Renewable energy consultants

GL Garrad Hassan

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Opportunities for the offshore wind industry in Mecklenburg-Vorpommern

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ANALYSIS OF CAPABILITIES OF HARBOURS IN MECKLENBURG-VORPOMMERN AND ASSESSMENT OF OPPORTUNITIES FROM OFFSHORE WIND DEVELOPMENT

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
BSH	Bundesamt für Seeschifffahrt und Hydrographie
CAPEX	Capital Expenditure
CD	Chart Datum (reference water level on marine charts)
CoG	Centre of Gravity
CGS	Concrete Gravity Structure – see also GBS
EEZ	Exclusive Economic Zone
GBS	Gravity Base Structure – see also CGS
GLGH / GH	GL Garrad Hassan
GL	Germanischer Lloyd
HAT	Highest Astronomical Tide
HLV	Heavy Lift Vessel
HV	High Voltage
Hs	Significant Wave Height [m]
H_{50}	50 Year Return Wave Height [m]
IMO	International Maritime Organisation unique vessel number
kJ	Kilo Joules – a measure of piling hammer impact energy [kJ]
LAT	Lowest Astronomical Tide
LoLo	Lift-on Lift-off
MHW	Mean High Water Depth (with respect to CD)
MW	Megawatt
OWF	Offshore Wind Farm
ROV	Remotely Operated Vehicle
RoRo	Roll-on Roll-off
SI	Site Investigation
SPMT	Self-Propelled Modular Transporters
SS	Sub station
SWL	Safe Working Load
TEU	Twenty-foot Equivalent Units (Containerisation measure for ship capacity)
TLP	Tension Leg Platform
TSA	Turbine Supply Agreement
TSO	Transmission System Operator
WTG	Wind Turbine Generator

1 INTRODUCTION

Against the background of a rapidly developing offshore wind sector in recent years, Invest in Mecklenburg-Vorpommern GmbH & Wind Energy Network Rostock e.V. have commissioned GLGH to carry out an analysis of the economic opportunities in offshore wind energy (particularly in the area of logistical services) for harbours in Mecklenburg-Vorpommern (MV). The aim of the study is to provide a detailed and well informed profile for Rostock, Wismar, Sassnitz and Lubmin, which is related to the suitability of each to engage in the offshore wind industry and to exploit the economic potential that lies therein.

Based on these profiles, the particular strengths and weaknesses, and specific opportunities and threats, will be analysed. The recommendations are intended to inform the Client about the areas in which measures should be taken, in order to improve the competitive position of the MV harbours in the offshore wind industry, in the short, mid and long terms.

For the purpose of the study, and in order to assess the situation of each harbour correctly, a wide range of information was sourced, analysed and compiled in the course of the project. The main sources of information for the analysis were:

1. GLGH conducted site visits to all harbours. During these site visits, which took place in August 2010, GLGH was able to visit all harbours and speak to port authorities and companies located on harbour premises. During the site visits, comprehensive data was collected, which was later complemented by interviews with staff who had been unavailable on the dates of the visits.
2. In order to support GLGH in the analysis, the Baltic Marine Consultancy (BMC) compiled data for the harbours, which was based on a structure provided by GLGH. This supportive action provided very useful input. In the course of the project, GLGH interacted with BMC staff on several occasions, in order to discuss and provide additional information.
3. GLGH used its wide-ranging internal knowledge of the offshore wind industry and markets (e.g. the Offshore Wind Farm and Vessel Databases).

This report summarises the results of the analysis that was conducted during the project. It is structured in the following way:

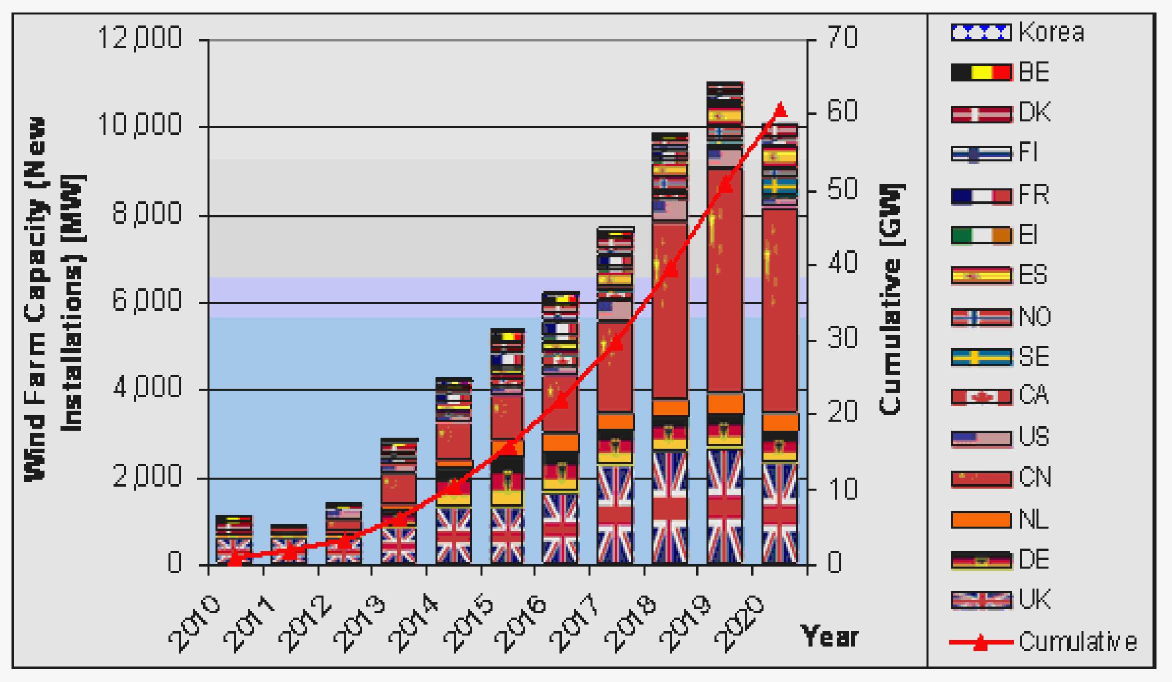
- Section 2 provides a summary of the analysis. It can be used as a stand-alone document, and can therefore also be used by the Client for communication purposes.
- Section 3 provides an overview of: a) the necessary activities related to installation of an offshore wind farm; and b) the resulting logistical requirements.
- On this basis, Section 4 analyses (in detail) requirements for harbours that result from offshore wind farm development and component manufacture. Technical profiles are developed for each harbour. These profiles can be used as an MV Offshore Wind Harbour directory, and can be used as the basis for further work in this area.
- Section 5 analyses the costs corresponding to the logistical requirements of offshore wind development. It also provides results from a cost optimisation model that was developed to help identify ‘least cost’ logistical solutions for offshore wind development and to inform about whether MV is well placed to engage in the wider Northern European supply chain. GLGH also provides an outlook on the cost development up to 2030.
- In Section 6, GLGH conducts an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of each harbour, and makes recommendations on possible measures to improve the competitive position of harbours in the offshore wind industry.

- The final section, Section 7, elaborates on some of the more strategic recommendations on measures to increase the share of the supply chain represented at the MV port locations. These recommendations, which are also aimed at informing government agencies, are not reflected in detail in the summary document, however; this is in case the summary is published or distributed to interested parties outside of the Client's organisation, at a later date.

2 SUMMARY[1]

2.1 Context and Scope of the Study

The speed of the development of the offshore wind market in the last few years is staggering. In a time of global recession, it is unsurprising that such a buoyant business field is attracting significant attention, and more and more competition begins to compete for a market share. Even so, supply chain bottlenecks are likely to occur, due to the expected delivery within the timescales envisaged.



Source: GLGH

Figure 2-1 - Global offshore wind market (by country) over the next 10 years

Economic opportunities will also develop (despite growing competition in the supply chain) for harbours in Mecklenburg-Vorpommern (MV), particularly in the areas of foundation manufacture and offshore construction of wind farms. As the report shows, there is a clear need for ports to place a high priority on attracting manufacturing facilities to their premises, as much future wind farm work may well be carried out directly from manufacturers' premises, and could avoid the use of secondary construction and marshalling facilities altogether.

Against the background of the rapid development, GLGH provides insight into the economic opportunities that lie in offshore wind energy for harbours in MV. In the study, GLGH:

- Describes main logistical requirements related to offshore wind;
- Analyses technical requirements related to offshore wind farm development and component manufacture for harbours in MV. Specific requirements for each harbour analysed in the study form the MV Offshore Wind Harbour directory;

[1] The following presents a summary of the report prepared by GL GH. For the full set of technical references please refer to the full report.

- Analyses logistical costs of offshore wind development. GLGH has modelled 'least cost' logistical solutions to inform whether MV is well placed to engage in the wider Northern European supply chain;
- Develops specific profiles for each harbour, analysing 'strengths', 'weaknesses', 'opportunities' and 'threats'. Based on these profiles, GLGH identifies opportunities for MV harbours to engage in the offshore wind supply chain and to improve their competitive position; and,
- Elaborates some strategic recommendations on measures to increase the share of the supply chain, represented at the MV port locations, in the mid and long term.

Main findings and results of the report are compiled in this summary.

2.2 Technical Requirements of Offshore Wind

In order to set the scene for the analysis of the logistics of offshore wind, and the economic opportunities that lie in this sector for ports in Mecklenburg-Vorpommern, GLGH has broadly analysed the logistical requirements of the offshore wind energy industry. The main areas investigated are the installation of offshore wind farms and the manufacturing of main turbine components, including transport, storage and handling.

From the GLGH perspective, these areas of the value chain are the most demanding in terms of logistical requirements, but they also hold significant economic potential at the regional level, i.e. for MV, as will be discussed in Section 5 of this report.

The available options for installation of offshore wind turbines and foundations, along with the range of vessels needed to carry out these functions, were reviewed. Consideration was given to the range of sites that are appropriate for each foundation type, and the pros and cons of each installation methodology were discussed.

The assembly of the turbine, on whatever foundation type (Monopile, Jacket, GBS etc.), involves a number of operations which require great precision and stability. It is generally desirable to keep the number of offshore operations to a minimum. However, a number of compromises are forced upon the assembly sequence, resulting in an optimum solution lying somewhere between installation of a largely pre-assembled turbine and offshore assembly of a large number of smaller components. The key drivers are:

- Size constraints of deck space available;
- Lift capacity of the crane; and
- Manufacturer requirements that the turbine rotor be assembled in a particular way.

