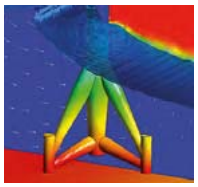
dynardo
dynamic software & engineering

ROBUST SUPPORT STRUCTURES OF OFFSHORE WIND TURBINES

Probabilistic safety assessment and optimization of robust support structures for Offshore Wind Turbines with ANSYS® and optiSLang®.



Optimization Task

Optimized and robust support structures for Offshore Wind Turbines (OWT) are essential to make offshore wind energy economically promising. The existing design concepts are based on knowledge and standards from offshore constructions regarding the oil and gas industry. Moreover, the regulations were influenced by experience obtained from constructing onshore wind turbines. However, for OWT, completely different circumstances are valid. The partial safety factors within these standards have not been validated yet for the specific conditions of OWT.

Types of support structures a) monopile, b) jacket, c) tripod

Solution Methodology

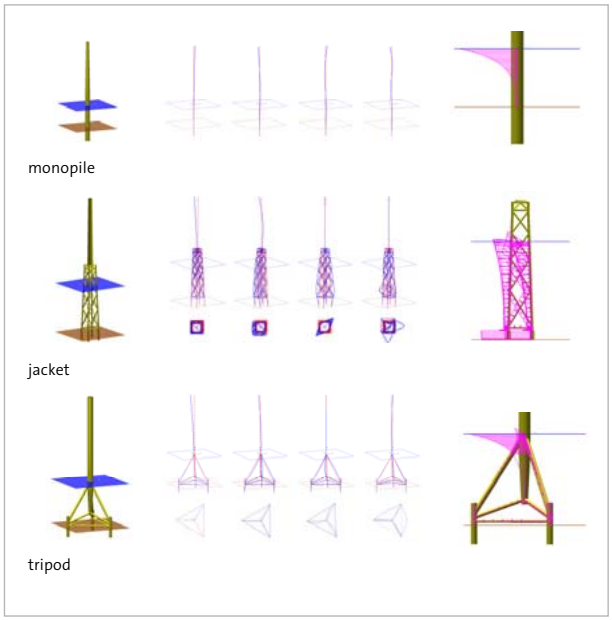
Parameter identification

In order to identify the real safety distance between resistance and loading effect for OWT support structures, calculations based on statistical distributions have to be conducted. Before probabilistic methods can be applied to the structure, its structural data has to be established in the first interval based on a deterministic design. With regard to varying complexity of support structures, the first structure to be analyzed needs to be selected carefully. The project partners agreed to analyze a monopile structure in a first step. Further possible substructures, among others, are jacket or tripod.

Besides the predefinition of the support structure types, a probabilistic design of wind turbines requires predefined input parameters. Therefore, the uncertain parameters such as dimensional imperfections, material properties and loads need to be set carefully within the stochastic modeling. The statistical values of the parameters, which are required for the resistance models of the support structure, are valid on- and offshore in a similar manner. They were already investigated and statistical values can be obtained from literature. Statistical values for loading effects were ascertained, too. In order to perform realistic reliability-based calculations, wind and wave data from the sample measuring platform FINO1 were evaluated. FINO1 is a research platform in the North Sea which records measurement data from wave height, wave direction and wind velocities at different heights.

Simulation

In the numerical simulation, common foundation structures are analyzed. Here, the results of the current deterministic design methods are compared with the results of probabilistic calculations. The dynamic structural properties and loads of wind and wave are used as input parameters for the simulation.



Simualation of loading effects on different support structures

Analysis and Robust Design Optimization with ANSYS® and optiSLang®: The probabilistic assessment is separated into different steps. In the first step the number of relevant parameters should be reduced by conducting a sensitivity analysis. For this working step, optiSLang is used. The software is compatible with already established numerical program systems as e. g. ANSYS. Reduction and identification of decisive parameters has to be done to achieve an adequate and acceptable calculation time.

Reliability analysis: The determination of the probability of failure of a system with scattering responses is the purpose of the reliability analysis. In optiSLang, suitable methods are available to perform an analysis for the generated models concerning foundation and support structure by using probabilistic methods.

