Model of wind shear conditional on turbulence and its impact on wind turbine loads - DTU Orbit (02/10/2019)

Model of wind shear conditional on turbulence and its impact on wind turbine loads

We analyse high-frequency wind velocity measurements from two test stations over a period of several years and at heights ranging from 60 to 200 m, with the objective to validate wind shear predictions as used in load simulations for wind turbine design. A validated wind shear model is thereby proposed for flat terrain and that can significantly decrease the uncertainty associated with fatigue load predictions for wind turbines with large rotors. An essential contribution is the conditioning of wind shear on the 90% quantile of wind turbulence, such that the appropriate magnitude of the design fatigue load is achieved. The proposed wind shear model based on the wind measurements is thereby probabilistic in definition, with wind shear jointly distributed with wind turbulence. A simplified model for the wind shear exponent is further derived from the full stochastic model. The fatigue loads over different turbine components are evaluated under the full wind measurements, using the developed wind shear model and with standard wind conditions prescribed in the IEC 61400-1 ed. 3. The results display the effect of the Wöhler exponent and reveal that under moderate turbulence, the effect of wind shear is most pronounced on the blade flap loads. It is further shown that under moderate wind turbulence, the wind shear exponents may be over-specified in the design standards, and a reduction of wind shear exponent based on the present measurements can contribute to reduced fatigue damage equivalent loads on turbine blades. Although the influence of wind shear on extreme loads was found to be negligible, the IEC 61400-1 wind shear definition was found to result in non-conservative estimates of the 50 year extreme blade deflection toward the tower, especially under extreme turbulence conditions. Copyright © 2014 John Wiley & Sons, Ltd.

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