms for hoisting service personnel on the top of the OWEP or by using landing stages and transition options at the waterline (see the following figure).

Figure 10 Transition of Service Crew on an OWEP

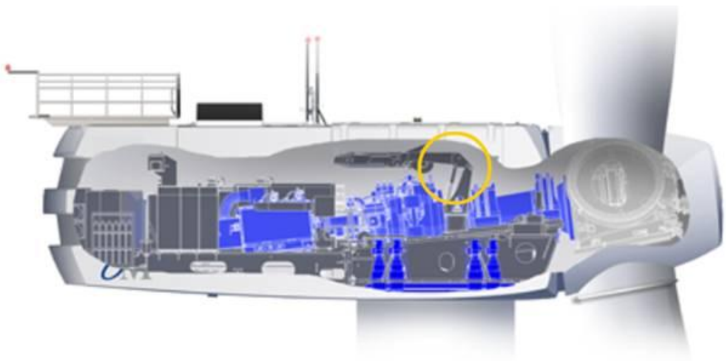
Source: Deutsche Offshore-Testfeld- und Infrastruktur GmbH & Co. KG (2010) and THB of 12.04.2010

Maintenance and Repair Works

Maintenance and repair works mean the replacement of larger components. The parts which have to be replaced are transported to the OWEP by using special service vessels. Those vessels not necessarily need to be equipped with ship-own craning and lifting equipment as the OWEP itself have own mobile cranes in their nacelles/turbine houses (see the following picture) which can be used for easy handling processes.

In the past (especially for some offshore test fields) the Offshore Wind Energy industry used converted work boats of the offshore oil and gas industry equipped with load-bearing deck cranes to operate and supply the OWEP with maintenance containers. In the meantime special Offshore Wind Energy related and designed service vessels are under construction to optimize maintenance and repair works for larger components. Furthermore some of the smaller installation vessels of the past might be deployed in the future for those works. However, it cannot be estimated at the moment whether those former installation vessels would really be suitable service vessels.

Figure 11 Nacelle/Turbine House of an OWEP



Source: REpower Systems AG (2013)

Substantial Repair Works and Repowering

Substantial repair works (replacement of tower segments, blades or turbines) and repowering require technical support which cannot be managed with the OWEP own mobile cranes. In that case the same techniques have to be used as it is done for the installation of an OWEP/OWF.

Summary

As the power generation through commercial OWF is still in the process of development currently there are no well-established experiences in terms of service and maintenance. For this reason no standardization trends can be observed regarding logistics and technical service solutions. At the moment service and maintenance works in Europe are carried out shore-based, i. e. based on a port. The operators of OWF currently are looking for suitable service ports, establishing hubs from where whole OWF-clusters could be served.

For far offshore OWF first sea-based concepts are planned. For instance Vattenfall as the future operator of the OWF "DanTysk" (part of the German "SylWin"-cluster) has ordered the building of an offshore accommodation and service platform which shall be used by the service crews to provide quick response service solutions in the OWF from the beginning of 2014.

At the moment some OWF-operators have equipped their OWF transformer stations with accommodation facilities (see the following figure).

Figure 12 Accommodation Facilities on the Transformer Substation of the OWF "BARD Offshore 1"

Source: BARD (2012)

European market players expect the development of a special business area in the field of Offshore Wind Energy service logistics for OWF, especially when the terms of guarantees of the turbine producers will end and more and more OWF will be commercially operated. It can be assumed that there will be an increasing market potential in the field of service, maintenance and repair in the forthcoming years.

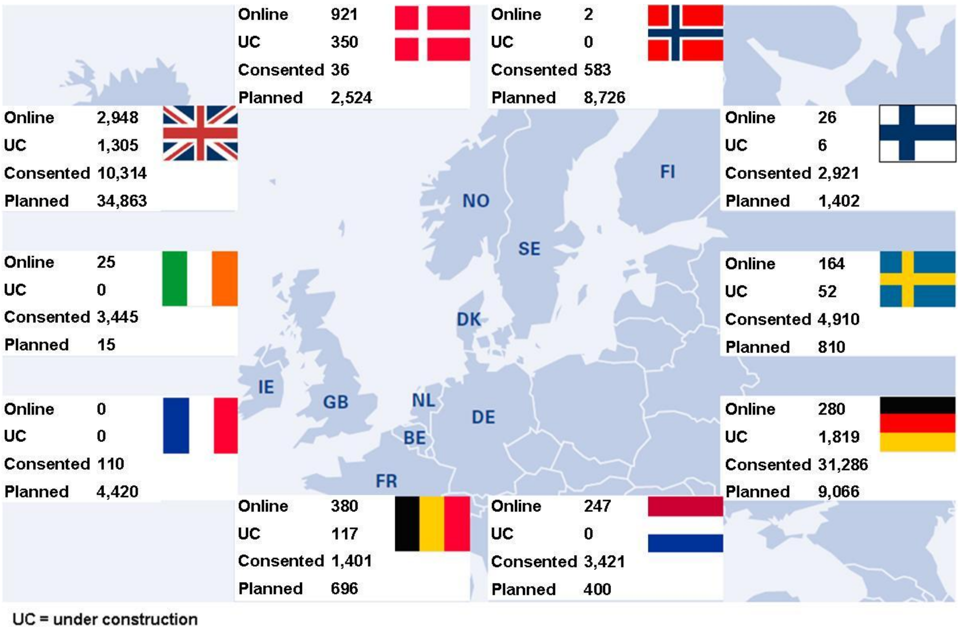
2.2 Port Functions and Offshore Wind Energy Industry Requirements

The development of the Offshore Wind Energy as power supply system of the future holds large potentials for seaports in terms of employment and value creation. Ports are the decisive logistics hubs for construction and service, maintenance of OWF as all OWEP components have to be passed through them. Looking on the following figure the EEZ of Germany and the United Kingdom will build the nucleus of OWF construction, installation and service in the forthcoming years and decades (planned offshore wind projects).

Therefore many ports along the North Sea coasts have started planning to become future base or service ports. Besides the core maritime Offshore Wind Energy logistics tasks like storage, stowage and transshipment/handling there are additional multifaceted opportunities for ports to benefit from the offshore wind power generation: settlement of companies, creation of new jobs, and further development of infrastructure and research facilities.

At the same time market players in the Offshore Wind Energy industry (OWF planners and developers, OWEP component manufacturers and designing engineers, ship-owners, OWF operators and energy providers) are checking different port locations regarding their qualifications for Offshore Wind Energy business activities. Especially in terms of pre-assembly and loading of heavy-lift OWEP components the infra- and supra-structural capacities are often still limited in many ports.

Figure 13 European Offshore Wind Projects in MW (Status Quo End of 2012)



Source: UNICONSULT (2013), map by KPMG (2010), data by EWEA (2013) and 4COffshore (2013)

Therefore it is essential to provide ports with the requirements of the Offshore Wind Energy industry players and to show the different functions that port locations can perform.

Due to the huge number of processes, which are related to the construction and operation of OWF and OWEP, there are many different possible functions for ports arising from the fact that they will be part of the Offshore Wind Energy industry supply chain. Out of that there are different requirement profiles for ports dependent on the role and function they play as logistics hubs for an Offshore Wind Energy supply chain.

In terms of production, the requirements are determined by the components. In the field of storage the requirements are dependent on the detailing depth of pre-installation. Transport and handling also need to be taken into consideration. Furthermore there is also value-added potential in the creation of special Offshore Wind Energy clusters, e. g. in regards of service, research or eco-monitoring.

For port locations four main Offshore Wind Energy businesses segments or functions can be distinguished which require different port characteristics:

- Fabrication and installation,
- Operations, maintenance and service,
- Research and development,
- Import and export of onshore and Offshore Wind Energy plants and components.

The following sections describe the mentioned port functions and the corresponding actions and analyze the different requirements that ports have to fulfill in order to enable those business segments.

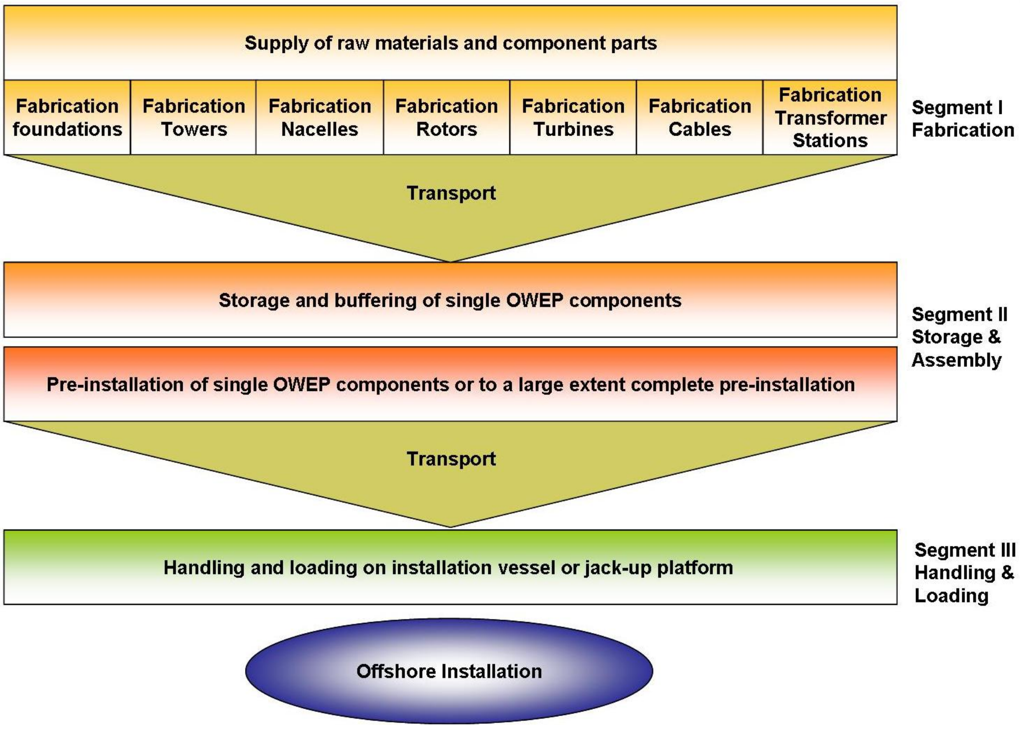
2.2.1 Fabrication and Installation

For port locations the settlement of OWEP component fabrication sites is very attractive as it creates an appreciable number of jobs and has positive influence on the local/regional gross value (see segment I in the following figure).

However, from the logistics' perspective the settlement of production sites is not a compulsory condition for a port to become an offshore base port. Hence, ports without production facilities can also become locations for the installation of OWF acting as consolidation port gathering the OWEP components for shipping them to the OWF (e. g. Port of Belfast).

In the process of installing an OWF, ports have the important function of storing, buffering and pre-assembly of components and OWEP modules (see chapter 2.1.1 and segment II in the following figure). Furthermore the loading of OWEP components on board of the installation vessels or jack-up platforms is the core function of ports in order to transport the OWEP components to the OWF construction field (see segment III in the figure below).

Figure 14 Potential Port Functions enabling Fabrication and Installation of OWF



Source: UNICONSULT (2013)

<u>Segment I: Fabrication</u>

The fabrication of OWEP is usually carried out in decentralized manner. This means that different components are fabricated in different production sites – which are situated to some extent in the hinterland – and are then stored in the direct vicinity of the seaports, partly pre-assembled and transferred to the offshore installation field. Compared to the overall installation process the transport of components plays a minor role in terms of cost-efficiency. For instance Vattenfall's OWF “Ormonde” with a capacity of 150 MW has been constructed in the Irish Sea, 10 km off Barrow-In-Furness, using a large supply chain and Belfast as consolidation port: turbines and nacelles were fabricated in Bremerhaven (REpower 5 MW turbines), foundations came from Cuxhaven (jacket-foundations) and the rotor blades were fabricated in Esbjerg and transshipped via Brunsbüttel. All components were consolidated in the port of Belfast in Northern Ireland where they were pre-stored and pre-assembled in advance to transferring them to the offshore construction field.

The following requirements need to be fulfilled to attract offshore component manufacturers to establish a production site in a port location:

- sufficient industrial real estate at reasonable prices,
- optional areas for future expansions (areas for handling, assembling, fabrication),
- efficient heavy load traffic infrastructure for in- and outbound component flows,
- high potential of the location in terms of qualified manpower,

- availability of Offshore Wind Energy cluster networks to ensure production, knowledge and logistics synergies,
- clear commitments of the political decision-makers for the development of such Offshore Wind Energy clusters,
- administrative support by the port authorities,
- promotion of already established Offshore Wind Energy industry settlements.

Segment II: Storage and Assembly

Due to the often decentralized fabrication of OWEP the port locations have decisive importance regarding the storage of components. Efficient hinterland connectivity as well as sufficient storage area and capacities are location factors with high relevance.

An efficient hinterland connection means that heavy-lift cargo transport can be carried out and that the port location possesses tri-modal connectivity, so that the port can be reached by inland waterway vessels as well as by train and road transport (e. g. heavy duty roads). The storage of OWEP components requires large areas resulting on the one hand from the size of the OWEP and on the other hand from the need to buffer OWEP. It is not possible to produce OWEP just-in-time due to the fact that the supply areas at the manufacturers' production sites are often limited. Furthermore there is an imbalance between the time needed for installation and fabrication. For instance, foundations can be installed within a few days (see chapter 2.1.1). However, the fabrication takes significantly longer times. Additionally, sufficient storage capacity is needed for the so-called winter-fabrication. During winter season less OWEP can be installed compared to the summer season because of bad weather and sea conditions with harsher winds and waves. The annual downtimes can amount between 30-40 %. For the storage location of an OWF with 80 OWEP there is land needed with at least 8-10 hectares (ha) of space. However, according to current market assessments, an area of 20 ha for storage/assembly and 10-15 ha for pre-assembly at the quay is more sufficient keeping in mind the increasing dimensions of new OWEP components in the future. Those areas should be able to carry up to 55 tons per square meters (m^2).

Some components are sensitive regarding dirt and dust. Electro conductive particles (e. g. coal dust) are therefore bearing a risk for OWEP components. Hence, an immission-free storage of the components should be ensured. Furthermore, there should be no limitations in terms of noise and light emission at offshore port locations.

Segment III: Handling and loading

The logistics requirements of the Offshore Wind Energy industry towards ports strongly depend on the dimensions of the OWEP components, and on the planned location of the OWF including water depth and on seabed conditions.

The possibility to carry out pre-assembly and handling activities at a quay that is able to carry heavy cargo is of decisive importance. Due to the high costs for heavy-lifting and craning equipment and the partially restricted time window for offshore installation activities, time-efficient processes at the quay wall are preferred. A just-in-time handling is not feasible. Therefore an area of at least 8–10 ha (10-15 ha preferred) is needed for the pre-assembly of OWEP next to the quay wall. According to market assessments the length of the quay wall should be at least 350 m. However, a quay wall of approximately 1,000 m is preferred by the industry. At these quay walls the permissible surface loading should be more than 50 tons per square meter. For the handling of components with a weight of at maximum 350 tons a craning capacity of at least 1,200 tons is needed. Some players from the offshore industry prefer the use of own craning and lifting or handling capacities (crawler cranes).[12]

Keeping in mind the increasing dimensions of new and future OWEP the industry is currently beginning to think about the possibilities of Roll-on-Roll-off (RoRo)-loading of OWEP components (turbines, blades, tower segments, nacelles) by using SPMT or rolling Mafi-trailers. With rising dimensions of the OWEP, ports should be prepared for offering such handling solutions to the industry.

Special vessels and equipment are used for offshore OWF installations (see chapter 2.1.1). The possibility to jack-up the installation vessel at the quay wall is an urgent need. The pressure on the ground of the port basin that results from the process of jacking-up can be as much as 600 tons per square meter. Therefore morphological assessments must prove the possibility to jack-up installation vessels without any damages to the port basin.

The minimum requirement regarding the draft of port basins near to the quay walls is approximately 9.50 m with a width of berth of 70 m – especially in terms of jack-up-platforms or pontoons. However, the future generation of installation vessel types (with regard to future 10 MW OWEP) and cable installation vessels will require drafts of the port basin at the quay walls of approximately 10-12.00 m and a width of berth of at least 85 m. This is necessary to allow waterside mooring of floating cranes or pontoons besides the installation vessel.[13] In case of near-shore installations in shallow waters modules of smaller OWEP are transported to the construction site mostly by using a seagoing pontoon. At the OWF they are then assembled by using floating cranes. The most important criteria for the selection of a pontoon are its dimensions and therefore its usable surface area. Usually pontoons of 80 m length and 25-30 m width are currently used in Europe for the transportation of large-scale modules. In case that OWEP components have to be transported vertically it is essential that there are no limitations in terms of height at the port location.

In general, installation vessels and other equipment are too largely dimensioned for using locks. Therefore there should be preferably no lock-related limits regarding port entries. The following table summarizes the requirements towards ports in terms of fabrication and installation (base ports).

The **precondition** and absolutely necessary requirements which a **base port** should fulfill in terms of the Offshore Wind Energy industry are the following:

- High quality of location factors (e. g. availability of expansion areas, qualified manpower, etc.).
- Easy usability of the port without any restrictions regarding locks and heights.
- At least bi-modal, preferably tri-modal connectivity of the port with its hinterland to establish high quality offshore-wind logistics chains.

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[12] One of the world's largest installation vessels, the Oleg Strashnov", is equipped with three own cranes with 5,000 tons, 800 tons and 200 tons lifting capacities.

[13] E. g. "BHV Offshore 1" which is used in the German port of Bremerhaven and has a length of 70 m and a width of 32 m and a capacity for loading up to 900 tons.

Table 2 Requirements towards Ports regarding Fabrication and Installation

Requirements	Specification
Hinterland connection	- ability to carry heavy cargo - tri-modal connectivity of the port
Storage / assembly area	- min. 8-10 ha - 20 ha preferred - surface load min. 55 tons/sqm
Area for pre-assembly at the quay	- min. 8-10 ha - 10-15 ha preferred
Jacking-up opportunity / surface load	- indispensable for jack-up installation vessels (not necessary in case of using floating techniques) - 600 tons/sqm
Ro-Ro-loading	- feasibility necessary for larger OWEP component types
Quay	- min. 350 m quay length - 1,000 m preferred - surface load min. 55 tons/sqm
Craning and lifting capacity	- maximum 1,200 tons (foundations' craning and lifting)
Draft	- minimum 9.50 m - 10-12.00 m preferred - preferably not affected by tides
Width of berth	- minimum 70 m - wider than 85 m preferred (due to larger blade racks on board of installation vessels)
Immissions	- none (especially electro conductive particles)
Noise and light emission	- preferably no restrictions
Height restrictions	- preferably no restrictions
Locks	- preferably no locks - minimum width of locks of 70-85 m
Port location quality	- expansion areas - qualified manpower - support of economic development by local business development agencies

Source: UNICONSULT (2013)

2.2.2 *Operations, Service and Maintenance*

Up to now experiences with service and maintenance of commercially operated OWF are hardly made in Europe. In this respect no standardized processes or concepts are established. In fact OWEP producers are developing tailor-made individual service concepts. It can be assumed that at the beginning of commercial operation service and maintenance will be taken over by subsidiaries of the turbine producers. For special services (e. g. helicopter supported services) third party logistics service provider will be integrated into the service concepts.

The field of service and maintenance covers the management of operations, breakdown, routine maintenance and repairs. This includes the remote control, troubleshooting, organization of service and maintenance as well as the commissioning and accounting control. The goal of all service concepts is a cost-efficient OWF operation at 365 days per year, 24 hours per day in a life-cycle of the OWEP of approximately 20 years.

Requirements towards service port locations depend on the kind of services which can comprise elementary condition monitoring and replacements of smaller electronic component parts (“quick response ports” and “service ports for direct maintenance of OWF”) up to anticorrosive coating of OWEP foundations. Heavy maintenance (e. g. replacement of blades or gear boxes (approximately once in a lifetime of each OWEP)) might be executed rather in a base port than in a smaller service port due to the larger storage area requirements and the space and heavy-load/lift facility needs for transshipping those heavy components (at the moment the time of delivery of blades is 3-6 months and of gears is up to 6 months).

The major requirements of the offshore-wind industry towards service ports for the operation of OWF are as follows:

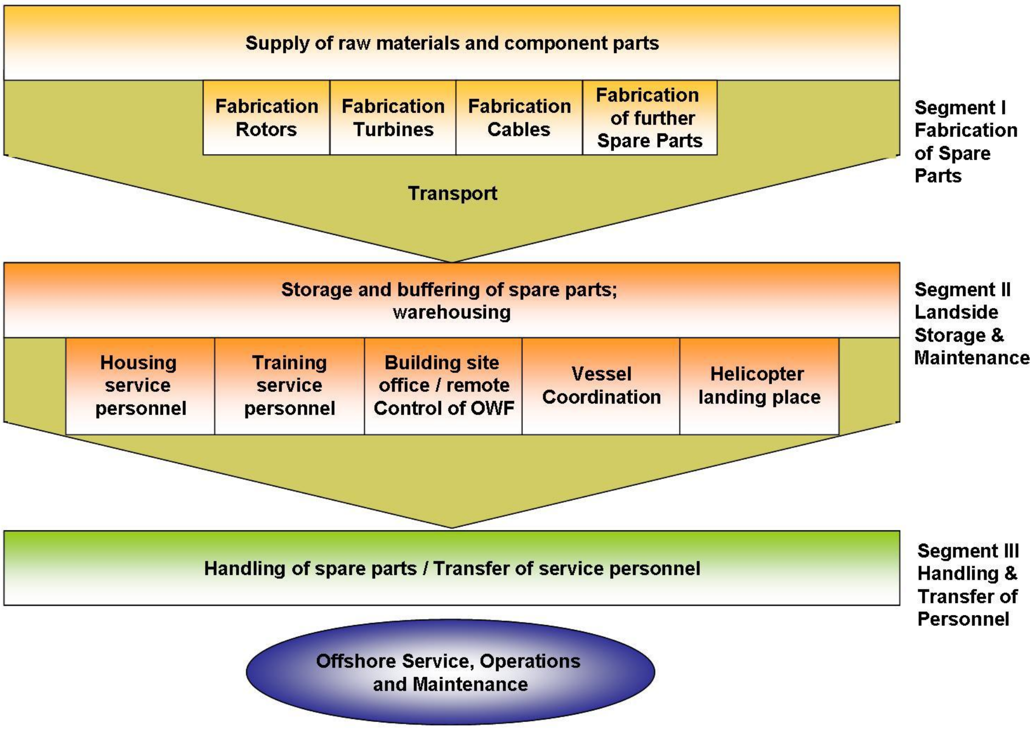
- quick logistics connectivity of the port to the OWF infrastructure,
- good accessibility of the OWF for the service crews,
- short seaward distance of the port to the OWF.

During the fabrication phase primarily the producers of rotors, turbines, cables and other spare parts are responsible for the replacement of spare parts. Those components not necessarily have to be produced directly at the port locations. Regarding the traffic infrastructure and hinterland connections of a service port there are same requirements as for a base port. For smaller components it is rarely predictable, which spare parts have to be exchanged when. Therefore it is important to buffer those parts in the service port.

The service crews need housing as well as education and training facilities close to the service port. In addition to that a helicopter landing place is essential for fast transfers of service personnel to the OWF.

The requirements towards port infrastructures are low compared to base ports. The focus lies upon the transfer of service personnel and materials for maintenance and elementary repairs by vessels. Compared to the requirements towards a base port the requirements towards the efficiency of supra- and infrastructure are lower. So far the demand for transport is at maximum 4 teams with each 1 ton of material in total.[14]

Figure 15 Potential Port Functions enabling Service of OWF



Source: UNICONSULT (2013)

The storage of spare parts requires an area of at least 3 ha. The housing of the service personnel should be as close to the port as possible in order to guarantee short response times. The training and education of the personnel is also carried out in testing facilities. This training can be done in a decentralized manner. The installation of a testing facility in the direct vicinity of the potential service port is of advantage.

An unlimited trans-horizon radio-relay system is important for the building-site office of the OWF. In that office the remote control and condition monitoring system of the OWF should be located. In Germany for instance, OWEP with an absolute performance higher than 100 kW need to be remotely controllable. This is important, because if the stability of the electricity grid is threatened it will be necessary to reduce the performance of OWEP or to switch them off.[15] The following table shows a summary of the requirements of the Offshore Wind Energy industry towards service ports.

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[14] There are different opinions on the volumes of material that can be transported on board of an offshore service vessel together with the service teams. Some experts calculate with 10 tons in total referring to e. g. http://www.bard-offshore.de/de/konzeption/betrieb/swatch-tender. Based on expert interviews that UNICONSULT executed in the framework of other Offshore Wind Energy projects, in the present study it shall be assumed that on average each service team carries 1 ton per service trip with it on the vessel. As it can be assumed that on average 4 service teams consisting of 3 persons each are transported with one service vessel there are 4 tons of material carried with it in total.

[15] See §11 (power feeder management) of the EEG (German renewable energy law).

The **precondition** and absolutely necessary requirements which a **service port** should fulfill in terms of the Offshore Wind Energy industry as service port for quick-response or direct maintenance services are the following:

- Geographical location near to the OWF,
- High quality of location factors (e. g. availability of expansion areas, qualified manpower, etc.).
- At least bi-modal, preferably tri-modal connectivity of the port with its hinterland to establish high quality logistics chains.

Table 3 Requirements towards Ports regarding Operations, Service and non-heavy Maintenance

Requirements	Specification
Hinterland connection	- ability to carry heavy cargo - tri-modal connectivity of the port
Helicopter landing place	- absolutely necessary
Distance to all OWF	- as short as possible - lower than 70 nm preferred
Storage / assembly area	- 3 ha
Quay	- 200 m quay length
Craning and lifting capacity	- 40 tons - Handling of containers possible
Draft	- Minimum 4.00 m - Preferably not affected by tides
Housing	- In the direct vicinity of the port
Training service personnel	- Possibility to set-up test plant
Building-site office/Remote control/vessel coordination	- unlimited trans-horizon radio-relay system
Port location quality	- expansion areas - qualified manpower - support of economic development by local business development agencies

Source: UNICONSULT (2013)

2.2.3 Research and Development

Another important aspect for the future development of the Offshore Wind Energy industry is the field of research and development. In Europe the Offshore Wind Energy market is still at the beginning of commercial operation so that process standardization regarding maritime logistics are still unknown, e. g. in terms of OWEP lifecycle-management, service and operations, repowering, fabrication and installation as well as service or spare parts logistics. Thus there is relevant need in economic and technological research in those fields which has led to settlements of research and development institutes at European ports that are already established in the industry (e. g. Bremerhaven in Germany).