The full range of installation options for turbines is as follows (Table 2-1):

	Total Number of Lifts	*Lift Number*						
		Lower Tower	*Upper Tower*	*Nacelle*	*Hub*	*Blade 1*	*Blade 2*	*Blade 3*
Individual components	**7**	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Bunny ears with 2-part tower	**4**	*1*	*2*	*3*				*4*
Bunny ears with 1-part tower	**3**	*1*		*2*				*3*
Pre-assembled rotorwith 2-part tower	**4**	*1*	*2*	*3*	*4*			
Pre-assembled rotor with 1-part tower	**3**	*1*		*2*	*3*			
Fully pre-assembled	**1**	*1*						

Table 2-1 Wind Turbine Installation Options

Vessels for transport, installation and supporting activities are a key element of the logistical chain of offshore wind, and these represent a significant cost factor, as will be analysed in Section 4. So far, just over thirty vessels have been used in foundation or turbine installation roles in the offshore wind farms. GLGH has provided details of each of these vessels, as well as an indication of the roles for which they would be suitable.

A perceived shortage of suitable vessels capable of carrying out installation work for UK Round 3 and German offshore wind projects has led to a spate of new-build commissions. The quantities of turbines and foundations expected to be installed, and the water depths and climatic conditions, have influenced vessel specifications. GLGH has listed all publicly announced concept vessels for the offshore wind market.

There are a number of risks to the offshore wind installation vessel market, including:

- Disruptive technologies: new foundation technologies that require unconventional installation vessels with widely differing capabilities, e.g. Gravity Based Structures (GBS); and,
- New installation vessel concepts, capable of completing installation work to improved project economics (i.e. delivering either lower installation costs or improved project value - for example, earlier commissioning, reduced risks, etc.).

GLGH has described the Gravity Base Structure Design (by Züblin) as a potentially disruptive foundation technology, which is expected to change the technical requirements relating to the installation of offshore wind turbines.

Ocean energy technologies continue to prototype technologies, and commercialisation and larger-scale deployment is currently commencing. Although the diversity of technologies and infancy of the industry do not allow any robust predictions to be made for the technical requirements for transportation and installation of these technologies, it can be assumed that some wind farm installation vessels will be unsuitable for carrying out work in this industry. It is clear, however, that the timescale envisaged for significant deployment is in the period after 2020.

It appears that wave technology devices will use conventional mooring systems used by shipping and oil and gas vessels, and that existing vessels used for anchorage installation in those industries will be utilised.

2.3 Mecklenburg-Vorpommern Offshore Wind Port Directory

GLGH assessed the technical requirements for each type of physical requirement placed upon a port by a particular activity, by stage of construction and component. The process or component imposing the limit has also been identified. The limitations are reflected in the MV Ports Directory, which documents (in a simple visual format) whether each port is suitable for each particular activity, against each subordinate requirement. The intention behind displaying the information in this way is to allow the Client to use the material in publications to promote the manufacturing and construction related capabilities of Mecklenburg-Vorpommern to Developers and Manufacturers who are considering relocating to the area and are seeking to identify suitable facilities.

The MV Ports Directory can be found in Annex 1.

2.4 Costs of Logistics of Offshore Wind

A vital outcome of this study is an appreciation of the cost drivers which underlie whether ports in Mecklenburg-Vorpommern will be used for either construction or manufacture of the various parts in the offshore wind farm supply chain.

The early offshore wind farm developments had far lower capital costs than recent constructions. Current capital costs observed by GLGH are in the order of € 4.2 million/MW. The budgeted CAPEX breakdown of a typical offshore wind farm currently undergoing construction in the UK is shown below (modelled by GLGH). It can be seen that the estimated proportion of the costs represented by the turbine is the main single cost (about one third), followed by the turbine foundation (assumed is a jacket structure). Main logistical costs (installation of turbine and foundation) represent about 15 % of capital costs or more than €600.000 per installed MW.

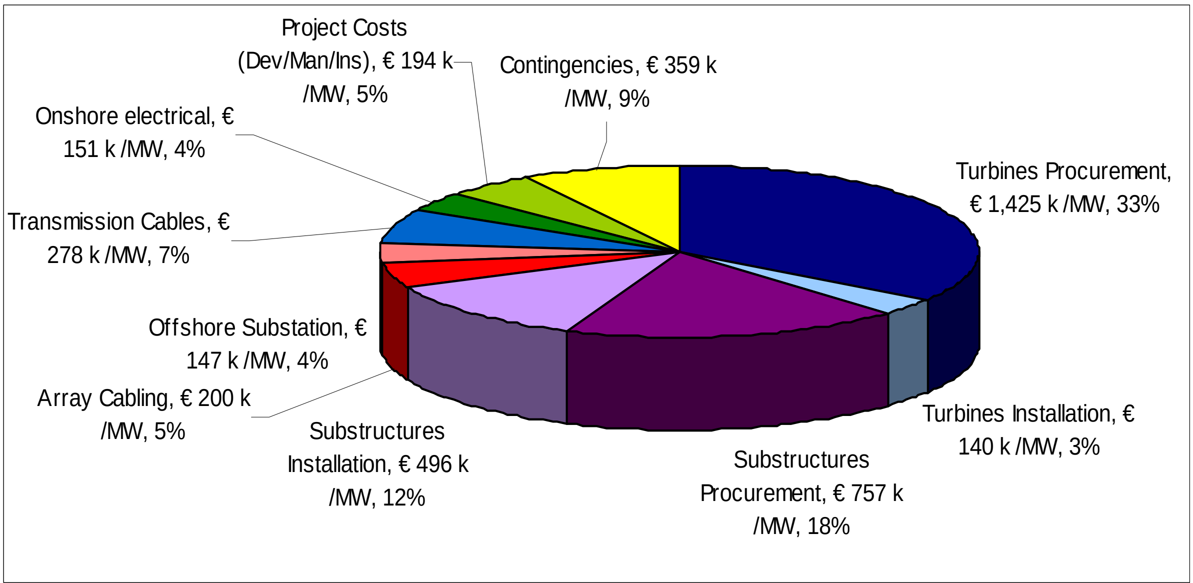


Figure 2-2 - CAPEX Breakdown of a typical OWF in the UK (GLGH modelled)

From a GLGH perspective, although other opportunities are possible, wind farms in the Baltic Sea represent the most straightforward and significant business opportunities for ports in Mecklenburg-Vorpommern. Main characteristics of these projects were used to inform upon both cost modelling and port technical capacity requirements.

The study also considers the MV ports' competitiveness in the wider Northern European offshore wind farm market, and in direct competition with the other ports in the area. Therefore, wind farms were included in the analysis, which are representative of the following areas:

- German North Sea Area;
- UK Southern North Sea;
- UK Scottish East Coast; and,
- The Irish Sea.

The study finds that construction phase costs are largely due to the charter costs of the large installation vessels used to install the major components. The cost optimisation model calculates any increase in transport costs resulting from longer transport distances against possible cost savings from manufacturing in ports in the MV area.

There is no implicit requirement to use a port for construction (mobilisation port), or to use any significant marine facilities, other than the foundation manufacturer's premises, to load out the finished components. The foundation contractor will weigh the additional charter costs of an expensive installation vessel (transiting with the foundations between the manufacturer's premises and the site) against alternative methods involving logistical combinations, including transport vessels, feeder vessels and a mobilisation port for storage of foundations and facilitation of transfer between vessels in a sheltered environment. The same economic argument regarding the optimisation of logistical costs applies to the approach which the turbine installation contractor will adopt to installing the turbines.

Cost of labour as a main driver of manufacturing costs

The study focuses on foundations and turbine tower-top works (combined nacelle, blades and hub or spinner). For these key items, logistics play a significant role in manufacturers' strategic planning. The major cost drivers associated with manufacture are:

- The fixed cost of equipment and premises;
- The variable cost of materials, including all consumable materials and energy bills; and,
- The variable cost of labour.

Since steel represents more than 50 % of the overall cost of monopiles, it would appear that the labour rate advantage which MV can offer would have relatively little impact in attracting monopile fabrication to MV. However, a company based in MV (EEW) is among the winners of competition for recent foundation contracts between manufacturers of monopiles, transition pieces and jackets.

Further analysis reveals that EEW's competitive edge is largely due to its capacity to produce rolled steel pile "cans" (the tubes which make up the long monopiles) in its Malaysian works, transporting them (to Lubmin) more cheaply than other Northern European manufacturers are able to. This globally competitive sub-assembly manufacture, with final finishing in MV manufacturing facilities, is clearly a highly effective strategy, and gives this manufacturer the ability to maintain control over the quality of its product. Whether this strong position can be maintained in the face of increasingly stiff international competition remains to be seen, but prospects appear to be good.

Jacket foundations are far more intricate, and labour represents a much larger proportion of the overall value added during manufacture. GLGH estimates that while 25 % of the overall cost of a monopile is related to labour costs, 50 % of jacket costs are related to labour. Under these circumstances, if MV manufacturers have already won monopile contracts in the recent past, it would appear that there is a strong case for winning a very significant proportion of the jacket work. There are already manufacturers with a track record in the market place, who are already located in port facilities suitable for jacket manufacture.

Although transportation of fully assembled jackets is more difficult, and therefore more costly, it appears that increased transportation costs may well be small compared to labour cost savings, if sub-assembled jackets are manufactured in MV and shipped to project sites.

There is a very large market predicted for offshore wind turbine foundation structures, which may well be capable of supporting several manufacturers. Recently, there has been a spate of announcements by foundation manufacturers keen to be involved in the supply chain for planned offshore wind farms. Whether individual companies will compete for work, or whether the past pattern of large-scale co-operation and specialisation will continue, is unclear. Increasing interest is noted from across the globe, with shipyards and oil-and-gas jacket fabricators expressing an interest in gaining a foothold.

The lucrative market for monopiles is likely to remain buoyant for a while. With minimal adaptation, the same facilities can produce components for jackets.

Results of the cost modelling

The following combinations of ports were chosen for cost comparison. The rationale was to compare the cost implications of fabricating foundations and manufacturing turbines in Mecklenburg-Vorpommern with other areas. A target project in the Irish Sea was chosen, as it implies the maximum distance from MV ports among all offshore projects known today. Therefore, this represents the "worst case" from a MV perspective. Hartlepoole in the UK (Teesside area) was chosen as an alternative scenario as significant offshore activity is expected to develop in this area, thus competition from this area is deemed to be a realistic possibility.

