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Challenges in the reliability and maintainability data collection for offshore wind turbines

Z. Hameed [a,*], J. Vatn [a], J. Heggset [b]

[a] Norwegian University of Science and Technology, Production and Quality Engineering, N-7491, Trondheim, Norway
[b] SINTEF Energy Research, Trondheim, Norway

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ABSTRACT

Wind energy is abundantly available both onshore and offshore. As a response to the present climate crisis focus on wind energy is increasing due to its renewable and environmentally friendly characteristics. Due to social and political reasons the trend has been shifted largely from onshore to offshore wind farms. Offshore wind energy production faces a wide range of new challenges in design, development, manufacturing, installation, and maintenance and operation. The need, objectives, method, benefits, and application of a proposed reliability and maintainability database are identified in this paper. In the offshore oil and gas industry the OREDA concept for data collection has been running for more than 25 years. Therefore it will be briefly described what is considered to be the state of the art in this industry when it comes to data collection. Potential challenges and issues pertaining to the reliability and maintainability data collection of offshore wind turbines are outlined and categorized. The architecture of the proposed database is illustrated. The main building blocks of the database are briefly described and their possible effects on the reliability and maintainability of offshore wind turbines are highlighted. It is expected that the realization of the proposed database will open a new vista of knowledge in understanding the real behavior of offshore wind turbines in the marine environment. Another expectation is the benefits it will bring to the technological areas ranging from design to operation.

1. Introduction

Wind energy is the emerging source of power today and its share of total energy production is increasing on a very rapid scale. Currently the installation of wind turbines is at its peak and focus is shifting from onshore to offshore locations. The projection of wind energy growth worldwide and the development of offshore compared to onshore wind turbines are shown in Figs. 1 and 2 respectively.

It is expected that the share of offshore wind energy will increase rapidly as the time passes and possibly may surpass other traditional and renewable energy sources. One such scenario for the growth of offshore wind energy is shown in Table 1.

Table 1 indicates that total offshore wind power production is calculated to be TWh 2,559 in 2050, offshore wind power will supply a little more than 6% of global final electricity consumption and will constitute approximately 18.4% of total wind power capacity. The assumed growth implies that the accumulated global offshore wind power capacity will double each 2nd to 3rd year until 2015, each 3th year from 2015 to 2020 and, finally 5th year from 2020 to 2050 [1].

Due to the rapid growth of offshore wind power (its share in the energy market is expected to rise exponentially within the coming decades) has necessitated researchers and industry partners to incorporate novelty from the design phase to operation and maintenance (O&M). With the emergence of this offshore wind power arena, research is focused on how to have robust design in a marine environment, what kind of vessels should be employed to install and maintain the wind turbines, how the issues related to transportation, logistics, and accessibility in a offshore environment will be addressed, and what the optimal O&M strategies will be. These issues are of great concern for the people engaged in different areas of offshore wind turbine work today. There are new concepts and thoughts to address all such kinds of challenges and one possible solution to deal with them is to have methodologies that ensure the reliability of the wind farm as a whole.

One such factor to ensure the reliability of offshore wind turbines (OWT) is to implement the RAMS (Reliability, Availability, Maintainability and Safety) engineering holistically, starting from the design to the operational phases. As reliability and maintainability

* Corresponding author. Tel.: +47 73 59 71 02; fax: +47 73 59 71 17.
E-mail address: zafar.hameed@ntnu.no (Z. Hameed).

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Table 1
Scenario for global offshore wind power development [1].

Year	Offshore wind GW	Yearly growth offshore wind/%	Offshore of total wind power/%	Production from offshore wind/TWh/y	Expected global electricity consumption/TWh/y	Penetration of offshore wind, %
2006	0.9		1.2	3	15,500	0.0
2015	12.8	34	2.6	42	21,300	0.2
2020	42.4	27	4.0	140	23,800	0.6
2030	251.1	19-5	9.5	829	29,750	2.8
2050	773.8	5.5	18.4	2559	40,100	6.4

are integral part of the RAMS concept, one way to address the new challenges of OWT is to have a dedicated RAMS database which will underpin the implementation of RAMS engineering on the whole system. In order to realize this database, data should be gathered from all available wind turbine manufacturers who are engaged in the OWT business. The database should contain all the necessary information for conducting RAMS engineering for having a reliable design, decreased downtimes, and stable production from the system.