Main goal of research and development[16] is to optimize the qualities of material used for the construction of OWEP and OWF, e. g. to minimize corrosion processes on foundation or blades surfaces. Further fields of research and development are i. a: environmental monitoring and social acceptance of the industry, development of intelligent sensor based OWEP systems, wind turbine design and control, OWF site conditions, forecasting of damages, grid integration.

Figure 16 Research and Development in the Offshore Wind Energy Industry

Source: UNICONSULT (2013)

Future research and development will focus on measurements to increase OWEP reliability and lifetime, to enlarge the efficiency of OWEP in the field of aerodynamics and of transmission components, and to advance the development of new material and production methods.

16 E. g. the research project "RAVE – Research at Alpha Ventus" which was finalized in 2012.

In advance to the installation of OWEP, intensive ground examinations are necessary. New concepts in terms of grid connection and integration of Offshore Wind Energy into the onshore power networks and with regard to onshore based remote control of OWEP will be developed. Furthermore the potential impacts of OWF on flora and fauna have to be examined.

The above listed research fields and the research in offshore-related vessel engineering and navigation imply great potentials to create gross value and jobs in the port locations (base port or service port) and its surrounding regions. There are no differences regarding the requirements of research vessels in terms of infrastructure and supra-structure compared to commercially operating corresponding vessel types. An offshore related profile of a port increases the attractiveness of the location for the settlement of research and development institutes.

2.2.4 Import and Export of Onshore and Offshore Wind Energy Plants or Components

Until today the export of onshore and Offshore Wind Energy plants and components is mainly in the focus of European port activities. However, due to the growing markets in China and other countries it is realistic that in the medium term components will also be imported.

Onshore-WEP are commonly fabricated in the inland, transported to ports and then transferred worldwide by seagoing vessels. This includes the transportation of rotor blades, with a length of up to 60 m and a weight of up to 18 tons, as well as turbines/nacelles, with a mass of 300 tons and dimensions of 18 m x 6 m x 6 m. The most frequently used seagoing vessel types are multipurpose vessels with a load-carrying capacity of up to 10,000 tons.[17] These ships are usually equipped with own craning and lifting equipment in order to be able to handle the components independently from the port supra structure. For the transportation of such components the hatches need to be correspondingly large. This allows a secure transportation of rotor blades. Hatches can be as long as 90 m. The most frequent dimensions of such vessels are the following: length of up to 150 m; width of up to 20 m, and draft of up to 8 m.

Due to the fact that the maximum load-carrying capacity is hardly used because of the significant loss of stowage space during the transportation of components the maximum draft is only achieved in exceptional cases. The requirements for an import/export port are the same as for a base port (fabrication and installation). Due to the huge amount of components that are fabricated in the inland an efficient hinterland connection is of crucial importance for import/export ports. Furthermore special focus has to be put upon the ability to handle heavy lift cargo/break bulk.

[17] Furthermore there are other types of heavy-lift vessels operating with load-carrying capacities up to 29,000 tons. See International Association of Classification Societies (IACS) (2012).

3. ANALYSIS OF WORLDWIDE OFFSHORE WIND ENERGY MARKET

In order to realize the benefit of the emerging Offshore Wind Energy industry currently it is important for ports worldwide – currently especially in Europe and Asia, to understand the industry's requirements towards infra- and supra-structure as well as port logistics. The same implies to the ports in other regions of the world such as those of South America, United States of America and Canada. Compared to their capability profiles and functions, the regional, national and worldwide market development, and the location of Offshore Wind Energy farms are elaborated in the following sections.

The above mentioned regions are already active in Onshore Wind Energy production but that does not naturally imply that their offshore activities have also been fully developed or started. The global view on the market shows that although the Onshore Wind Energy market is substantially bigger considering the total Megawatt hours (MWh) produced per annum, and the number of turbines installed, studies show that the offshore market will develop drastically. Estimates for 2020 indicate a share of 11 % of all installed rotor blades by the Offshore Wind Energy industry while in 2011 this share was less than 1 percent.[18] Despite the limited worldwide geographical spread of installed OWF its influences have significant impact on the companies producing OWEP components.

3.1 Identification of Offshore Wind Energy Regions

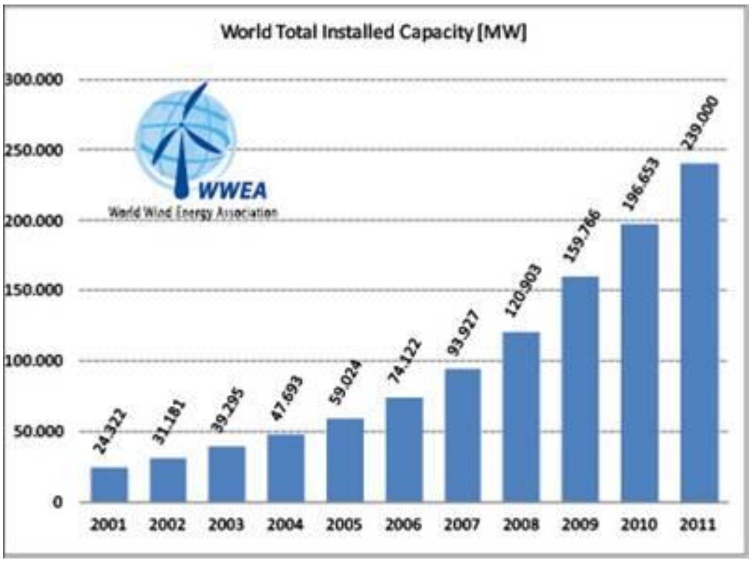
Relevant activities and developments regarding the installation of Offshore Wind Farms have been investigated in Europe and Asia. Especially North America with the United States and Canada is a strong onshore wind energy location but significant offshore wind activities could not be identified. Nevertheless some noteworthy projects and market developments will be considered. There are also some notable projects at an early development stage in India, Australia, Africa and South America but due to their unspecific outputs they will be just mentioned but not regarded for further conclusions.

The complete wind energy market is divided into two segments namely onshore and offshore installed energy producing facilities. Although the focus of this study is mainly on the Offshore Wind Energy market the whole wind energy market is mentioned in the following section to show that the development of both sectors is quite independent from each other although they seem to be quite similar. During the last decade the globally installed wind energy capacity increased drastically, growing from 24,300 MW in 2001 to 239,000 MW in 2011 implying a tenfold increase within ten years. The growth rate for the period from 2010 to 2011 was 22 percent. In 2012, an additional capacity of 36,000 MW has been erected worldwide, which is significantly less than the 41,700 MW in 2011.[19] By the end of 2012 the total installed wind capacity on- and offshore was 273,000 MW worldwide.

[18] See http://www.globaldata.com (2013).

[19] See http://www.sustainablebusiness.com/index.cfm/go/news.display/id/23539

Figure 17 World total installed Capacity (MW)



Source: WWEA (2012)

Europe used to be a pioneer in the field of wind energy in the past, but new markets emerge in various countries. According to the World Wind Energy Association (WWEA), 86 countries worldwide now are using the wind energy to generate electricity.[20] However, 86 % of the installed capacity can be found in only 10 countries, of which six are members of the European Union (EU). The leading nation in terms of installed capacity is China with nearly 68,000 MW by mid of 2012. Between the end of 2009 and mid of 2011 China was able to double the capacity and between mid of 2011 and mid of 2012 it grew by 28 % and thereby reaching a global market share of about 27 percent.

Table 4 Top 10 Countries of Wind Energy by Mid of 2012

Position	Country	Total Capacity by June 2012 [MW]	Added Capacity first half 2012 [MW]	Total Capacity end 2011 [MW]	Added Capacity first half 2011 [MW]	Total Capacity end 2010 [MW]
1	China	67'774	5'410	62'364	8'000	44'733
2	USA	49'802	2'883	46'919	2'252	40'180
3	Germany	30'016	941	29'075	766	27'215
4	Spain	22'087	414	21'673	480	20'676
5	India	17'351	1'471	15'880	1'480	13'065
6	Italy*	7'280	490	6'787	460	5'797
7	France**	7'182	650	6'640	400	5'660
8	United Kingdom	6'840	822	6'018	504	5'203
9	Canada	5'511	246	5'265	603	4'008
10	Portugal	4'398	19	4'379	260	3'702
	Rest of the World	35'500	3'200	32'227	3'200	29'500
	Total	254'000	16'546	237'227	18'405	199'739

* till end of May 2012 ** till end of April 2012 ©WWEA 2012

Source: WWEA (2012)

[20] See WWEA (2012).

The global wind turbine market is a consolidated market of which the top ten companies represent nearly 80 %. European manufacturer Vestas, from Denmark, dominated the global market in 2011, with a market share of 12.9 % on the basis of installed capacity, which was 5,054 MW. This was however a drop from 2010's share of 14.8 %. Goldwind, from China, ranked second with a share of 9.4 % and 2,939 MW of installed capacity.

As China is one of the fastest growing wind turbine markets in the world it supports domestic manufacturers such as the already mentioned Goldwind, as well as Sinovel (ranked second in 2010), Guodian United Power and Ming Yang Wind Power. All these companies are in the top ten ranking of wind turbine producers worldwide for the first time in 2011 and are providing stiff competition to other global players such as GE Energy (USA), Vestas and Enercon (Germany) and Suzlon (India).

The top-ten-list does consist of four European companies and four Chinese manufacturing companies, one US-based company and one Indian company.

Table 5 Top 10 Onshore and Offshore Wind Energy Turbine producing Companies Worldwide

Company	Country	% Market Share 2011
Vestas	Denmark	12,9
Goldwind	China	9,4
GE	US	8,8
Gamesa	Spain	8,2
Enercon	Germany	7,9
Suzlon	India	7,7
Sinovel	China	7,3
United Power	China	7,1
Siemens	Germany	6,3
Mingyang	China	2,9
Others		21,5

Source: UNICONSULT based on data from BTM (2012)

In relation to the onshore wind industry, the Offshore Wind Energy industry has a relatively short history. The market is growing rapidly, supported by technological advancement and the latest energy policy developments in various countries. Although its share of total wind capacity remains small, the Offshore Wind Energy sector continues to expand, increasing by more than 900 MW in 2011 having a total capacity just less than 4,100 MW. When this is compared to 1,200 MW installed globally in 2010, the statistics shows fluctuations of yearly capacity increase indicating the volatility in this industry.

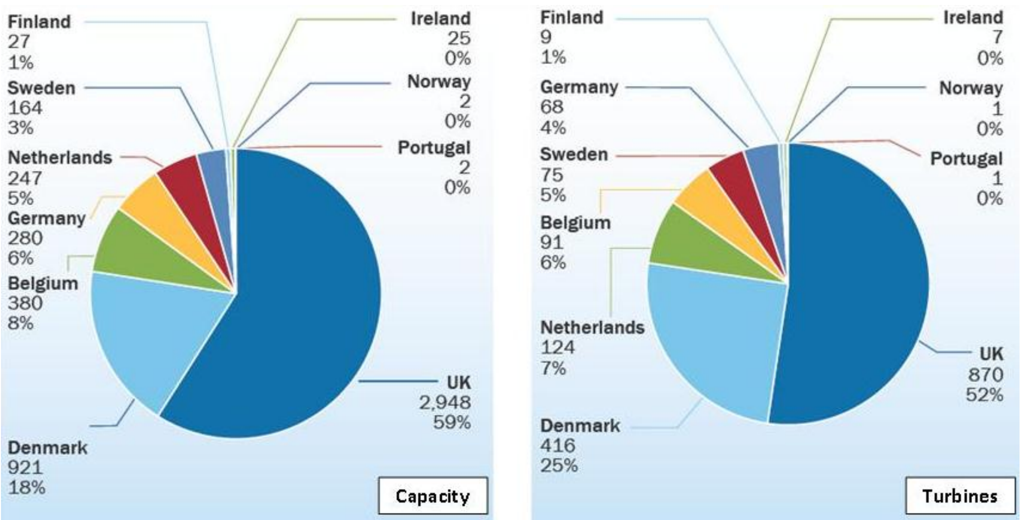
3.1.1 Europe

According to European Wind Energy Association (EWEA) 1,662 turbines have been installed offshore by the end of 2012. This totals in 4,995 MW produced by 55 grid-connected Offshore Wind Farms (OWF) in ten European countries. Coming from around 1,370 turbines in 2011, totaling 3,830 MW leads to an increase of 31 % in 2012 in comparison to 2011.

In 2012, over 73 % of all new capacity was installed in the U.K. (854 MW). The second largest amount of installations were in Belgium (185 MW or 16 %), followed by Germany (80 MW, 7 %) and Denmark (46.8 MW, 4 %).[21]

The two leading countries in cumulated capacity in Europe, U.K. and Denmark, represent around 77 % of the European offshore capacity in MW. By the beginning of 2013, additional 4,460 MW of offshore capacity were under construction offshore of EU coastlines or in advanced stages of preparations.

Figure 18 Cumulative Share by Country of installed Offshore Capacity and Turbines (2012)



Source: EWEA (2013)

Other European nations, such as Portugal, Sweden and Finland, do not have comparative much operational capacity yet, but they have a lot of projects in the pipeline. The European Offshore Wind Energy market is rapidly growing and has a steady MW annual growth. In 2006, less than 100 MW of additional capacity were installed but 2010 figures indicate 900 MW of additional capacity. The industry experienced a minor decline of 1.1 % of new installed capacity in 2011 but the positive trend continued in 2012 with additional 1.166 MW which have been connected to the grid.

One important difference between Europe and the rest of the regarded regions like for example Asia and North America is the non-existence of weather phenomena like hurricanes, typhoons, and earthquakes. The consideration of these events generates additional costs due to very robust constructions and probably increased demand of service and maintenance in those regions in comparison to European farms.

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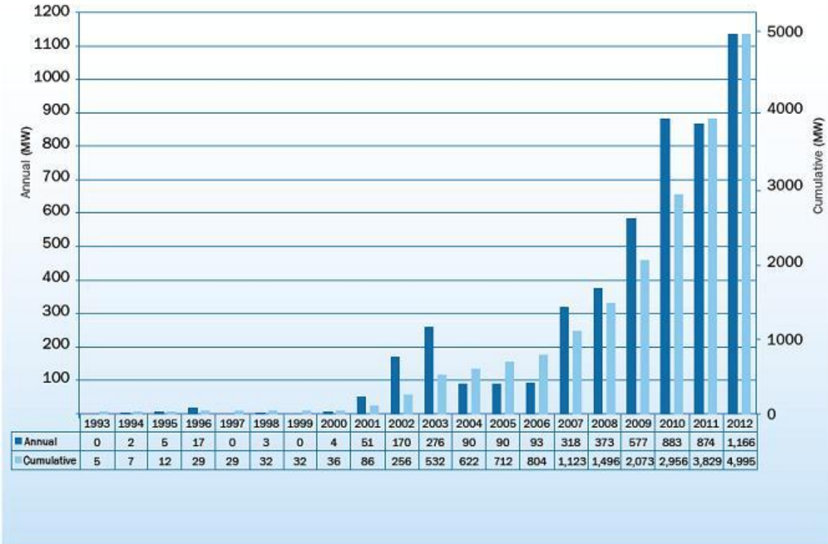
[21] See EWEA (2013).

Figure 19 Cumulative and Annual Offshore Wind Installations in Europe

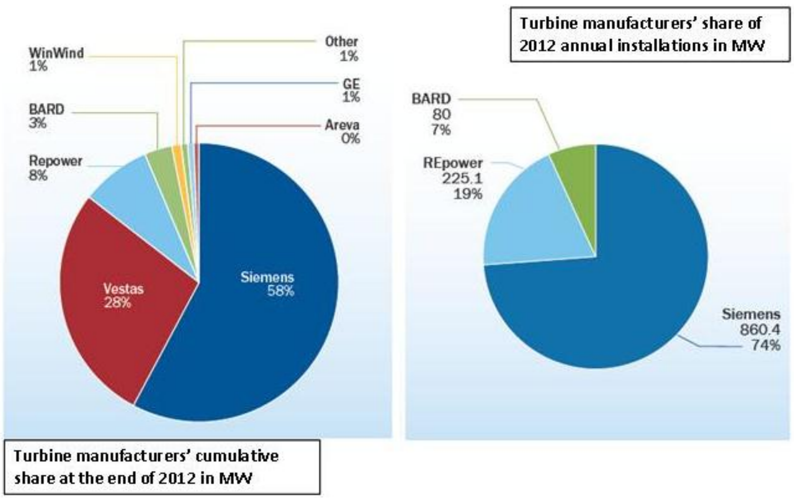


Country	UK	DK	BE	DE	NL	SE	FI	IE	NO	PT	Total
No. of farms	20	12	2	6	4	6	2	1	1	1	55
No. of turbines	870	416	91	68	124	75	9	7	1	1	1,662
Capacity installed (MW)	2,947.9	921	379.5	280.3	246.8	163.7	26.3	25.2	2.3	2	4,995

Source: EWEA (2013)

There are various manufacturers producing Offshore Wind Energy turbines for the European Offshore Wind Energy market. However, the market is dominated by two of them in terms of cumulative installed capacity. These are Siemens and Vestas with a combined market share of about 86 percent. The remaining 14 % is split amongst other players such as REpower, Bard, WinWind, GE, AREVA and others. But, looking at the annual market shares for new installed capacity in 2012, Vestas installed none, and REpower and Bard stand for 26 % of installed MW.

Figure 20 European Offshore Wind Turbine Manufacturers' Cumulative and Annual Market Shares at the End of 2012



Source: EWEA (2013)

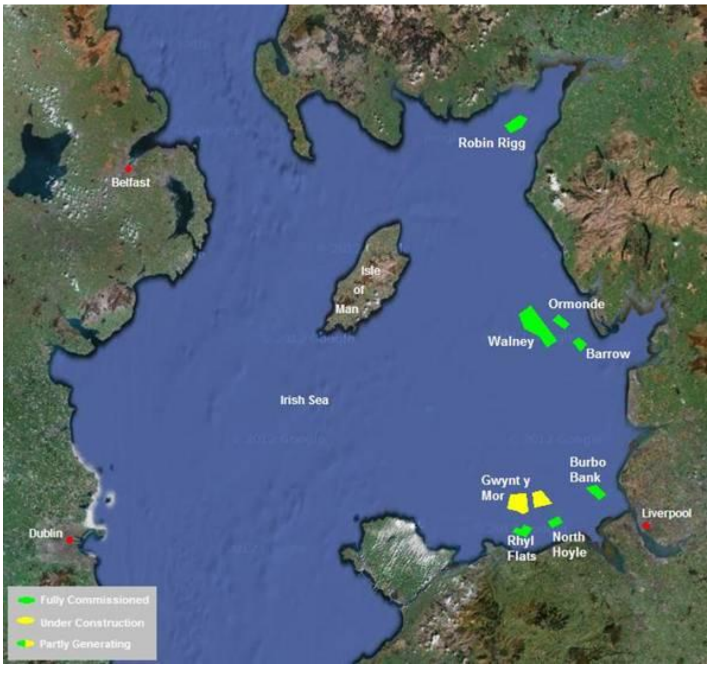
In the European Offshore Wind Energy market the U.K. is the major player in terms of installed capacities and is followed by the offshore wind pioneer Denmark which is currently ranked second and then Germany which has a more dynamic growing market. The three countries have been purposively sampled to describe the European offshore market in the sections that follows below

United Kingdom

The U.K. is by far the global leader in offshore wind power deployment, installing 854 MW in 2012 bringing the total nearly to 3,000 MW. The U.K. is a major player in the offshore wind power market thanks to its substantial financial commitment and ideal location.

The largest OWF is located at the U.K. coast in the area of the Thames estuary. It is named Greater Gabbard and has a capacity of 504 MW. The latest OWF has been established by Dong Energy. The OWF Walney is located in the Irish Sea. The Walney wind farm project was completed in two phases, at a cost of € 1.4 billion. The wind farm, which consists of 102 wind turbines, is expected to generate enough power to provide electricity to 320,000 homes. It has a total installed capacity of 367 MW. The Danish company Dong Energy is one of the most experienced OWEP producers in the world. The second phase of the project has been implemented in record time, with huge financial savings compared to similar projects. The project set a precedent as it is the first renewable energy project to be funded entirely by foreign pension funds. The map below shows the OWF in the Irish Sea.

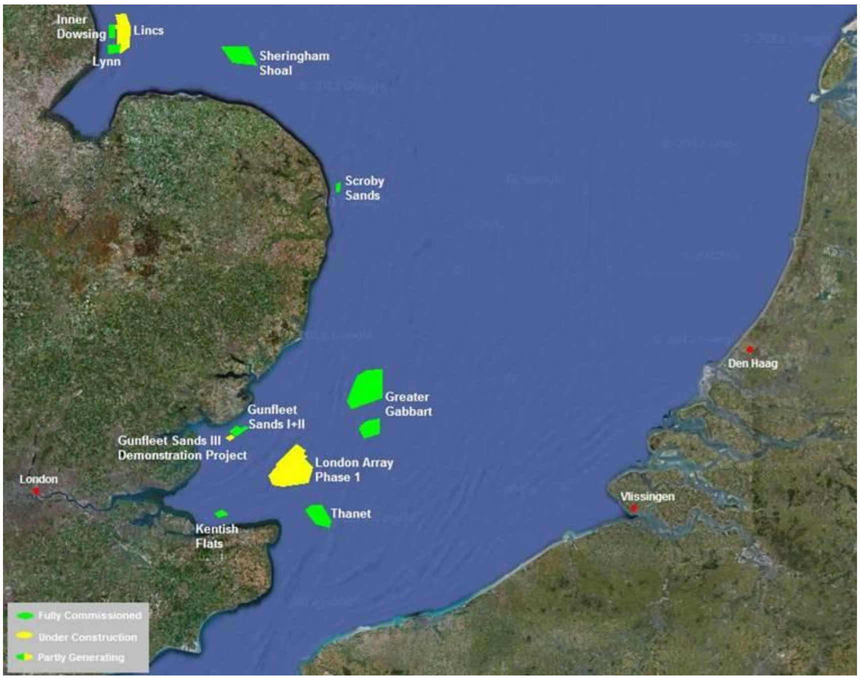
Figure 21 U.K. Offshore Wind Farms in the Irish Sea



Source: UNICONSULT based on 4COffshore (2013)

Greater Gabbard and Walney will be ranked second and third largest OWF after the completion of the London Array 1 project in the Thames Estuary which, when it becomes operational during the first half of 2013 with its 175 turbines will generate 630 MW of power. If the second phase of the London Array will be implemented, its additional 65 turbines will generate 240 additional MW, bringing the total for the whole London Array project to 870 MW. The map shows the British OWF in the North Sea.

Figure 22 U.K. Offshore Wind Farms in the North Sea



Source: UNICONSULT based on 4COffshore (2013)

OWF that are already fully commissioned and/or generating electricity:

- Barrow (90 MW) in the Irish Sea,
- Beatrice Demonstration (10 MW) in the Moray Firth offshore to the northern east coast,
- Blyth (4 MW) offshore to the east coast,
- Burbo Bank (90 MW) in the Liverpool Bay in the Irish Sea,
- Greater Gabbard (504 MW) in the London Bay offshore to the east coast,
- Gunflets Sands 1 + 2 (173 MW) in the London Bay offshore to the east coast,
- Inner Dowsing (97 MW) offshore to the east coast,
- Kentish Flats (90 MW) in the London Bay offshore to the east coast,
- Lynn (97 MW) offshore to the east coast,
- North Hoyle (60 MW) in the Liverpool Bay in the Irish Sea,
- Ormonde (150 MW) in the Irish Sea.
- Rhyl Flats (90 MW) in the Irish Sea,
- Robin Rigg (180 MW),
- Scroby Sands (60 MW),
- Sheringham Shoal (317 MW),
- Thanet (300 MW),
- Walney (367 MW) in the Irish Sea.

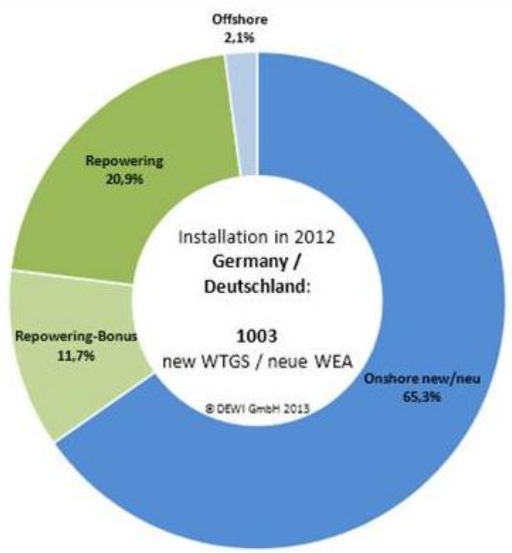
OWF currently under construction:

- Gunfleet Sands 3 (12 MW) in the London Bay offshore to the east coast,
- Gwynt y Mor (576 MW) in the Liverpool Bay in the Irish Sea,
- Lincs (270 MW) in The Wash offshore to the east coast,
- London Array Phase 1 (630 MW) in the London Bay offshore to the east coast,
- Teesside (62 MW) offshore to the east coast.

Germany

The established OWF in the German Exclusive Economic Zone (EEZ) have a total capacity of 320 MW provided by 76 turbines; 280 MW are connected to the grid. In 2012 105 MW have been installed whereof 80 MW have been connected to the grid. In comparison to the total German wind energy market the offshore sector represents 2.1 percent.

