

Report 2021

Task 42

Picture of the DTU V-52 research turbine, which has been chosen as case turbine for estimating the remaining useful life time of older onshore wind turbines based in turbine instrumentation data as well as aero elastic models. The DTU V-52 research was installed at the DTU Risø campus in 2015, but the Vestas V-52 turbine was introduced to the marked in year 2000 and is therefore a typical turbine model that will operate beyond the design life time in the coming years.

Wind Turbine Lifetime Extension

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IEA Wind Task 42 on Lifetime Extension was formulated, since a large number of wind turbines are approaching an age similar to their design life time.

Some wind turbines are even operated for considerable longer time than the design life time in some of the established wind markets like northern Europe and the US. The objectives of the Task is to examine methods for evaluating, if a life time extension for a wind asset will be economical feasible.

This is addressed by examining any information about the environmental conditions of the turbine, such as wind speed and direction, as provided by the SCADA measurements of the turbine and then aeroelastic simulations of the corresponding loads of the turbine. Secondly inspection methods of the main structural parts

Table 1. Task 42 Participants in 2021

COUNTRY/SPONSOR	PARTICIPATING INSTITUTION(S)
Denmark / EUDP	Technical University of Denmark Aarhus University EMD International A/S
Germany	Hanover Stuttgart Wölfel Enercon
China	Goldwind

of wind turbines have been investigated in order to provide recommendations to the regulatory frame work and authorities. A recommendation on life extension procedures will be provided when the task 42 is completed.

Progress and Achievements

The main focus of the task has been on a re-evaluation of the reliability index associated with a life extension of a wind farm as well as evaluating the value of data in the process of examining if a life extension is feasible.

A re-evaluation of the reliability index for turbine life extension has been performed by Aalborg University, since the current design standard IEC 61400-1 does only specify a reliability index of 3.3 for the construction, but is lacking a reliability index for existing turbines operating beyond the design life time of 20 years. A generic economical case has been formulated by scaling the cost of the life extension to the annual profit of the turbine. By minimising the present value also taking into account the fatigue on the O&M cost it was possible to recommend a reliability index of 3.1 and with an expected increase in the number of collapsed turbines by only a factor of two. A more specific economical model of a wind farm holding 44 turbines with a power rating of 2.3 MW has been analyzed using the recommendation of a reliability index of 3.1 resulting in an estimate of additional life time of 15-25 years [2].

The advantage of using measurement data in the assessment of life extension of wind turbines has been applied to the case of the German offshore wind farm Alpha Ventus by University of Hanover [3]. It has been investigated how to utilise strain-gauge measurements on the turbine tower. Strain-gauge measurements are often only available for a limited fraction of the operation time of a wind farm since they fail and a method for extrapolating the consumed fatigue life of a structure to the future is needed for evaluating life extension projects. It has been found that above half a year of strain gauge measurements preferably obtained in the winter period for the North Sea is needed to provide an extrapolation of the damage with an error in the order of 10-40 %. If the measurement period is expanded to cover 1-2 seasonal cycles of the wind farm site then the error is reduced to about 10 % [3].

bine (fig. 1) has been selected for a comparison of the prediction of the remaining useful life estimated from a detailed and generic aero-elastic model using the measurements from the turbine.

Highlight

- The work of Nielsen et. al. [1,2] on establishing a reliability index recommendation of 3.1 for onshore wind turbines operating beyond their 20 year design life time is seem as major result, since this is providing a method for balancing the risk of failure with the economic benefits of continued operation of the turbines.

Outcomes and Significance

The recommendation of a reliability index of 3.1 for the life extension period of onshore turbines for another 15-25 years is seen in a considerable input to the methodology of evaluating if life extensions are feasible. It is believed that further standardisation work will benefit from this input, but further work is needed to also cover offshore wind in more details.

Next Steps

The final activity of task 42 life extension is to perform an estimate of the remaining useful life of the DTU V-52 research turbine using measurements in combination aeroelastic models.

Recommendations for authorities will be formulated and the final reports of the tasks will be written in 2022.

The task 42 Life extension is working on formulating an extension of task for another 2-3 years in order to investigate how life time extension can be supported by minimum measurements in electricity markets, where the price of electricity has increased considerably.

References

[1] Nielsen, J. S., & Sørensen, J. D. (2021). *Riskbased derivation of target reliability levels for life extension of wind turbine structural components. Wind Energy, 24(9), 939-956.* https://doi.org/10.1002/we.2610

[2] Nielsen, J. S., Miller-Branovacki, L., & Carriveau, R. (2021). *Probabilistic and risk-informed life extension assessment of wind turbine structural components. Energies, 14(4), [821].* https://doi.org/10.3390/en14040821

[3] Hübler, C. and Rolfes, R.: *Probabilistic Temporal Extrapolation of Fatigue Damage of Offshore Wind Turbine Substructures Based on Strain Measurements, Wind Energ. Sci. Discuss. [preprint],* https://doi.org/10.5194/wes-2022-15, in review, 2022.

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