DESIGN BASIS – WHAT IS REQUIRED BY A TURN-KEY SUPPLER?

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SUMMARY

Site specific information about climatic and geological conditions is required for a successful and economical offshore wind farm project. The importance of this information is often underestimated by project developers that are just entering the offshore wind business. Sufficient and reliable site information will reduce uncertainties and result in cost savings.

Site specific design parameters are ideally determined from surveys at the specific offshore site. But often available information from near-by offshore or coastal structures can alternatively be used. What information is available, should be investigated within a desk study. Preliminary site information can be fast achieved from a desk study and can be used for the further planning of necessary site investigations and help to reduce the number of expensive offshore surveys.

The design basis is the central document where all site specific information about climatic and geological conditions is compiled. This document shall ensure that all parties in the project at an early stage agree on a common set of design parameters and design principles.

It is the aim of this paper to give a better understanding of the importance of site specific information about climatic and geological conditions, necessary site investigations and the central role of the design basis document.

KEY WORDS

Site investigations, design basis, design parameters, foundation design, substructure, load calculation, certification

INTRODUCTION

The economic consequences of failure are much higher for offshore projects than for well known and easy accessible onshore wind farms. This risk can be reduced already

in the early planning phase when sufficient and reliable site information about climatic and geological conditions is available.

Compared to onshore sites are the required site information about climatic and geological conditions at offshore sites much more intense and the accessibility of offshore sites is also limited by the climatic conditions.

Next to this are offshore wind projects much more cost intensive than onshore wind farms. Realistic design parameters are therefore the key to an economic and efficient design, efficient installation methods and an optimised accessibility.

The incorrect choice of design parameters will have strong economical impact on the overall costs of an offshore wind farm. Therefore site investigations should be carried out already in a very early stage of the development of an offshore wind farm.

The climatic and geological conditions of the offshore site are required for a number of different tasks during the planning phase:

- As for onshore wind turbines is site specific information about the wind climate needed in order to estimate the annual energy production of the wind farm and in order to evaluate the most economic wind farm layout and hub height.

- The choice and design of the support structure (foundation and turbine tower) and the evaluation of its most applicable installation method depend on the site specific climatic and geological conditions, such as soil conditions, water depth, seabed erosion, wave and wind climate, tidal range and currents. In some areas also drifting ice must be taken into account for the design of foundations.

- The most important factor with regard to service of offshore wind turbines is their accessibility. The choice of an applicable service vessel and the placement and design of the boat landing system(s) depends on the site specific climatic conditions, such as wave and wind climate, tidal range and currents. Special focus should be on the directional distribution of wave and current with regard to the orientation of boat landing systems.

- In order to find an applicable installation method including all vessels and tools is it important to have good knowledge about the available weather windows, where specific operations during the installation phase can be proceeded. Another important factor is as for service of offshore wind turbines the accessibility.

- The choice of cable routes, design of J/I-tubes, design of scour protection and the evaluation of the most applicable installation method of cables depend on the site specific climatic and geological conditions, such as soil conditions, seabed erosion, waves and current.

Generally the owner of the site is responsible for the necessary site investigations and should inform about all relevant design parameters. But it is of cause Vestas intention to assist the client. Vestas has through participation in a large number of offshore projects as turn-key or main contractor gained substantial experience with regard to required design parameters and will support the client best as possible in order to find the right

contractors for the necessary site investigations and to ensure that sufficient site information is available.

After site investigations have been carried out, it must be ensured that all available site information will be distributed to all parties in the project, viz. Client, Consultants, Contractors, Certification Body, etc. . Important is also that new or revised site information is distributed to all parties.

DESIGN BASIS

For the design of the integrated wind turbine are the site specific environmental design parameters typically listed in the Design Basis. Next to this are also the design principles for the support structure specified as well as general information about the wind farm are specified in the Design Basis.

Site specific environmental design parameters are not only required for the design of the substructure but also important for a number of other tasks within the planning phase, like e.g. installation method of foundation, design of the boat landing system and its orientation or cable installation method. These tasks have a big impact on the design of the substructure. Therefore the design basis should be extended with the design parameters and principles relevant for these tasks.

The general description of the wind farm should consist of the wind farm layout including the geographic co-ordinates of the turbine location, of transformer station(s) and of the cable routes. Important is the specification of the geodetic reference system in order to avoid any misinterpretations.