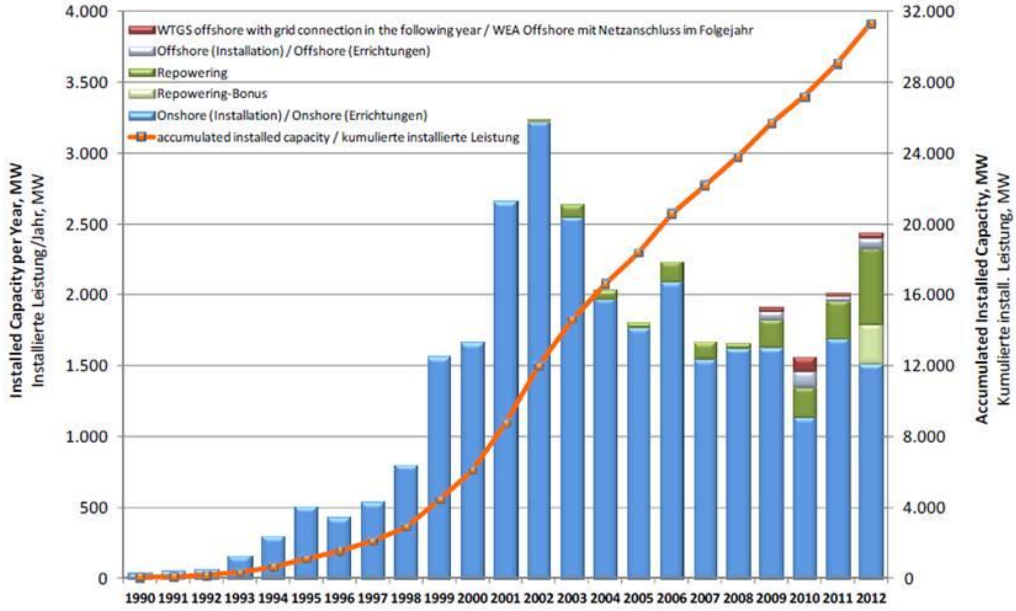
Figure 23 Share of Offshore Capacity considering the total German Wind Energy Market



Source: DEWI (2013)

The development of the German on- and Offshore Wind Energy industry is shown in the following graphic. During the last decade, from 2001 to 2011, the installed capacity more than tripled from about 8,500 MW in 2001 to more than 29,000 MW in 2011.

Figure 24 Installed Capacity in Germany 1990-2012 (MW)



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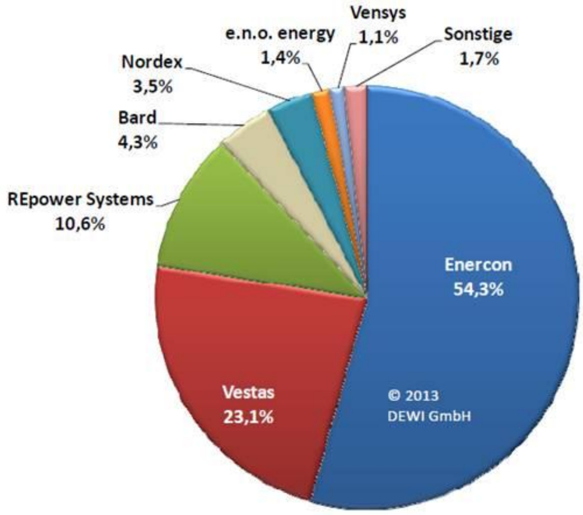
Source: DEWI GmbH (2013)

In 2012, a capacity of 2,430 MW was installed in Germany. Based thereon the market shares of the leading wind energy turbine manufacturers were identified. Enercon clearly dominates the total German wind energy market with a market share of nearly 55 % (60 % in 2011). Together, the two companies Enercon and Vestas have a cumulative market share of around 77 % (80 % in 2011).

Figure 25 Market Shares of Wind Energy Turbine Producers in Germany 2012



Source: DEWI GmbH (2013)

OWF that are already fully commissioned and/or generating electricity:

- Alpha Ventus (60 MW) in the North Sea,
- EnBW Baltic 1 (48 MW) in the Baltic Sea,
- BARD Offshore 1 (400 MW) in the North Sea (partly generating),
- Breitling (2.5 MW) in the Fehmarn Belt in the Baltic Sea (near shore),
- Ems Emden (4.5 MW) offshore to the North Sea coast (River Ems Estuary; near shore),
- Hooksiel (5 MW) in the North Sea (near shore).

OWF currently under construction:

- BARD Offshore 1 (400 MW) in the North Sea (partly generating),
- Borkum Phase 1 (200 MW) in the North Sea,
- DanTysk (288 MW) in the North Sea,
- Global Tech 1 (400 MW) in North Sea,
- Meerwind Süd/Ost (288 MW) in the North Sea,
- Nordsee Ost (295 MW) in the North Sea,
- Riffgat (108 MW) in the North Sea.

Around 2,000 MW are under construction, although only 100 MW of new capacity has been installed in 2012. The main part of the German offshore capacity is located in the North Sea (see the following figure).

Most German Offshore Wind Farms will be built 20-60 km from the coastline in waters 20-40 meters deep. To date, 25 projects have been licensed by the national maritime authority and the federal states, bringing the overall licensed capacity close to 8,500 MW. The costs for connecting Offshore Wind Farms to the mainland grid have been assumed by transmission system operators (TSO), and they have started to plan for connecting lines for clusters of offshore projects. Three connections (400 MW HVDC light lines) have already been completed. However, difficulties in securing sufficient finance to install offshore cables in a timely fashion are causing delays to current and future offshore projects.

Figure 26 German Offshore Wind Farms in the North Sea

Source: UNICONSULT based on 4COffshore (2013)

The following picture shows the German OWF in the Baltic Sea.

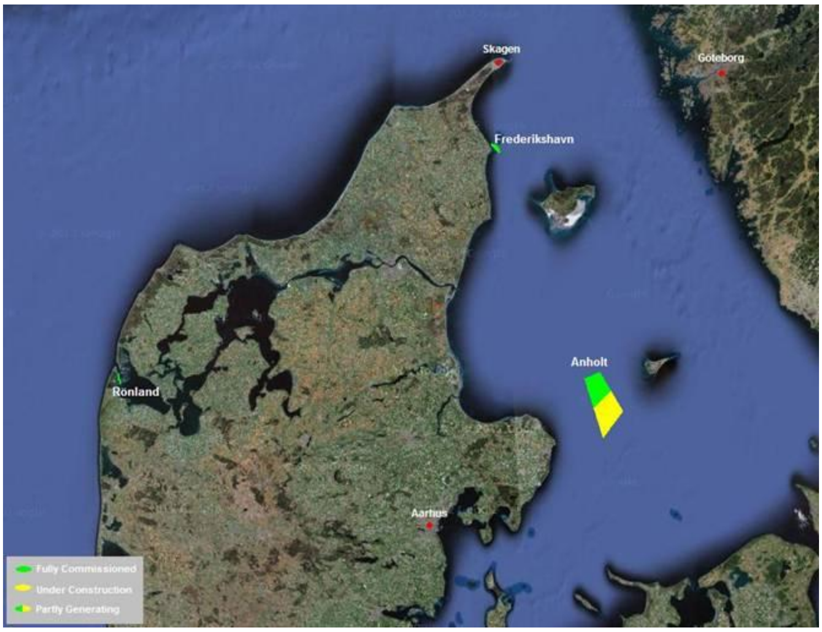
Figure 27 German Offshore Wind Farms in the Baltic Sea

Source: UNICONSULT based on 4COffshore (2013)

Denmark

Currently the OWF Anholt is in progress. With a capacity of 400 MW it is the largest OWF established in Danish waters. At the end of January 2013, 28 wind turbines had been installed in for this OWF, a further 28 are connected to the grid and 19 have already produced electricity. The following picture shows the OWF in Northern Denmark.

Figure 28 Offshore Wind Farms in Northern Denmark's Baltic and North Sea



Source: UNICONSULT based on 4COffshore (2013)

The installation vessel, Sea Jack, arrived in Grenaa Harbor, in January 2013. A total of three installation vessels are in operation during first quarter of 2013 to exploit the few and often short-term installation windows which the season allows.

Figure 29 Installation Vessel Sea Jack at Grenaa Harbor

Source: Dong Energy (2013)

A new state-of-the-art installation vessel from A2SEA, Sea Installer, will then replace Sea Jack which has other tasks to tend to. Together with the vessels Sea Power and Sea Worker, the installation of wind turbines will be continued. The following map shows the OWF in Southern Denmark.

Figure 30 Offshore Wind Farms in Southern Denmark's Baltic and North Sea

Source: UNICONSULT based on 4COffshore (2013)

Fully commissioned OWF:

- Anholt (400 MW) in the Baltic Sea offshore to the east coast (partly power generating),
- Avedöre Holme (8 MW),
- Frederikshavn (8 MW) in the Kattegat in the Baltic Sea,
- Horns Rev I (160 MW) in the North Sea offshore to the west coast,
- Horns Rev II (210 MW) in the North Sea offshore to the west coast,
- Middelgrunden (40 MW),
- Nysted (166 MW) in the Baltic Sea,
- Rödsand II (207 MW) in the Baltic Sea,
- Rönland (17 MW),
- Samsö (23 MW) in the Baltic Sea,
- Sprogö (21 MW) in the Great Belt in the Baltic Sea,
- Tunö Knob (5 MW) in the Baltic Sea,
- Vindeby (5 MW).

Under construction:

- Anholt (400 MW) in the Baltic Sea offshore to the east coast (partly power generating).

The number of new turbines on sea will increase significantly in the years up to 2020. Anholt Offshore Wind Farm is planned to be completed by the end of 2013. Its total capacity of 400 MW will provide 4 % of the Danish electricity demand.

3.1.2 Asia

Relevant Offshore Wind Energy activities in Asia have been identified for China, Japan and South Korea.

China

The most remarkable progress took place in China, when two projects with a total capacity under 100 MW were finalized in 2012. China completed its first Offshore Wind Energy project in 2010 which had a capacity of 102 MW and was installed at Shanghai's Donghai Bridge. By the end of 2011 the first phase of Jiangsu Rudong OWF was connected to the grid. With the completion of the second phase the farm provides a capacity of around 150 MW. This makes Rudong the largest operating Offshore Wind Farm in the country only if the OWF Chenjiagang Xiangshui which is mentioned below is not regarded as a "real" offshore farm because it is near shore with water depths of 0 - 1 m.

Fully commissioned OWF:

- Chenjiagang Xiangshui (201 MW) in the Yellow Sea (near shore),
- Dafeng (2 MW),
- Datang Laizhou (50 MW) in Laizhou Bay (partly power generating),
- Donghai Bridge (102 MW) in Shanghai Bay in the East China Sea,
- DDHI Composite Bucket Foundation Test Project (2.5 MW) in the East China Sea,
- Guodian (6 MW) in Laizhou Bay,
- Huaneng Rongcheng Prototype (6 MW) in the Yellow Sea,
- Jiangsu Rudong I (100 MW),
- Jiangsu Rudong II (50 MW),
- Jiangsu Rudong Extension (50 MW) (partly power generating),
- Longyuan Rudong (32 MW),
- Suizhong (1.5 MW),
- Xiangshui Intertidal (6.5 MW) in the Yellow Sea.

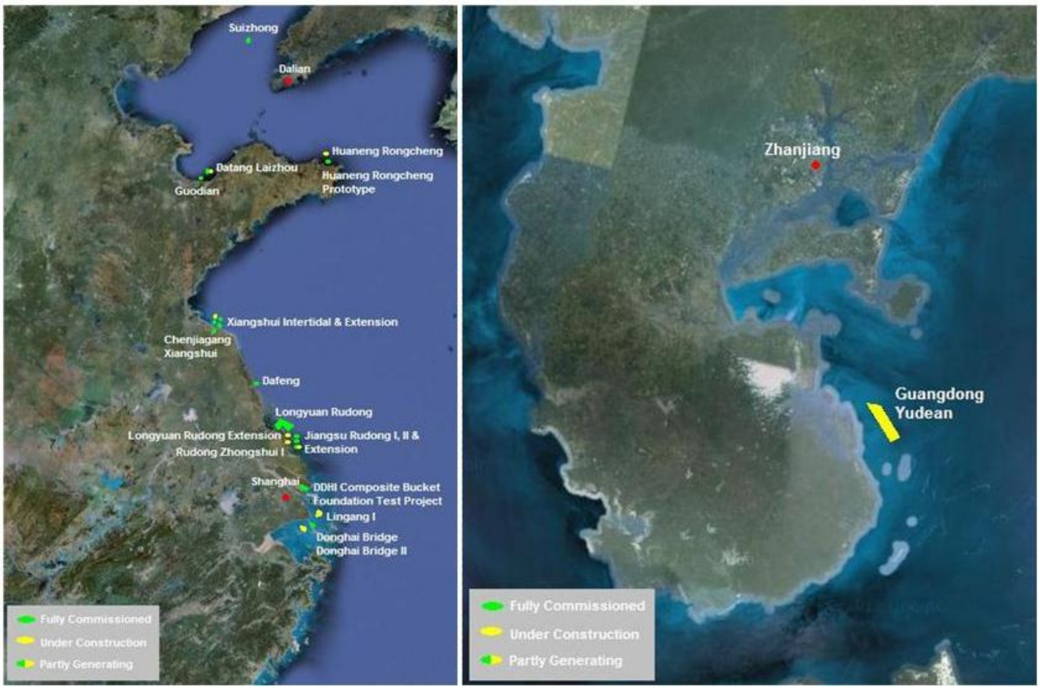
OWF currently under construction:

- Datang Laizhou (50 MW) in Laizhou Bay (partly power generating),
- Donghai Bridge II (102 MW) in Shanghai Bay in the East China Sea,

- GuangdongYudean (48 MW) offshore to the South Coast,
- Huaneng Rongcheng (102 MW) in the Yellow Sea,
- Jiangsu Rudong Extension (50 MW) (partly power generating),
- Lingang I (102 MW) in East China Sea,
- Longyuan Rudong Extension (49 MW),
- Rudong Zhongshui I (20 MW),
- Xiangshui Extension (6 MW) in the Yellow Sea.

Adding the capacities of all OWF projects that are currently under construction the Chinese Offshore Wind Energy will provide additional 525 MW in the near future. The Government plans to reach a capacity of 32,800 MW by 2020. As China has most of its expertise and experience in the field of Onshore Wind Energy, the Ministry of Science and Technology supports organizations in the development and research of important key technologies for the Offshore Wind Energy sector.

Figure 31 Chinese Offshore Wind Farms



Source: UNICONSULT based on 4COffshore (2013)

Japan

Prior to the Fukushima disaster in 2012, about 60 % of Japan's energy portfolio was provided by fossil fuels while approximately 30 % came from nuclear. In June 2012, Japan decided to implement a Feed-in Tariff for wind power and other renewable energies. It requires Japanese utilities to buy electricity from renewable sources such as wind, solar, and geothermal at pre-set premiums for up to 20 years. The Japan Wind Power Association estimates the offshore wind potential that can be realistically used at 608,000 MW.[22]

The Ministry for Environmental Affairs has estimated that Japan has the potential to eventually build a huge 1,600 MW offshore farm but Japan has to overcome a raft of technological challenges to meet this goal. Japan also has to deal with a challenging sea surface which is very rutted and by this great floor level differences or depth differences do occur. For this reason especially Japan partly focuses its research activities on floating concepts which allow the “erection” of offshore wind turbines without preparation of solid foundations.

Currently fully commissioned OWF:

- Coshi (2.4 MW),
- Kabashima (0.1 MW) Demonstration Project for floating offshore wind turbines,
- Kamisu I (14 MW) near shore project,
- Sakata (10 MW),
- Setana (1.3 MW).

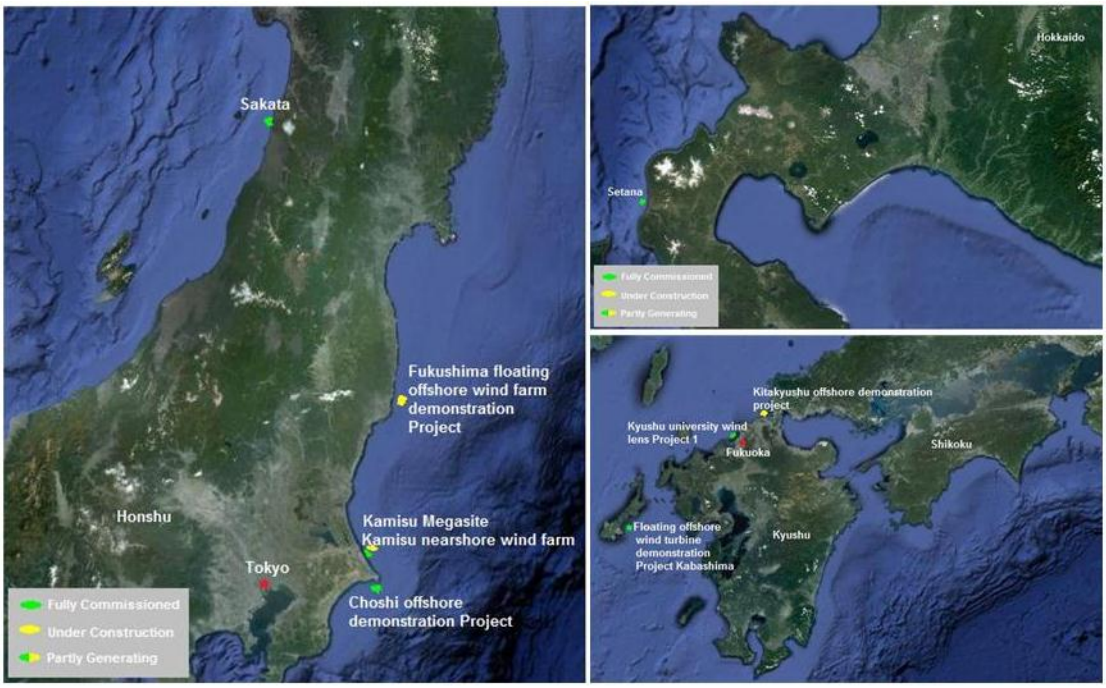
OWF currently under construction:

- Fukushima I (2 MW) Demonstration Project for floating offshore wind turbines,
- Kamisu II (16 MW) near shore project,
- Kitakyushu (2 MW).

The wind facility, off the coast of Choshi, east of Tokyo, is being jointly developed by the New Energy and Industrial Technology Development Organization (NEDO) and Tokyo Electric Power, which also operates the nuclear power plant at Fukushima.

[22] See „Potential for Introduction of Wind Power Generation and Mid/Long Term Installation Goals (V3.2); Japan Wind Power Association (2012), p. 5.

Figure 32 Japanese Offshore Wind Farms



Source: UNICONSULT based on 4COffshore (2013)

<u>South Korea</u>

Although South Korea is relying on imported sources for 97 % of its energy needs, the country has lingered its first steps into the development of wind power resources until 2011. The South Korean Government then announced to invest US $ 9 billion in building a 2.5 GW Offshore Wind Farm, the largest in the world.

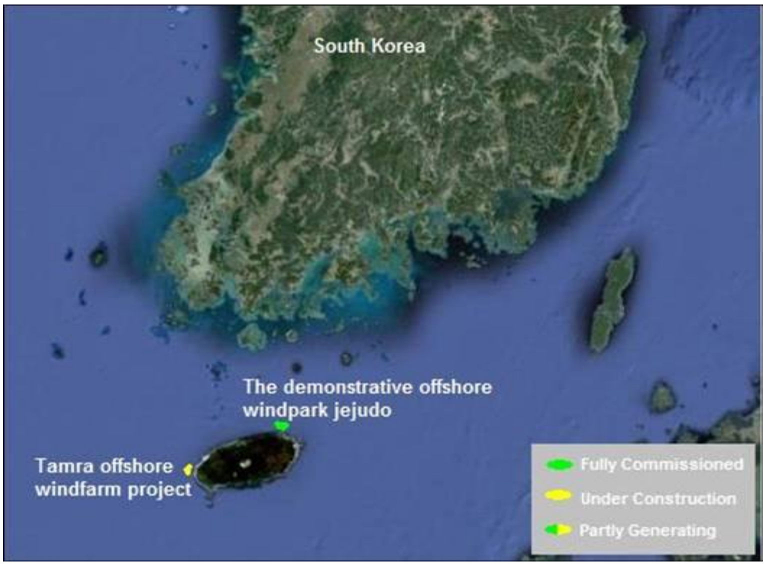
Planning to locate it offshore of South Korea's southwestern coast, the construction and implementation of the Offshore Wind Farm will be separated in three phases. Developers are South Korean companies led by Korea Electric Power, the country's largest electric utility. The first phase is a 100 MW demonstration phase to be completed by 2014. Wind turbines with capacities ranging from 3 MW to 7 MW are expected to be erected mainly off the coast of Jeollabukdo and Jeollanamdo provinces. A second 400 MW phase is scheduled for completion in 2016.[23]

Despite being a technical focused country, South Korea is a latecomer to wind energy and is coming in at a very difficult time for the industry, where severe competition and falling turbine prices are squeezing the profits of the entire supply chain. Probably offshore wind is a suitable entry point for Korean companies into this sector due to their extensive shipbuilding and marine engineering experience as well as the country's offshore wind resources.

Currently the only fully commissioned OWF is Jeju Island with a total capacity of 5 MW. The OWF Tamra (30 MW) is currenty under construction.

[23] Bloomberg News (2013).

Figure 33 Offshore Wind Farms in South Korea



Source: UNICONSULT based on 4COffshore (2013)

3.1.3 *North America*

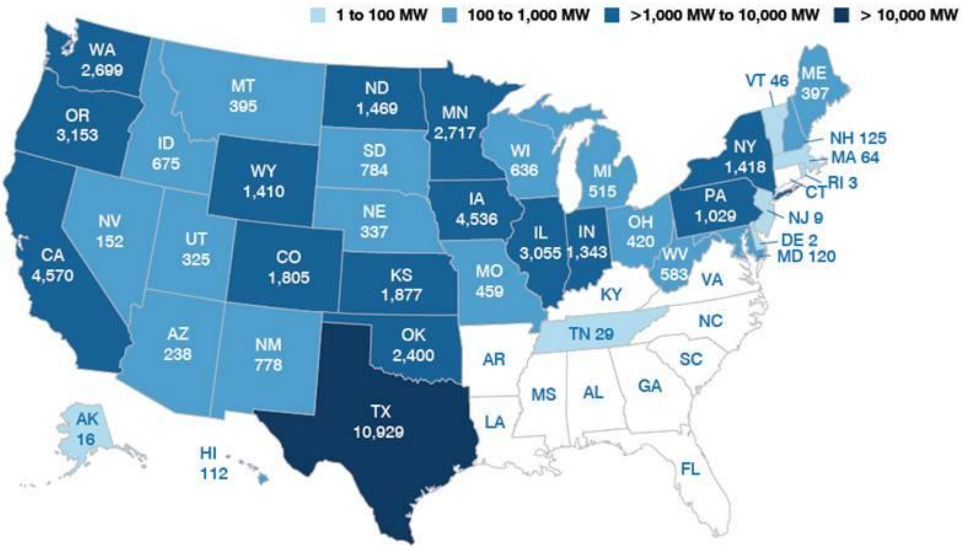
USA

Although the United States are the second largest wind energy market in the world (see onshore wind capacities in the following figure), there are no offshore projects established yet. However, this is planned to be changed. [24] A strategic plan for the use of Offshore Wind Energy was unveiled in February 2011. The aim is to install 10 GW by 2020 and up to 54 GW by 2030[25].

[24] End of March 2012, the US Government and five States have reached an agreement to speed up approval of OWF in the Great Lakes, which have been delayed by cost concerns and public opposition. See http://www.cleveland.com/business/index.ssf/2012/03/5_of_8_great_lakes_states_join.html.

[25] See American Wind Energy Association (AWEA) (2012).

Figure 34 Installed Onshore Wind Energy Capacities in MW per State



Source: AWEA; Third Quater 2012 Market Report (2012)

There are some smaller projects like Fisherman's Atlantic City at the New Jersey coast and the test site at Galveston coast (Texas) which consents are currently authorized but start of construction is not foreseen. The Keuka test project (Florida) is currently under construction.

On 26th February 2013 Interior Secretary Ken Salazar reported about a gathering of offshore industry stakeholders dealing with the project Cape Wind. He projected a distinct progress of this project until end of 2013.

Cape Wind is one of the most promising Offshore Wind Energy projects in the U.S. The designated area for this project is located at the East Coast of the USA close to Rhode Island. It will consist out of 130 turbines with a capacity of 3.6 MW each. That leads to a total capacity of 468 MW. Another promising project is Deepwater Wind (RI/MA) in the same region with a planned capacity of about 1,000 MW.

Since Cape Wind was proposed in 2001 as a wind farm which could provide 75 % of regional (Cape Cod's) energy needs, it has been involved in more than a dozen lawsuits dealing with boat traffic interference to avian and marine life. Also Deepwater Wind has been seen as disturbance to endangered right whales.

Beside the environmental objections also technical and/or logistical reasons are responsible for the lingered development. Not a single ship in the Unites States is equipped to handle wind turbines.[26]

The world's relatively small fleet of installation vessels is based primarily in Europe. As the Jones Act (law from 1920) requires ships sailing between two US ports to be US-flagged and once the foundation of an offshore turbine is laid it counts as a "port" no foreign flagged vessel could legally operate during OWF erection.

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[26] Chris van Beek, Deepwater's president: "At this point, there is not an existing vessel in the US that can do this job." (Citation in February 2013)

The company Weeks Marine from New Jersey is working to solve the problem by building the country's first installation vessel. It is planned to get in operation in 2014.

Figure 35 Offshore Wind Farm Projects in the USA

Source: UNICONSULT based on 4COffshore (2013)

Canada

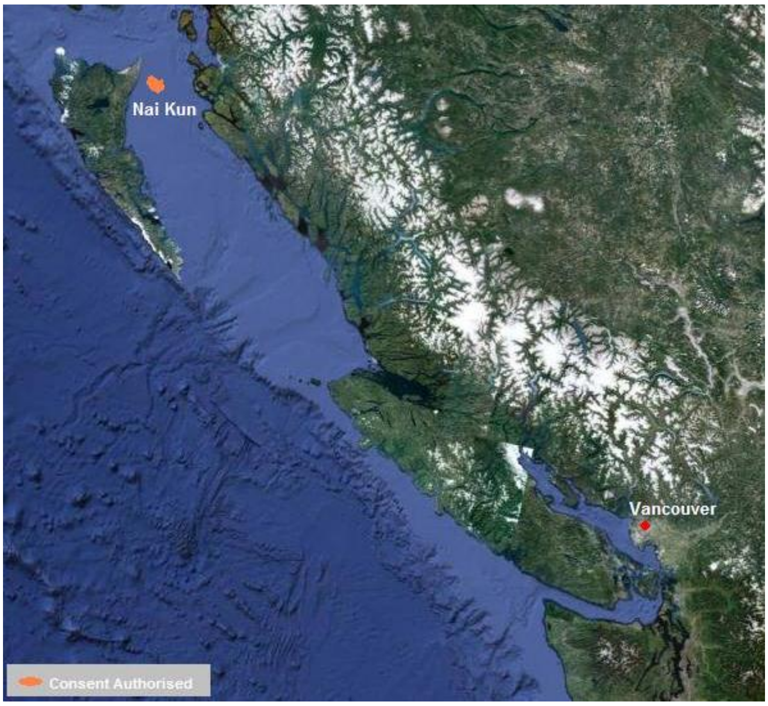
Currently there is no OWF project under construction or already installed in the Canadian region. Only one is categorized “consent authorized”. This is the Nai Kun OWF with a planned capacity of 400 MW. It is located offshore to the west coast of Canada in the Hecate Strait. It is pretty much protected by Queen Charlotte Island.