		IRISH SEA	
MV Fab, no mob	Lubmin	Sassnitz	None
MV Fab, IS mob	Lubmin	Sassnitz	Belfast
DE NS Fab, no mob	Bremerhaven	Bremerhaven	None
DE NS Fab, IS mob	Bremerhaven	Bremerhaven	Belfast
UK E. Coast Fab, no mob	Hartlepool	Hartlepool	None
UK E. Coast Fab, IS mob	Hartlepool	Hartlepool	Belfast
UK Irish Sea Fab, no mob	Belfast	Belfast	None
UK Irish Sea Fab, IS mob	Belfast	Belfast	Belfast
UK Scottish E. Coast Fab, no mob	Methil	Methil	None
UK Scot E. Coast Fab, IS mob	Methil	Methil	Belfast
Lithuania Fab, no mob	Klaipeda	Klaipeda	None
Lithuania Fab, IS mob	Klaipeda	Klaipeda	Belfast

Table 2-2 Irish Sea Cost Modelling – Ports Chosen for Manufacturing and Construction

Due to the project specific nature of some of the cost elements, and the annual variability in others, the total cost of logistics is open to considerable uncertainty[2]. For this reason, the results are presented as relative costs, rather than absolute costs. The following graph shows comparative results from the modelling of current costs (2010).

[2] Detailed information on the cost modelling methodology and assumptions used can be found in Appendix B.

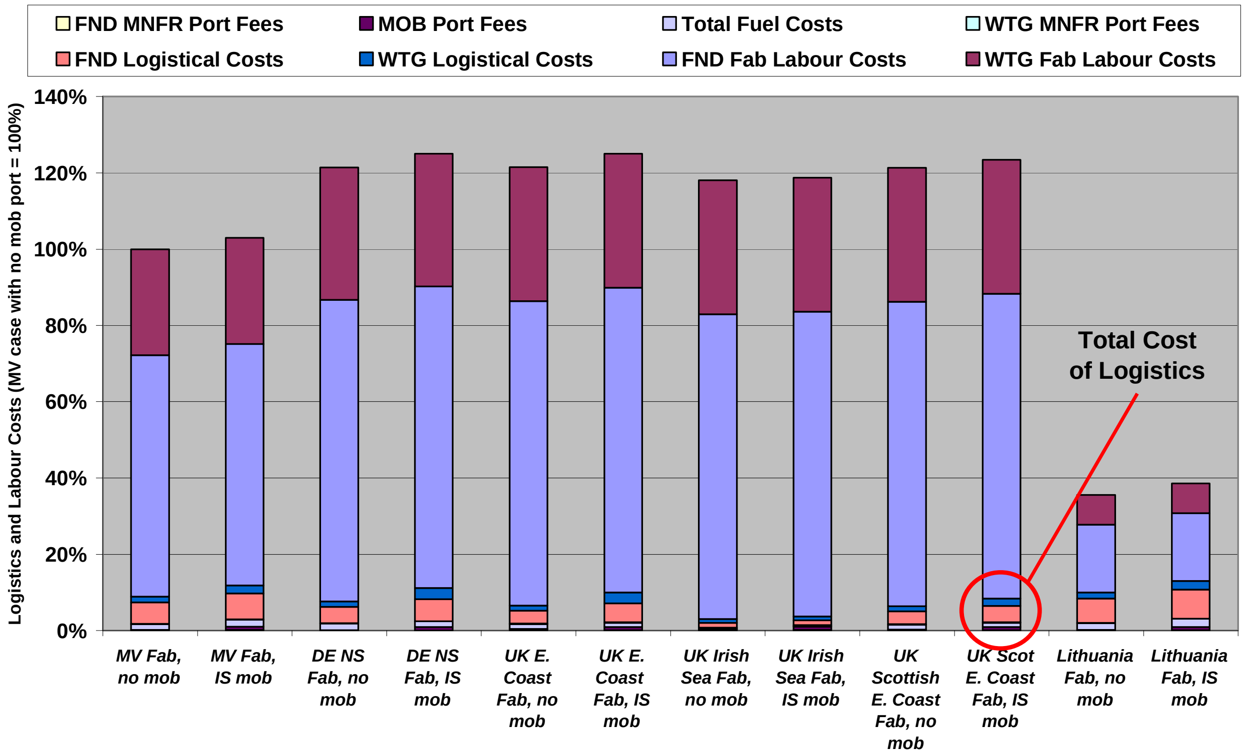


Figure 2-3 Comparison of OWF Construction Costs (2010)

The first two columns present the relative costs of manufacturing foundations in Lubmin and turbines in Sassnitz (1) - without using a mobilisation port, and (2) using Belfast as a mobilisation port.

The key feature is that the labour element of the foundation and turbine manufacture is vastly more significant than logistical costs associated with ports or vessels. The significantly lower labour rate in Mecklenburg-Vorpommern contributes to a more competitive overall cost, compared to most of Western Europe.

The lower rate figures for Lithuania show that, whilst MV port locations may have an overall cost advantage over most of Western Europe, Eastern European and Far Eastern nations will have a competitive advantage in this respect. Only the costs are considered, and other important influencing factors such as availability of infrastructure, specialised skills and political support are not reflected.

It appears that it is the cost savings associated with its Far Eastern manufacturing subsidiary company which have allowed EEW to dominate the recent foundation market. Its location in MV has further strengthened the negotiating position.

The study has also considered the mid and long-term time horizon up to 2020, and GLGH has modelled the increase in labour costs as a significant cost driver[3]. For the time period up 2020, the comparative analysis shows the following picture:

[3] A trend line was applied, which reflects the average increase between 1998 and 2009. EUROSTAT figures were used for this purpose.

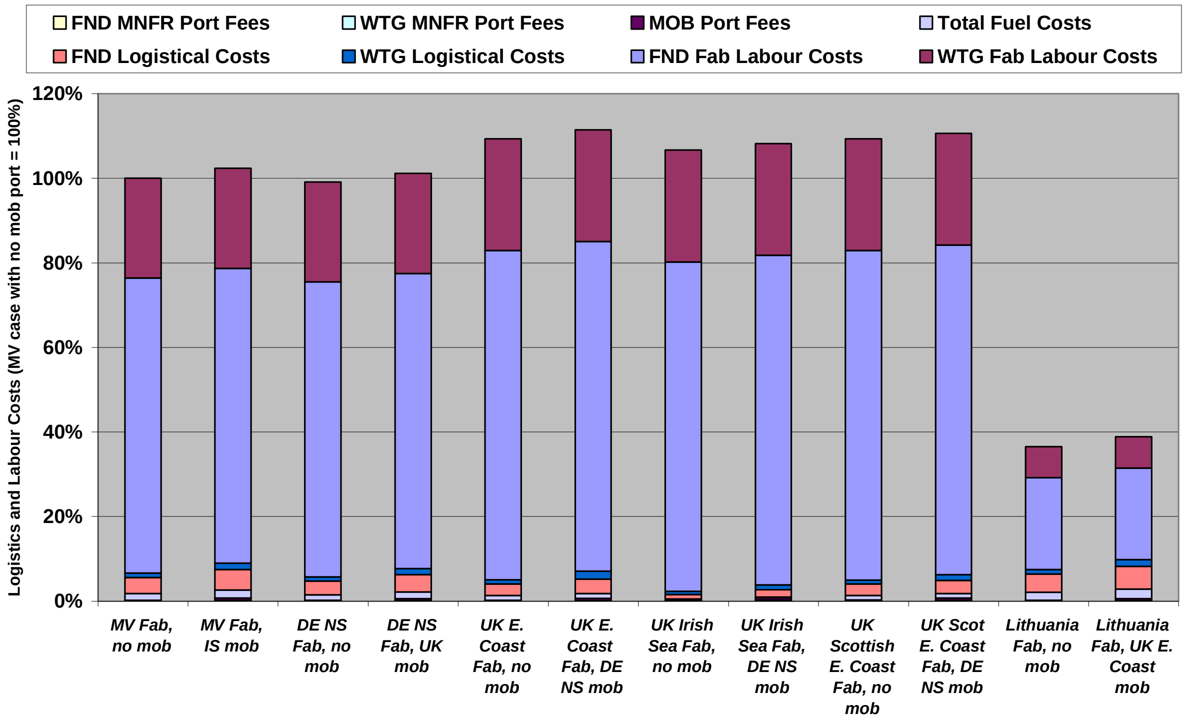


Figure 2-4: Comparison of OWF Construction Costs (up to 2020)

The labour element of the foundation and turbine manufacture continues to outweigh logistical costs by far, and the competitive advantage enjoyed by Mecklenburg-Vorpommern has significantly decreased by 2020. Labour cost development is the most influential factor in the modelling[4]:

- By 2020, under the chosen assumptions, MV will have lost its comparative advantage against Western German locations, as the cost comparison shows almost equal costs;
- MV locations still have a comparative advantage against UK sites, but at a smaller scale. In 2010, this is about 15-20 %, whereas by 2020 it is in the order of 10 %;
- The cost gap with Eastern European locations (such as Lithuania) is closing slowly, due to the expected higher growth of labour costs in Eastern European countries. However, the comparative cost advantage of Eastern European locations is expected to remain beyond 2020. These locations are not seen as prime competitors at this point, however.

From a GLGH perspective, the following conclusions can be drawn from the comparative analysis:

1. The time window for MV to make use of its comparative cost advantage is narrow. Realistically, it will close before 2020. Therefore, measures aiming to improve MV's location position in the industry, and to increase its share of the value chain, need to be taken in the years to come.
2. Pressure is on MV to find other, long-term, "competitive routes" into the supply chain after 2020, e.g. through building partnerships with industry actors, including those from outside Europe.

[4] GLGH has assumed yearly labour cost growth rates based on the historic development (1998-2009, Eurostat): MV: 2,5%, NS: 1.5%, B: 1.4%, UK: 3.5%, Lit: 8.3%.

Costs of logistics

If the cost of logistics is observed specifically for the same set of combinations, the following comparative picture for the current logistical costs can be derived.

