ABSTRACT

For current offshore wind farms, monopiles are by far the most popular support structure type. However, for deeper water and/or larger turbines, the fatigue loading is becoming critical and the monopile dimensions are exceeding the current economical feasibility. Therefore the paper focuses on an integrated optimization process for a 5MW offshore wind turbine design on a monopile. The chosen site with 25m water depth is considered to be challenging for such a large and heavy turbine type. The approach presented in this paper is to integrate an optimization for load mitigation in the design process of offshore support structures.

A reference design of the support structure is made following a conventional design approach and using data from measurements at a site in the Dutch sector of the North Sea. The focus is on the reduction of the dominant hydrodynamic loads on the support structure. The implemented load mitigation concept leads to significant reductions in loading, allowing considerable material savings and therefore a more cost-effective structural design. Undesired side effects, such as increased wear of turbine components are unlikely as other system loadings and characteristics remain within an acceptable range. Even if some of the rotor-nacelle-assembly loads are slightly increased by the applied controller, the increases are low and probably still within the margins of the type-class fatigue loads. Furthermore a significant increase in energy output could be obtained by applying an extended cut-out range.

KEY WORDS: Offshore Wind Turbines, Support Structures, Load Mitigation, Integrated Design Optimization, Controls

INTRODUCTION

The UpWind project looks towards wind power of tomorrow and towards the design of very large turbines in wind farms of several hundred MW. The project is divided into several work packages (WP). The work presented here is part of WP4, which deals about offshore foundations and support structures. The primary objective of WP4 is to develop innovative, cost-efficient wind turbine support structures to enable the large-scale implementation of offshore wind farms. The work package achieves this by seeking solutions which integrate the designs of the foundation, support structure and turbine machinery in order to optimize the structure as a whole.

One possible solution for support structure optimizations is to mitigate dynamic support structure loading through integration of support structure and turbine design and the use of turbine control. The focus here is on the mitigation of aerodynamic and hydrodynamic loads on the total offshore wind turbine system, as through this an optimized and cost-effective design can be ensured. This can be achieved by integrating the design of the rotor-nacelle assembly (RNA) and support structure in the design process. Hence, the RNA is considered as an active component to mitigate the loads on the support structure. For this load mitigation of the support structure, different concepts are possible and can be distinguished at three different levels (see Figure 1).

Figure 1: Levels of load mitigation

The first level is to already consider loads in the design of the offshore wind turbine or offshore wind farm, such as through the type of turbine and support structure or shape of the farm. Here examples are full truss tower solutions or wind farm layouts taking loading from wake effects into account. However, the main emphasis in this paper is given to the two further levels, where control options are used in order to reduce loads. In general, one can distinguish between operational and dynamic control systems. In the operational control level, the goal is to use already available operational control capabilities in order to reduce the loading on the support structures. Moreover, different advanced dynamic control systems are available to damp the loads on an offshore