The developer of Nai Kun, Nai Kun Wind, has signed a supplier agreement with Siemens Canada Ltd. for 100 of Siemens’ 4 MW turbines. Nai Kun Wind is a British Columbia-based renewable energy company. Siemens and Nai Kun Wind will cooperate considering design of foundation as well as the design and certification of the turbine tower transition piece. A challenge will be the connection to the grid which access point is 100 km apart in Prince Rupert.

A lot of efforts have been made during the past to develop Offshore Wind Farms mainly on the Great Lakes like Lake Eire and Lake Ontario. In February 2011 a CDN $ 20 million financing deal for a 414 MW wind farm named Trillium Power Wind 1 proposed for Lake Ontario was signed. But at the same time the province has suspended all offshore projects in order to base their development on further studies. Now further developments are uncertain, as the province decided offshore wind projects are no longer eligible for contracts under the feed-in-tariff component of its established Green Energy and Economy Act.

Despite the province’s objections, the Great Lakes are particularly well-suited to wind power developments. Freshwater reduces maintenance costs associated with saltwater corrosion, and high tides are less of a risk relative to offshore wind projects located in the North Sea, where swells can reach anywhere from four to eight meters. Ontario’s Ministry of the Environment had previously outlined a proposed framework for developing Offshore Wind Farms that included a five kilometers “shoreline exclusion zone” to mitigate potential effects of installing turbines in the lakebed. Seventy percent of Ontarians get their drinking water from the Great Lakes which is one of several reasons cited by the Province for their critical view on Offshore Wind Energy plants in the Great Lakes.

Figure 36 Offshore Wind Farm Projects in Canada



Source: UNICONSULT based on 4COffshore (2013)

3.1.4 South America

South America has a huge potential for the installation of wind power plants for both Onshore and Offshore Wind Energy. According to the study “Latin America Wind Power – Markets and Strategies: 2010-2025” 46,000 MW is expected to be installed by 2025 in South America. Brazil as market leader is expected to have an installed capacity of 31,600 MW by 2025 followed by Mexico with 6,600 MW. Currently most of the countries still have a lot of fossil combustibles and hydro power plants, so that currently the interest of using wind energy is very limited. Only a few countries in South America have the idea of using the wind potential for generating electricity. Only the onshore market in Brazil, Argentina and Chile has shown a remarkable increase since 2006. There are no offshore projects having the status “under construction” or “fully commissioned” in this region.

Brazil

Geographically the focus on areas for onshore as well as for offshore activities is at the northeast coast of Brazil, Ceara State and Pernambuco Rio Grande do Norto. The northeast coast is qualified due to their steady winds of about 4 Beaufort. More and more companies like Wobben (37 % of the currently onshore installed capacity), a subsidiary of the German Enercon or Indian Suzlon (42 % of the currently onshore installed capacity), Alstom, Win&P, Tecsis and further more are located in Brazil.

The only activity considering Offshore Wind Energy in South America can be found close to Brazil’s port of Fortaleza. The so-called Asa Branca field is an area that will be prepared for Offshore Wind Farms. The field is segmented into 22 sections. The following figure shows the location and dimensions of the Asa Branca field.

Figure 37 Asa Branca Field

Source: UNICONSULT based on 4COffshore (2013)

It is planned to start at the site in 2016/17. It covers a total area of 179 km² and with about 2,200 turbines in total it will produce approximately 12 GW, assuming a capacity of about 6 MW per turbine. The area is located up to 25 km away from the shore and has water depths of about up to 11 m.

3.1.5 *Other Countries*

India

India has a long coastline of over 7,500 km. In April 2012, the Ministry for New and Renewable Energy constituted an Offshore Wind Energy Steering Committee to drive offshore wind power development in India in a planned manner. The Government is looking to prepare a time-bound action plan to develop Offshore Wind Energy, especially in the coastal states of Andhra Pradesh, Gujarat, Maharashtra, Odisha, Kerala, Karnataka, West Bengal and Tamil Nadu.

A policy and guidelines for Offshore Wind Energy are likely to be announced by the Ministry of New and Renewable Energy in the near future. The State of Tamil Nadu is likely to take a lead in the Offshore Wind Energy development as it is in the process of installing a 100 meter mast for wind monitoring in Dhanushkodi.

The Scottish Development International (SDI) has conducted a detailed survey of the region to assess various parameters required for installing Offshore Wind Farms. The technical feasibility study looked at Offshore Wind Energy potential in favorable areas in the southern Peninsula and Kutch region in Gujarat. In a recent study conducted by WISE, the offshore wind potential of Tamil Nadu has been estimated as 127 GW, which has to be further validated.

Until March 2013 no offshore projects have been identified in India.

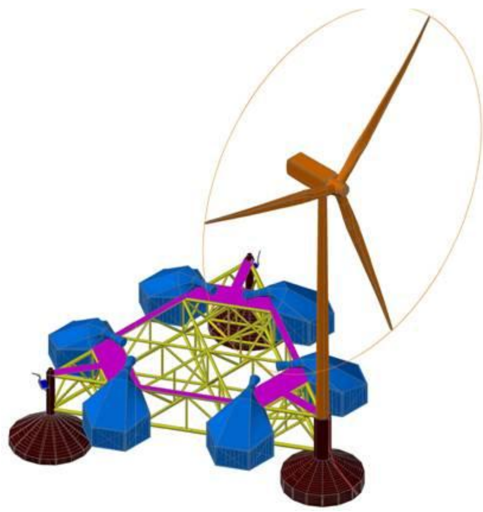
Australia

Australia is the sixth largest country in the world and is the only one of the top six completely surrounded by water. The total length of coastline of the main land is 35,900 km; including the coastlines of the numerous islands belonging to Australia it totals in almost 60,000 km. Despite these apparently suitable preconditions for Offshore Wind Energy production no relevant activities can be noticed.

Only the concept of the so-called “energy islands” to be located offshore of Australia’s south coast in the Great Australian Bay came up mid of 2012. A British-U.S. American consortium (Wood Group/JP Kenny and Marine Power Technologies) is planning to develop the first combined wind and wave power station worldwide to provide renewable power for up to 16,500 households.

Under an initial eight-month work scope, JP Kenny is to provide project management and engineering support for the project, which will initially involve data gathering on environmental and technical issues, and then on a conceptual engineering study to define the layout of an energy island assembly which will feature both wind and wave power devices. Each energy island is to feature six oscillating water column energy generators, and an offshore wind turbine, capable of generating up to 10 MW of power. The following graphic shows the draft design of the energy island concept.

Figure 38 Renewable Energy Island



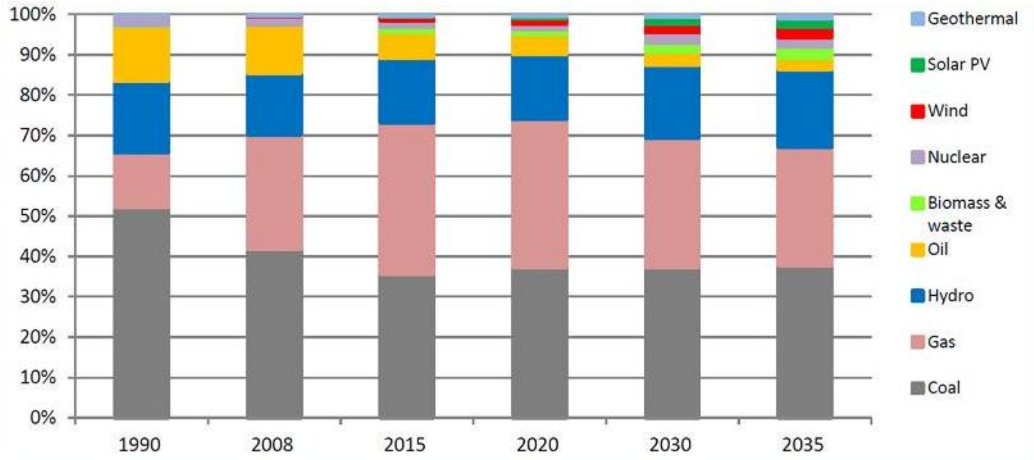
Source: http://offshore.no (2013)

Africa

The five African countries namely Mozambique, Tanzania, Angola, South Africa and Namibia potentially have large Offshore Wind Energy resources in comparison to other African countries. The International Energy Agency estimates that wind energy for both on- and offshore will only contribute about 2 % of the total energy generation in Africa by 2030. Currently no Offshore Wind Energy projects do exist in the way that their implementation could be foreseen. Ninety nine percent of the current Onshore Wind Energy sources are located in North Africa in Egypt, Morocco and Tunisia.

The following figure shows the projection of energy mix development on the African continent. The figure shows that coming from 1990 electricity generation by coal, gas and hydro power plants is expected to continuously cover more than 80 % of energy demand and this will continue until 2035. Only Oil based power generation is expected to be almost compensated by renewable energy.

Table 6 Projected Split of Africa's Electricity Mix



Source: International Energy Agency (2010)

3.2 Offshore Wind Energy Market Developments in selected Regions

The global Offshore Wind Energy market, supported by the depletion of fossil fuel reserves, the declining costs for wind energy equipment and comprehensive investments done by British developers or respectively on British territory is expected to be promoted outstanding over the next decade.

As the global Offshore Wind Energy market provided a cumulative installed capacity of 5,100 MW in 2012 it is expected to provide 54,000 MW by 2020, growing at a Compound Annual Growth Rate (CAGR) of 34.5 %.[27]

Germany for example has plans to grow its Offshore Wind Energy sector substantially in the future, too. It has announced a target of 25,000 MW installed capacity by 2030 and 95,000 MW by 2050. For the timeframe between 2012 and 2020, there are forecasts from the market researchers of GlobalData that Germany's offshore wind power installed capacity will climb from a modest 220 MW to 8,000 MW.[28]

3.2.1 Political and Institutional Framework

This chapter provides an overview of the political and institutional actions for developing the renewable energy sector in general and the wind energy market in particular. This is relevant for the present study as it provides an insight in one of the parameters influencing the current and future development of the wind energy industry and with it also the potential of number of relevant Offshore Wind Energy farms and plants during the forthcoming years.

The political and institutional framework and the objectives of different worldwide regions, e. g. the United Kingdom (U.K.), the United States of America (USA), China, and Brazil will be described. This reflection of varying efforts of the different nations

[27] http://www.globaldata.com/PressReleases.aspx?Type=Industry&Title=Alternative+Energy (2013).

[28] http://www.globaldata.com/PressReleases.aspx?Type=Industry&Title=Alternative+Energy (2013).

for boosting the wind energy sector shows the diverse approaches like feed-in tariffs, quota, and tax incentives.

3.2.1.1 Europe

As it is expected that U.K. will continue playing the major role in the European offshore market, Denmark as the offshore pioneer will stay second ranked and Germany being the most dynamically growing market mainly due to the nuclear phase-out, these three countries have been selected for the following section as a representative European offshore market stakeholders.

United Kingdom

The U.K. Government firmly supports the development of Offshore Wind Energy. The Energy Bill was approved by end of November 2012. Because offshore wind is expected to make a large impact upon the U.K.'s 2020 renewable energy targets a major expansion is planned. Correspondingly, the country's offshore wind power installed capacity is expected to hit 21,000 MW by the end of 2020, increasing almost by 800 % from 2012 installed capacity.

There is a feed-in tariff for renewable energies in the United Kingdom, which has been introduced in 2010. This feed-in tariff is only permitted for energy plants smaller than 5 MW. So the main instrument for subsidizing the Offshore Wind Energy in the U.K. is the "Renewable Obligation". This regulation was introduced in April 2002 and determines an obligatory minimum share of renewable energy in the total mix of energies of the U.K.. This quota increases from year to year and aims for an increasing share of renewable energy.

The Renewable Obligation Orders commit the electricity suppliers in the U.K. to abide the defined quota. The suppliers get a certain amount of Renewable Obligation Certificates (ROC) for each megawatt hour (MWh) generated by renewable energy plants, depending on the technology. The U.K. Government introduced this "technology banding" in 2009, which rather supports young and undeveloped technologies than mature and advanced ones. Therefore 1 kWh generated by Onshore Wind Energy is needed for 1 ROC whilst only 0.66 kWh generated by Offshore Wind Energy is required for receiving 1 ROC. These ROC can be exchanged perpetually by contracts with other suppliers or at monthly auctions. They can also be retained for one year by the suppliers. The value of the ROC arises from the sum of the buy-out penalty and the distribution of the buy-out fund.[29]

If one supplier cannot fulfill the quota, then there is the possibility of a "buy-out". This buy-out penalty has to be paid for each MWh that the target set by the Government was missed and is determined annually. For the period from April 2011 to March 2012 this price amounted to 38.69 Great Britain Pounds (GBP) per MWh. This fine is collected in a fund and is distributed annually to those suppliers fulfilling the defined quota.

The long term objective of the U.K. Government is a share of 15 % of renewable energy in the total mix of energies in 2020. The U.K. Renewable Energy Roadmap aims

[29] See the Renewable Energy Policy Country Profiles in the 2011 version, prepared within the Intelligent Energy Europe project RE-Shaping.

at an installed capacity of up to a minimum of 18,000 MW of Offshore Wind Energy by the year 2020 and a possible capacity of 40,000 MW by 2030.[30]

Germany

The German law called “Erneuerbare Energien Gesetz” (EEG); [Renewable Energy Law] will be depicted preliminary, which regulates the subsidies or rather feed-in tariffs for advancing the renewable energy sector. The EEG is therefore of significance for the future development of the wind energy industry in Germany and by this also for the potential traffic for existing and future offshore ports. Regarding the development of the wind energy in Germany the objectives of the German Parliament for the year 2030 are also specified.

The renewable energy sector in Germany is subsidized by the German Government by feed-in tariffs. These subsidies for each particular mode of renewable energy production are ruled by the EEG, which has already been mentioned above. This law was approved on October, 25th in 2008 and adapted in late 2011.

The subsidies for the Offshore Wind Energy are defined in § 31 of the EEG. The basic model of the subsidization of offshore wind can be split in two fundamental components. This is the basic remuneration on the one hand and the initial remuneration on the other hand. The initial remuneration is being paid for the first 12 years of operation and the amount can vary between 15 Cent per kWh and 19 Cent per kWh. This depends on the date of initial operation. OWF with a start of operation before the January 01, 2018 are subsidized by a feed-in tariff in the amount of 19 Cent per kWh. OWF with a start of operation later than December 31, 2017 are remunerated in the amount of 15 Cent per kWh.

The time frame of 12 years for the payment of the initial remuneration can be exceeded under certain circumstances. The initial remuneration is extended for 0.5 months for each nautical mile (nm) that the OWP is more distant than 12 nautical miles to the German shore. The initial remuneration is also extended for 1.7 month for each meter (m) that exceeds a construction depth of 20 m. This extension of the initial remuneration is independent from the date of initial operation and amounts to 15 Cent per kWh.

The Offshore Wind Energy information platform “offshore-windenergy.net” of the German Government refers that “…the basic remuneration of 3.5 Cent per kWh and the initial remuneration of 15 Cent per kWh are reduced in accordance with the EEG annually from January 1st, 2018 for all wind energy plants taken into operation by a fixed percentage of 7 % (degression).[31] This, for example means a reduction of the basic remuneration to 3.26 Cent per kWh for wind energy plants that go into operation in 2018 and/or a reduction of the initial remuneration to 13.95 Cent per kWh. For Offshore Wind Energy plants that go into operation in 2019 the remuneration once again is being reduced by 7 percent. The same applies to subsequent years. The remuneration for a plant then stays stable for the full claim period of 20 years once the plant is in operation and does not decrease annually.”

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[30] See U.K. Renewable Energy Roadmap, July 2011, p. 42.

[31] For this and the following information see http://www.offshore-windenergie.net/en/politics/eeg-remuneration (2012).

These regulations shall help to fulfill the long term goals of the German Government of boosting the development of the Offshore Wind Energy. Government has planned to reach an installed capacity of 25,000 MW by the year 2030. Therefore, the state owned "Kreditanstalt für Wiederaufbau" (KfW) founded the program "Offshore Wind Energy" in 2011. This program is designed for financing up to ten offshore projects in Germany.

<u>Denmark</u>

The wind power in Denmark is subsidized in form of a price premium or rather feed-in tariff for delivered electricity. The subsidization scheme was revised in 2008 by the Danish Government. The producer is bound to sell the generated electricity in the market and receives a fixed price premium in the amount of 3.4 Cent per kWh for the first 25,000 full load hours. In addition balancing costs in the amount of 0.3 Cent per kWh is paid to cover marked based balancing costs.[32]

During history there were also special tenders for wind farms on sea (Hors Rev II, Rodsand II), which replaced the support scheme described above. The operators of wind farms can apply for a fixed feed-in tariff instead of a price premium. Theses fixed payments are 6.95 Cent per kWh for Horns Rev II and 8.44 Cent per kWh at the Rodsand II wind farm.[33] There are also additional funds for supporting the renewable energies provided by the Danish Government. The above-named REPAP-projects (Renewable Energy Policy Action Paving) calculate with a possible installed capacity in the amount of 1,339 MW of Offshore Wind Energy in Denmark and annual output of 5,322 gigawatt hours (GWh) in the year 2020.

Besides the direct subsidization of produced offshore electricity the offshore development in Denmark is also influenced positively by a certain tendering system of the Government. This includes pre-screening, evaluating and selecting of sites for the tender. Usually this is done by the investing company or project developer. So in Denmark the bidders compete for the rights to build on pre-selected sites, where a pre-screening for Environmental Impact Assessment (EIA) has already been done and where the Transmission System Operator (TSO) is obliged to deliver the offshore grid connection to the wind farm. The bidder offering the lowest Contract-for-difference for the first 50,000 full-load hours gets the assignment. This system has proven over the years, delivering offshore wind at considerably lower prices than in any other country in Europe, and with relatively short construction periods due to executed site approval procedures in advance.

3.2.1.2 Asia

As a global partnership program the Asia Sustainable and Alternative Energy Program (ASTAE) was established in 1992. Its mandate is to scale up the use of sustainable renewable energy options to improve energy efficiency and increase access to energy to reduce poverty in Asia and protect the environment. The program has been instrumental in increasing the share of sustainable energy projects in the World Bank energy portfolio in Asia. ASTAE covers client countries in the East and South Asia Regions. ASTAE is focused on downstream and operations-oriented activities that directly support and enhance World Bank lending projects related to the three

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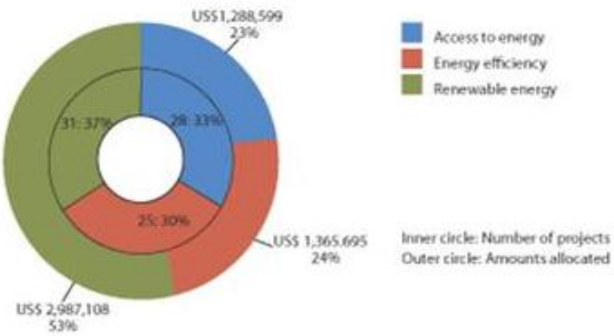
32 See the Danish Energy Agency (2012).

33 See http://www.energinet.dk (2012).

ASTAE pillars mentioned below. During the period from 2007 to 2010 the Asia Sustainable and Alternative Energy Program (ASTAE) was supported by the World Bank. Its disbursements amounted to almost US $ 7.4 billion. Financial resources have been mainly provided by two trust funds, one established by the Government of the Netherlands and the other by the Government of Sweden.

The program supported three issues that are "access to energy" dealing with the development of appropriate energy infrastructure, "energy efficiency" which covers the aspects of reduction of energy consumption and the third "renewable energy" dealing with the generation of electricity without using fossil fuels.

Figure 39 Share of Disbursement for Renewable Energy



Source: World Bank (2011)

A second phase for the ASTAE Program which has expired 2011 is currently in the pipeline but not established or agreed yet.

China

The Chinese Government pursues various approaches for supporting the development of technologies of renewable energy like onshore wind power and offshore wind power. These support schemes include a discounted corporate income tax or value added tax as well as feed-in tariffs or funds.[34]

The China wind energy development roadmap 2050 predicts an installed capacity of 1 terrawatt (TW) of wind power in China in the year 2050. This is to be realized by developing both Onshore Wind Energy and Offshore Wind Energy. The scenario expects a total installed capacity of 200,000 MW of wind power by the year 2020, of which 30,000 MW should be distributed by near offshore wind farms. China has planned to double the total installed capacity to the amount of 400,000 MW of wind power in the period from 2020 to 2030 of which 335,000 MW should be provided by onshore, 60,000 MW by near offshore, and another 5,000 MW by far Offshore Wind Energy facilities. The aforementioned 1 TW of wind power in the year 2050 is composed of 800,000 MW onshore wind power, 150,000 MW near offshore wind power and 50,000 MW far offshore wind power.[35]

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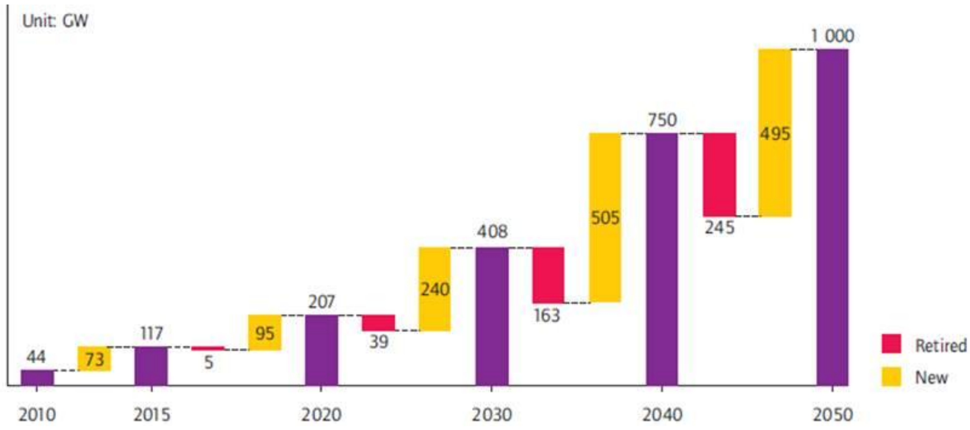
[34] See KPMG: Taxes and Incentives for Renewable Energy (2011), pp. 16.

[35] See China Wind Energy Development Roadmap 2050 (2011), pp. 23.

Figure 40 Estimated additional Wind Power Capacity and Retirement 2010-50



Source: China Wind Energy Development Roadmap 2050 (2011)

In addition to the already mentioned measures the China Renewable Energy Scale-up Program (CRESP) was launched in 2006 by the Government of China (GOC) in cooperation with the World Bank (WB) and the Global Environment Facility (GEF) to provide assistance to the implementation of a renewable energy policy development and investment program. This program covers issues like studying the current renewable energy resources status, learning from the experiences of developed countries in the development of renewable energy, studying and formulating renewable energy development policy in China, implementing renewable energy scale-up development, providing cost-effective and commercial renewable energy electricity to the electric power market, and replacing coal-fired power production and reducing the local and global negative environmental impacts.

The program implementation is divided into three different implementation phases of which the first has been completed in 2011 and the second is currently in preparation. The phasing is intended to assist a gradual roll out of the policy and supporting measures, in step with the implementation capacity of administrative and regulatory bodies, at the state and provincial levels, and of the commercial renewable energy industry.

Japan

The Government of Japan seeks to move away from nuclear energy especially due to the nuclear power plant disaster which happened in March 2011 at Fukushima. Since then the awareness for wind power energy in Japan has gained popularity. This is stated among others by a growing number of power utilities and heavy industrial manufacturers starting offshore turbine construction projects.

On July 1st, 2012 the first feed-in-tariffs went into effect in Japan which includes 23 Yen per kWh for wind power with a 20 year power purchase agreement period. It can be assumed that this will also apply to the Fukushima pilot wind farm. There are discussions about establishing a higher tariff for offshore than for onshore wind power, but until now no final decision could be identified. The budget set aside by the Japanese Government for this project is approx. US $ 160 million. The objective is to establish the basis for eventually building the world's largest floating Offshore Wind Farm development and therefore developing power plant component technology for floating wind farms offshore to the coast of Fukushima Prefecture by conducting an experimental study of power systems to develop a common platform for floating offshore wind power.

South Korea

The former Korean feed-in tariff which was too low to support wind power development was replaced in 2012 by a Renewable Portfolio Standard (RPS). Its proposal was approved by Korean Congress and the Government enacted the program in 2012. Renewable Portfolio Standard is a regulation that requires the increased production of electricity from renewable energy resources. The mechanism of a RPS in general places an obligation on electricity supply companies to produce a specified share of their electricity from renewable energy sources. Certified renewable energy generators earn certificates for each unit of electricity they produce and can sell these along with their electricity to supply companies. The required rate of the Korean RPS in 2012 was 2 % and will increase to 10 % by 2022.

Since 2009, the Government has concentrated on the development of local component suppliers to secure the supply chain. The Government Research and Development budget (R & D budget) continues to include funds to localize component supply and develop national core technologies for wind power.

Following a new regulatory policy, the Korean Government has announced an investment in Offshore Wind Farms with a total capacity of 2,500 MW until 2018. This initiative is to be expected to change costs and benefits. Experts recommend although Korea is going to introduce RPS system from 2012, it seems that Korean Government should stick to feed-in-tariff policy partially in case of offshore wind power. Since Offshore Wind Energy is expected to obtain economic, so that it helps the Government plan to cover 11 % of energy consumption to renewable energy by 2020.