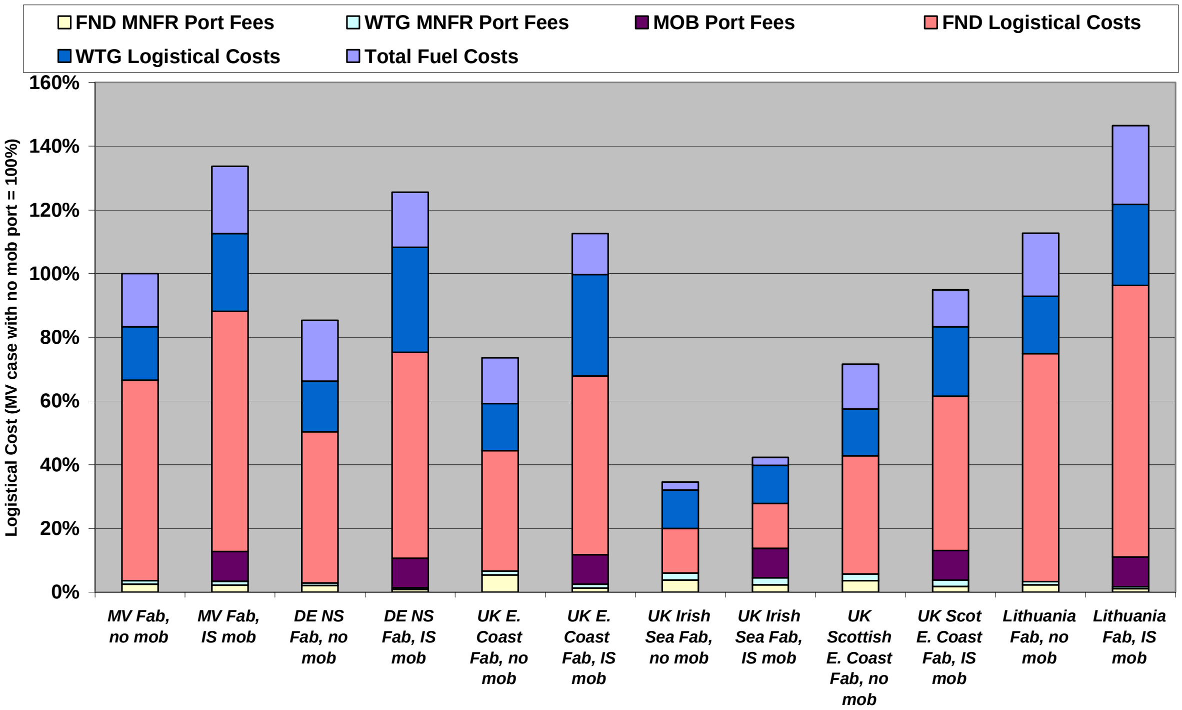


Figure 2-5 Comparison of Logistical Costs for a OWF in the Irish Sea (2010)

A major proportion of the cost is related to vessel charter charges. The port costs are small compared to these, but the additional costs of the construction mobilisation port may be considerable. Fuel costs become an ever greater element as transport distances increase. Labour costs, although difficult to isolate in the overall costs of logistics (e.g. included in vessel rates and port costs) are not considered to be significant. The most economic option is the direct transport of components to offshore wind farms from the manufacturing location.

Generally speaking, the closer the manufacturing location is to the wind farm the lower the logistical costs for the developer. If the offshore wind market in the North Sea and Baltic Sea regions expands in the future, this can improve the MV ports' competitive position.

To obtain a mid and long-term view, GLGH has modelled logistical costs, assuming changing water depth[5] and fuel costs. For the period up to 2020, the comparative analysis shows the following picture:

[5] Using GL GH knowledge of all projects currently being built, planned and future likely locations of offshore wind farms. Deeper waters require different vessel types.

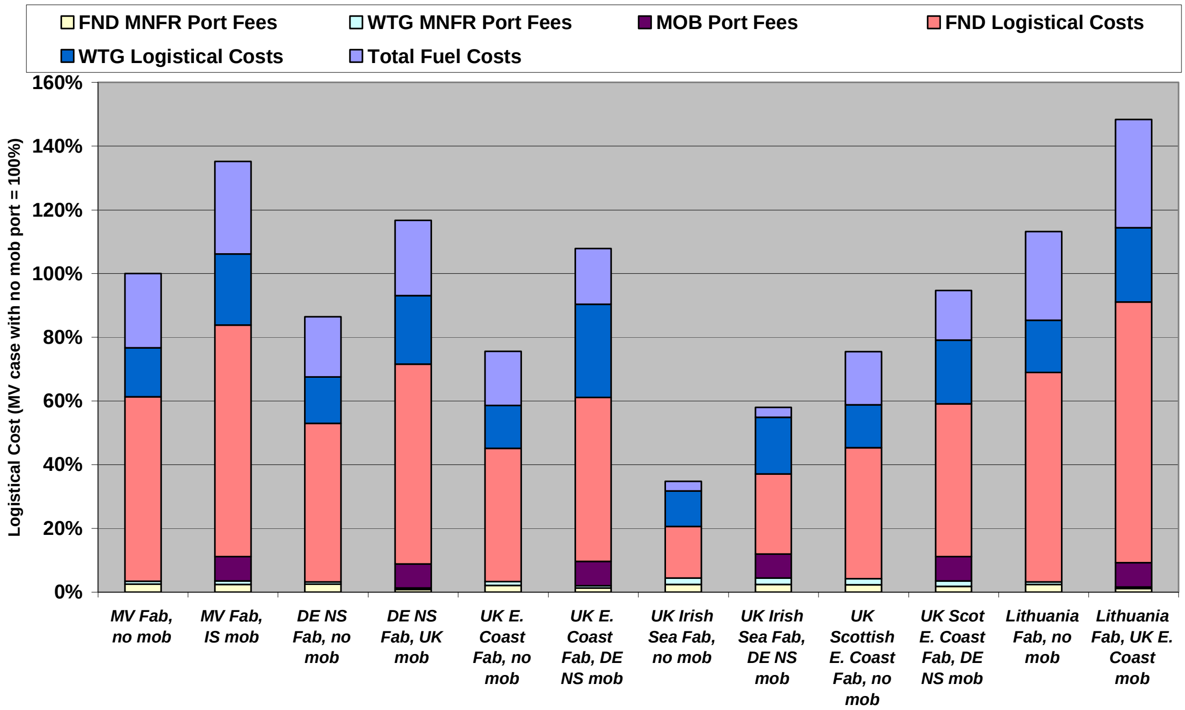


Figure 2-6 Comparison of Logistical Costs for a OWF in the Irish Sea (Up to 2020)

The future outlook shows that the overall picture is not changing dramatically over the time period observed. Nevertheless, it appears that fuel becomes an increasingly significant part of the logistical cost. This will put further pressure on transportation optimisation, and means that future fuel price volatility could have an impact on MV locations' ability to compete.

Recent announcements that foundation and turbine manufacturers intend to relocate to UK ports with logistical options which include ports that are closer to the main project sites may not represent so significant an advantage as it might appear, once the higher labour rates are factored in. Logistical savings will be outweighed by additional labour costs during manufacture.

MV ports and manufacturers would be advised to target projects close to the MV ports aggressively, to secure a strong local market, although (as pointed out in the analysis), their Far Eastern supply chain links and low labour rates for the next decade mean that companies from MV are likely to be heavily involved in remotely located projects as well, despite the higher logistical costs. Although the cost of logistics cannot be seen as a main driver or barrier for MV ports, it is nevertheless an important element.

Conclusion and outlook

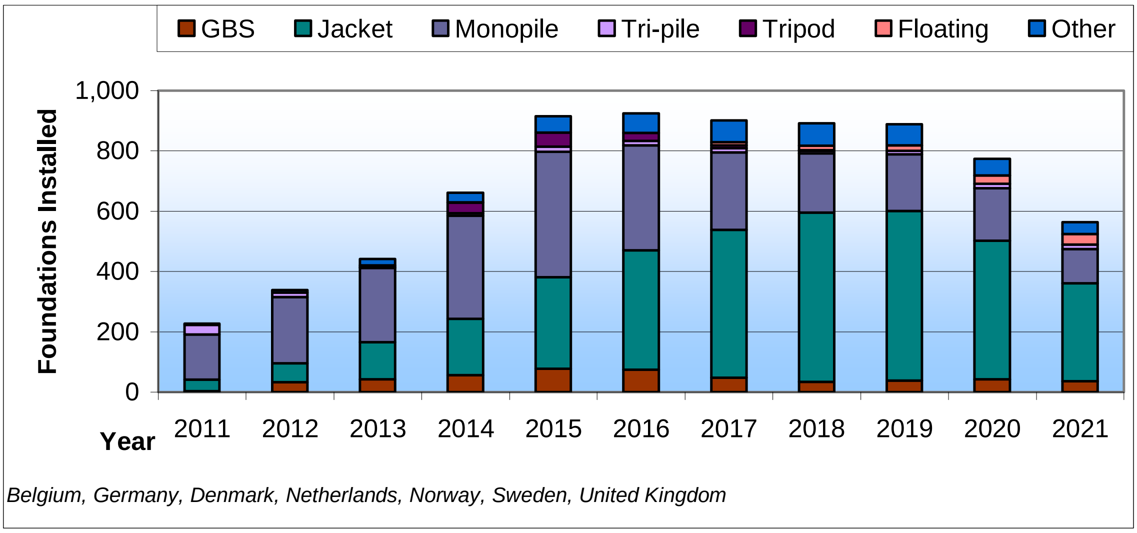
It appears from the cost modelling that there is a clear need for ports to place a high priority on attracting manufacturing facilities to their premises, as much future wind farm work may well be carried out directly from manufacturers' premises. Avoiding secondary construction and marshalling facilities together can significantly reduce logistical costs. The modelling shows that his will also be the most economic solution for the construction of offshore wind farms in the long term.

The cost modelling suggests that, even with (moderately) increasing labour costs in the future, MV ports can hold a competitive position in the market. It also appears that the manufacturing model pioneered by EEW is a highly competitive option. Far Eastern turbine manufacturers may well wish to emulate this model. Further, Mecklenburg-Vorpommern's proactive engagement with trade partners, in the US and worldwide, and its expressed intention to seek out those turbine manufacturers involved in development of prototype turbines, but with no European manufacturing base, may well prove to be the best course of action.

2.5 Economic Opportunities for Ports in Mecklenburg-Vorpommern

Based on the detailed SWOT analysis which was conducted for each of the port locations, the study draws conclusions on economic opportunities for ports in MV to engage within the offshore wind industry.

