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Measurement campaign of a large rotor wind turbine

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Abstract

This work reviews some of the main tools used for designing a measurement campaign on a multi megawatt scale wind turbine. The aim of the measurements is to contribute to the qualification of new large turbine technology, assess the fatigue life of wind turbine components, as well as to validate simulation tools. Due to the size of the wind turbine structure, there are potentially new dynamic properties and identifying these will reduce the design- and operational risks. The complexity of measuring the dynamic properties of a large wind turbine is addressed and some of the main theoretical methods are outlined. In addition possible measurement equipment has been reviewed.

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1. Introduction

The cost of energy for offshore wind turbines must be reduced in order to be competitive with other energy sources. This has led to a rapid increase in wind turbine size due to the belief that fewer and larger wind turbines will yield lower overall cost of energy. Offshore wind turbines are not dependent on road transport since the blades, nacelle and tower are only transported at sea and thus the sizes are less restricted. The wind turbines being developed for offshore use are therefore increasing in size relative to the onshore industry.

Together with the development of new material and new technology, the limits for the size of the wind turbines are increasing. At present, the largest rotor in use is the Samsung 7 MW turbine with over 171 m in diameter [1], while the largest generator size is Vestas 8 MW [2]. The boundaries are continuously being moved, and it is expected that the limits will soon be stretched even further.

Previous studies [3] have indicated that the increasing size of wind turbines may affect the failure rate of wind turbines. Fig. 1 illustrates the failure rates collected over a period from 1993 to 2004. The term large wind turbine was used for wind turbines larger than 1 MW in the study of failure rates, in the present study a large turbine is considered to be above 5 MW and with a turbine diameter above 120 m.

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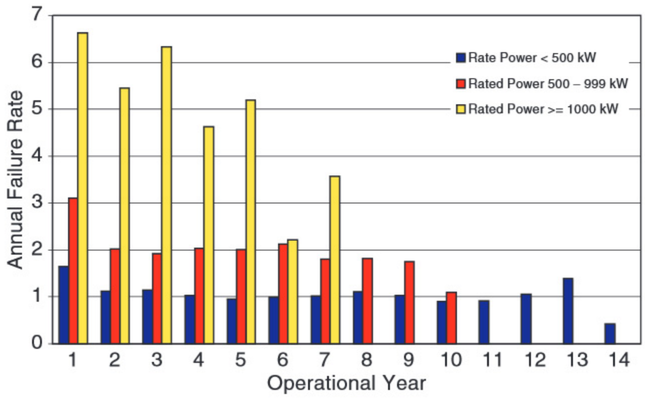

Fig. 1: Failure rates for wind turbines in the LWK survey averaged over an 11 year period [3].

The operators of wind farms are investing in increasingly larger wind turbines for their offshore wind farms. Statkraft is currently operator of the Sheringham Shoal wind farm which consists of 88 Siemens 3.6 MW wind turbines [4], and is together with Statoil developing Dudgeon wind farm which will consist of 67 Siemens 6 MW wind turbines [5]. The Dudgeon wind farm is planned fully commissioned by the end of 2017. A significant cost saving due to increasing the turbine size at Dudgeon relative to Sheringham Shoal is expected. In addition, Statkraft is preparing for a developer role for one or more subjects within the UK round 3 projects at Dogger Bank.

To reduce the risks related to the large wind turbines and qualify wind turbine technology for Dogger Bank, Statkraft is planning to install a test turbine at the island Haugsøya in Smøla municipality. Smøla is located north of the city Kristiansund, and the area is subjected to offshore-like wind conditions. A license application to the Norwegian Water Resources and Energy Directorate (NVE) has been approved. In the application, the size of the wind turbine is estimated to be 6-8 MW, hub height 100-130 m and the diameter is between 140-180 m [6].

One important objective of the large onshore test turbine is to use measured results and the operational experience to reduce the risks related to increased rotor diameter for future offshore wind farms. Understanding the dynamic interactions, the corresponding structural behavior and response characteristics are essential for ensuring safe and reliable operation and increasing the lifetime of the system [7].

An important part of transferring the knowledge from an onshore wind turbine to an offshore wind turbine will be the numerical tools. The measured response of the structure will be compared to the results from numerical simulation and a validation scheme is therefore required. The load measurements must be related to responding loads for a wind turbine integrated with its support structure acting as a highly dynamic global structure. Thus, simulation models must be used for assessing the system quantities prior to the measurement campaign in order to get a high-quality assessment of eigenmodes and damping. Global foundation and tower loads will be correlated to the eigenmodes given by the onshore support structure.

Load measurements from the test wind turbine can also be used to verify models for life-time estimates and in particular remaining life time of the main components of the wind turbine. Due to the concern for the failure rates of the wind turbine main bearings and drivetrain, condition monitoring systems are offered as standard equipment for megawatt scaled wind turbines. In Fig. 2, a comparison of the frequency spectra of the torque in the main shaft between a floating and fixed wind turbine is shown. It illustrates how the flexible modes, as well as the rotor loads (3P, 6P, 9P) influences the loading of the drive-train. Combining the condition monitoring system, with the knowledge from the detail measurements of the test turbine, the project aims to improve the current state of condition monitoring for use in future projects.