3.2.1.3 North and South America

North America – USA

On February 26, 2013 the Senate Finance Committee agreed on the Maryland Offshore Wind Energy Act of 2013. The next level to enact the offshore wind bill is the full Senate. The bill focuses on the establishment of a mechanism to incentivize the development of the 200 MW offshore wind facility and a regulatory framework that will allow further projects to interconnect in Maryland. It would limit rate increases for residential customers to USD 1.50 per month and businesses to 1.5 %. If approved, the Maryland Offshore Wind Energy Act would be effective from June 1st, 2013.

Every Offshore Wind Farm has at least two phases and these are the construction phase, and a production or operating phase. The second phase should also include a contract with the electric utility for the developer to sell the farm's power into the grid at a fixed price for a set period of time. As this goes hand-in-hand in Europe and in the United States the necessary permission for deep water operations for wind turbines is managed by the Federal Interior Department, while the contracts are awarded by on state level. By this a project could wind up winning the site lease, but getting passed over for the contract, or vice versa. Since Deepwater and Cape Wind have the only two federal permits for offshore wind, this state-federal tension hasn't been a major issue until now. While the wind industry scores more contracts, the federal institutions will need to rethink how they decide who gets to develop the site.

There are a few states having ambitious regional growth targets regarding renewable energy. Besides general state and federal incentives the following renewable energy portfolio standards for certain states have been established:

- New Jersey: approximately 20 % until 2021,
- Texas: approximately 7 % until 2025,
- California: 33 % until 2020,
- Hawaii: 40 % until 2030.

The U.S. Department of Energy established the National Renewable Energy Laboratory (NREL) in 1977 to act as a public institution for research and development of renewable energy and energy efficiency. Its aim mainly is to develop suitable technologies and practices, to advance related science and engineering fields, and to transfer knowledge and innovations in order to address the U.S. energy and environmental standards. Government's support of the NREL has been reached almost USD 390 million in 2011.[36] Besides "electricity generation and delivery" which includes all efforts regarding Offshore Wind Energy the lab has defined three other key aspects of activity like "fuel production", "transportation", and "the built environment". The NREL has 1,700 fulltime employees available and operates the National Wind Technology Center close to Boulder, Colorado. Part of the NREL is the National Wind Technology Center (NWTC) where researchers and industry partners work side-by-side to develop new technologies that can compete in the global market and to increase system reliability and reduce costs.

President Obama has expressly underlined the support for renewable energy in his State of the Union (SOTU) address in February 12th, 2013. Together with a policy framework released by the White House in conjunction with the SOTU address highlighted the specific approaches. Among them is a proposal to make the renewable energy production tax credit (PTC) a permanent fixture of the tax code although it has been established for temporary use.

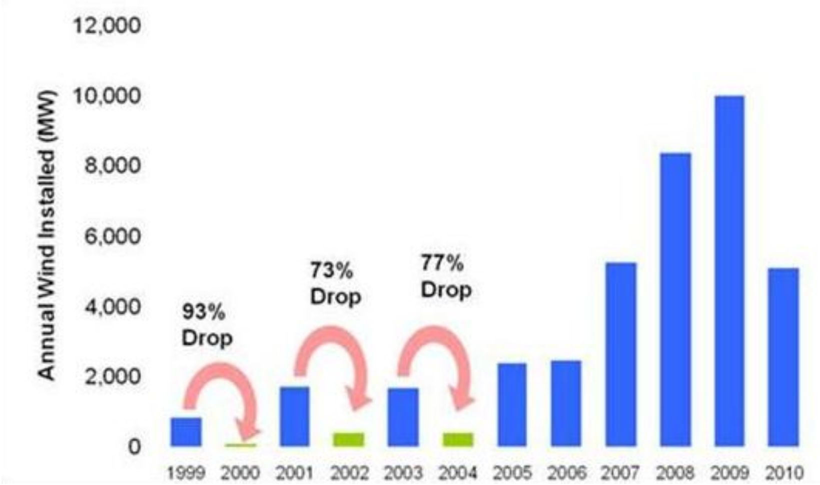
The federal renewable electricity production tax credit (PTC) is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. Originally enacted in 1992, the PTC has been renewed and expanded numerous times, most recently by the American Recovery and Reinvestment Act of 2009 in February 2009 (often referred to as "ARRA") and the American Taxpayer Relief Act of 2012 in January 2013.

The measure is cited as a step towards meeting the goal to double renewable energy production by 2020. This idea has been proposed already in February 2012 when business tax reform has been discussed. Interestingly the AWEA has stressed repeatedly although the wind energy industry obviously prefers a permanent PTC in the near term, the incentive was intended to be temporary. During December 2012 AWEA stated that a six year stepwise reduction gives the wind industry the time necessary to ramp-down the tax initiative. The PTC would begin at the current $ 0.022 per kWh and be phased down by 10 % each year, to 90 % of that value for projects placed in service in 2014, 80 % in 2015, 70 % in 2016, and 60 % in both 2017 and 2018, when it would end. In the immediate term, the association is concen-

[36] http://www.nrel.gov/about/overview.html (2013).

trating on continuing the momentum resulting from the recently passed one-year PTC extension.

Figure 41 Impact of Non-Extension of PTC on U.S. Annual Wind Installation



Source: AWEA (2013)

The main supporting tools for subsidizing renewable energy in the U.S. are the production tax credit (PTC) and the investment tax credit (ITC). Congress extended wind energy's vital production tax credit (PTC) for one year in 2012. The tax extender granted the $ 0.022 per kWh tax credit to the electricity generated by wind projects over the first ten years of their production service and to wind farms "under construction" by the end of 2013. As shown in the figure above this adjustment is empirically important because wind developers, in the absence of certainty the tax credit to be extended for 2013, did not place orders for the massive turbine machinery after the middle of 2012, and it will take at least six to nine months for manufacturers to take orders and gear up to meet them again.

North America – Canada

In March 2011 the Conference Board of Canada conservatively estimated that 2,000 MW of power could come from offshore wind in Ontario by 2026. The total translates into roughly 60,000 person-years of employment and up to CDN $5.6 billion in added gross domestic product. At the same time the province of Ontario was suspending all offshore projects pending further study.

The power produced by the onshore project "Wolfe Island" is sold under a 20-year Renewable Energy Supply II Contract with the Ontario Power Authority (OPA). Generators must enter into a contract with the OPA for a term of 20 years. The applicants must also meet certain requirements, including a connection impact assessment, environmental assessment and demonstrated site access, as well as other contractual terms.

Ontario's feed-in-tariff program has been North America's first comprehensive guaranteed pricing structure for renewable electricity production. The program provides a way to contract for renewable energy generation. It includes standardized program rules, prices and contracts for anyone interested in developing a qualifying renewable energy project. Prices are designed to cover project costs and allow for a reasonable return on investment over the contract term.

South America

The political framework is rather undeveloped in the South or Latin American countries but the particular Governments are keen to lay the groundwork for a prosperous future of the wind energy. The Mexican Government introduced e. g. reduced tariffs for electricity transmission or an accelerated depreciation of up to 100 % in one year.[37]

Brazil

The Brazilian Government introduced the Proinfa Program in 2002 for supporting renewable energy. This program was based on feed-in tariffs and exceeded on December 31, 2011. The actual situation of the supporting scheme is rather sketchy and should be fixed in the nearer future.[38]

The Ministry of Mines & Energy (MME) focuses on geology, mineral resources, Energy, Electrical Energy and furthermore. Companies like Energy Research Company (EPE), Brazilian Geological Services (CPRM) and Brazilian Emergency Energy Market (CBEE) are directly linked to the MME and supports it in the political and administrative organization of the respective sectors. The EPE is responsible for Planning, research and studies in the sectors crude oil, natural gas, electric energy and renewable energy and also creates the 10 year plan for expansion of the energy sector together with the Brazilian energy matrix, which includes the usage of alternative energy sources and technologies plus the development of concepts for the use of certain or alternative sources every second year. The main function of the National Energy Policy Council (CNPE) beside the guarantee of energy supply is the funding and usage of energy resources. Furthermore the National Electric Energy Agency (Aneel) is directly linked to the MME and manages the chain from Production to distribution of energy. It is also the contact point for complaints and conflicts of interest. The MME is under a high influence of a so called “construction lobby” which focuses on hydro power plants.

Brazil offers an extraordinary rare bright spot in the global wind energy market which, with the exception of the offshore boom, is somewhat subdued, and looks set to remain a fast growing wind market for the foreseeable future.

3.2.2 *Market Developments*

The major challenge for the Offshore Wind Energy sector is to continue reducing costs. The selection of sites in deeper waters, which are far offshore, with more difficult ocean floor conditions and higher waves, contribute to the increase of costs faster than the technology is able to drive them down by more efficient turbines due to higher capacity per unit and reliability of operational availability. In addition to that financing costs are increasing. As learned from other industries the costs of energy from offshore wind will be reduced distinctly as the industrialization of the production of future generations of offshore wind turbines and standardization of maritime logistics begins to take place. The Danish Offshore Wind Energy industry for example expects a reduction of 50 % for comparable sites between 2010 and 2020. But investments will still remain comparably high to onshore wind farms. Thus, the devel-

[37] See IEA Wind (2011): 2010 Annual Report, p. 128.

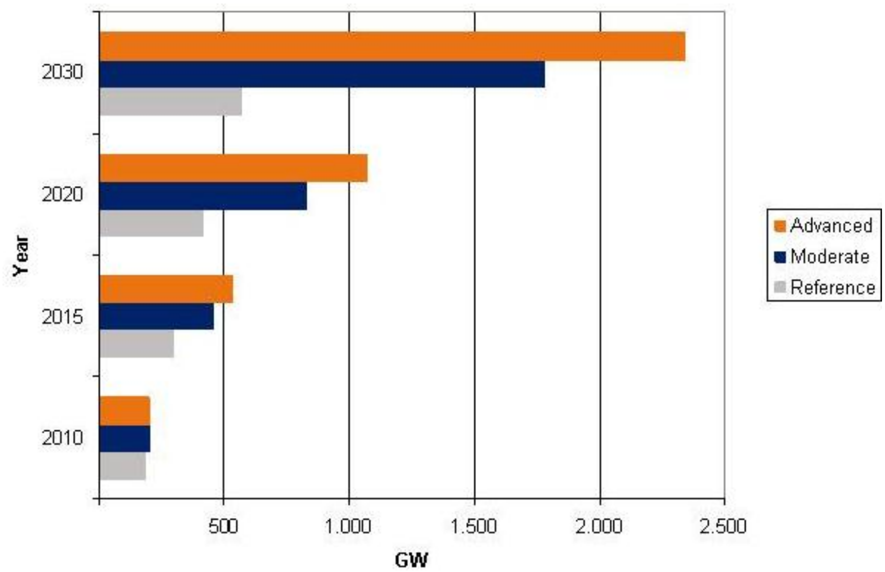
[38] See GWEC (2012): Global Wind Report – Annual Market Update 2011, p. 24.

opment and operations of Offshore Wind Farms will continue to be implemented by “big players” out of the energy industry or investment business.

Only for onshore projects other influences could be identified. The trend towards increasing size of individual wind projects continued, driven mainly by cost considerations. At the same time, interest in community wind power projects is rising in Australia, Canada, Japan, the U.S., and Europe. For example, an estimated 6.7 % of U.S. wind capacity in 2012 is community owned, up from 5.6 % in 2010, and more than 50 % of Germany’s wind capacity is individually or community owned.

The industry is projected to grow even further as more countries are expected to enter the market and thereby contributing to its development. In 2010, the Global Wind Energy Council prepared an outlook for the global wind energy industry. The scenarios are based on a mixture of historical figures, current policies and trends, possible future energy policy and other factors. The results in terms of installed capacity, measured in GW, are shown in the following figures.

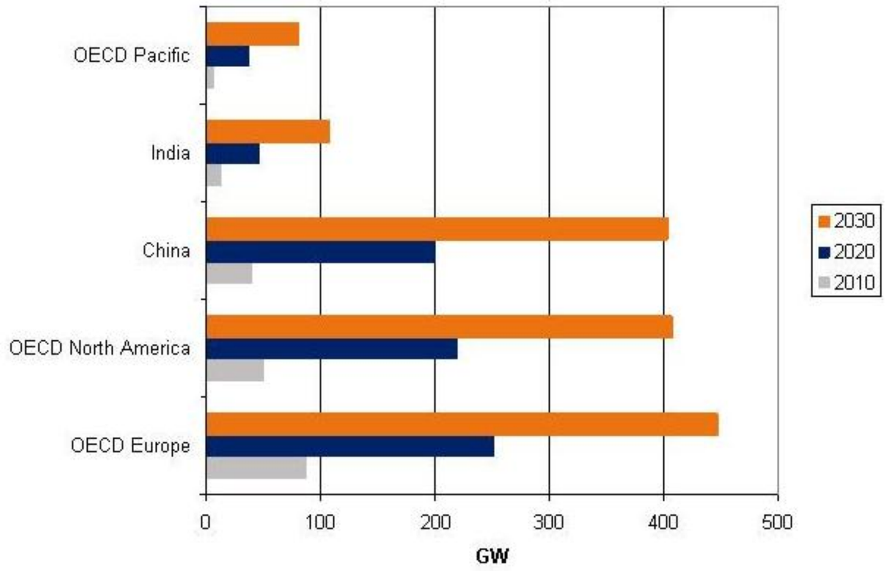
Figure 42 Global Cumulative Wind Power Capacity in 2030



Source: UNICONSULT (2012) with data of Global Wind Energy Council (GWEC)

The regional breakdown in the following figure shows a continuation of the started development in the same ranking and as it has been reported until 2010. Europe as a region with different nations will remain as the location with the highest production of electricity measured in GW followed by North America (USA and Canada) and the single nation China.

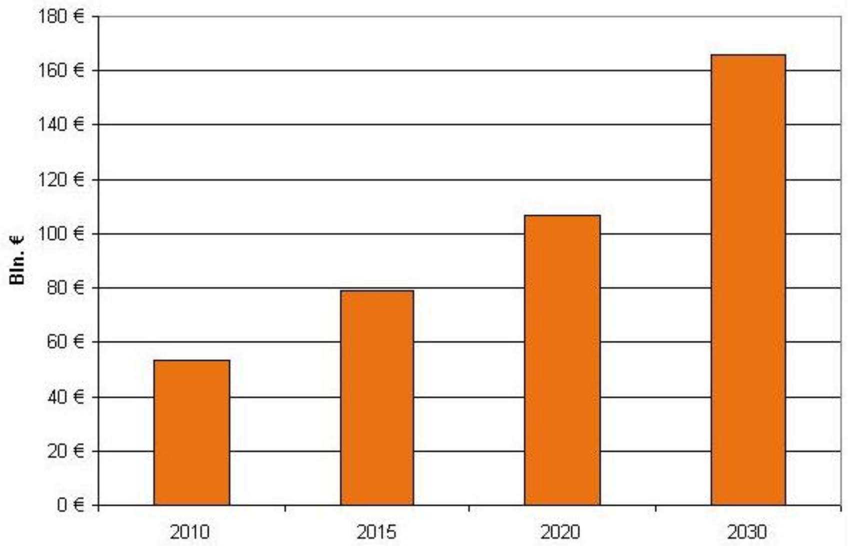
Figure 43 Regional Breakdown: Moderate Scenario (2010-2030)



Source: UNICONSULT (2012) with data of Global Wind Energy Council (GWEC)

The anticipated capacity growth until 2030 correlates with the investment, that is necessary to finance this expansion. Therefore, an annual global investment of 166 billion Euros will be needed in 2030.

Figure 44 Anticipated Annual Investment in Global Wind Energy Sector



Source: UNICONSULT (2012) with data of GWEC

Another technical challenge for the global offshore wind industry will occur when the far offshore generation of projects will start. In the mid- to long-term future there will be the farer the possible wind farms will be located offshore. Thus, even the largest, most intelligent traditional offshore wind turbines have a fundamental limitation. As they are fixed installations, they are actually unable to access deep water locations, where wind speeds are higher and more consistent than coastal areas. But where fixed turbines are out of their depth, floating systems may be ready to step in and fill the gap. This implies that Europe for example will benefit from the tendency to floating solutions which are already tested and designed mainly in Japan.

In 2012 the Governments of the U.S. and the U.K. announced collaboration to speed-up the development of turbines which allow an operation in deep waters of 100 m - 200 m in depth. The idea is to tether the constructions to the sea bed which consist out of floating underwater structures which provide ballast to prevent the turbine from toppling over. Besides a higher yield of wind, the technology's main advantage is expected to be the ability to warp the construction for maintenance reason back to the shore. Additionally a lower impact on marine ecology during installation and the potential to mitigate concerns about spoiling sea views for humans on the coast could be seen as positive differences compared to the conventional foundations. Both Governments are establishing funding opportunities for this technology.

As the technology is currently unproven, and it has to be shown whether floating turbines will be suitable to face given challenges, such as rough weather and the difficulty of transmission. However, several test projects are underway or in the planning stages, and the distinct public and private investment in the technology indicates a general confidence that it could be effective and economically viable once commercialized.

3.2.2.1 Europe

It is expected that the average Offshore Wind Farm size will increase further. While it has been 200 MW in 2011, projects currently under construction already have an average size of about 300 MW. Developers plan for the U.K. offshore wind with project capacities of more than 600 MW like London Array Phase 1. This trend is supported by technological advance in the field of offshore wind turbines. Currently the average capacity of all installed Offshore Wind Energy plant is 3.6 MW. There are already 5 MW turbines available and it is expected that turbines with a 10 MW capacity will be built in the future (see also chapter 2.1.1).

In addition, the planning process has started for Horns Rev III of 400 MW, Krieger's Flak of 600 MW and the near shore turbines which will have a combined capacity of 500 MW, of which 50 MW will be test turbines.

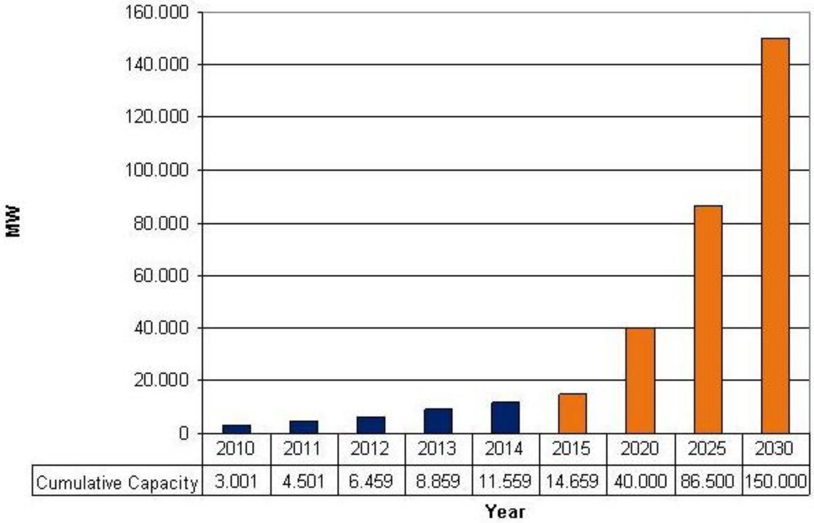
Repowering of Offshore Wind Farms will also be an important market segment in the future. Due to a lack of experience, only assumptions can be made about the lifetime of an offshore wind turbine. Nowadays it is calculated between 15 and 25 years.[39] In general, repowering will be practiced, if it is economically advantageous. Repowering could not only mean to replace the wind turbine itself, but also the foundation, as the new installed turbine requires different specifications. But due to less experience this is not verified. Furthermore, the distances between the wind turbines need to be increased due to the diameter of the rotor. The result will be not just the replacement of the offshore wind turbine, but a new planning of the whole Offshore Wind Farm.[40]

However, the European market for Offshore Wind Energy is expected to grow further in a rapid pace. For 2030 a cumulative installed capacity of 150,000 MW is forecasted, compared to 6,500 MW in 2012.

[39] Based on expert interviews with market players

[40] See also chapter 2.1.1 of the present study.

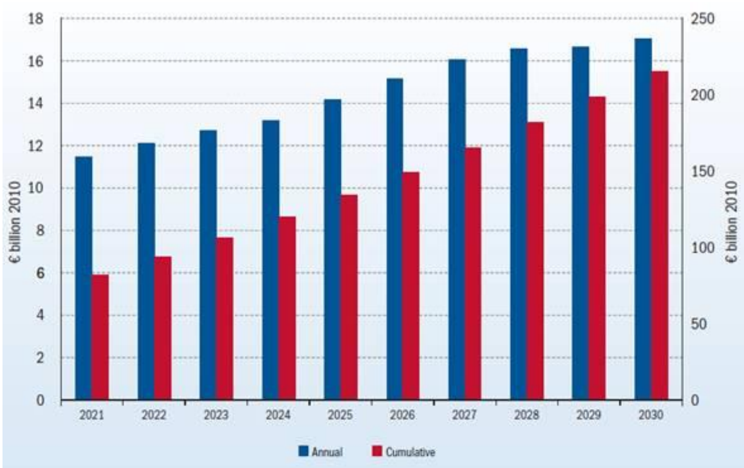
Figure 45 Cumulative Offshore Wind Energy Capacity in Europe 2010-2030



Source: UNICONSULT (2012) with data from EWEA 2009

The expected capacity growth demands high financial investments. For 2030, annual investments of 17 billion Euros are needed.

Figure 46 Cumulative and Annual Investment in the European Offshore Market (2021-2030)



Source: EWEA (2011)

3.2.2.2 Asia

China's Offshore Wind Energy industry is developing from demonstration projects to large-scale construction. At the same time, the exhibition Offshore Wind China 2013 will be held. Organized by the Chinese Renewable Energy Industries Association, the National Renewable Energy Center, and Shanghai International Exhibition Co., Ltd, it has become Asia's largest and the world's second largest offshore wind trade event.

Phase II of the Shanghai Donghai Bridge Offshore Wind Farm will lead to additional 100 MW installed capacity with 26 sets of wind turbines. One of these turbines will have a capacity of 5 MW and will be the largest turbine in Asia at the time being. The other 25 will provide 3.6 MW. The project's construction is expected to be completed by the end of 2014.

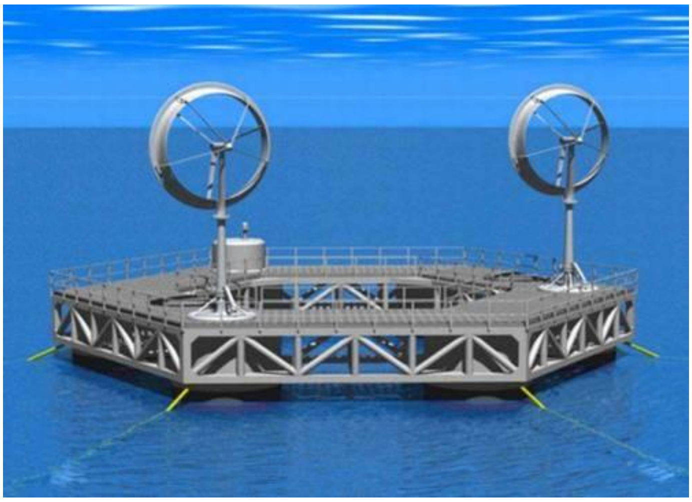
In March 2012 the **Japanese** Government awarded a project to a consortium of Japanese companies who will construct the floating wind pilot farm offshore to the Fukushima coast. This research project will include a floating substation as well as different floating wind turbine generators. In phase 1 of this research project started in 2011 with one floating offshore wind power generator with a 2 MW down wind turbine, a 66 kV sub-station and subsea cable will be installed. The downwind turbine has its rotor on the back side of the turbine. The nacelle typically is designed to seek the wind, thus negating the need for a separate positioning mechanism. Phase 2 will start in 2013 and two floating wind platforms will be added with 7 MW turbines.

While Japan has some shallow water offshore wind resources, the majority of Japan's offshore wind areas are in deep waters. Japan therefore has more than 20 years of research on floating structures, including for offshore wind. Various designs have been developed to concept stage, including barge designs, semi-submersibles, spars as well as tension leg platform concepts. The majority of Japanese research has been Government funded. Japanese industry was however reluctant to commercialize the various research. The reasons being the absence of Japanese Government subsidies for offshore wind and a limited Government focus on offshore wind due to strong opposition from the powerful and influential Japanese fishing industry. The Fukushima nuclear power accident in March 2011 however changed the dynamics, and floating offshore wind is getting a new 'push' in Japan. In November 2011 a first scale model was launched in Hakata Bay in Kyushu. In June 2012 a 1:2 spar design was deployed off Kabashima Island in Kyushu. A full scale spar is planned for 2013. At the same time, Mitsubishi deployed their 2.4 MW Offshore Wind Energy turbine on a gravity foundation off Choshi at the entrance of Tokyo Bay. In 2013 phase I of the Fukushima floating pilot project will be commissioned which is funded by the Japanese Government and will result in a wind farm with two turbines each deployed on three different floating technologies by 2015. These projects could probably turn Japan into a global leader with regards to full scale floating pilot projects.

Still reeling from the earthquake and tsunami that destroyed the Fukushima nuclear power plant in 2011, Japan has announced its intention to build what could become the world's largest Offshore Wind Farm. The "New Scientist" reported in March 2013 that the world's third largest economy plans to build by 2020 a wind farm with 143 turbines 16 km offshore to the destroyed Fukushima nuclear reactor. The new wind farm is expected to generate 1,000 MW of power.

The Kyushu University's Research Institute for Applied Mechanics (RIAM) has designed a newly wind turbine, called a 'wind lens'. Efficiency could be nearly three times higher in comparison to conventional wind turbines.

Figure 47 Possible Layout of a Floating Wind Lens



Source: Kyushu University, Japan (2013)

By incorporating a diffuser shroud that encircles the outer circumference of the rotor blades, and an outer brim, strong vortices are created, which lowers the pressure behind the turbine, creating a wind suction effect that draws more air through the turbine. The result is that the power of the wind is magnified.

Collaboration between the U.K. and South Korean renewable energy associations and between the country's Ministry of Knowledge Economy (MKE) and the U.K. Department of Business, Innovation and Skills (BIS) will support **South Korea** in making rapid progress in offshore wind generation regarding technical, organizational and financial issues.