Since there is a continuing trend towards using larger turbines and deeper waters, it is clear that the foundation market is likely to move from monopiles to jackets.



Source: GL GH

Figure 2-7 Forecast of the market for offshore wind foundations[6]

From the cost breakdown (see above) it is understood that substructures account for about 20 % of capital costs of current offshore wind farms; by 2015 the foundation market is expected to turn into a market with a yearly volume of several billion Euro. The market for installation services, i.e. logistics, is estimated to be larger than 1 billion/year by 2015.

The study finds that MV-based companies would be in a good position to increase their share of the market for turbine foundations, if the competitive position of MV locations can be held or improved. In reviewing the facilities of the four ports in this report, it became apparent that, in terms of optimisation of existing facilities for jacket fabrication, there was potential for co-operation between existing port users. From a GLGH perspective, based on the technical analysis carried out, two pairs of facilities appear to have potential for co-operation in this area:

- Rostock and Lubmin; and
- Sassnitz and Wismar.

A full economic analysis was not performed as part of this study, but it needs to be done as a next step in order to quantify the opportunities for companies based in MV in more detail.

[6] Market Analysis based on actual projects hence likely to be conservative towards end of decade.

Jacket foundation production and assembly at Rostock & Lubmin

Potential savings are identified from a Co-operation between Rostock and Lubmin by using existing facilities, rather than development of competing facilities.

The existing fabrication facility at Rostock has been producing tri-piles for BARD offshore wind turbine foundations. The facility clearly has the capability to fabricate jacket leg sub-assemblies. What the facility lacks is a high fabrication facility for final assembly of the jacket structure.

The old turbine hall of the former nuclear power station in Lubmin is both high and wide enough to accommodate wind farm jacket final assembly. It also has rail-lines in the floor, oriented perfectly for the production proposed.

There is very little modification and investment required for existing facilities at Lubmin to accommodate a highly efficient production operation. With rail-lined floors, and excellent coverage with heavy-duty overhead craneage, and a company providing coating services at the workshop exit, the premises are very well served.

Existing facilities in Rostock and Lubmin are understood to import their pre-rolled “cans” (monopile sections) from the Far East; assembly is then finished locally. In GLGH’s view, such commercial co-operation with Asian suppliers would benefit future jacket production.

This implies that, under the proposed co-operation between Rostock and Lubmin, the former would receive leg-cans and would fit these to leg-nodes (or leg-knots), and then form fully assembled leg sub-assemblies, which would be transported to the large old turbine hall in Lubmin for final assembly into a complete jacket.

Jacket foundation production and assembly at Sassnitz &Wismar

In Sassnitz, there is an existing production facility for gas pipeline welding. Jacket foundation legs vary with each design, but in general are of a diameter that is very similar to the pipeline. In general, while the differences should not be belittled, there cause for optimism that a review of the existing facilities would reveal a large amount of re-usage of existing facilities, equipment, and the skills of the current workforce.

The investment costs for adaption could make the facility attractive to organisations wishing to enter the jacket fabrication business. Given that the current owner of the facility will be interested in securing future contracts, there would seem to be a strong case for discussing whether such a change of role for the facility would be of mutual benefit, earlier rather than later, although this may already have been discussed.

The former Aker shipyard at Wismar has a very high and wide fabrication workshop, and could doubtless accommodate jacket-leg sub-assemblies (probably transported aboard dumb barges) from Rostock.

A similar arrangement to that between EEW and a supplier in another region may be possible. A low cost source of sub-assemblies would mean a significant competitive edge over facilities on the North Sea Coast. It is believed that there is spare capacity within the future order book at the ship-building facility mentioned above, as well as an appetite for co-operation towards optimising the use of existing facilities. Verbal advice gives the impression that there may be interest in such an arrangement.

As the logistical costs of installing offshore foundations are very expensive, there may well be a requirement to store significant numbers of jacket foundations (storage areas of 5 hectares per wind farm can be anticipated).

Timeframe for realisation of opportunities

GLGH assumes that the described opportunities can be realised in the mid term, i.e. by 2015. In fact, if a strategic positioning of MV ports is to be pursued, measures need to be initiated quickly by ports, in order to achieve results within the coming years, in the light of growing international competition. Other countries, such as the UK, have set up programs for preparing ports for the requirements of the quickly expanding offshore industry.

2.6 Strategic Development Recommendations

In discussions with the Client during visits, strategic recommendations for mid and long-term measures have been elaborated upon. Whilst the recommendations drawn from the SWOT analysis are aimed more at ports and at industry, these strategic recommendations are directed to both the industry and government authorities in MV. Recommendations are somewhat exploratory at this point and need to be looked at in more detail.

1. Offshore wind test facility

Some developers of North Sea and Irish Sea wind farms may still have concerns that although the turbine may perform well in the more benign Baltic met ocean conditions, it may not be fully convinced that this is a true test of whether the machine is suitable for the harsher conditions elsewhere. The Client is advised that further work is needed on the comparability of an offshore test in MV waters with harsher environments, in order to underline the value of this offer to potential manufacturers.

The Client made clear that any offshore wind turbine manufacturer wishing to consider relocation to the area would have the need for an offshore test site to prototype test their turbines looked upon very favourably. GLGH feels that this is vital.

2. Attracting Offshore Turbine Manufacturers to MV Ports

There is a rapidly developing market for offshore turbines, and there will be some manufacturers who feel that the best approach to exploiting this opportunity is to expand their manufacturing facilities. Others may not be able to expand in their current location, and will require new premises to do so.

In GLGH's perspective, it is also worth exploring any possibility to attract manufacturers who are not yet established in the offshore wind turbine market but who wish to be so. This could be done through a workshop targeted at potential industry players. GLGH, through its network of contacts, may consider working with MV Invest on establishing such a trade seminar in the Far East.

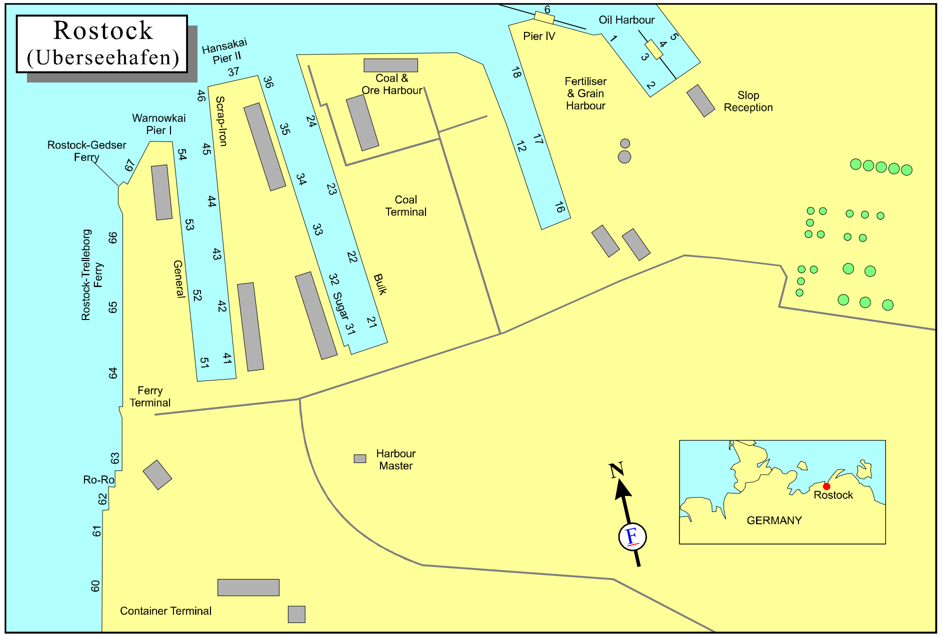
Such measures could possibly be implemented in the short to mid term, i.e. by 2015. Whilst talks with existing manufacturers could start immediately, developing more long-term industry partnerships will require some more conceptual work and analysis.

APPENDIX A

MV Offshore Wind Ports Directory

ROSTOCK

Port owner's name :	HERO Hafen-Entwicklungsgesellschaft Rostock mbH	**Postal address :**	
Port contact's name :	Dr. Ulrich Bauermeister	Ost-West-Straße 32	
Port website address :	www.rostock-port.de	18147 Rostock Germany	
Port contact's eMail :	u.bauermeister@rostock-port.de		
Port contact phone number :	+49 (381) 350 - 40 00	**Location :**	54º 09.0' N 012º 06.0 E



GL Garrad Hassan

PORT SUITABILITY – MONOPILE AND TRANSITIION PIECE FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Port access channel with adequate headroom (unrestricted)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	?
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside reinforced for storage of a monopile before loading (>20t/sqm)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – JACKET FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>25m wide, 10 t/sqm, 30t axles)	X
Port access channel with adequate headroom >75m	✓	Reinforced area for mobile crane load-outs (~700Te)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	✓
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of jackets before loading (>10t/sqm)	✓	Large area for jacket storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – CONCRETE GRAVITY FOUNDATION FABRICATION & INSTALLATION BASE			X
Port access channel of suitable width for installation vessels (>73m)	✓	Large GBS fabrication area (~2,000sqm / base @ 20t/sqm)	X
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>5,000t @ 20t/sqm)	X
Water depth suitable for installation vessels (>6 m CD)	✓	Quayside load-out area suitable for catamaran installation vessels	X
Quayside reinforced for load-out/storage of GBS (>5,000t @ 20t/sqm)	✓		

PORT SUITABILITY – ELECTRICAL SUBSTATION (SS) INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>73m)	~	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel with unlimited headroom	✓	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – MONOPILE (MP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Quayside reinforced for storage of MPs before loading (>20t/sqm)	✓	Quayside seabed suitable for jack-up vessel crane usage	?
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TRANSITION PIECE (TP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	RO-RO for high and heavy components (20 t/sqm))	?
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~400Te)	✓
Quayside length adequate for installation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside reinforced for storage of TPs before loading (>10t/sqm)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for monopile storage (>1,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – LEG SUB-ASSEMBLIES			✓
Covered fabrication & finishing workshops (>90 x 10m)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Rail equipped floors & EOHT cranes (2 x >10t) in workshops	✓	Ro-Ro facility – preferably rail equipped	X
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large open area for component storage (>16,000sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – FINAL ASSEMBLY			X
Long, wide and high fabrication workshops (>75 x 30 x 30m)	✓	Reinforced area for mobile crane load-outs (~600Te)	✓
EOHT cranes (>2 x 75t)	X	Ro-Ro facility – ~30m wide, un-restricted headroom	✓
Rail equipped floors in fabrication, and paint-finishing workshops	X	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – – ELECTRICAL SUBSTATION (SS) MANUFACTURE			X
Wide and high fabrication workshops (>35 x 35 x 30m)	X	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel of suitable width for installation vessels (>73m)	~	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	✓
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - TOWER FABRICATION			✓
Long fabrication workshop (>50 x 10 x 10m)& EOHT cranes (>2 x 15t)	✓	Reinforced area for mobile crane load-outs (~500Te)	✓
Rail equipped floors in fabrication, and paint-finishing workshops	~	Ro-Ro facility – un-restricted headroom	~
Quayside length adequate for transportation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	?
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE – NACELLES - NORDEX PLANT			✓
Fabrication workshops & EOHT cranes (>2 x 75t)	✓	Reinforced area for mobile crane load-outs (~350Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (10t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for nacelle storage (>5,000sqm storage @ 10 t/sqm)	✓
Quayside seabed suitable for jack-up vessel crane usage	?		