The concept of having a common database for the industry is not a new idea. It follows the inception of reliability approaches and consequently their applications in engineering after World War I. A good repository of existing databases related to reliability and accidents is summarized in [2] and the reader is strongly recommended to consult in order to gain an overview of the existing databases and their nature. Databases related with reliability, safety, and offshore accidents could be of direct use in formulating the new database for the OWT industry.

Today's best-known wind turbine databases include WMEP [6] and LWK [23] from Germany, and the WindStats Newsletter published in Denmark. Additional databases originate from Finland (VTT), and Sweden (Elforsk) [3]. Besides these data sources for wind turbines, a dedicated RAMS database is available under the heading of "OREDA" (**O**ffshore **Re**liability **Da**ta) for the oil and gas industry which was the joint venture of different industries engaged in this business. Although this database is related to the oil and gas industry it still may provide a good foundation for making a reliable and accurate RAMS database for OWT and could be a good starting point for having a repository for a RAMS database. This database is dealing exclusively with reliability issues and it is expected that the experience gained from this database could be translated into a dedicated RAMS database for OWT.

2. RAMS database for OWT

2.1. The need for a RAMS database

The rapid growth of the wind power has compelled the need for a database for the reliability and safety of wind turbines. The situation in the wind power industry today is that there is no coordinated and dedicated RAMS database for wind power equipment in the Nordic countries. The typical situation is that the manufacturers of wind turbines retain the detailed data about faults and other incidents through O&M contracts with the wind turbine owners. Such contracts usually define the requirements for availability and reliability, and detailed reports about component faults and power interruptions are typically neither required nor made available to the wind turbine owner upon request. A challenge to solve in this context will be to work out a suitable compromise between the data transparency required in the database and the protection of information that is considered to be sensitive/competitive by the owners.

In order to enable the assessment of RAMS for critical components, such a database is a necessity and the work to implement and make it operational should thus be given high priority. By the involvement of several countries in accomplishing such a task, the number of comparable components will be large and thus provide more reliable statistics. This means that the wind turbine owners will get a standard to base their O&M contracts upon.

2.2. Description of the objectives of a RAMS database

The main objective of a reliability study should always be to provide decision support. Before a reliability study is initiated, the decision maker should clarify the decision problem, and then the objectives and the boundary conditions and limitations for the study should be specified such that the relevant information needed as an input to the decision is at hand, in the right format and on time [4].

The objective of such an activity will be to develop the scientific foundation for a future RAMS database for critical components in wind power farms. This could be achieved through the following activities:

- definition of basic requirements including terminology, and stakeholders.
- definition of stakeholders' needs regarding RAMS data.
- analysis and definition of input data required to fulfill the user needs.

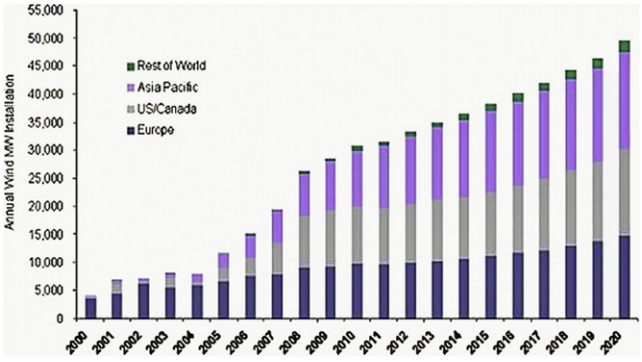

Fig. 1. Global wind energy growth scenario [20].

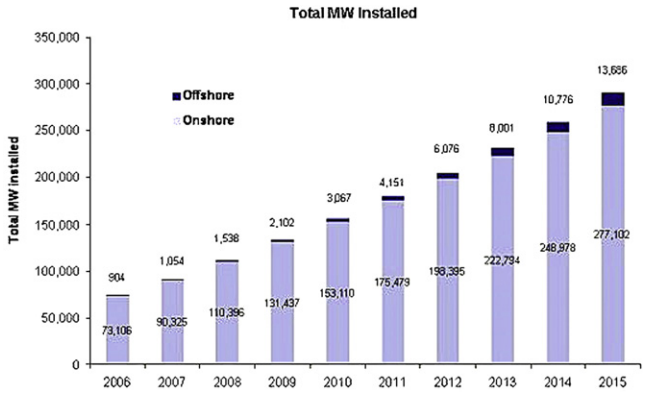

Fig. 2. Development of onshore and offshore wind energy [20].