3.2.2.3 North and South America

The **North American** development of offshore wind facilities in the U.S. and Canada is still comparative slow due to comprehensive concerns of different associations and personal positions. Although studies see many different potentials progress still sticks. In fact, a University of Delaware study estimated the wind resource in the area from Cape Cod, Massachusetts, to Cape Hatteras, N.C., to be sufficient to generate an average of 330,000 MW of electricity. In addition, the study notes that U.S. manufacturers have the ability to play a substantial role in the supply chain. Two-thirds of the components of U.S. land-based wind farms are already manufactured domestically.

In the Mid-Atlantic region, more than 70,000 direct jobs would be created in the manufacturing sector to meet the demand for wind turbine foundations, hubs, blades and other parts, and more than 40,000 jobs would be created by businesses that serve the supply chain for wind turbines. An additional 50,000 jobs would be created by the effect of added economic activity in the region, the report says. But first of all the awareness and willingness of the citizens have to be on hand.[41]

In **South America** until the end of the first decade of the new century the Brazilian renewable energy market was mainly focused only on hydropower. But since 2010 (onshore) wind power industry is one of the fastest growing renewable energy industries in the country.

The Government has started attracting established international wind energy companies in order to increase the number of national wind manufacturing facilities. Although contributing – on international level - a relatively low share of 2,769 MW to Brazil's total installed capacity in 2012, the Government's plans to take advantage of the untapped offshore market could see the this portion reach 19,420 MW by 2020. Also investors believe in the large future growth of wind power market in Brazil. Although it only operates onshore wind farms currently, especially Brazil targets to capitalize on the South's strong offshore wind potentials. But all in all the offshore market has to be fundamentally developed first.

[41] See Global Business Intelligence (GBI) Research (2013): http://www.gbiresearch.com.

4. BEST-PRACTICE EXPERIENCES IN THE GERMAN OFFSHORE MARKET

Based on the Offshore Wind Energy industry requirements and the analysis of the corresponding worldwide market and OWF locations, the following chapters give an outlook on fields of actions for ports to fulfill the offshore-wind industry's requirements. This will include recommendations from best-practice experiences made in the German Offshore Wind Energy market stemming from some of the offshore-ports listed below.

Table 7 Services of German Offshore Ports along the North Sea Coast

Port	Port function
Brake http://www.jmueller.de	Heavy-lift terminal "Niedersachsenkai" providing pre- and final assembly area
Bremerhaven http://www.offshore-windport.de	Base port with heavy-lift terminal providing pre- and final assembly areas
Brunsbüttel http://www.schrammgroup.de	Base port providing assembly and fabrication areas as well as service port
Büsum http://www.egeb.de	Service port for frequent transports to OWF and to "quick response ports"
Cuxhaven http://www.offshore-basis.de	Base port with heavy-lift platform, two dedicated offshore terminals, real estate areas
Dagebüll http://www.offshore-haefen-sh.de	Service port for frequent transports to OWF and to "quick response ports"
Emden http://www.nports.de	Base port with heavy-lift terminal providing pre- and final assembly areas; quick response and service port
Helgoland http://www.kreis-pinneberg.d	Quick response and service port for direct maintenance service of OWF
Hörnum http://www.gemeinde-sylt.de	Service port for frequent transports to OWF and to "quick response ports"
Husum http://www.seeschmid.de	Quick response and service port for direct maintenance service of OWF
List http://www.gemeinde-sylt.de	Quick response and service port for direct maintenance service of OWF
Norddeich http://www.nports.de	Quick response and service port for direct maintenance service of OW
Nordenham http://www.zds-seehaefen.de/	Base port with fabrication areas
Rendsburg http://www.rendsburg-port-authority.de	Base port with heavy-lift terminal providing pre- and final assembly areas
Stade http://www.nports.de	Base port with fabrication areas
Wilhelmshaven http://www.wilhelmshaven-windenergie.de	Expansion to base port with assembly / fabrication areas, quick response/service port
Wyk auf Föhr http://www.hafen-wyk.de	Quick response and service port for direct maintenance service of OWF

Source: UNICONSULT (2013) based on DVZ (2012)[42]

[42] See Deutsche Verkehrszeitung (DVZ); special issue "heavy lift cargo"; 05.10.2012, p. 16.

As already mentioned in chapter 2.2, Germany is the second largest market in terms of future fabrication and installation of OWF and OWEP in Europe. The German Government has decided to phase-out nuclear power by 2022 and Offshore Wind Energy will play a decisive role in Germany assuring a reliable energy supply with a high share of full load hours.

Therefore many German ports especially along the North Sea coast have intensified their efforts to be prepared for the requirements of the Offshore Wind Energy industry – especially functioning as base/consolidation ports for fabrication/installation and as service ports for service, operation and maintenance.

4.1 Fields of Actions for Offshore Ports

The present chapter derives the most relevant fields of action – following the opinion of market players and experts – which have to be considered by ports when qualifying for and positioning themselves in the Offshore Wind Energy industry as base and service ports. It shows how ports can use the results of the above elaborated chapters 2 and 3 for initializing offshore-related qualification activities for their facilities.

In a **first step** ports can use the results of the chapter 2 of the present study. Checking the offshore-wind industry's requirements allows ports to identify their own market position as base/consolidating or as service port in comparison to competitive ports. For instance ports can use the requirements to evaluate their as-is-situation in terms of infra- and supra-structure, hinterland connectivity, pre-assembly areas, quays, width of berths, or the existence of any constraints at their ports with regard to tides or locks.

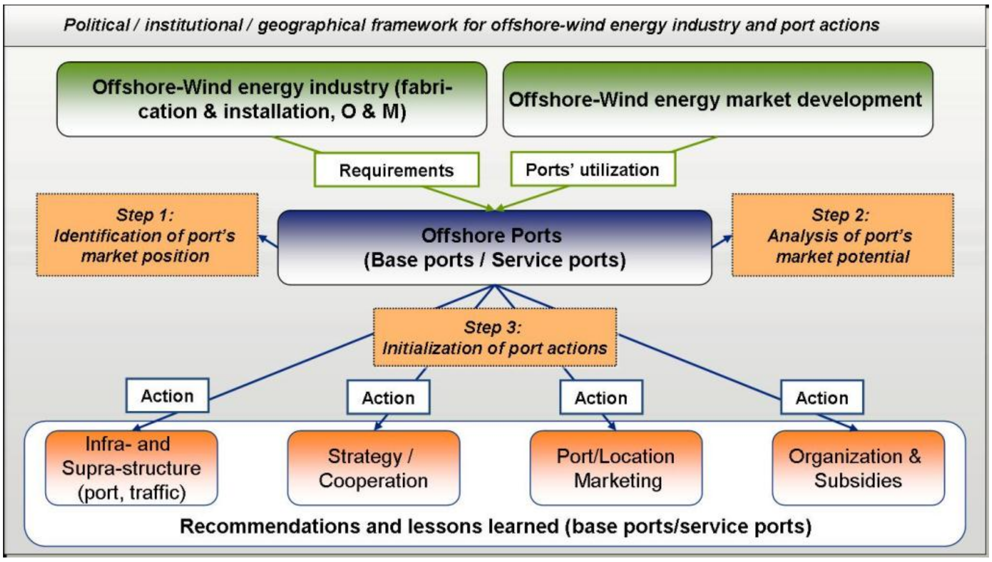
In a **second step** the ports can analyze their market potential which arises from the developments in their corresponding regional/national/continental offshore-markets (refer to chapter 3). Based on detailed analyses of the number and locations of planned installations of OWF, offshore-related utilization forecasts can be elaborated by the ports in the vicinity of those OWF.

Then ports can initialize different actions for fulfilling the industry's requirements and for realizing the identified market potentials (**third step**) in the fields of infra- and supra-structure, strategy and cooperation, location marketing, and organizational setup and subsidy acquisition. The framework for all port actions is set by the corresponding national or international political and institutional framework as well as by the geography of the sea areas where OWF installations are planned.[43] Those build basic conditions for the Offshore Wind Energy industry and for the ports' actions. The following figure depicts the positioning of the ports in between the industry's requirements and market developments and the thereof resulting fields of actions.

[43] The depths of the waters as well as meteorological conditions are influencing the probability whether OWF can be installed and operated in a sea area. Installation and operation of OWF might be hindered or endangered especially in some regions in Asia and North America by heavy storm seasons, i. e. typhoons, hurricanes, earthquakes or Tsunamis. As the financing and assurance for any Offshore Wind Energy actions in those regions can be seen as challenging the market potential for ports to become base or service ports might be rather low. However, those ports might be attractive for import or export of OWEP in case that there would be high location quality for OWEP manufacturers or in case that the port is an important node for transshipments of Onshore Wind Energy plants.

Based on these displayed fields of actions the following chapters will describe and summarize what steps already have been taken by German ports to position themselves in the Offshore Wind Energy market as base and service ports. Lessons-learned and corresponding recommendations in terms of offshore related port actions will be pointed out. The subsequent figure displays this approach.

Figure 48 Potential Fields of Actions and Recommendations for Offshore Ports



Source: UNICONSULT (2013)

4.2 Lessons-Learned and Recommendations

In Germany the ports along the coasts of the North Sea and Baltic Sea have identified a huge market potential serving as logistics hubs for fabrication, installation, service, operations and maintenance of OWEP and OWF. However, the year 2012 has shown that the realization of those potentials highly depends on the political and institutional framework: it was only after stable liability regulations in terms of grid connections of the OWF were politically decided and a dedicated offshore grid development plan was finalized[44] that the Offshore Wind Energy industry has observably continued with OWF installations.[45]

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[44] See http://www.bmvbs.de/SharedDocs/DE/Pressemitteilungen/2013/022-ramsauer-netzplan.html.

[45] Besides grid connectivity currently the fields of finance and assurance as well as environmental protection (especially noise abatement during OWF installations) and higher cost-efficiencies of OWEP productions and OWF installations are the most important challenges for the OWF-projects in Germany. Furthermore there are efforts in the market to research in different foundation technologies and special logistics requirements regarding OWF installations in deeper depths of waters and higher distances of the OWF to the coastlines. See wind:research-trend:research Institut für Trend- und Marktforschung: "Potentiale der Offshore-Windenergie in der Wachstumsregion Ems-Achse" (2012), pp. 23.

Lesson-learned: Developers, constructors, operators of OWF as well as OWEP manufacturers are dependent on reliable planning and investment frameworks and therefore on transparent liability regulations in case that an OWF is installed without having finalized the connection to the onshore grids. The grid network expansion and the onshore grid network connection is a decisive bottleneck for the successful development of the Offshore Wind Energy industry.

Therefore the study recommends that **offshore ports** should **actively support** the political and institutional stakeholders to push forward the following general steps easing and attracting the installation of OWF:

- Transparent and simplified approval procedures for OWF projects.
- In early phases of the location planning of OWF and preferably in advance to the approval procedures, the grid connection of the OWF to the onshore grids has to be assured as well as liabilities have to be finally cleared between grid network operators, OWF planners and OWEP manufacturers.
- Also in an early stage of planning of OWF the environmental protection during installation and operation of OWF has to be guaranteed.
- Initiation of mid-/long-term subsidy programs for the offshore-wind industry.

Those framework conditions have to be cleared as early as possible and should be valid for a rather long-term time horizon of 20 years minimum to guarantee solid basic conditions for as many planned and finalized OWF projects as possible. This is important as for instance in Germany, the complete timeframe which includes planning, approval (building permission), construction, installation and start of operations for an OWF takes approximately 10-12 years. In between this time horizon there should be stable regulatory and liability conditions.

However, ports can only indirectly influence the direction of the overall framework conditions. Therefore it is recommended to participate in any possibility of influencing those topics. The chapters below will provide ports with recommendations for direct actions using best-practice examples from the German offshore market and indicate lessons learned. This will be done by differentiating between the most important port functions in the offshore market: fabrication/installation (base port) and operations, service and maintenance (service port).

Figure 49 Synopsis of Recommendations for Port Actions

Port functions	Recommendations from the perspective of the German Offshore Market			
	Infra- and suprastructure	Strategy & Cooperation	Marketing	Organization & Subsidies
Fabrication and installation (Base ports)	"Flexibility vs. Dedication"	"Diversification and cooperation"	"Visibility through coordinated marketing"	"Creative, strategic classification and planning"
Operations, service and maintenance (Service ports)	"Geography rules"	"Logistics integration and pooling of services"		
	Port Product / Service-Portfolio		Marketing-Mix & Subsidy options	

Source: UNICONSULT (2013)

Depending on the fact whether a port has identified itself as a potential base or service port the present study develops function-related recommendations and shows lessons learned. The synopsis displayed above depicts the differentiation between function-related recommendations leading to the ports' service-portfolios and the subsequent recommendations in terms of marketing of those portfolios including the investigation in subsidy options and organizational planning.

4.2.1 Infra- and Supra-structure

4.2.1.1 Base Ports – "Flexibility vs. Dedication"

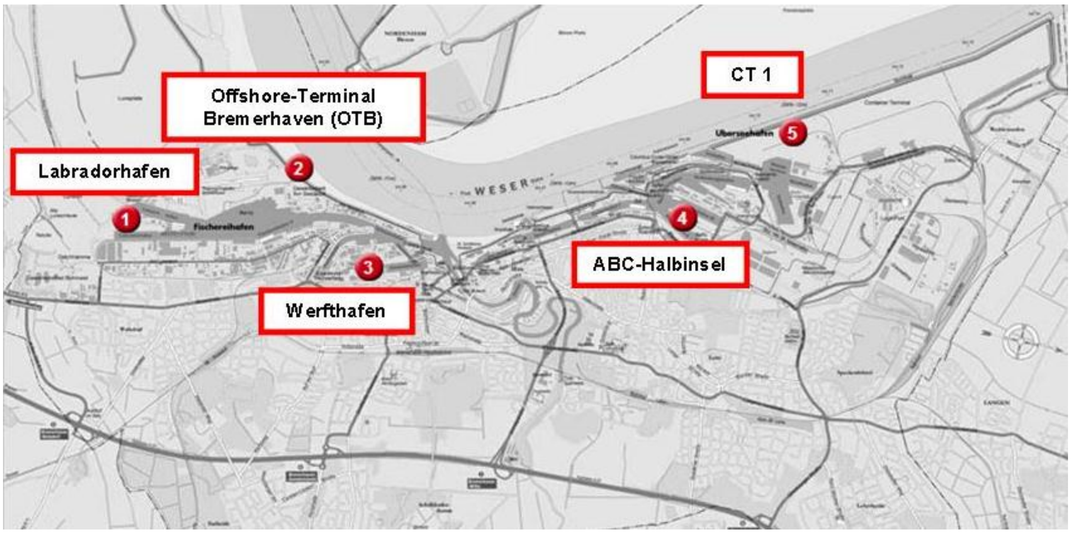
Until 2030, approximately 25-30 GW of electricity shall be generated through Offshore Wind Energy in the German EEZ. Therefore all suitable seaport areas with corresponding infra- and supra-structure will be required for the fabrication and installation of OWF. In general two different approaches can be identified in Germany how ports are currently preparing their infra- and supra-structure towards the offshore industry's requirements:

- Use of already existing and not exactly offshore-related port facilities and building/offering multipurpose oriented infra- and supra-structure to the industry, such as heavy-lift terminals ("**flexibility**").
- Building/offering of especially offshore-wind industry related infra- and supra-structure, for example offshore terminals with dedicated fabrication/installation areas for the industry ("**dedication**").

<u>Best-practice Examples "Flexibility"</u>

A best-practice example for reallocating already existing port facilities (container, Ro-Ro- and multipurpose terminals) to the offshore industry's purposes is the port of **Bremerhaven**. Bremerhaven is situated on the eastern bank of the Weser River, located 32 nautical miles (nm) from the estuary of the Weser. The port of Bremerhaven is of international importance and mainly focused on container, Ro-Ro (import and export of new cars) and the fishing industry. In addition to the major container terminals, port facilities are available to a large extent for the specific needs of automotive handling. The port is accessible by vessels with a maximum draft of 12.7 m (ensured water depth of 13.9 m) independently of the tides. The picture below shows the different parts of the port of Bremerhaven where offshore-related activities are carried out at the moment or will be executed in the future (OTB).

Figure 50 Offshore Port Bremerhaven



Source: UNCONSULT based on http://offshore-windport.de (2013)

During the years of the world financial crisis the port of Bremerhaven decided to participate in the booming Offshore Wind Energy market and offered parts of its at that time insufficiently utilized container and Ro-Ro-terminal infrastructure to the Offshore Wind Energy industry enabling storage, pre-assembly and handling of OWEP-components. RWE Innogy uses facilities in the container port at the Stromkaje since 2011 as base port for the installation of the OWF “Nordsee Ost” (North Sea East) which is located in the HelWin-Cluster in the vicinity of the island of Heligoland. The contracts provide areas of up to 17 ha and a directly adjacent and suitable quay wall of a length of 400 m at CT 1 (Container Terminal 1 at the southern end of the Stromkaje) in Bremerhaven at least up to 2015. RWE plans to supply its OWF project with 48 wind turbines of the 6 MW categories. “Nordsee Ost” should start operations in 2015 with a total capacity of 295 MW.

Offshore activities have been started in another port area in Bremerhaven called “Kaiserhafen” on the Ro-Ro terminal ABC-Halbinsel, too. The joint venture, Offshore Logistics Bremerhaven GmbH has designed an offshore pontoon ("BHV Offshore 1") which has a length of 70 m, a width of 32 m and a capacity for loading of up to 900 tons. It is used to transport OWEP foundation structures from the Bremerhaven-based manufacturing plant at the Labradorhafen to the ABC-Halbinsel where parts of the Ro-Ro terminal actually used for handling import and export cars has been dedicated to Weserwind (manufacturer of the foundations) for storing the heavy components. Specifically for this purpose, a new system was designed to secure the huge and heavy components on deck of the pontoon. The picture below shows the heavy-lift pontoon during the process of loading of OWEP foundations.

Figure 51 Pontoon-supported Transport of OWEP Foundations in the Port of Bremerhaven

Source: BLG (2013)

Besides the foundation manufacturer Weserwind, other offshore-related companies are settled in Bremerhaven in the Labradorhafen like REpower (turbines), AREVA Wind (turbines) and PowerBlades (rotor-blades) using the infra- and supra-structure for loading/discharging (parts of) their produced components or materials on/off general cargo vessels or pontoons.

> **Lesson-learned**: Already existing and perhaps underutilized infra- and supra-structure which in general is already in line with the requirements of the offshore-wind industry (e. g. depth of water at the quay wall or heavy surface loads) but not especially dedicated to offshore handling can be reallocated to offshore-wind related fabrication and installation purposes in the ramp-up phase when a port is originally starting to offer facilities and services for the offshore-wind industry.[46]

The described CT 1 quays where the OWEP are loaded onto jack-up platforms and installation vessels, the fabrication areas of the OWEP manufacturers in the Labradorhafen and the loading and unloading area of the OWEP foundations are geographically distributed over the port of Bremerhaven (see the figure above). This is bearing the advantage that the area for loading the installation vessels (CT 1) is separated from the fabrication areas of the OWEP manufacturers leading to sufficient spaces for buffering and storage of the components at CT 1. So there are optimum port location qualities for the OWEP producers with large areas (including expansion areas) in the vicinity of the water-side but not directly at the offshore-related terminal quay walls of CT 1. Those areas are dedicated to the loading and unloading of installation vessels and the corresponding pre-assembly and storage areas.

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[46] Of course in most cases the ports will have to upgrade their port basins besides the quay walls to allow the jacking-up of installation vessels. This wouldn't be necessary when using the above described floating technologies.

However, from a long-term perspective those reallocations will be transferred into an offshore dedicated solution (Offshore Terminal Bremerhaven) due to the fact that with a dedicated offshore or heavy-load terminal the industry can reduce logistics costs and handling processes can be decreased, e. g. by avoiding the currently necessary additional transshipments from SPMT onto the pontoon as the OWEP components could then be directly shipped with the SPMT from the production facilities to the offshore terminal. Furthermore the port can then re-dedicate the CT 1 areas and Ro-Ro terminal for their actual purposes of container and car handling.

As the offshore-wind industry is and will be characterized by up- and downturns (e. g. caused by changes of the political/institutional framework conditions) it can be recommended that ports should initially plan, reallocate or build **multipurpose terminals or multipurpose storage areas rather than dedicated offshore-terminals**. The terminals could then be used for general heavy-lift, project or general cargo handling besides the Offshore Wind Energy related handlings.

> **Recommendation**: While already existing infra- and supra-structure can be used by ports for offshore-related purposes in the ramp-up phase, new built offshore-related port infrastructure and supra-structure (quayside areas, storage and assembly areas and production/fabrication areas) should rather be planned for flexible than for dedicated usage.

For instance the offshore port of **Brunsbüttel** located in the Hamburg Metropolitan Region has decided to orientate its port infra- and supra-structure for multipurpose use. The port could be accessed by the Elbe River and the Kiel-Canal connecting the North Sea and the Baltic Sea. Various services such as cargo handling, transportation, warehousing, contract logistics and maritime services are offered in the port by different companies. The segment "offshore wind" has been continuously expanded since 2006.[47]

In December 2012 the development and construction of an offshore/multipurpose pier was approved by the Federal State Government of Schleswig-Holstein.[48] The multipurpose orientation of the investment will preserve the port’s flexibility in terms of utilization of infrastructure. There will be an 8 ha pier area including heavy-lift area (400 kN/sqm) with a 200 m quay wall with jack-up possibility and a hinterland road connection allowing heavy-cargo transportation. The draft of the port basin will be up to 11 m. In addition there will be 26 ha of industrial real estate available for the offshore-wind industry in the vicinity of the port; especially convenient for the production and handling of tower sections, foundations and offshore cables.

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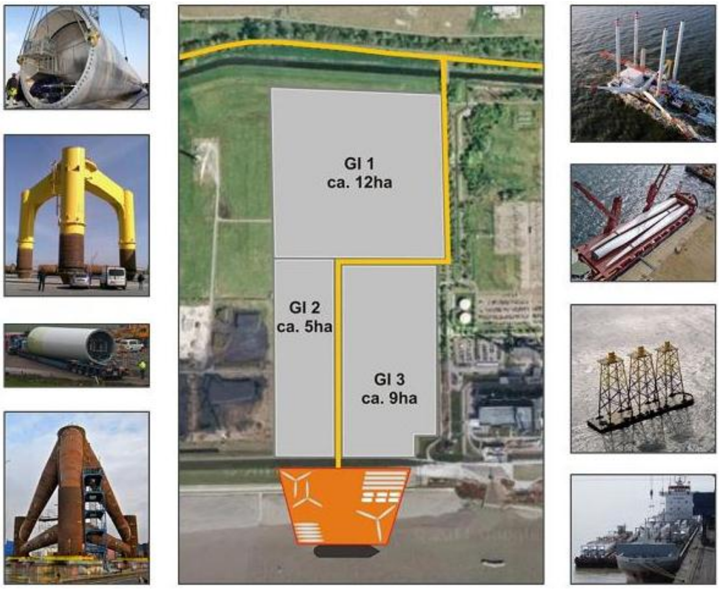
47 During the construction of the Offshore Wind Energy test field “alpha ventus” the port was involved by the modification of the jack-up barge "Buzzard" in 2009. Furthermore rotor-blades were transshipped on behalf of REpower Systems AG for the installation of the OWF “Ormonde” in the Irish Sea: as of January 2011 the blades were shipped to Belfast to the shipyard Harland & Wolff where the blades were pre-fitted with the complete OWEP to be later installed on platforms by jack-up rigs. See http://www.elbehafen.de/en/node/363.

48 In advance a morphological report confirmed the possibility to install a jack-up sole in the river bed at the Elbehafen in Brunsbüttel

Figure 52 Offshore / Multipurpose Pier Brunsbüttel



Source: http://www.egeb.de (2013)

Best-practice Examples "Dedication"

The Offshore Wind Energy base port of **Cuxhaven** which is also located in the Hamburg Metropolitan Region is indeed equipped with a heavy-load platform, multipurpose pier, Ro-Ro terminal and heavy-duty roads.[49] However, the most important characteristic of the port is the dedication of terminals and industrial real estates to the Offshore Wind Energy industry. As shown on the following figure the offshore-related industrial and commercial areas are located in close proximity to the offshore-terminal and transshipment zones and are especially well-suited to the needs of the OWEP producers (e. g. offering large storage spaces OWEP components).

[49] There is a 1,500 sqm heavy-load platform for loading and handling of very heavy goods and OWEP components. The platform has a maximum load bearing capacity of 90 tons per sqm allowing the use of mobile or stationary cranes weighing up to 2,500 tons to load completely assembled OWEP onto pontoons or installation vessels. The multipurpose pier offers optimum conditions for erecting, maintaining and servicing OWF offering 15.80 m water depth, heavy cargo and special craning equipment. Via the multipurpose pier numerous OWEP components were loaded for OWF projects in the North Sea or Irish Sea as well as steel and semi-finished products (towers, ramming tubes, and steel foundation structures were transhipped. Furthermore the port of Cuxhaven is equipped with a Ro-Ro-terminal which can also be used for offshore related loading and unloading processes.

Figure 53 Offshore Base Port Cuxhaven

Source: Offshore Basis Cuxhaven and City of Cuxhaven (2013)

In fact these locations of real estates near to the water-side are highly attractive for the industry. However, the fact that the offshore terminal I and II are closely surrounded by those areas is limiting the formal arrangements of the port authority to further expand the offshore terminal and quay areas and to adjust them to the special requirements of the installation logistics and the space needs of future larger scale OWEP:

In the North Sea area all construction, installation and repowering actions can only be carried out in a restricted timeframe of approximately 170-220 days per year due to heavy weather conditions (high waves and strong wind). Therefore the Offshore Wind Energy industry aims to pre-assemble OWEP components to complete modules or to store larger single components in the ports directly at the quay wall shortly before shipping them as quickly as possible to the OWF and installing them offshore.

Together with the fact that there will be a future increase of sizes of OWEP components (e. g. the new 6.0 MW series) this will require larger installation vessels, higher frequencies of transports in between base ports and OWF in combination with larger storage and pre-assembly areas at the quay walls of the offshore-related terminals at base port locations.