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - BLADES			✓
Long fabrication workshop (>75 x 10 x 10m)& EOHT cranes (>2 x 10t)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for blade storage (>25,000sqm storage @ 5t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – CABLE MANUFACTURE – EXPORT CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

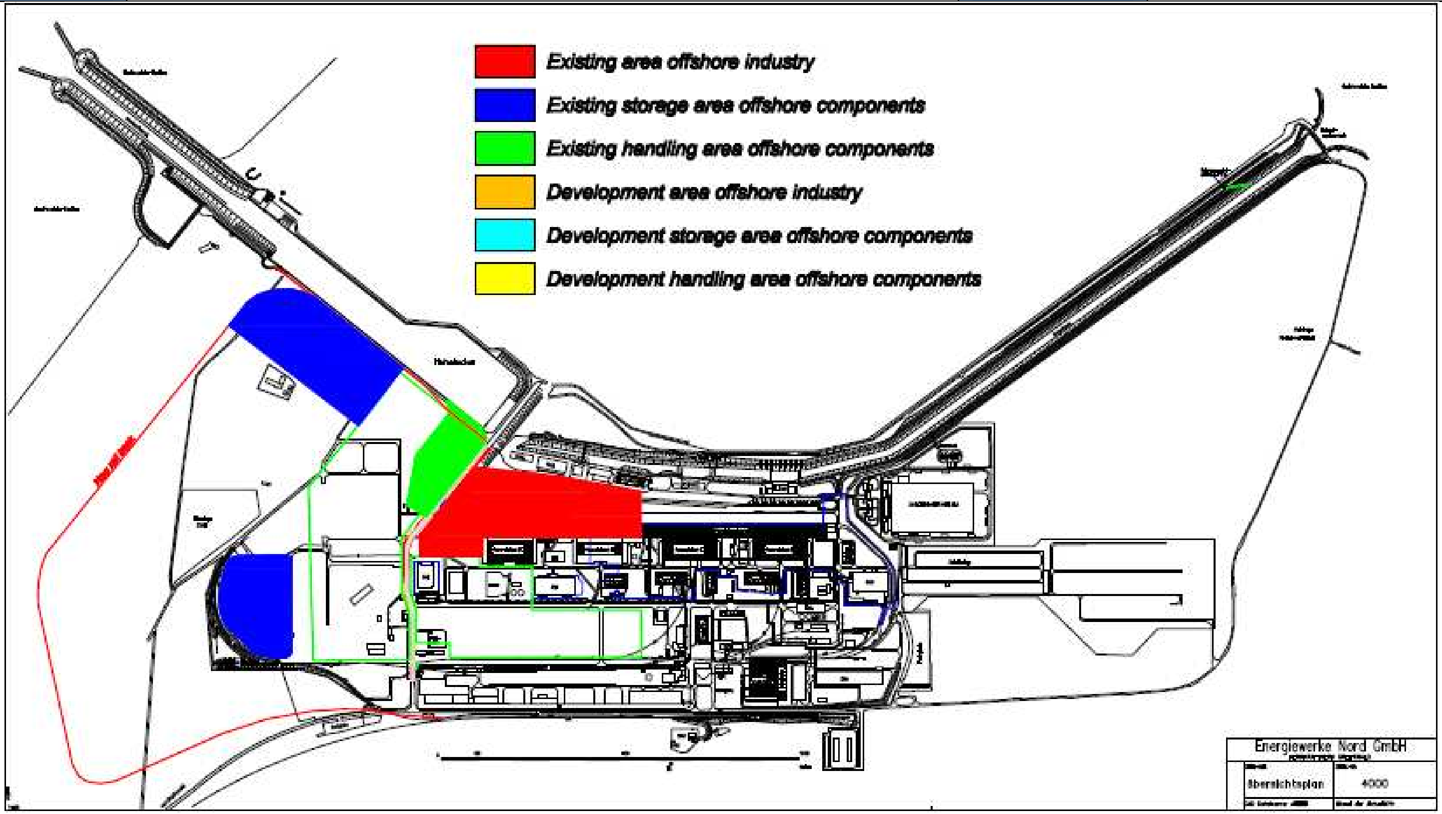
MANUFACTURING FACILITIES AND OTHER SERVICES –CABLE MANUFACTURE - ARRAY CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

OTHER FACILITIES AND SERVICES			
Port areas fenced and has 24hr port security	✓	Availability of potable water	✓
Secure areas have fixed flood-lighting	✓	Availability of electrical connection in covered areas	✓
No restrictions on working hours/ noise		Channels are dredged	
No exclusive labour agreements restricting load / unloading activities			
Additional Note 1			
Additional Note 2			

KEY	✓	Has capability or service	~	Lacks capability - but can be addressed or is non-critical	N	Lacks capability, critical to operations
Question background colour	REQUIRED FEATURE or DIMENSION	Question background colour	DESIRABLE FEATURE or DIMENSION			

LUBMIN

Port owner's name :	Energiewerke Nord GmbH	**Postal address :**	
Port contact's name :	Herr Dieter Rittscher	Energiewerke Nord GmbH Postfach 1125 17507 Lubmin	
Port website address :	www.ewn-gmbh.de		
Port contact's eMail :	Dieter.rittscher@ewn-gmbh.de		
Port contact phone number :	+49 (0) 38354 4 5000	**Location :**	54º 09.0' N 013º 38.0' E



PORT SUITABILITY – MONOPILE AND TRANSITIION PIECE FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Port access channel with adequate headroom (unrestricted)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	?
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside reinforced for storage of a monopile before loading (>20t/sqm)	~	Large area for monopile storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – JACKET FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>25m wide, 10 t/sqm, 30t axles)	✓
Port access channel with adequate headroom >75m	✓	Reinforced area for mobile crane load-outs (~700Te)	~
Water depth suitable for installation vessels (>5.8m CD)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	?
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of jackets before loading (>10t/sqm)	✓	Large area for jacket storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – CONCRETE GRAVITY FOUNDATION FABRICATION & INSTALLATION BASE			X
Port access channel of suitable width for installation vessels (>73m)	~	Large GBS fabrication area (~2,000sqm / base @ 20t/sqm)	~
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>5,000t @ 20t/sqm)	X
Water depth suitable for installation vessels (>6 m CD)	✓	Quayside load-out area suitable for catamaran installation vessels	X
Quayside reinforced for load-out/storage of GBS (>5,000t @ 20t/sqm)	X		

PORT SUITABILITY – ELECTRICAL SUBSTATION (SS) INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>73m)	~	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel with unlimited headroom	✓	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	~

MANUFACTURING FACILITIES AND OTHER SERVICES – MONOPILE (MP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Quayside reinforced for storage of MPs before loading (>20t/sqm)	~	Quayside seabed suitable for jack-up vessel crane usage	?
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TRANSITION PIECE (TP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	RO-RO for high and heavy components (20 t/sqm))	?
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~400Te)	✓
Quayside length adequate for installation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside reinforced for storage of TPs before loading (>10t/sqm)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for monopile storage (>1,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – LEG SUB-ASSEMBLIES			✓
Covered fabrication & finishing workshops (>90 x 10m)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Rail equipped floors & EOHT cranes (2 x >10t) in workshops	✓	Ro-Ro facility – preferably rail equipped	X
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large open area for component storage (>16,000sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – FINAL ASSEMBLY			X
Long, wide and high fabrication workshops (>75 x 30 x 30m)	X	Reinforced area for mobile crane load-outs (~600Te)	✓
EOHT cranes (>2 x 75t)	X	Ro-Ro facility – ~30m wide, un-restricted headroom	✓
Rail equipped floors in fabrication, and paint-finishing workshops	X	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – – ELECTRICAL SUBSTATION (SS) MANUFACTURE			X
Wide and high fabrication workshops (>35 x 35 x 30m)	X	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel of suitable width for installation vessels (>73m)	~	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	✓
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - TOWER FABRICATION			✓
Long fabrication workshop (>50 x 10 x 10m)& EOHT cranes (>2 x 15t)	✓	Reinforced area for mobile crane load-outs (~500Te)	✓
Rail equipped floors in fabrication, and paint-finishing workshops	~	Ro-Ro facility – , un-restricted headroom	~
Quayside length adequate for transportation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	?
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - NACELLES			✓
Fabrication workshops & EOHT cranes (>2 x 75t)	✓	Reinforced area for mobile crane load-outs (~350Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (10t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for nacelle storage (>5,000sqm storage @ 10 t/sqm)	✓
Quayside seabed suitable for jack-up vessel crane usage	?		

