FIGURE 1: ALPHA VENTUS WIND FARM IN GERMANY THAT IS USED TO VALIDATE METHODS FOR PREDICTING REMAINING LIFE

TASK 42 REPORT 2020

The objectives of the IEAWIND

With a significant number of wind turbines reaching their planned design life (usually 20 years), it is essential that wind farm owners take decisions regarding their viable options: life extension, repowering, or decommissioning.

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The objectives of this Task are to coordinate international research activities towards the assessment of the remaining operational life of wind turbines nearing the end of their certified design life and identification of strategies for extending the end of useful life. This will be done through research activities for determining the probability of failure of different wind turbine components upon continued operation, examination of procedures that demonstrate the feasibility for life extension, the requirements for maintenance and to recommend findings to international standards and regulatory bodies. The decision on lifetime extension is to be taken based on technical, legal, and economic aspects.

To enable life extension, the wind turbine components should have sufficient remaining useful life (RUL), for which they need to be assessed to ensure their integrity upon continued operation. This implies that the annual probability of failure of structural components is still acceptable, considering the maintenance history and component-failure modes. Key actions in the first year of the project included assessment of the missing elements today in lifetime extension procedures, the determination of wind farm data available for life extension studies, quantification of the usefulness of types of data to decision making for life extension and the level of confidence in life prediction possible with the data.

Progress and achievements

The Task has held three online meetings in 2020 where all partners have participated. Several presentations on the benchmarking of methods for remaining life prediction of structures and components were made. Details of economic analysis of wind farms for remaining life assessment was also presented. Based on the meetings held in the Task, the deliverable report D-2, entitled 'Procedures for determining risk of failure and preventive maintenance' has been compiled and submitted. The publications from the Task can be found at https://iea-wind.org/task42/t42-publications/

The Task actively defined the benchmarking exercise, as based on data from the following sources

1) Alpha Ventus Wind farm as shown in Fig. 1.

2) DTU V52 wind turbine

3) Canadian wind farms with cost information

Prediction of the remaining life on major structures and components of the wind turbines was carried out with the data from the above sources. It was observed that the damage equivalent loads of different parts can be forecast based on the data that were acquired, and the forecasting accuracy is reasonably accurate for major components in the near term period. Data for offshore substructures such as jackets was found to be corrupted and not useable. High scatter in some of the measured data causes the forecasting accuracy of remaining life to have a large uncertainty. Therefore, while the methods for life estimation can be sufficiently accurate, the measurement uncertainty must be significantly low to be able to enable accurate remaining life forecasting. Further analysis is being made to determine the variation in remaining life forecast using measurement data and will be presented in the deliverable report D6: Benchmark methods for remaining life prediction based on case study.

The benchmark study also investigated the effect of structural reliability on the economic feasibility for lifetime extension of a wind farm based on cost data provided by University of Windsor. It was found that the use of the probabilistic assessment method will generally lead to longer predicted fatigue life than deterministic analysis. If the target reliability upon life extension is reduced from 3.3 to 3.1, it would lead to about 15 additional years of fatigue life, if the deterministic assessment results in a lifetime of 25 years or more. The longer fatigue life can provide a larger potential for profit generation.

Highlight

Probabilistic life assessment methods can lead to longer additional fatigue life than traditional deterministic assessment methods used today as the uncertainties in the models and measurements can be introduced in the life model directly without added conservatism. Extrapolation methods are required in order to predict the damage equivalent load levels on wind turbine structures in the future, based on present load measurements or simulations. Such extrapolation is usually made using probabilistic methods of understanding the probability of exceedance of DELs, given environmental conditions. The extrapolation can also be based on correlation studies between loads and met-ocean conditions. This allows the determination of the threshold DEL, that should not be exceeded

TABLE 1. COUNTRIES PARTICIPATING IN TASK

Table 1. Task 42 Participants in 2020		
	Country/Sponsor	Institution(s)
1	Denmark	Technical University of Denmark (DTU), Aalborg University, EMD A/S
2	Germany	University of Stuttgart, Enercon, Woelfel, Technical university of Munich, University of Hannover, Fraunhofer IWES
3	Canada	University of Windsor
4	China	China General certification, Goldwind

and a period of wind turbine operation, wherein this threshold will not be exceeded with a target probability level. A key economic factor for lifetime extension are the maintenance costs and here preventive maintenance and constant tracking of the risk of failure should be made feasible. A major need for enabling preventive maintenance is the digitization of inspection reports and the digital validation that defects reported in inspections are rectified under maintenance. This is not happening today leading to failures that can be prevented based on digital alarms on non-addressed issues found during inspections.

Outcomes and significance

One of the key objective of the Task is to determine procedures that are essential for lifetime extension standardization and present findings on developed procedures to different IEC standards committees as applicable. Methods of extrapolation of measured DELs to predict future trends are essential, as well as determining the risk of failure of wind farm assets on a continual basis. Hence a greater focus on remote monitoring and decision making based on data analytics is required. Measurement uncertainty must be lower than the uncertainty in the models used for determining remaining useful life. A probabilistic approach to life extension is appropriate and integratable with data to determine the reliability of major structures and components upon life extension.

Next steps

In 2021, the project would focus on completing the benchmarking exercise to come out with recommendations on the methods for remaining life estimation and the value of data. The project will develop measures to quantify the value of data for lifetime extension based on an existing wind farm, measurement data. A comparison will be made using the methods developed by the different participants as to the targeted end of life of the wind farm for the specified annual reliability, the predicted mean time between failures, the estimated maintenance cost, and the performance upon lifetime extension.