Also the conceptual design and the conceptual installation method of the support structure should already be given in the Design Basis. This should include the hub height of the wind turbine and the interface level between turbine and foundation. Important is here again that all levels are specified relative to certain reference level (e.g. chart datum). Special focus should also be on the design and placement of boat-landing systems, ladders, intermediate resting platforms and J-tubes as these secondary steelwork items have an influence on the wave loads on the primary support structure.

The environmental design parameters should consist of the following information:

- Operational and extreme wind climate incl. information about ambient turbulence, wind shear and directional distribution
- Operational and extreme wave climate incl. information about directional distribution, currents and marine growth
- Joint probability of wind and waves
- Weather windows available for installation and service related operations
- Analyse of accessibility of wind turbines
- Water depths incl. information about tidal levels and range, long term seabed movements, global seabed erosion and storm surge levels.

- Soil conditions consisting of mechanical properties of soil and their range of stratum
- Properties of sea ice floes in some areas

The design principles consist of the following information:

- Design life, return periods, safety factors
- Definition of load cases
- Hydrodynamic coefficients
- Material properties (e.g. steel, concrete, grout)
- Corrosion protection system, corrosion allowance, definition of splash zone
- Local scour development
- Loads on secondary steelwork and functional description of secondary steelwork
- Ship impact

The Design Basis is the primary basis for the load calculations for the integrated structure and the subsequent structural design of the primary support structure, consisting of turbine tower and foundation, but also for most of the secondary structure.

The Design Basis is typically compiled by the foundation designer in a close co-operation with the turbine manufacturer and will often have to be certified by an independent verification body as part of the project certification scheme adopted for the specific project in order for the Client and the Contractor(s) to have a third-party confirmation of the applied design parameters and principles.

The design Basis is one of the most important documents for designing the support structures of an offshore wind farm as it shall ensures that all parties in the project at an early stage agree on a common set of design parameters and design principles for the support structure.

SITE INVESTIGATIONS

Offshore wind farms comprise a considerable amount of capital expense. Surveys that have to be carried out in order to define the foundation design and its installation method are rather costly and time consuming and may be difficult to execute due to rough site conditions. Therefore is it important to collect and utilise all available information in order to plan the necessary surveys.

In the primary stage not all design parameters will be available. Until site surveys are carried out, information from other sources like design bases of near-by offshore or coastal structures (e.g. lighthouses, piers, sea cables or pipelines), from offices of the national geological surveys, from national meteorological offices, from tidal tables, from port or fishery authorities, from naval chars, from databases, etc. can be used for

the first estimations. The primary phase consists mainly of desk studies and interviews of locals. Often plenty of information is available.

The information gathered at this stage, may be sufficiently detailed and could be used in the primary design and planning phase. An early determination of the most cost efficient foundation type and an early determination of the wind farm layout are helpful for the planning of the necessary surveys. The amount of necessary site investigations / surveys depends on the complexity of the specific offshore site and the available information from the desk study.

In the secondary phase a seismic survey of the wind farm should be carried out, in order to determine the sequence of sediments or the surface of the bedrock. If possible the survey should be extended to adjacent sites where the soil profiles and the soil properties are known. The seismic survey should be carried out in lines covering the area of the cable routes from the wind farm to the landfall of the cable, along the lines, where the wind turbines are planed to be erected, around the perimeter of the wind farm and at the locations of substations or meteorological masts. If a highly non-uniform seabed is detected, the number of lines may be increased. Bottom samples of sediments should be taken. In case of rocky bottom, areas with rock outcrops and areas with sediments should be determined. If a meteorological mast is erected on the site by driving a pile, the driving record will be extremely valuable for determining the soils strength. The seismic survey should be combined with a Bathymetric survey. Both seismic and Bathymetric survey can be executed from a light vessel.

Next to soil conditions are met-ocean data required for the design of offshore wind turbines and their substructures. For this purpose a meteorological mast for wind measurements and a wave gauge should be installed on the site. In order to receive sufficient and reliable data it is necessary to have measurement records of at least one year. The metocean data may at this stage also be supplemented by computer simulations for hindcasting of waves and local modelling of currents and waves. Long-term measurements at nearby sites could be used for calibration of computer simulations.