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - BLADES			✓
Long fabrication workshop (>75 x 10 x 10m)& EOHT cranes (>2 x 10t)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for blade storage (>25,000sqm storage @ 5t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – CABLE MANUFACTURE – EXPORT CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

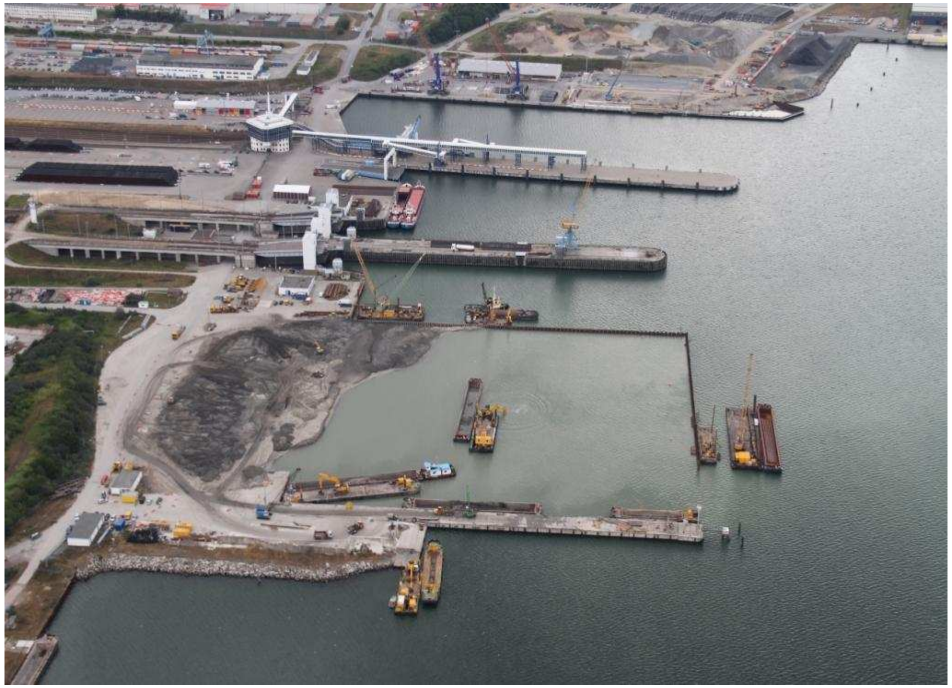
MANUFACTURING FACILITIES AND OTHER SERVICES –CABLE MANUFACTURE - ARRAY CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

OTHER FACILITIES AND SERVICES			
Port areas fenced and has 24hr port security	✓	Availability of potable water	✓
Secure areas have fixed flood-lighting	✓	Availability of electrical connection in covered areas	✓
No restrictions on working hours/ noise		Channels are dredged	
No exclusive labour agreements restricting load / unloading activities			
Additional Note 1			
Additional Note 2			

KEY	✓	Has capability or service	~	Lacks capability - but can be addressed or is non-critical	N	Lacks capability, critical to operations
Question background colour	REQUIRED FEATURE or DIMENSION	Question background colour	DESIRABLE FEATURE or DIMENSION			

SASSNITZ

Port owner's name :	Fährhafen Sassnitz GmbH	**Postal address :**	
Port contact's name :	Captain Harm Sievers	Faehrhafen Sassnitz GmbH Im Faehrhafen 1 18546 Sassnitz Germany	
Port website address :	http://www.faehrhafen-sassnitz.de/index-fl.htm		
Port contact's eMail :	info@faehrhafen-sassnitz.de		
Port contact phone number :	+49 (0)38392 55-0	**Location :**	54º 31.0' N 013º 39.0' E



PORT SUITABILITY – MONOPILE AND TRANSITIION PIECE FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Port access channel with adequate headroom (unrestricted)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	✓
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside reinforced for storage of a monopile before loading (>20t/sqm)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – JACKET FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>25m wide, 10 t/sqm, 30t axles)	X
Port access channel with adequate headroom >75m	✓	Reinforced area for mobile crane load-outs (~700Te)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	✓
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of jackets before loading (>10t/sqm)	✓	Large area for jacket storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – CONCRETE GRAVITY FOUNDATION FABRICATION & INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>73m)	✓	Large GBS fabrication area (~2,000sqm / base @ 20t/sqm)	✓
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>5,000t @ 20t/sqm)	✓
Water depth suitable for installation vessels (>6 m CD)	✓	Quayside load-out area suitable for catamaran installation vessels	✓
Quayside reinforced for load-out/storage of GBS (>5,000t @ 20t/sqm)	✓		

PORT SUITABILITY – ELECTRICAL SUBSTATION (SS) INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>73m)	✓	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel with unlimited headroom	✓	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – MONOPILE (MP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	?
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	✓
Quayside reinforced for storage of MPs before loading (>20t/sqm)	✓	Quayside seabed suitable for jack-up vessel crane usage	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TRANSITION PIECE (TP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	RO-RO for high and heavy components (20 t/sqm))	?
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~400Te)	✓
Quayside length adequate for installation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside reinforced for storage of TPs before loading (>10t/sqm)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for transition piece storage (>2,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – LEG SUB-ASSEMBLIES			✓
Covered fabrication & finishing workshops (>90 x 10m)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Rail equipped floors & EOHT cranes (2 x >10t) in workshops	✓	Ro-Ro facility – preferably rail equipped	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large open area for component storage (>16,000sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – FINAL ASSEMBLY			X
Long, wide and high fabrication workshops (>75 x 30 x 30m)	X	Reinforced area for mobile crane load-outs (~600Te)	✓
EOHT cranes (>2 x 75t)	X	Ro-Ro facility – ~30m wide, un-restricted headroom	✓
Rail equipped floors in fabrication, and paint-finishing workshops	X	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – – ELECTRICAL SUBSTATION (SS) MANUFACTURE			X
Wide and high fabrication workshops (>35 x 35 x 30m)	X	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel of suitable width for installation vessels (>73m)	✓	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	✓
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - TOWER FABRICATION			✓
Long fabrication workshop (>50 x 10 x 10m)& EOHT cranes (>2 x 15t)	✓	Reinforced area for mobile crane load-outs (~500Te)	✓
Rail equipped floors in fabrication, and paint-finishing workshops	~	Ro-Ro facility – , un-restricted headroom	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	?
Quayside reinforced for storage of a components (>100m long @ 5t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - NACELLES			✓
Fabrication workshops & EOHT cranes (>2 x 75t)	~	Reinforced area for mobile crane load-outs (~350Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility -> 8m headroom	✓
Quayside reinforced for storage of a components (10t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for nacelle storage (>5,000sqm storage @ 10 t/sqm)	✓
Quayside seabed suitable for jack-up vessel crane usage	?		

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - BLADES			✓
Long fabrication workshop (>75 x 10 x 10m)& EOHT cranes (>2 x 10t)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for blade storage (>25,000sqm storage @ 5t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – CABLE MANUFACTURE – EXPORT CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

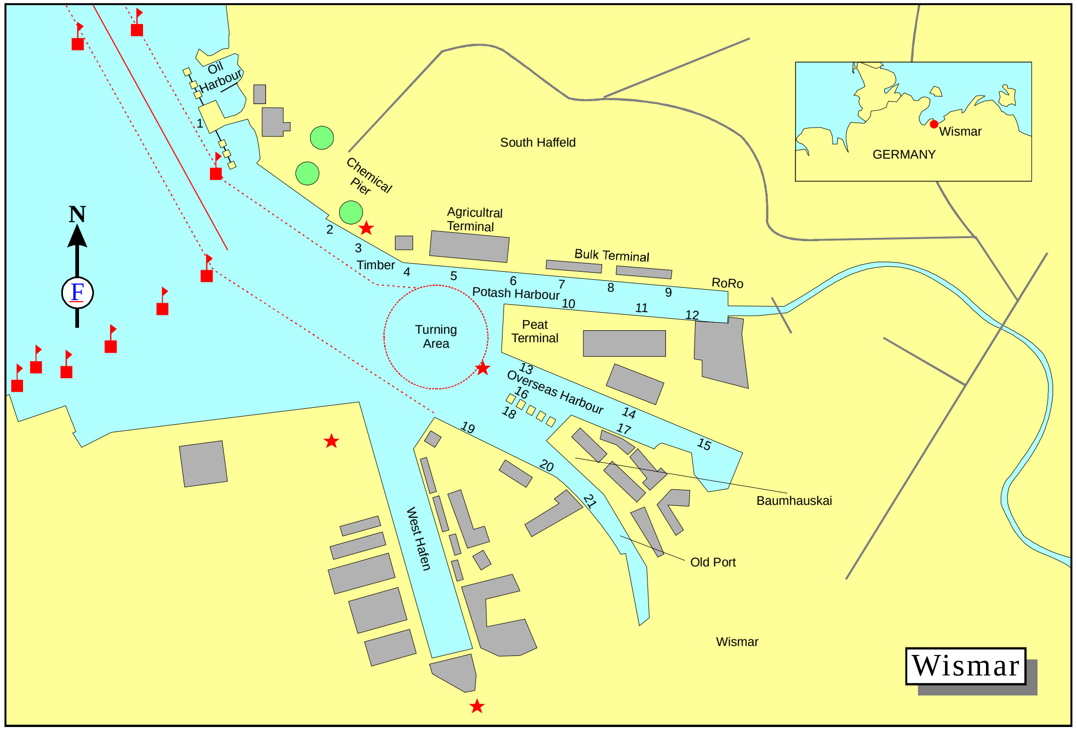
MANUFACTURING FACILITIES AND OTHER SERVICES –CABLE MANUFACTURE - ARRAY CABLE			✓
Port access channel width for cable installation vessels (>28m Check)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD Check)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m Check)	✓		

OTHER FACILITIES AND SERVICES			
Port areas fenced and has 24hr port security	✓	Availability of potable water	✓
Secure areas have fixed flood-lighting	✓	Availability of electrical connection in covered areas	✓
No restrictions on working hours/ noise	✓	Channels are dredged	✓
No exclusive labour agreements restricting load / unloading activities	✓		
Additional Note 1			
Additional Note 2			

KEY	✓	Has capability or service	~	Lacks capability - but can be addressed or is non-critical	X	Lacks capability, critical to operations
Question background colour	REQUIRED FEATURE or DIMENSION	Question background colour	DESIRABLE FEATURE or DIMENSION			

WISMAR

Port owner's name :	Seehafen Wismar GmbH	**Postal address :**	
Port contact's name :	Herr Michael Kremp	Seehafen Wismar GmbH Kopenhagener Straße, Hafenhaus 23966 Wismar	
Port website address :	http://www.hafen-wismar.de		
Port contact's eMail :	mkremp@hafen-wismar.de		
Port contact phone number :	+49 (0) 3841 452 300	**Location :**	53º 54.0' N 011º 28.0' E



