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Evaluation of RAMS + I Factors Affecting Different Offshore Wind Turbine Concepts

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In the offshore wind energy sector, there are many different conceptual wind turbine structures, from traditional monopile structures to floating platforms. The management of Reliability, Availability, Maintainability, and Safety (RAMS) issues is essential as early as possible at the beginning of the turbine conceptual design phase. This paper presents guidelines to compare different offshore wind energy assets and their critical components from a system availability and safety point of view. Classification and evaluation criteria for different Reliability, Availability, Maintainability, Safety, and Inspectability (RAMS + I) factors are outlined and discussed.

INTRODUCTION

Offshore wind turbines are complex machinery systems consisting of many multi-technology subsystems. Beginning with the underwater substructures, there are many different conceptual structures, depending on the water depth, from traditional monopiles to new floating platforms.

Current offshore turbines in shallow waters are mostly developed from onshore designs. According to EWEA's medium and long-term scenarios, offshore wind turbine concepts will be changed from onshore-based constructions to turbine types designed specifically for an offshore environment. The main driver for offshore wind turbine development is efficiency, rather than generator size (EWEA, 2009a).

The development based on land-based designs is not optimal for offshore wind turbines because of some fundamental differences in the offshore operating environment and infrastructure. Sites are far from harbours and support bases, construction costs are much higher, and operations are highly dependent on weather conditions, wave height and wind speed. Corrosive seawater exposure, wave loading added to extreme wind and fatigue load combinations, and other external conditions requiring special attention (e.g., ice and hurricanes) require different technological solutions for offshore structures and solutions.

Because of these differences, future trends may move toward significant divergences between offshore and land-based designs (Musial and Ram, 2010).

Wind turbines in cold climates such as Northern Europe are exposed to conditions outside the design limits of standard wind turbines. According to Baring-Gould et al. (2010), specific issues in the Nordic context, such as accessibility, temperature, ice, snow, energy potential, technology, economic risk, public safety, infrastructure and occupational safety, will require special solutions.

Many of the technologies for offshore wind development have already been proven in the oil and gas industry, such as structural designs, foundations, remote monitoring, data integration, and so on. Many of the same issues that govern oil and gas platforms will also influence the design of wind platforms, but the importance of each variable will be weighted differently. Because platforms in the oil and gas industry are much larger and have unique applications, applying this experience to offshore wind will require technological innovations and new methods for manufacturing, logistics and maintenance that will be critical in lowering costs and expanding the offshore wind farms to potential new areas (Musial and Ram, 2010).

There are high reliability requirements and increasing cost reduction demands in the offshore wind energy sector. The management of reliability, availability, maintainability and safety issues (RAMS) becomes essential as early as the system requirement specification phase at the beginning of the turbine conceptual design phase. Some initial attempts have been made in a collaborative project in NORCOWE to develop and extend the RAMS concept for specific Nordic conditions, by emphasising inspectability performance to develop the RAMS + I concept (Tiusanen et al., 2011 a).

RAMS + I (Reliability, Availability, Maintainability, Safety, and Inspectability) objectives, benefits and costs can and should be considered from different perspectives: the wind energy company building and operating the wind farm, turbine and substructure providers, nacelle component providers, maintenance companies and electric grid companies. In these issues, as is common in system engineering, sub-optimisation is no good in the long run. RAMS + I issues related to single wind turbines and their critical components should be considered in relation to the objectives and site-specific requirements of the whole wind farm.

In this paper, we present guidelines to compare different offshore wind turbine concepts and their critical components from a system availability and safety point of view. Classification and evaluation criteria for different RAMS + I factors are outlined and discussed. RAMS + I factor classification and qualitative assessment makes it possible to develop comparable risk profiles for different concepts or combinations of components. The multi-factor risk profiling presented in this paper is based on the known multi-criteria decision analysis (MCDA).

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