> **Lesson-learned**: Port areas directly located at the offshore-related terminals and quay walls should not be dedicated to industrial real estates.

Therefore, the sizes of the quay wall and of the heavy lift areas for pre-assembly and loading/unloading have to be planned with regard to peak-times and expansion opportunities for larger OWEP-series in the future. Ports should reserve those expansion options for transshipment, pre-assembly and buffering/storage areas to be available directly at the quay walls.

> **Recommendation**: Dedicated industrial real estates or areas for the OWEP producers (e. g. assigned for storage of semi-finished goods) should be planned in the vicinity but preferably not directly at the quay wall of the offshore terminals where installation vessels are loaded and unloaded. The areas located directly at the quay wall should be kept in the hands of the port authorities. So they can keep the option for flexible future expansion of the terminal areas following the installation and OWEP dimension requirements of the industry.

Based on the above described examples the following **main items** can be summarized for **base ports** in terms of the action field **infra- and supra-structure**:

- Subject to fulfilling the industry's requirements, ports can use and reallocate the already existing infra- and supra-structure to the purposes of the Offshore Wind Energy industry, especially in ramp-up phases of offshore-related activities in the ports.
- New built offshore-related port infrastructure and supra-structure (quayside areas, storage and assembly areas and production/fabrication areas) should be preferably planned for flexible usage, i. e. multipurpose pier.
- Areas located directly at the offshore-related terminals and quay should be kept in the hands of the port authorities to preserve the option for flexible future expansion in terms of offshore-related pre-assembly, loading/unloading and handling/storage purposes.

4.2.1.2 Service Ports – "Geography rules"

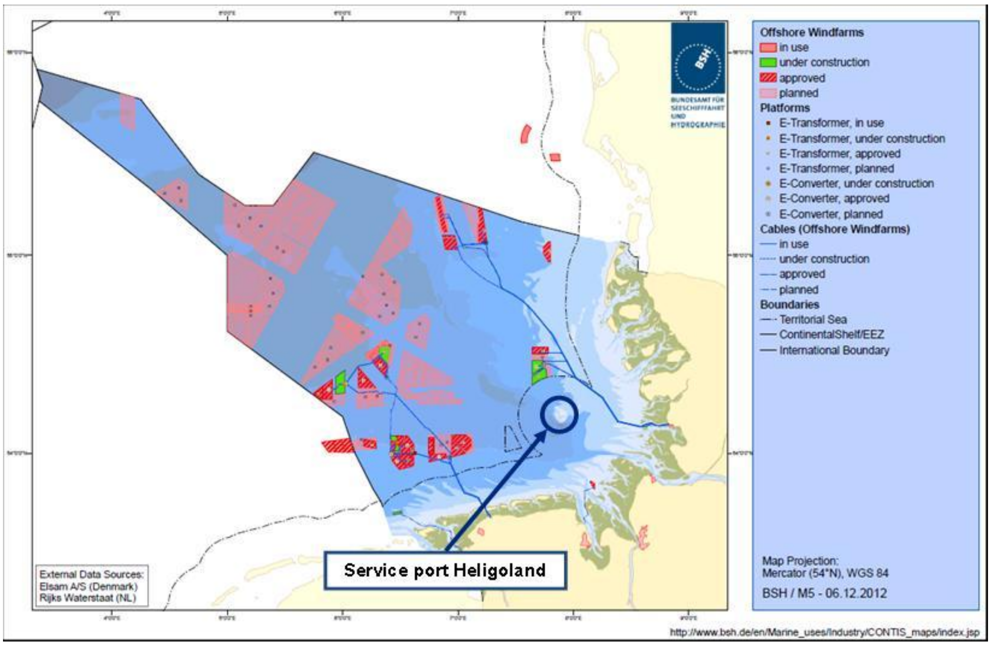
At the moment there are only few experiences in terms of operations, services and maintenance of commercial OWF in the German and the whole European market. Therefore no standardized processes or concepts have been established, yet. Currently OWP producers and OWF operators are developing tailor-made individual service concepts.

The current best-practice experience from the German and European market which can be identified regarding service ports is that the equipment with infra- and supra-structure is not as relevant as the **geographical location of the port**. The distance to the OWF is important to get a clear picture on the fact whether a port in general might be qualified as service port (e. g. for quick responses, direct non-heavy maintenance or as a service port for frequent transports of components and service material to the OWF). The geographical location decides about the implementation of service concepts as it determines the cost-quality-level of logistics solutions.

> **Lesson-learned**: The geography determines the cost-benefit-quality ratio of service concepts for OWF. Therefore the equipment with infra- and supra-structure of potential service ports is of minor importance for becoming a service port (quick response port for direct maintenance service of an OWF or a service port for frequent transports to the OWF).

In Germany especially the best-practice example from the port of Heligoland shows that the geographical location and the distance to the OWF are deciding about becoming a service port. The special infra- and supra-structural design and development are executed downstream to that decision. The island of Heligoland is situated 40 km off the German North Sea coast, and therefore is particularly well-suited as quick response service port for the operation and maintenance of the OWF in its vicinity.

Figure 54 Geographical Location of the Future Service Port Heligoland



Source: UNICONSULT (2013) based on Federal Maritime and Hydrographic Agency (2013)

The southern port of Heligoland will be developed into a service and operations base for several OWF.[50] At the planned service port of Heligoland vessels with service crews will daily set off to the OWF in the morning and return after completion of the works in the evening. The vessels will be loaded with tools and spare parts and will be refueled from the quay edge. Together with the island of Ruegen (offshore-port of

[50] An area of approximately 10,000 square meters (sqm) has been earmarked for service buildings to be erected (i. a. warehouses). A total of ten berths are also to be created on the quay edge of the southern port. This will require the construction of an additional landing pier. See http://www.offshore-haefen-sh.de/en/content/heligoland

Sassnitz) Heligoland will be the second island in the German North and Baltic Sea region to benefit from the development of the Offshore Wind Energy industry. Being the first island to serve as an offshore wind service base in the German North Sea, Heligoland will be a model for servicing many more OWF currently being developed in German waters.

The Offshore Wind Energy industry is currently discussing three main **service and maintenance concepts**. However, there are no significant experiences during commercial OWF-operation at the moment so that no lessons-learned can be derived for service ports. Therefore first recommendations towards ports based on the different service concepts shall be given.

a) **Shore-based vessel supported concepts** are characterized by using a service-base port from where the service crews can be transferred daily or reactively to the OWF. The advantages of this concept are relatively low fixed costs as no accommodation platform needs to be raised or an accommodation vessel would have to be chartered. In case that a dedicated spare parts logistics concept would be used all the relevant parts would be available when needed. Service technicians would be at home every evening so that the jobs would be compatible with family life.

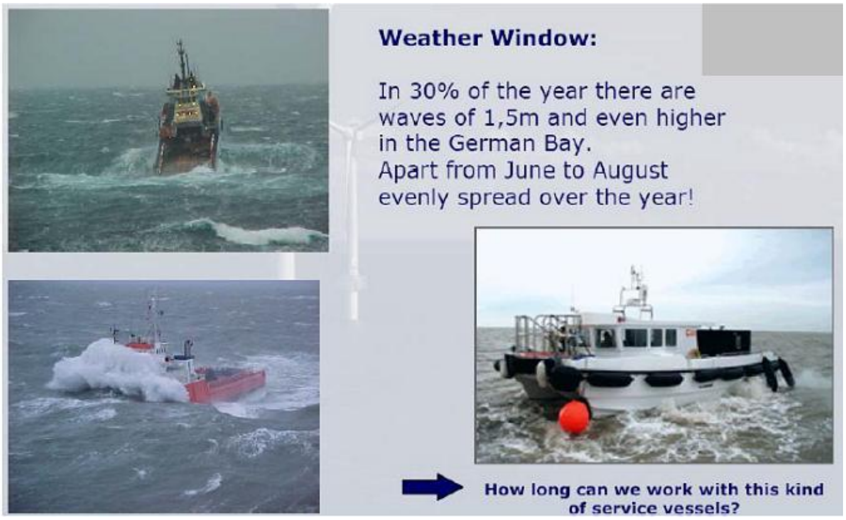
Figure 55 Vessel-supported Operation, Service and Maintenance of OWEP

Source: Fr. Fassmer GmbH & Co. KG (2011)

A major disadvantage is the limited accessibility of OWF by vessel transport due to heavy weather conditions on sea. However, the industry is currently developing catamarans and SWATH-tender vessels (Small Waterplane Area Twin Hull) adaptable for cost-efficient service crew transfers to OWF. Traditional catamarans and SWATH would have deployment restrictions dependent on wave heights larger than 3.5 m. With on average two service technicians becoming sea sick, five technicians would have to be transferred to an OWF so that in the end three of them could be able to work. Furthermore charter and bunker costs have to be integrated into conceptual calculations.

Recommendation: Shore-based vessel supported concepts are applicable for OWF in a distance of maximum 30 nm off the coast. Tri-modal hinterland connectivity of the ports is required as major precondition for quick spare part transports as well as for regular shuttle services.

Figure 56 Weather Condition Influence on OWEP Service Works



Source: Fr. Fassmer GmbH & Co. KG (2011)

b) Some OWEP producers discuss **shore-based helicopter supported service concepts**. In those concepts service technicians would be transferred to OWF by helicopters. The helicopter would then land on the transformer platforms (where it could be refueled). The technicians would then be hoisted to the OWEP or could be transferred by SWATH or mono-hull vessel from the transformer platform to the OWEP. The advantage of this concept would be the quicker transfer of service technicians from the service port to the OWF leading to an increase of working hours offshore. Furthermore there would be shorter response times and lesser sea sicknesses. However, this concept leads to high transportation costs by using helicopter flights. Icy or foggy weather conditions could lead to restrictions in using the helicopter. In addition, this concept needs to be supplemented by vessels to transport spare parts to the corresponding transformer stations. The warehousing of those parts would take place at the port location.

In Germany there is a strategic cooperation currently established between HTM (Helicopter Travel Munich), AREVA Wind, and the OWF “Trianel Windpark Borkum” and “Global Tech I” aiming at reducing operations and maintenance costs as well as generating high levels of technical availability of the OWEP in those OWF. The airfield of the seaport Emden will be used to service both OWF with the help of helicopters equipped with special instruments for hoisting service personnel and spare parts on the OWEP.[51]

Recommendation: This mixed shore-based sea- and airside orientated service concept is generally applicable for near and far offshore OWF. Shore-based helicopter supported service concepts require at least a helicopter landing site and preferably a smaller airfield for cargo transport or personnel transfers in the vicinity of the service port.

[51] See http://www.windkraft-journal.de/2013/02/19/areva-wind-und-htm-helikopter-bilden-strategische-service -partnerschaft-in-der-offshore-branche/.

Figure 57 Helicopter-supported OWEP Service Concept

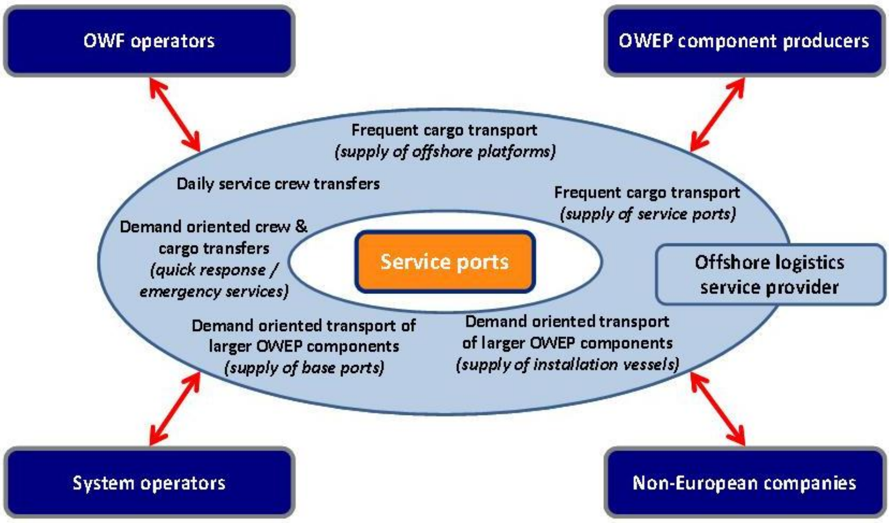
Source: BARD (2011)

c) **Sea based concepts using accommodation platforms/vessels** are discussed for far offshore OWF (as already mentioned in chapter 2.1.3 there will be an accommodation platform used for the installation of the OWF “DanTysk” in the North Sea). An accommodation platform or vessel could be chartered and stationed or jacked-up at an OWF connecting the OWF with the service port every 14 days for an exchange of service crews. From the origin of the platform service technicians could be transferred to the OWEP by helicopter or transfer vessel. The main advantage of this concept is that there wouldn’t be any significant transfer times of the service personnel to the OWEP so that labor productivity could be increased and response times reduced to a minimum. However, there would be high chartering costs for the accommodation platforms and low compatibility of job and family life.

Recommendation: Sea-based concepts are especially applicable for far offshore OWF. For participating in this concept, ports have to attract OWF operators so that they commit themselves by locating service and crew units. Accommodation facilities as well as storage areas for larger spare parts are required as the ports serve as service port for frequent transports to the platform and the OWF. Service shuttles to different OWF and accommodation platforms could be established.

The following figure summarizes the service concept-related requirements of the offshore wind-energy industry towards logistics service providers. The ports build the infra- and supra-structural hubs for the service providers enabling daily, frequent or quick response transport processes (on-the-spot emergency services) to the OWF. In the end the distance to the OWF and the qualification of the port location regarding the hinterland connections decide about the special functions of the service ports.

Figure 58 Ports as Hubs for Service, Operations and Maintenance of OWF



Source: UNICONSULT (2013)

Based on the above described examples and service concepts the following **main items** can be summarized for **service ports** in terms of the action field **infra- and supra-structure**:

- The geographical location of a port and its distance to the OWF is the most important qualification criteria for a quick response service port and determines the cost-benefit-quality ratio and therefore the selection of suitable Offshore Wind Energy service concepts.
- Besides the geographic location the tri-modal connectivity of the port, storage areas of up to 3 ha (especially important for service ports to be used as hubs for frequent transports to the OWF or storage location of larger spare parts) and access to a smaller airfield or helicopter landing sites are preconditioned criteria to become a service port.
- Ports on islands near to OWF have a genuine geographic advantage in comparison to shore based ports to become quick response and service ports. In case there would be no natural islands, “artificial islands” or platform concepts could be an alternative solution for far offshore OWF installation and operation services.

4.2.2 Strategy and Cooperation

4.2.2.1 Base Ports – "Diversification and Cooperation"

Regarding the strategic positioning and development of a **base port** the best-practice example of the port of **Bremerhaven** can be referred. The strategy of the port is to attract preferably all kinds of OWEP-component producers offering industry-specific infrastructure in the vicinity of the water-side with sufficient water depth for sea-going ships and expansion areas characterized as follows:[52]

- Production and assembly areas for foundation, tower, nacelle and rotor blade production as well as for storage and final assembly.
- Traffic areas with capacity and dimensions suitable for the transport of OWEP components.
- Heavy cargo terminal at the water front with sufficient water depth for sea-going ships.
- Tri-modal hinterland transport infrastructure.

This has attracted several companies of the Offshore Wind Energy industry, for example PowerBlades GmbH (Joint Venture of AR Rotec and REpower Systems AG), the Weser Wind GmbH Offshore Construction Center Georgsmarienhütte as well as REpower Systems AG (5 to 6 MW) and AREVA Wind (see the following figure).

Figure 59 Diversified Settlement of OWEP Component Producers in Bremerhaven

Source: Offshore Windport Bremerhaven (2013)

[52] http://offshore-windport.de.

With the further development of expansion areas (Luneplate) there are plans for the building of a dedicated offshore terminal on the Weser River with its own connection to the industrial area lying behind (OTB – Offshore Terminal Bremerhaven).

A great diversity of OWEP component producers can strengthen the market position of a base port as point of origin for fabrication and installation of OWF due to economies of scope and synergy effects for the industry and for logistics service providers operating at the port location.

> **Lesson-learned**: Due to the fact that a base port is a consolidation point for the complete installation-supply chain of an OWF it is favorable for ports to follow a diversification strategy in terms of settlement of OWEP-component manufacturers. Having as many different components produced as possible at the same port location increases the attractiveness of the port as consolidating base port and strengthens the perceptions of the base port as valuable logistics partner for the industry. A base port equipped with diversified OWEP manufacturers can offer the basis for logistics service providers that they in turn can offer complete contract logistics service packages to their customers (e. g. OWF developers and constructors).

In case that a port wouldn't have the possibility to settle diversified OWEP-component producers or would still be in the offshore ramp-up phase with none or at most one single OWEP component manufacturer already settled, a cooperation with another base or consolidating port could be a feasible strategic option. Then the port could act as central production location for some OWEP-components which would then be shipped to the final consolidation port. The cooperation between the ports of Rendsburg-Osterrönfeld ("New Kiel Canal Port")[53] and Brunsbüttel (both located in the Hamburg Metropolitan Region) can be taken as an example with appreciable best-practice potential.

After transporting OWEP components with a shuttle link across the Kiel Canal from Rendsburg-Osterrönfeld to Brunsbüttel (see the following figure), the port of Brunsbüttel can then play the future role of a consolidation hub where OWEP could be loaded onto jack-up platforms and installation vessels. Brunsbüttel would then function as a consolidating base port and Rendsburg-Osterrönfeld as central production port for single OWEP components.[54]

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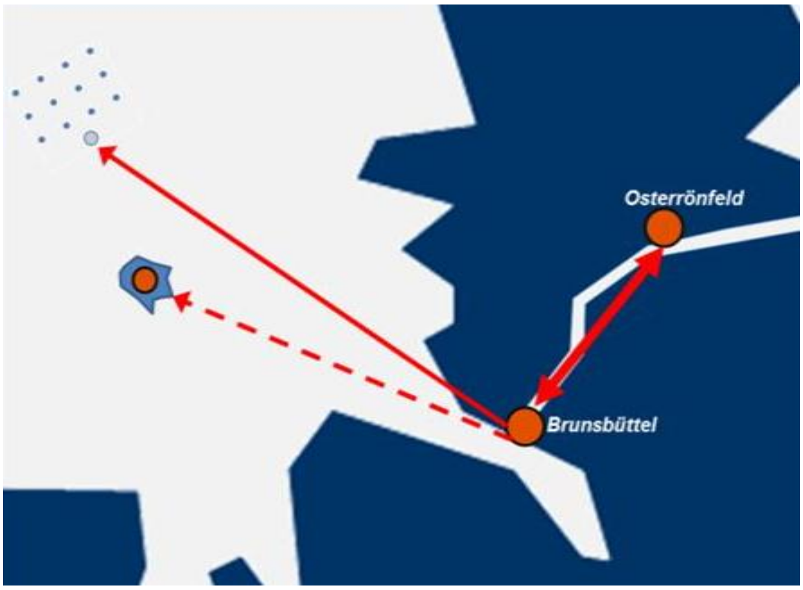
[53] In conjunction with the port to handle heavy loads, this provides excellent conditions for erecting production facilities for OWEP. In December 2011 the civil construction company Max Bögl has committed to start the production of wind energy tower segments at the Rendsburg-Osterrönfeld location beginning in 2013. The connection to the waterway system and access to the North and Baltic Sea have been the major criteria choosing this location for the planned production of 200 towers per year. The tri-modal accessibility of the location is of high importance for Max Bögl although it focuses on Onshore Wind Energy plants during the starting phase.

[54] The competition situation between the base ports of Bremerhaven and Cuxhaven can be taken as a rather cannibalizing "bad-practice" example. However, the reason for this situation is based in the German federal system. Although both ports are geographically located in close proximity to each other they are part of different federal states which are both aiming to develop own offshore base ports.

Figure 60 Shuttle Link between Rendsburg, Brunsbüttel and the OWF in the North Sea



Source: UNICONSULT (2013)

> **Recommendation**: From the very beginning of strategic port planning, base ports should bear in mind not only acting as transshipment locations but also becoming valuable logistics partners for the Offshore Wind Energy industry (especially for logistics service providers and OWEP producers and OWF developers and constructors). The overall goal of base ports should ideally be to offer complete logistics service packages to the offshore-wind industry. In case, that ports wouldn't be able to offer those service packages on their own they should check the option of strategic cooperation or alliances with other base or consolidating ports. Especially smaller or not deeply diversified ports with single OWEP component producers could strengthen their market position through cooperation.

Based on the above described examples the following **main items** can be summarized for **base ports** in terms of the action field **strategy and cooperation**:

- As many different OWEP-components as possible settled in a port location increases its attractiveness as consolidating base port and strengthens the perception of the base port as valuable logistics partner: base ports equipped with diversified OWEP manufacturers can offer the basis for complete service packages for the Offshore Wind Energy industry (contract logistics).
- Cooperation with larger or more diversified ports (perhaps due to the fact of limited area capacities) might be an option for smaller and perhaps not deeply diversified ports to gain market position and awareness in the Offshore Wind Energy industry.

4.2.2.2 Service Ports – "Logistics Integration and Pooling of Services"

With regard to their geographical location and infra- and supra-structural equipment service ports can position themselves as quick response ports or as service ports with frequent transports to OWF being part of different service logistics concepts (see chapter 4.2.1.2). As the infrastructure plays a subordinated strategic role in contrast to base ports (see chapter 4.2.2.1) their major strategic goal is to offer a location to the offshore-wind industry with best qualifications to guarantee short response times together with high spare parts availability and logistics reliability. As there are no significant experiences during commercial OWF-operation at the moment no lessons-learned can be derived. Therefore the present chapter shall give first general recommendations towards potential service ports in terms of strategy and cooperation.

Cooperation between shore-based ports and quick response ports on islands or accommodation/operations platforms near to the OWF make sense in terms of far offshore concepts. In this context as well as in terms of cooperation between shore-based service ports (vessel or helicopter supported shore based service concepts) the pooling of resources might lead to the realization of economies of scope (positive bundling effects) at the cooperating ports. The sharing of resources, e. g. of transfer vessels in between different service port locations and OWF, might generate value added to the offshore-wind industry and the ports as well. However, it has to be noticed that OWF are built and operated by competing operators so that a neutral resource pooling offered by service ports would make it necessary to establish a high-sophisticated resource coordination system to realize synergies.

The following example shows how service port locations are currently starting to mutually network along the North Sea coast of the German Federal State of Schleswig-Holstein under the umbrella organization "Offshore-Ports North Sea Schleswig-Holstein" (see also the next chapter). Indeed these are networking scenarios, but all are generally feasible. The extent to which the ports will interact with each other will finally depend on the customers' requirements and the chosen service concepts for the OWF.[55]

<u>Cooperation between Service Ports</u>

The ports of Dagebüll, Husum, Hörnum and List located along the German North Sea coast are generally qualified for long-term supply as well as for quick response maintenance of OWF. The ports of Dagebüll and Husum cooperate to function as supply ports for Hörnum and List which are qualified as quick response ports. Regular shipments of spare parts, service crews and materials/tools from Dagebüll and Husum to the quick response ports will enable constant and adequate supply flows. With the ports of Hörnum and List situated off the coast on the island of Sylt, short approach routes for supply and maintenance of OWF can be established.

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55 For this and the following example see http://www.offshore-haefen-sh.de/en/content/networking-port-locations.

Recommendation: In case that in the offshore-related ramp-up phase a potential service port wouldn't promptly be suited to the industry's requirements or in case that a potential service port would be surrounded by competitive service ports a cooperation would make sense to offer an added value to the customers. This could be reached by adapting the freight village thinking in terms of access of customers on mutual resources (e. g. crew or cargo transfer vessels, waste management, helicopter landing sites, hospital or emergency facilities).

Figure 61 Port Cooperation Offshore-Ports Schleswig-Holstein

Source: Port Cooperation Offshore-Ports North Sea Schleswig-Holstein (2013)

<u>Cooperation between Service Ports and Base Ports</u>

Through cooperation between base and service ports logistics advantages can be generated leading to the possibility to offer complete service and installation logistics packages to the customers; single location advantages of the ports can be bundled to a larger overall advantage and interfaces between the ports can be minimized.

The cooperation of the ports of Brunsbüttel (base port), Büsum (service port), Husum (service port) and Heligoland (service port) facilitates installation processes of OWF and enables their operation's supply and maintenance on a long-term base.[56]

The ports of Brunsbüttel, Büsum and Husum could also be activated as supply ports for Heligoland with direct and frequent maintenance service transports. As already mentioned above, Heligoland offers well-suited conditions for functioning as a quick response service port. Due to its geographically favorable location it can offer short approach routes to the OWF located in its vicinity. However, since Heligoland is an island location with restricted space availabilities, flexible supply ports on the shores are a decisive precondition. With Brunsbüttel, Büsum and Husum, three rapidly ac-

[56] For this and the following example see http://www.offshore-haefen-sh.de/en/content/networking-port-locations.

cessible supply ports are located on the coast of Schleswig-Holstein. The following graphic depicts the possible traffic flows in between the ports and to the OWF.

Figure 62 Cooperation between Base and Service Ports

Source: UNICONSULT (2013)

> **Recommendation**: Smaller service ports can enhance their market position through cooperation with other service ports and base ports at the same coastline building "installation and service clusters". In the framework of a cooperation knowledge, resources and therefore also investment risks can be shared and cluster-related logistics packages can be offered. Ports then have the ability to fulfill all requirements of different service concepts (shore-based or far-offshore concepts including air and/or vessel support).

