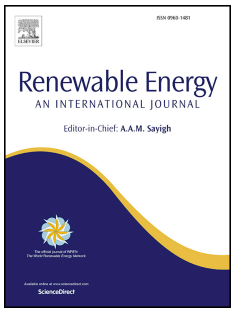
Accepted Manuscript



A comprehensive fatigue load set reduction study for offshore wind turbines with jacket substructures

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PII: S0960-1481(17)31065-0

DOI: 10.1016/j.renene.2017.10.097

Reference: RENE 9385

To appear in: *Renewable Energy*

Received Date: 1 June 2017

Revised Date: 15 September 2017

Accepted Date: 27 October 2017

Please cite this article as: Häfele J, Hübler C, Gebhardt CG, Rolfes R, A comprehensive fatigue load set reduction study for offshore wind turbines with jacket substructures, *Renewable Energy* (2017), doi: 10.1016/j.renene.2017.10.097.

A comprehensive fatigue load set reduction study for offshore wind turbines with jacket substructures

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Abstract

Designing jacket substructures for offshore wind turbines demands numerous time domain simulations to face different combinations of wind, wave, and current states. Regarding sophisticated design methods incorporating structural optimization algorithms, a load set reduction is highly desirable. To obtain knowledge about the required size of the design load set, a study on fatigue limit state load sets is conducted, which addresses mainly two aspects. The first one is a statistical evaluation of random subsets derived from probabilistic load sets with realistic environmental data obtained from the research platform FINO3. A full set comprising 2048 load simulations is gradually reduced to subsets and the results are compared to each other. The second aspect is a systematic load set reduction with the assumption of unidirectional wind, waves, and current. Firstly, critical directions are determined. Then, unidirectional load sets are systematically reduced. The corresponding damages are compared to those obtained from probabilistic load sets for eight test structures. It is shown that the omission of wind-, wave-, and current-misalignment does not necessarily imply an excessive simplification, if considered wisely. The outcome of this study can be used to decrease the numerical effort of the jacket design process and the levelized costs of energy.

Keywords: Offshore wind energy, Fatigue limit state, Load set reduction, FINO3, Jacket substructures, Lattice substructures

Nomenclature

Γ	Gamma-function
α	Statistical shape parameter (β-distribution)
β	Statistical shape parameter (Gumbel and β-distribution)
β_b	Ratio of bottom brace-to-leg diameter (jacket model)
β_t	Ratio of top brace-to-leg diameter (jacket model)
γ_b	Ratio of bottom leg radius to leg thickness (jacket model)
γ_t	Ratio of top leg radius to leg thickness (jacket model)
θ	Statistical scale parameter (γ-distribution)
θ_{wave}	Wave direction (north: 0°, west: 90°)
θ_{wind}	Wind direction (north: 0°, west: 90°)
λ	Statistical scale parameter (Weibull distribution)
μ	Mean, statistical location parameter (Gumbel, Log-normal distribution)
ξ	Head-to-foot radius ratio (jacket model)