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PORT SUITABILITY – MONOPILE AND TRANSITIION PIECE FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	~
Port access channel with adequate headroom (unrestricted)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	?
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside reinforced for storage of a monopile before loading (>20t/sqm)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – JACKET FOUNDATION INSTALLATION BASE			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>25m wide, 10 t/sqm, 30t axles)	✓
Port access channel with adequate headroom >75m	✓	Reinforced area for mobile crane load-outs (~700Te)	~
Water depth suitable for installation vessels (>5.8m CD)	✓	Quayside seabed suitable for jack-up vessel crane usage (CPTs/SNAME)	?
Quayside length adequate for installation vessels (LOA <150m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of jackets before loading (>10t/sqm)	✓	Large area for jacket storage (>10,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

PORT SUITABILITY – CONCRETE GRAVITY FOUNDATION FABRICATION & INSTALLATION BASE			X
Port access channel of suitable width for installation vessels (>73m)	~	Large GBS fabrication area (~2,000sqm / base @ 20t/sqm)	~
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>5,000t @ 20t/sqm)	~
Water depth suitable for installation vessels (>6 m CD)	✓	Quayside load-out area suitable for catamaran installation vessels	X
Quayside reinforced for load-out/storage of GBS (>5,000t @ 20t/sqm)	X		

PORT SUITABILITY – ELECTRICAL SUBSTATION (SS) INSTALLATION BASE			~
Port access channel of suitable width for installation vessels (>73m)	~	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel with unlimited headroom	✓	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	~

MANUFACTURING FACILITIES AND OTHER SERVICES – MONOPILE (MP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro berth for high & heavy cargos (>10m wide, 20 t/sqm, 30t axles)	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~1,000Te)	~
Quayside reinforced for storage of MPs before loading (>20t/sqm)	~	Quayside seabed suitable for jack-up vessel crane usage	?
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Large area for monopile storage (>10,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TRANSITION PIECE (TP) FABRICATION			✓
Port access channel of suitable width for installation vessels (>42m)	✓	Ro-Ro for high and heavy components (20 t/sqm))	✓
Water depth suitable for installation vessels (>5.8m CD)	✓	Reinforced area for mobile crane load-outs (~400Te)	✓
Quayside length adequate for installation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside reinforced for storage of TPs before loading (>10t/sqm)	✓	Haul routes suitable between quay and store (>20t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for transition piece storage (>2,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – LEG SUB-ASSEMBLIES			✓
Covered fabrication & finishing workshops (>90 x 10m)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Rail equipped floors & EOHT cranes (2 x >10t) in workshops	✓	Ro-Ro facility – preferably rail equipped	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large open area for component storage (>16,000sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – JACKET FABRICATION – FINAL ASSEMBLY			✓
Long, wide and high fabrication workshops (>75 x 30 x 30m)	✓	Reinforced area for mobile crane load-outs (~600Te)	~
EOHT cranes (>2 x 75t)	✓	Ro-Ro facility – ~30m wide, un-restricted headroom	✓
Rail equipped floors in fabrication, and paint-finishing workshops	?	Quayside seabed suitable for jack-up vessel crane usage	✓
Quayside length adequate for transportation vessels (LOA <170 m)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES – – ELECTRICAL SUBSTATION (SS) MANUFACTURE			✓
Wide and high fabrication workshops (>35 x 35 x 30m)	✓	Water depth suitable for installation vessels (>6 m CD)	✓
Port access channel of suitable width for installation vessels (>73m)	~	Quayside reinforced for storage of SS (>2,500t @ 20t/sqm)	~
Port access channel with unlimited headroom	✓	Haul routes suitable between quay and store (>2,500t @ 20t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - TOWER FABRICATION			✓
Long fabrication workshop (>50 x 10 x 10m)& EOHT cranes (>2 x 15t)	✓	Reinforced area for mobile crane load-outs (~500Te)	✓
Rail equipped floors in fabrication, and paint-finishing workshops	~	Ro-Ro facility – , un-restricted headroom	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Quayside seabed suitable for jack-up vessel crane usage	?
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for jackets storage (>20,000sqm high & heavy storage)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE – NACELLES – KENERSYS PLANT			✓
Fabrication workshops & EOHT cranes (>2 x 75t)	✓	Reinforced area for mobile crane load-outs (~350Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (10t/sqm)	✓	Haul routes suitable between quay and store (>10t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for nacelle storage (>5,000sqm storage @ 10 t/sqm)	✓
Quayside seabed suitable for jack-up vessel crane usage	?		

MANUFACTURING FACILITIES AND OTHER SERVICES – TURBINE COMPONENT MANUFACTURE - BLADES			✓
Long fabrication workshop (>75 x 10 x 10m)& EOHT cranes (>2 x 10t)	✓	Reinforced area for mobile crane load-outs (~100Te)	✓
Quayside length adequate for transportation vessels (LOA <170m)	✓	Ro-Ro facility – >8m headroom	✓
Quayside reinforced for storage of a components (>100m long @5t/sqm)	✓	Haul routes suitable between quay and store (>5t/sqm)	✓
Water depth suitable for draft/beam of heavy lift cargo vessels (>9.5 CD)	✓	Large area for blade storage (>25,000sqm storage @ 5t/sqm)	✓

MANUFACTURING FACILITIES AND OTHER SERVICES – CABLE MANUFACTURE – EXPORT CABLE			✓
Port access channel width for cable installation vessels (>28m)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m)	✓		

MANUFACTURING FACILITIES AND OTHER SERVICES –CABLE MANUFACTURE - ARRAY CABLE			✓
Port access channel width for cable installation vessels (>28m)	✓	Long fabrication workshop (>100 x 10m)	✓
Water depth suitable for cable installation vessels (>5m CD)	✓	Fabrication facility adjacent to quayside	✓
Quayside length adequate for installation vessels (LOA <100m)	✓		

OTHER FACILITIES AND SERVICES			
Port areas fenced and has 24hr port security	✓	Availability of potable water	✓
Secure areas have fixed flood-lighting	✓	Availability of electrical connection in covered areas	✓
No restrictions on working hours/ noise	✓	Channels are dredged	✓
No exclusive labour agreements restricting load / unloading activities	✓		
Additional Note 1			
Additional Note 2			

KEY	✓	Has capability or service	~	Lacks capability - but can be addressed or is non-critical	N	Lacks capability, critical to operations
Question background colour	REQUIRED FEATURE or DIMENSION	Question background colour	DESIRABLE FEATURE or DIMENSION			

APPENDIX B

Cost Modelling Methodology and Assumptions

The Cost Optimisation Methodology

The cost estimation methodology assumes that manufacturers of foundations and turbines are located in port-side facilities. The model includes an optimisation function which identifies for any chosen combination of a manufacturer port and a wind farm, the least cost logistical option (sum of labour, port and logistical costs). The graphs present the best solution for each scenario.

Costs calculation were not intended to represent total fabrication or installation costs, but to provide comparability of the variable cost elements of labour, logistics and port fees. Due to this focus, the selected costs reflect a smaller element of the global wind farm costs and absolute numbers were not provided to avoid any confusion (for example, steel costs were excluded).

Labour costs were isolated from the total CAPEX figures of both foundations and turbines. The labour (man-hours) required to fabricate various wind turbine foundations from current welding manufacturing practice and for the final assembly of a wind turbine nacelle was estimated from GL GH experience. This was converted into a per tonne rate.

Most information used for the cost modelling was derived from GL GH's internal offshore wind project and offshore vessel databases. For particular cost items, the following approach and assumptions were used:

Vessel Charter Rates

There is great volatility in the actual price charged for installation vessels, based on variables like charter-party duration and type, buoyancy of the vessel spot-purchase market and the long term potential for business with an individual client etc. Ship owners recommend taking the capital value of the ship and dividing this by 1000 to get a reasonable dayrate for the vessel. GL GH has a vessel library which includes the shipyard contract value of all of the vessels (including new-builds) likely to be operating in the Northern European market. These costs were all extrapolated to the year by a standard inflation rate and the dayrates used in the estimates calculated.

For heavy-lift cargo vessels, dayrate figures obtained during previous discussions with project cargo, and offshore construction charterers were used for transportation, and feeder vessel duties. Tug and dumb barge rates were used which reflect quotations obtained for these craft.

Distances between Ports and Windfarms

The distances between the various ports were obtained from the Veson Nautical Distance database[1] supplied as part of the Lloyds Fairplay Ports Directory. The distances between each windfarm and each port was derived from GL GH GIS mapping software.

Voyage durations

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[1] Veson Distance Database http://www.veson.com

Transit rates for vessels are included in the GL GH database, and were used to estimate voyage durations. Seasonal weather variations were not considered since it was assumed that waiting on weather time would affect the vessels similarly.

Vessel Carrying Capacities

The physical dimensions and weighs of foundations and both known and generic wind turbine models were calculated from the project data for each set of wind farm data. The GL GH vessels database already has a carrying capacity calculation function to estimate turbine carrying capacities of heavy-lift cargo vessels, but monopile and jacket carrying capacity estimates were derived for other vessel types to allow the actual number of voyages to be ascertained and associated port costs.

Port Fees

Actual published port fees used in the cost modelling were obtained from the ports. Three key port fees were calculated

1) Cost of each entry and exit to the port (based on actual vessel Gross Registered Tonnages, where known or square metre deck area where ports provided such figures for windfarm vessels).

2) The loading and unloading fees, per tonne and

3) Charges for additional days of laying alongside (standard loading and unloading durations were included, and if maximum duration periods allowed by each port were exceeded, then fees were assessed).

In the few cases where figures were not obtained, the nearest adjacent port's figures were used. As port costs represent only a small fraction of overall costs any cost errors introduced by this approach are considered to be small.

Fuel Consumption

The actual propulsion power of vessels compared in the study are available from the GL GH database. Marine diesel engine manufacturers publish the specific fuel consumption of their engines, in terms of how many grams of fuel they use to generate one kilowatt-hour of output. To obtain fuel estimates, the proportion of engine power utilised for various applications was multiplied by the actual engine power, and a mid-range marine diesel specific fuel consumption figure to obtain fuel usage estimates during voyages. A standard mid-range northern European marine diesel oil bunkerage fuel cost was used, and assumed to apply for all vessels –other fuel types (HFOs and MGO) were ignored as these would not bring significant savings.

Physical sizes and Weights of Components

GL GH has carried out numerous wind turbine design studies, during FEED studies and other projects and has data on all offshore turbines and foundations installed to date. From project site conditions (like water depth, 50year return wave height, seabed type) and knowing likely turbine and foundation type, estimates were made of the physical size and weight of foundations, and the turbine components.

Labour Costs

Figures from Eurostat and Statistisches Bundesamt were used to identify typical labour costs for MV, Western German regions and other countries.

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