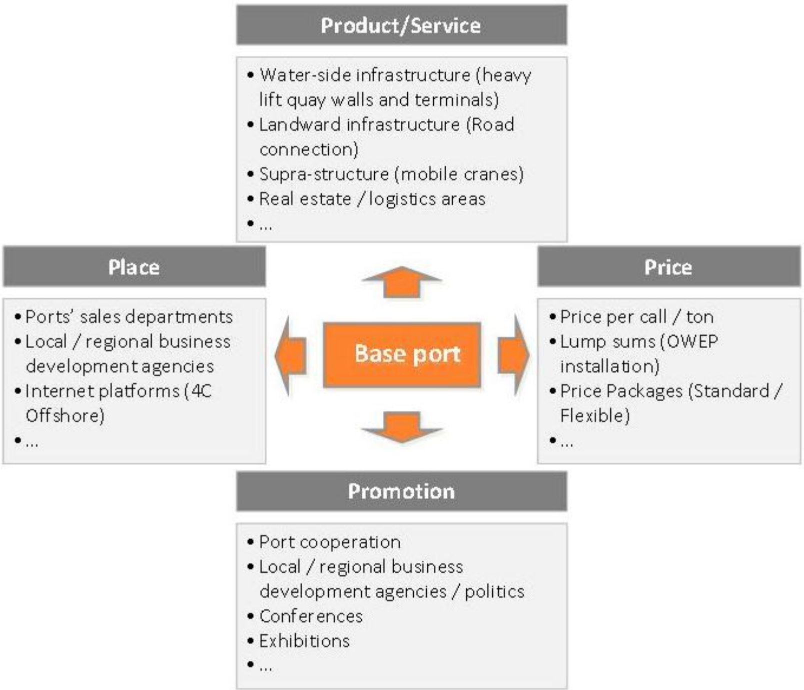
Based on the above described examples the following **main items** can be summarized for **service ports** in terms of the action field **strategy and cooperation**:

- Service ports can achieve visible market position through cooperation with other service ports and base ports at the same coastline building "installation and service clusters" offering a value added to the customers (e. g. OWF operators, logistics service providers, etc.) through integrated service packages.
- In the framework of the cooperation the sharing of knowledge (e. g. in terms of heavy cargo craning and lifting), resources (e. g. crew or cargo transfer vessels, waste management, helicopter landing sites, hospital or emergency facilities) and therefore also investment risks (e. g. in new service vessel technologies) might be suitable options for offering e. g. cluster-related logistics packages.
- With the help of a cooperation service ports can fulfill diverse requirements of different offshore-wind service concepts (shore-based or far-offshore concepts including air and/or vessel support) although they wouldn't be able to fulfill them on their own. Bottlenecks in terms of storage or warehousing areas in single ports can be compensated.

4.2.3 Port Location Marketing – "Visibility through coordinated Marketing"

The above described fields of infra- and supra-structure as well as strategy and co-operation might give recommendations or guidelines for ports how to specify their offshore-related product respectively service portfolio. Based on that, ports could then take the next step and actively bring their service portfolio to the market using marketing methods as product/service, promotion, pricing and placement strategies. The following figure depicts an exemplary marketing-mix for a base port.

Figure 63 Marketing-Mix for a Base Port



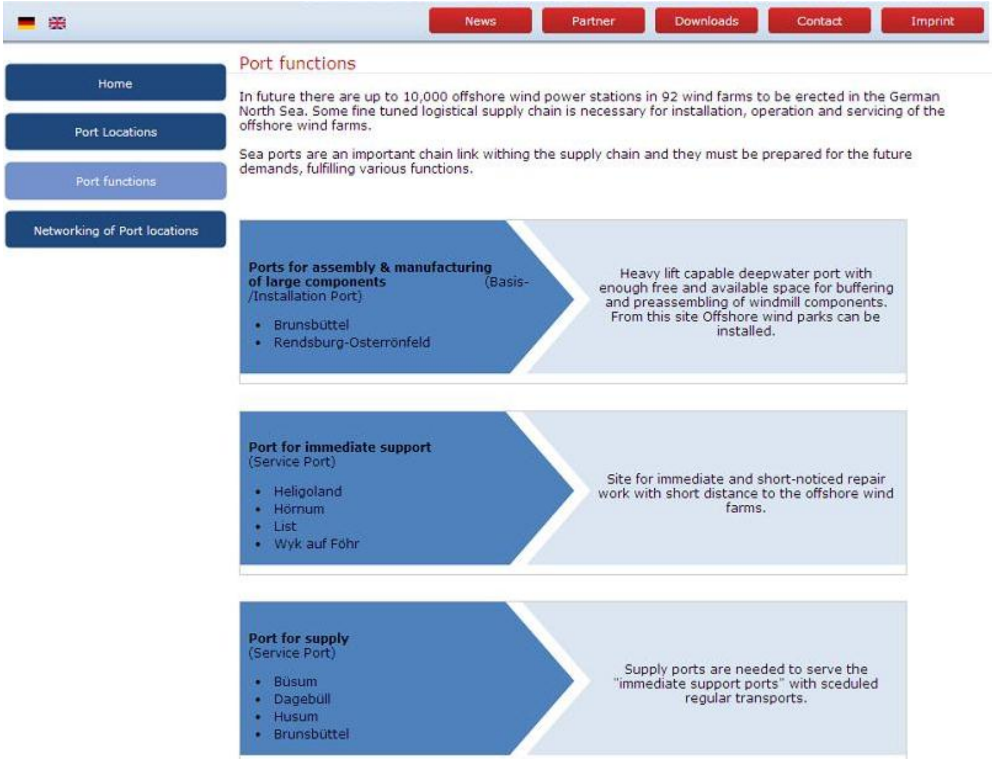
Source: UNICONSULT (2013)

The active marketing of a port location is a decisive step as particularly small to mid-size ports and not the already well-known larger container ports are and will be participating in the Offshore Wind Energy market (for instance due to higher availabilities of cheaper and larger production, pre-assembly or storage areas). Therefore it is important for them to be visible in the market, i. e. for the OWF developers, constructors, OWEP component manufacturers or OWF operators. As those players are mainly not deeply specialized in logistics the ports have the chance to support them bringing in their logistics competences and making this expert knowledge visible to them.

Especially for establishing the offshore port functions (base or service port functions) and for the settlement of OWEP component producers or other companies of the Offshore Wind Energy industry, an interregional, nation-wide and international profile and visibility of the ports is important. An active use of promotion and sales channels is therefore recommended.

Based on experiences from the German offshore market the promotion tool "cooperation" can help ports to enhance their visibility. The following graphical example of the website of the "Port cooperation offshore-ports North Sea Schleswig-Holstein" shows a best-practice approach how ports can be presented including their individual capabilities and offshore related functions.

Figure 64 Visibility of Ports through Cooperation



Source: Offshore-ports North Sea Schleswig-Holstein (2013)[57]

> **Lesson-learned**: Initiating or joining offshore-related port cooperation has proven to be an important marketing tool to enhance the visibility of ports acting in the Offshore Wind Energy market.

Furthermore it is essential to integrate local business development agencies as promotion and sales channel. For the settlement of manufacturers of different OWEP-components and hence for a structured development of the port in line with the requirements of the offshore-wind industry it is important to involve those agencies into the port's strategic development and vice versa. Mutually elaborated and coordinated offshore-related settlement strategies avoid "monoculture" settlements of single OWEP-component producers and not "port-alike" settlements of companies not using the water-side for transshipment or transportation.

OWEP-component producers largely focus on the overall industrial location quality of the port. Therefore base and service ports can only attract the offshore-wind industry by offering a well-balanced mixture of high quality offshore-related infra- and suprastructure as well as real estates near to the water-side but not directly at the offshore-related terminals (see chapter 4.2.1.1).

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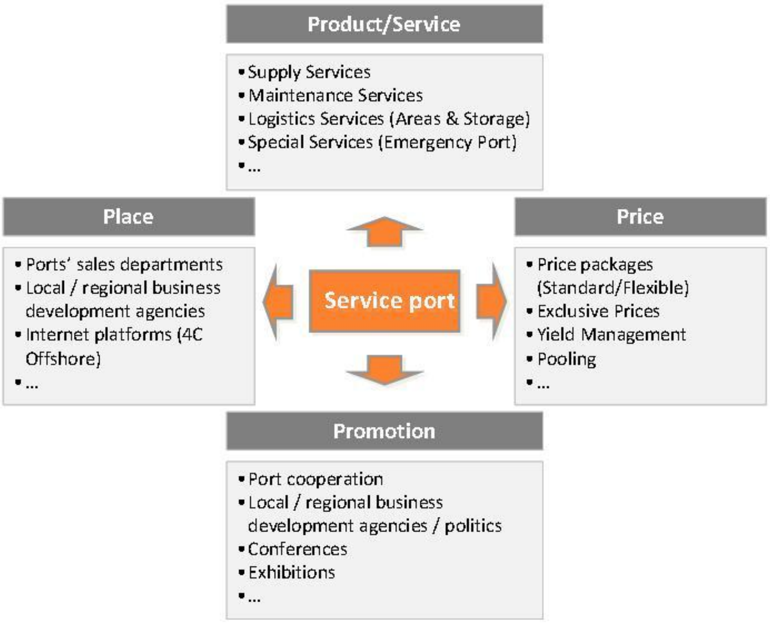
57 See http://www.offshore-haefen-sh.de/en/content/port-functions.

Recommendation: Base and service ports should use the marketing option of cooperation. Furthermore (especially important for base ports) the direct marketing of the port location (real estates) towards the Offshore Wind Energy industry is recommended. This has to be coordinated with the regional/local business development agencies and should be supported by port promotions on fairs and conferences (e. g. the international Offshore Wind Energy fair HUSUM Wind). The marketing process should present a clear market position of the port as base or service port. In case of service ports it should be made visible for which service, operations and maintenance concepts (e. g. sea-based concepts supported by air or vessels, far-offshore-platform concepts) the ports are especially qualified.

The following figure shows an exemplary marketing-mix for a service port. Through pooling of resources, service ports can gain several options for a diversified pricing strategy (e. g. yield management, price packages, exclusive pricing for special services, open/multi-user oriented pricing systems for time-schedule based service shuttle transports to OWF, etc.). Local or regional business development agencies should also be integrated in the marketing process.

Figure 65 Marketing-Mix for a Service Port



Source: UNICONSULT (2013)

Based on the above described examples the following **main items** can be summarized for **base and service ports** in terms of the action field **marketing**:

- Ports should enhance visibility through well-defined marketing-mixes.
- Marketing-mixes should lead to a clear market positioning of the ports (e. g. in terms of service concepts).
- Direct marketing of the offshore ports towards the industry is of high importance, especially for base ports.
- Local or regional business development agencies should be integrated in the strategic marketing of port locations leading to mutually coordinated and well-structured port settlement strategies. Especially for base ports this is important to achieve a highly diversified settlement of different OWEP-component manufacturers.

4.2.4 Organization and Subsidies – "Creative, strategic Classification and Planning"

Based on the different worldwide ports' organization models the possibilities for the acquisition of subsidies are varying. The best-practice experiences from the German market show that private ports in fact are rated positively by the Offshore Wind Energy industry market due to their flexible, non-bureaucratic organizational characteristics. However, landlord ports or public service ports in general have easier access to public subsidies.

A best-practice example for a subsidized infrastructural offshore-related development in Germany is the offshore base port of Cuxhaven. The first construction phase of the offshore-base was financed by the City of Cuxhaven with an investment of 10.45 Mio EUR from July 2005 until September 2008. The second construction phase at the offshore terminal was realized with the help of subsidies from the Federal State of Lower Saxony while the City of Cuxhaven made the industrial real estates ready for building. For the expansion of the 3rd and 4th construction phase, financial resources of 31.2 Mio EUR were provisioned by the European Regional Development Fund (ERDF), the second economic stimulus package of the German Government and of the Joint Agreement for the Improvement of Regional Economic Structures.

> **Lesson-learned**: In Germany financial means not only stemming from dedicated renewable energy funds were used for the development of offshore base or service ports. In many cases subsidies from other local, regional, national or international development funds were acquired.
>
> **Recommendation**: Ports worldwide should creatively screen all subsidy options (e. g. African Development Bank, Asian Development Bank, Inter-American Development Bank, World Bank, the European Regional Development Fund, etc.) and not only concentrate on the renewable energy segment.

Besides the creative screening of the available subsidy options it is decisive for ports to execute an integrated port planning including subsidies. This should include a selective classification of the port as base or service port and the early involvement of the water and navigation administrations. This is of interest in case that licensing requirements for heavy-cargo transport or transshipment facilities have to be obtained.

The long-time decision making and approval processes of the involved administrations and authorities should be considered as early as possible in the overall development and planning schedules.

Furthermore infra- and supra-structure development projects for the offshore-wind industry should be planned and organized as flexible as possible leading to the recommendation (as already mentioned in chapter 4.2.1) to develop multipurpose instead of dedicated offshore terminals. In case that subsidy money from special renewable energy funds would be limited or should be used for earmarked port facilities, more generally designed regional development funds could be an alternative option for financing multipurpose-facilities which can be used later on for offshore-related handling, storage, or pre-assembly.

Based on the above described examples the following **main items** can be summarized for **base and service ports** in terms of the action field **organization and subsidies**:

- Ports should execute integrated screening of public subsidy options. Creativity and flexibility in terms of the usability of the infrastructure (multipurpose instead of dedicated offshore infrastructure) could help broaden the potential for financial support.
- An early integration of local regional authorities and of the water and navigation administrations in the offshore-related strategic port planning and corresponding actions is decisive.

5. SUMMARY

5.1 Requirements of the Offshore Wind Energy Industry towards Ports

The development of the Offshore Wind Energy as renewable power supply system of the future holds large potentials for seaports in terms of employment and value creation. Ports build the decisive logistics hubs for fabrication, construction, installation, service, operations and maintenance of Offshore Wind Energy farms (OWF) as all Offshore Wind Energy plant (OWEP) components have to be passed through them.

Due to the huge number of processes, which are related to the construction and operation of OWF and OWEP, there are many different functions for ports as part of the Offshore Wind Energy industry's supply chains. Four main Offshore Wind Energy business segments or functions for port locations can be distinguished whereof the first two functions as base and service ports are most important for the industry:

- Fabrication and installation (base port),
- Operations, maintenance and service (service port),
- Research and development,
- Import and export of Onshore and Offshore Wind Energy plants and components.

In the process of installing an OWF, ports have the important function of storing, buffering and pre-assembly of components and OWEP modules. Furthermore the loading of OWEP components on board of the installation vessels or jack-up platforms is the core function of ports in order to transport the OWEP components to the OWF construction field. Those **base ports** functioning as logistics hubs for the fabrication, installation and heavy maintenance of OWF and OWEP are confronted with the industry's requirements displayed in the following table.

The **most important and preconditioned** requirements which a **base port** should fulfill in terms of the Offshore Wind Energy industry are:

- high quality of location factors (e. g. availability of expansion areas, qualified manpower, etc.),
- easy usability of the port without any restrictions regarding locks, tides, heights,
- at least bi-modal, preferably tri-modal connectivity of the port with its hinterland to establish high quality logistics chains.

Table 8 Offshore Wind Energy Industry's Requirements towards Base Ports

Requirements	Specification
Hinterland connection	- ability to carry heavy cargo - tri-modal connectivity of the port
Storage / assembly area	- min. 8-10 ha - 20 ha preferred - surface load min. 55 tons/sqm
Area for pre-assembly at the quay	- min. 8-10 ha - 10-15 ha preferred
Jacking-up opportunity / surface load	- indispensable for jack-up installation vessels (not necessary in case of using floating techniques) - 600 tons/sqm
Ro-Ro-loading	- feasibility necessary for larger OWEP component types
Quay	- min. 350 m quay length - 1,000 m preferred - surface load min. 55 tons/sqm
Craning and lifting capacity	- maximum 1,200 tons (foundations' craning and lifting)
Draft	- minimum 9.50 m - 10-12.00 m preferred - preferably not affected by tides
Width of berth	- minimum 70 m - wider than 85 m preferred (due to larger blade racks on board of installation vessels)
Immissions	- none (especially electro conductive particles)
Noise and light emission	- no restrictions
Height restrictions	- no restrictions
Locks	- preferably no locks - minimum width of locks of 70-85 m
Port location quality	- expansion areas - qualified manpower - support of economic development by local business development agencies

Source: UNICONSULT (2013)

Requirements towards **service ports** depend on the kind of services which can comprise elementary condition monitoring and replacements of smaller electronic component parts ("quick response ports" and "service ports for direct maintenance of OWF") up to anticorrosive coating of OWEP foundations. Heavy maintenance (e. g. replacement of blades or gear boxes (approximately once in a lifetime of each OWEP)) might be rather executed in a base port than in a smaller service port due to the fact that heavy maintenance requires larger storage and handling areas with higher surface loads.

The **major requirements** of the Offshore Wind Energy industry towards **service ports** for the operation of OWF are as follows:

- short seaward distance of the port to the OWF leading to quick logistics connectivity of the port to the OWF infrastructure,
- at least bi-modal, preferably tri-modal hinterland connections of the port to assure the set-up and operation of high quality logistics chains to and from the service port.

In comparison to base ports the industry's requirements towards port infra- and supra-structures are lower. The focus lies upon the quick transfer of service personnel and material to the OWF by vessels or helicopters for maintenance needs and elementary repairs. The following table summarizes the Offshore Wind Energy industry's needs towards service ports:

Table 9 Offshore Wind Energy Industry's Requirements towards Service Ports

Requirements	Specification
Hinterland connection	- ability to carry heavy cargo - tri-modal connectivity of the port
Helicopter landing place	- absolutely necessary
Distance to all OWF	- as short as possible - lower than 70 nm preferred
Storage / assembly area	- 3 ha
Quay	- 200 m quay length
Craning and lifting capacity	- 40 tons - handling of containers possible
Draft	- minimum 4.00 m - preferably not affected by tides
Housing	- in the direct vicinity of the port
Training service personnel	- possibility to set-up test plant
Building-site office/Remote control/vessel coordination	- unlimited trans-horizon radio-relay system
Port location quality	- expansion areas - qualified manpower - support of economic development by local business development agencies

Source: UNICONSULT (2013)

5.2 Worldwide Offshore Wind Energy Markets

Market Situation

Currently the world's most involved regions or nations concerning Offshore Wind Energy are Europe (3,800 MW) with its leading country United Kingdom (more than 3,000 MW), China (600 MW; mainly near shore) and Japan (30 MW). Although the U.S. is the second largest onshore wind power producing country worldwide with over 50 % more capacity than the third-ranked Germany it plays a rather minor role in the offshore industry. It just comes up with two large-scale projects which are currently developing. But implementation dates cannot be foreseen, yet. The same applies for Canada which is ranked under the top ten Onshore Wind Energy producers (ranked 9th) but having just started to develop one serious Offshore Wind Farm project at its west coast. This shows that the Offshore Wind Energy market has to be regarded as almost independent from the Onshore Wind Energy market.

Outside Europe only China provides large-scale Offshore Wind Farms like Chenjiagang Xiangshui with 201 MW near shore, Jiangsu Rudong I and II with in total 150 MW and Donghai Bridge with 102 MW.

Japan has initiated a couple of test sites and contrasts from other players by its focus on the development of floating-based (foundation) OWEP constructions.

The **largest already operating Offshore Wind Farms worldwide** (capacities larger than 200 MW) are:

- Greater Gabbard (504 MW), U.K., east coast
- Anholt (400 MW), Denmark, Baltic Sea (partly power producing)
- Bard Offshore I (400 MW), Germany, North Sea (partly power producing)
- Walney (367 MW), U.K., Irish Sea
- Sheringham Shoal (317 MW), U.K., east coast
- Thanet (300 MW), U.K., east coast
- Horns Rev II (210 MW), Denmark, North Sea
- Rödsand II (207 MW), Denmark, Baltic Sea
- Chenjiagang Xiangshui (201 MW), China, Yellow Sea (near shore facility)

The **largest Offshore Wind Farm projects worldwide** (capacities larger than 200 MW) currently **under construction** are:

- London Array I (630 MW), U.K., east coast
- Gwynt y Mor (576 MW), U.K., east coast
- Global Tech I (400 MW), Germany, North Sea
- Nordsee Ost (295 MW), Germany, North Sea
- DanTysk (288 MW), Germany, North Sea
- Meerwind Süd/Ost (288 MW), Germany, North Sea
- Lincs (270 MW), U.K., east coast

Future Offshore Wind Farms in Europe will be designed to provide a capacity up to 1,000 MW. On the other side countries that are not really involved in offshore wind business, yet, but planning to do so as for instance South Korea or India, announce to start with “the worldwide largest Offshore Wind Farm” with capacities around 1,600 MW each. But this seems to be measurements to increase the visibility of the corresponding country in the offshore market being part of location marketing.

Although countries like for example Australia provide ideal conditions for offshore wind production from the logistical point of view due to numerous islands that could probably function as service ports, the activities concerning Offshore Wind Energy are almost not existent. Also Brazil, India, and some African nations are just starting to develop opportunities to participate in the offshore market.

The very main target for all stakeholders concerning Offshore Wind Energy is the reduction of installation, operational and maintenance costs. This will done by gaining more and more experiences in standardization of installation and service procedures and the steadily advancement of efficiency of the technical components like turbines and blades.

National and Legal Framework

A reliable legal framework for the just worldwide starting offshore wind industry is vital to its further development. Due to currently unknown or unpredictable risks large-scale investments in Offshore Wind Energy technology will not be implemented without legal or better financial collateral. The instrument of subsidies is a suitable way to support the development and implementation of Offshore Wind Farm projects. This support could be expressed by feed-in-tariffs that guarantee a fixed amount of money per produced unit over a fixed period of time that should cover a minimum of 20 years. The structure of these tariffs has to be defined very transparent and clear as they are the basis for the feasibility calculation of an Offshore Wind Farm project.

To render additional assistance Governments or regions could set up investment supporting programs which provide loans with low interest rates or similar. The cooperation with international institutions like the World Bank or Asian Development Bank have already been proofed as successful opportunities as they have been implemented for other renewable energy industries like biomass or solar power. The support is especially important in regions with currently no activities as the “first project is assumed to be the most expensive project”. These programs do not only cover the technology directly but also other essential issues like for example the establishment of suitable infrastructure.

Offshore Wind Energy development also depends remarkably on the commitment of the national Government on political support of this way of producing energy. By naming and defining an expected contribution of the Offshore Wind Energy to the national energy road map a reliable and long-lasting framework can be established. This creates the securities needed for serious investments.

Reliability is a very important aspect. This holds true for financial and political support. The framework for tariffs for example may not be adjusted retrospectively. If something like this happens it creates an uncertainty that prevent further investments. The planning of projects and frameworks is long-term based.

As seen for example in the U.S. existing legal frameworks have to be adjusted to fit to the new requirements. Or completely new guidelines and laws have to be implemented. In case of the U.S. a foundation (of an offshore wind turbine) gets the status of a port after is has been grounded on or piled into the sea bed. As only U.S.-flagged vessels are currently allowed to connect two U.S. ports, no foreign flagged vessel would be allowed to participate during construction and maintenance phase. As no large-scale Offshore Wind Farm has been established until now, there is still time to solve this road block.

Development / Perspective

There is international common sense that the Offshore Wind Energy market will grow worldwide. It is expected that the current big players will stay the same. The scales of the future Offshore Wind Farms are getting larger and technical components will get more and more efficient as for example turbines with higher capacity (up to 10 MW per unit) and longer blades (more than 80 m) will be developed, produced and become standard components.

Further completely new developed technical strategies like for example floating structures and down-wind turbines open new operational opportunities like deep water operations with a higher wind yield and adjusted maintenance concepts as non-grounded structures could be moved to the shore or maintenance port. Probably this opens completely new opportunities for ports. The development in today's technical niches mainly forced by small players could be advantages for currently lager stakeholders which concepts rest on conventional technology, as they enter their next development phases which mean development of Offshore Wind Farms much farer offshore in deeper waters than today.

Countries like China which has strong interest in selling or exporting their offshore technology worldwide will force the implementation projects on the political level in order to proof its operational capability.

Influences on offshore wind development are eclectic. Financial and political support, as well as technical know-how and competition with other (energy) resources also like for example biomass, fossil fuel and even onshore capacities affect the speed and the scale of the development of Offshore Wind Farm projects.

5.3 Best-practice Experiences and Recommendations

Many German ports especially along the North Sea coast have intensified their efforts to be prepared for the requirements of the Offshore Wind Energy industry – especially functioning as base/consolidation ports for fabrication/installation and as service ports for service, operation and maintenance. The following table summarizes recommendations for ports worldwide taken out of best-practice examples stemming from those German offshore ports.

Taken those recommendations ports can initialize their own different actions for fulfilling the industry's requirements and for realizing the identified market potentials in the fields of infra- and supra-structure, strategy and cooperation, location marketing, and organizational setup and subsidy acquisition.

In advance to this step ports should compare the offshore-wind industry's requirements with the as-is-situation of the port facilities to identify their own market position as base/consolidating or as service port (e. g. in terms of infra- and supra-structure, hinterland connectivity, pre-assembly areas, quays, width of berths, or the existence of any constraints at their ports with regard to tides or locks).

In addition to that the ports should analyze their market potential which arises from the developments in their corresponding regional, national or continental offshore-markets.

Table 10 Recommendations for the Positioning of Ports in the Offshore Wind Energy Market

Field of action	Examples	Recommendation
Infra- and supra-structure		
Base ports	Bremerhaven	Reallocate existing infra- and supra-structure in offshore-related ramp-up phases
	Brunsbüttel	Keep flexible dedication of infra- and supra-structure – "multipurpose-piers"
	Cuxhaven	Preserve expansion options for terminals
Service ports	Heligoland	Check your port's geographical distance to OWF; this is more relevant than infra- and supra-structure
	Shore-based service concepts	Establish bi-/tri-modal hinterland connection, storage areas, and access to airfield/helicopter landing site
	Sea-based service concepts	Establish accommodation facilities, storage areas for larger spare parts for shuttling OWF platforms
Strategy and Cooperation		
Base ports	Bremerhaven	Settle different OWEP producers instead of following "monoculture" strategies
	Rendsburg/Brunsbüttel	Cooperate with other base ports if you can herewith enhance your market position
Service ports (together with or without base ports)	Dagebüll, Hörnum, Husum, List	Establish service clusters to reduce capacity bottlenecks, and to participate in different service concepts
	Brunsbüttel, Büsum, Husum, Heligoland	Pool your knowledge, resources, services and risks for offering bundled logistics services to several OWF
Port location marketing		
Base and service ports	Offshore ports North Sea Schleswig-Holstein	Enhance visibility and position your port clearly as base or service port using well-defined marketing mix
	Bremerhaven/ Cuxhaven	Use direct marketing to attract your base port towards the Offshore Wind Energy industry
	Bremerhaven/ Cuxhaven	Integrate local/regional business development agencies as promotion channel
Organization and subsidies		
Base and service ports	Cuxhaven	Creatively screen public subsidy options
	Brunsbüttel	Integrate water/navigation administration in early stage

Source: UNICONSULT (2013)