

# **Simplified design algorithm for an offshore monopile support structure**

An offshore wind farm is a fairly complex system that consists of several interacting subsystems. Therefore an integral design method is the best method to obtain the optimal result for the total system. In order to aid this integral design process an optimization software tool has been developed by Zaijier [1] which takes into account the interaction between the subsystems.

One of the subsystems of a wind farm is the support structure of the wind turbine. This research aims to devise a computationally efficient design algorithm for a monopile support structure (monopile) that can be implemented in the wind farm optimization tool.

## **Problem analysis**

A main challenge in the design of a wind turbine support structure is the calculation of the fatigue damage in the design life of the support structure. Because of the non linearities in the wind turbine such as the aerodynamics of the rotor, the stochastic nature of the loads that act on the wind turbine and its support structure and the dynamic response of the support structure a large number of load cases has to be evaluated to calculate the fatigue damage over its design life time.

The most cost effective support structure solution has a natural frequency that is close to the blade passing excitation frequencies and the wave excitation frequencies. The natural frequency of the support structure should not coincide with one of the excitation frequencies because this will cause resonance which will negatively affect the fatigue life of the support structure. In the present situation the support structure design algorithm that is implemented in the wind farm optimization tool does not directly calculate the fatigue damage. Instead a static analysis is performed in which the loads are multiplied with a safety factor of 1,5 to take into account fatigue. However since fatigue can be a design driver for deeper waters, the natural frequency and the fatigue damage should be taken into account more carefully than in the algorithm that is currently implemented.

In order to take the non linearities into account wind turbine components and the support structure are usually designed using nonlinear time domain analysis. This way the extreme responses and fatigue damage can be calculated quite accurately. However because of the stochastic nature of the loads a large number of design load cases must be simulated, which typically takes hours of simulation time. Therefore this analysis method cannot be applied in the wind farm optimization tool because the calculation of several configurations than will not be computationally feasible.

## **Objective of the research**

This research aims to devise a computationally efficient design algorithm for a monopile which takes into account the fatigue limit state and the structural response of the monopile. The algorithm should calculate the principal dimensions of the support structure, taking into account the environmental conditions (wind, waves, soil) and the other subsystems in the wind farm (rotor, neighboring wind turbines).

## References

- [1] M. Zaaijer, Great expectations for offshore wind turbines – Emulation of wind farm design to anticipate their value for customers, 2013.