Hill of Fare Wind Farm

Technical Appendix 12.3

Calculating Standardised Wind Speed

Author	Peter Brooks
Date	12 September 2023
Ref	04542-6411044

Contents

1 Calculating Standardised Wind Shear

1.1 Introduction

1.1.1 In order to derive appropriate noise limits the ETSU-R-97 guidance requires the correlation of background noise survey data with wind speed data referenced to 10 m height. In contrast, acoustic emission measurements on turbines are undertaken in accordance with international standard IEC 61400-11, 'Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques'[1], which specifies that the turbine noise emission should be reported as a function of 'standardised' wind speed at 10 m height. In practice this involves extrapolating hub height wind speed down to 10 m height using a specified, and fixed, relationship. The resulting 'standardised' 10 m wind speed is essentially a proxy for hub height wind speed which is the primary driver of noise emission from the turbine.

1.1.2 The use of a fixed relationship between hub height and 10 m wind speed means that potential exists for the background noise data and acoustic emission data to be misaligned i.e. a wind speed measured at 10 m height is not necessarily equivalent to a 'standardised' 10 m wind speed of the same magnitude, with the difference depending upon the site specific shear exponent (the rate of change of wind speed with height).

1.2 Methodology

Accounting for Site Specific Shear

1.2.1 To account for the effects of site-specific shear, the background noise data is referenced to the same wind speed as the acoustic emission data. The approach used is consistent with that recommended in an article published in the Institute of Acoustics Bulletin and the subsequent Good Practice Guide (option b in paragraph 2.6.3).

1.2.2 To account for site specific wind shear effects in accordance with the aforementioned approach, the standardised 10 m height wind speed is found by:

1 'Wind turbine generator systems - Part 11: Acoustic noise measurement techniques', IEC 61400-11:2003 (Amendment 1: 2006)

Calculating the shear exponent from the wind speed measured at two heights. The following formula is used to determine the shear exponent:

$$\alpha = \frac{\log\left(\frac{v_2}{v_1}\right)}{\log\left(\frac{h_2}{h_1}\right)}$$

Where: v_2 = upper height wind speed
v_1 = lower height wind speed
h_2 = height of upper wind speed (125 m)
h_1 = height of lower wind speed (115 m)
α = wind shear exponent

Extrapolating the measured wind speed to the proposed hub height using the calculated wind shear exponent. The hub height wind speed for each 10 minute period may be calculated using this equation:

$$v_{hub} = v_{top}\left(\frac{h_{hub}}{h_{top}}\right)^{\alpha}$$

Where: v_{top} = wind speed measured closest to hub height
v_{hub} = wind speed at proposed hub height
h_{top} = height of closest measurement (125 m)
h_{hub} = maximum proposed hub height (122.5 m)
α = calculated wind shear exponent

The corresponding 'standardised' 10 m wind speeds are then calculated from the derived hub height wind speed using the following formula and it is this resultant standardised 10 m wind speed that shall be used in correlation with the measured background noise levels:

$$v_S = v_{hh}\left[\frac{ln\,\frac{z_{ref}}{z_0}}{ln\,\frac{hh}{z_0}}\right]$$

Where: v_s is the 'standardised' wind speed
v_{hh} is the hub height wind speed
Z_0 is the reference roughness length (0.05 m)
Z_{ref} is the reference height (10 m)
hh is the maximum proposed hub height (122.5 m)

The resulting ‘standardised’ 10 m wind speed is correlated with the measured background noise survey data.

1.2.3 Referencing the background noise levels to standardised 10 m wind speed calculated from the wind speed at 122.5 m height means that the resulting noise limits will also be referenced to wind speed at this height.