In the tertiary phase test borings for sampling of soil, for identifying soils and for testing soil strength should be carried out. In order to get information from boreholes of sufficient depth, the conceptual foundation design should be available. A sufficient number of boreholes equally distributed over the wind farm area have to be carried out in order to determinate the mechanical properties of the soils and their stratigraphy in the underground.

The borings should be supplemented by Cone Penetration Tests (CPT’s) for checking the soil strength in depth of other positions. These tests do not recover any soil samples and can only be made in sediments.

The number of boreholes and CPT’s depends on the basic knowledge and the uniformity of the area found by the investigations in the primary and secondary phase. It further depends on types of sediments or the type of rock.

At offshore sites where the upper layer consists of sand, waves and current will generate long term changes in water depth caused by seabed movements (e.g. large scale sand dunes or sand waves) or global seabed erosion. In such cases it is recommended to base the design on a minimum of two recent repeated Bathymetric surveys with a spacing of at least one year in order to estimate maximum seabed lowering during the lifetime of

the turbine. Further information of seabed movements could be determined from old naval charts.

After the tertiary phase should all design parameters be available and the design basis can be completed. Latest at this stage the most cost effective foundation design can be determined.

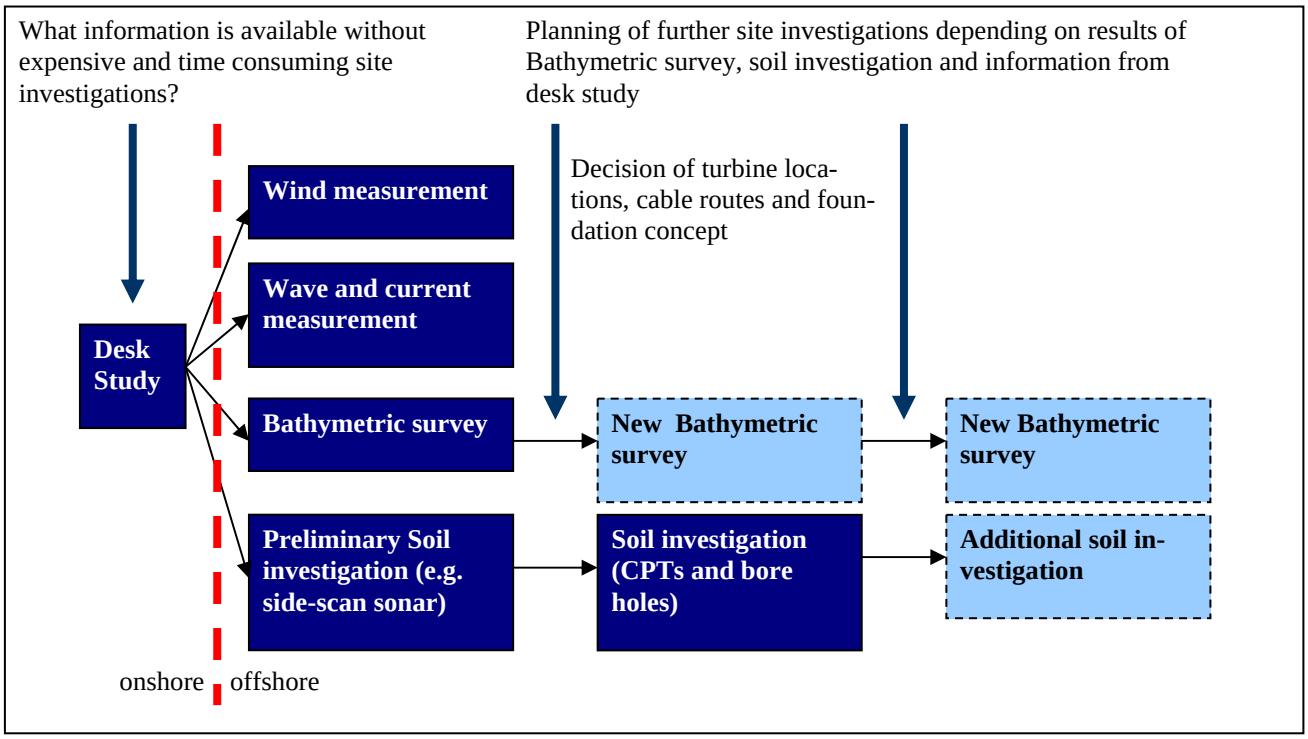

Figure 1: Planning of site investigations