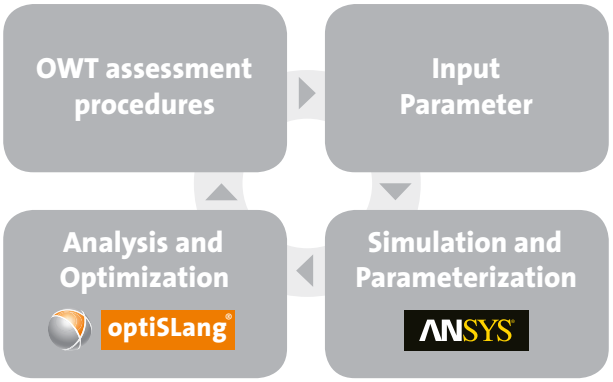
Sensitivity analysis: With the help of a sensitivity analysis, optiSLang automatically identifies the relevant input and output parameters and quantifies the forecast quality with the help of the Coefficient of Prognosis (CoP) and the Metamodel of Optimal Prognosis (MOP). A predictable forecast quality is the key to an efficient optimization.

Robustness evaluation: With optiSLang, a robustness evaluation is conducted to prove the validity of the model under arbitrary scatters in the input parameters.

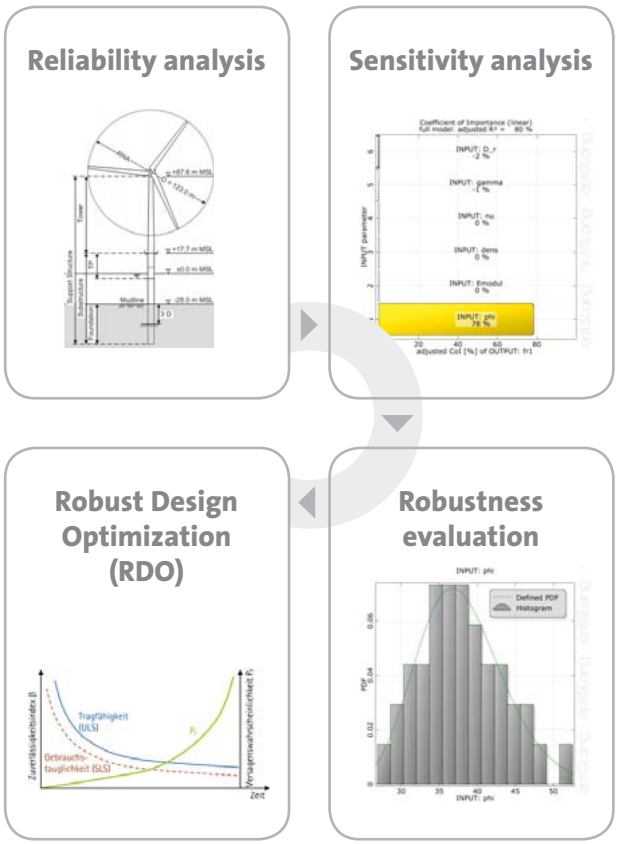
Robust Design Optimization (RDO): The determination of the failure probability of the support structure enables a goal-oriented optimization. RDO optimizes the design and simultaneously ensures the robustness. Quality and reliability are explicit optimization aims.

Customer Benefits

The objective targets of this project are to obtain adjusted environmental actions on Offshore Wind Turbines and to determine the safety elements for the design with respect to a harmonized safety level. The project shows the benefit of introducing probabilistic algorithms because conventional deterministic design methods recognize uncertainty implicitly and unequally. Thus, there is a necessity to implement probabilistic analyses on a representative design of typically used OWT foundations.
By the use of ANSYS coupled with optiSLang, the reliability and the optimization of the modeled structure can be accomplished and gained knowledge and results can be introduced to assessment procedures of OWTs.



Assessment workflow



Evaluation and Robust Design Optimization with optiSLang

ForWind Center for Wind Energy Research Bremen Hannover Oldenburg

Project time: December 2009 - November 2014 | Sponsorship: Niedersächsisches Ministerium für Wissenschaft und Kultur Weitere | Informationen: www.psb.uni-hannover.de
Participating institutes: Institute of Steel Constructions | Institute of Statics und Dynamics | Institute of Concrete Construction
Project leader TP 4 - Foundation and support structure: Prof. Dr.-Ing. Peter Schaumann, Dr.-Ing. Michael Hansen; hansen@ifma.uni-hannover.de, phone +49 (0)511 762 - 33 53

Steubenstraße 25 • 99423 Weimar • phone +49 (0)3643 900830 • contact@dynardo.de • www.dynardo.de