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Extrapolation of Extreme Response for Wind Turbines based on Field Measurements

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ABSTRACT

The characteristic loads on wind turbines during operation are among others dependent on the mean wind speed, the turbulence intensity and the type and settings of the control system. These parameters must be taken into account in the assessment of the characteristic load.

The characteristic load is normally determined by statistical extrapolation of the simulated response during operation according to (IEC 61400-1 2005). However, this method assumes that the individual 10 min. time series are independent and that peaks extracted by the Peak Over Threshold method are independent. In the present paper two new methods for loads extrapolation are presented.

The first method (method 1) is based on the same assumptions about independence of the individual extremes and the 10 min. time series as the existing method. However, for this method the statistical extrapolation is only performed for a limited number of mean wind speeds where the extreme load is likely to occur. The wind speed for which the response can start to become critical is denoted the storm wind speed and determined from the nominal wind speed for the wind turbine and the turbulence intensity.

The second method (method 2) for load extrapolation divides the 10 min. mean wind speeds into storms which are assumed independent. The assumption about independence is secured by adding a time separation between the storms and combined two storms into one if the mean wind speed between the storms is not below 80% of the storm wind speed. The characteristic load is determined by statistical extrapolation of the extreme load in each storm.

RESULTS

In order to compare the existing method in (IEC 61400-1 2005) with the two new methods proposed in this paper the characteristic load is calculated for the same wind turbine using the three different methods. The calculated characteristic loads are given in table 1 where the loads are normalized with the characteristic load calculated for IEC 61400-1 without statistical uncertainty.

Table 1. Characteristic loads for the three methods.

Method	Characteristic load	
	without stat. unc.	with stat. unc.
IEC 61400-1	1.000	1.037
Method 1	1.025	1.162
Method 2	1.106	1.348

For the first method (method 1) the calculated characteristic load without statistical uncertainty is approximate 3% higher than using (IEC 61400-1 2005). For the second method (method 2) the characteristic load without statistical uncertainty is approximate 11% higher. The significant increase in the characteristic load by using this method can be due to that the assumptions of independence of the extremes and the 10 min. time series in the (IEC 61400-1 2005) method are not satisfied.

Based on the present study it is recommended that load extrapolation for wind turbines during operation is performed by the second method where the characteristic load is determined based on the extreme loads in each storm. The advantage of this method is that the load extrapolation is performed based on independent extremes leading to a statistically more accurate determination of the characteristic load. The drawback of the method is the large amount of measurement or simulations required in order to perform the load extrapolation.