Fully integrated load analysis included in the structural reliability assessment of a monopile supported offshore wind turbine

Objective
To investigate where cost reduction are possible in the support structure while keeping a sound and safe design:
- Probabilistic design methods are used.
- For time efficient load computations TURBU, a fast fully integrated wind turbine design and analysis tool in the frequency domain, is integrated in the probabilistic approach.

TURBU
- Full non-linear steady state model (multi-body average deformation)
- Time-invariant linear dynamic model (multi-body, Newton, Coleman)
- Linear frequency and time domain analysis of 3-bladed Horizontal Axis Wind turbines

Fatigue limit state:
\[ g = \Delta - D = 0 \]
\[ N_{\text{max,}i} = f(\log C_1, \log C_2) \text{ of SN-curve (DNV RP-C203)} \]
\[ D = \sum_{i} \frac{n_i}{N_{\text{max,}i}} \]

Case study
- Modern 4MW wind turbine with monopile support structure, rotor diameter 130m, in 30m water depth.
- Twelve wind bins with for every wind bin six time series of one hour.
- Windspeed Weibull distribution \( k = 2.15 \) and \( u = 9.36 \text{m/s} \).

Conclusions and recommendations
- Integration of full load calculations in probabilistic design method (FORM) is successful for fatigue limit state at mudline.
- The contribution of the Miner rule (Delta) and SN-curve (logC2) variables to the variance of the limit state function is largest.
- Calculated reliability index \( \beta = 6.35 \) shows there is room for design optimisation.
- Ultimate limit state and additional locations still need to be included.

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