Interpretation and Use
of
Proven Energy P35 Wind Turbine Noise Data

ACOUSTIC NOISE LEVELS				
Turbine Make:	PROVEN		Model:	WT 15000 (WB6000x3)
NOISE EMISSION LEVEL				NOISE PENALTY
Sound Power $L_{Wd,8m/s}$	97 dB(A)	Noise slope, S_{dB} (dB/m/s)	1.94	NO

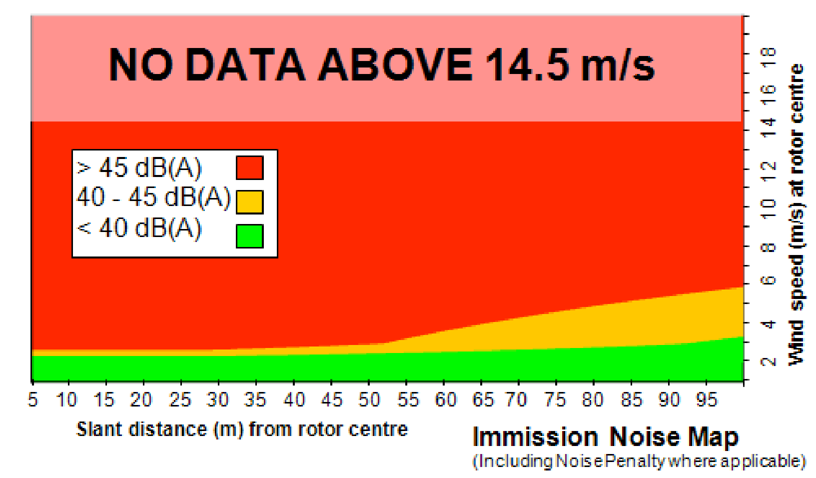

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Figure 1 Certified Noise Label for Proven P35 (formally known as the WT 15000)

1 INTRODUCTION

The Proven Energy P35 (formally known as the WT15000) wind turbine has undergone acoustic testing by an independently accredited third party (TUV NEL) in accordance with the BWEA Small Wind Turbine Performance and Safety Standard (2008). The turbine's acoustic performance is summarised in a Noise Label, Figure 1, issued by TUV NEL.

The purpose of this document is to provide the reader with information that explains the background and content of the noise label and, perhaps more importantly, how the noise label can be used to assess the suitability of the turbine for a planned installation. This is of particular relevance to planning authorities, installers and end users. The key issues discussed are:

- The Noise Label structure and content. This covers:
    - Noise Emission: i.e. fundamentally how much inherent noise is generated
    - Noise Immission: i.e. how much noise can be heard by a listener (receiver) at a distance

- Assessing the Noise Impact: i.e. what is the likelihood of complaint at a given receiver distance

2 NOISE LABEL STRUCTURE AND CONTENT

The top panel, Figure 2, of the Noise Label contains the summarised **Noise Emission data**.

NOISE EMISSION LEVEL				NOISE PENALTY
Sound Power $L_{Wd,8m/s}$	97 dB(A)	Noise slope, S_{dB} (dB/m/s)	1.94	NO

Figure 2 Noise Emission Data

This shows the Sound Power of the turbine (at a reference rotor centre wind speed of 8 m/s) and how that power changes with wind speed (the noise slope in dB/m/s). The units of sound power are dB(A) referenced to 10^{-12} Watts.

Fundamentally the Sound Power is the inherent amount of acoustic power generated by the turbine. Its use is primarily to quantify the acoustic output of a machine so that it can be compared to that of similar machines and also to allow predictions of sound pressure levels at distance to be made.

The Sound Power is measured in accordance with the BWEA procedure. This Standard has been developed by the UK small wind turbine industry to address the particular requirements of small wind turbines; generally any turbine less than 50 kW in size. The Standard provides a methodology for tests to satisfy the requirements of MCS 006 product testing and the process of CE Marking. The acoustic procedure is based on a modified form of IEC 61400-11 test but bespoke for small turbines since these differ in many respects from the large turbines for which IEC 61400-11 was designed.

To obtain the sound power, the turbine noise is measured under controlled conditions over a wide range of wind speeds and the data plotted as a noise versus wind speed relationship. Regression analysis is carried out and the noise relationship summarised as the declared noise level given in Figure 2. The declared noise level is the preferred method of expressing machinery noise in the European Community and follows the principles laid down in standards such as **ISO 4871** and IEC 61400-14. The declared level takes into account the uncertainty of the test method used to measure noise and is, in effect, the noise level, to a confidence level of 95%, that will not be exceeded.

The top panel also shows whether any Noise Penalty need be applied. This essentially indicates whether the turbine noise has any acoustic features. The key feature checked as part of the BWEA (and IEC) procedure is the turbine's tonality. The criterion used in the BWEA procedure is the simplified tonal assessment as described in ISO 1996:2(2005) Annex D.

The lower part of the Noise Label, Figure 3, contains the **Immission Noise Map**. This is a prediction (estimate), for given rotor centre wind speeds, of whether the sound pressure level at a distance from the turbine rotor centre will be in one of three regions; <40 dB(A), 40-45 dB(A) or > 45 dB(A).

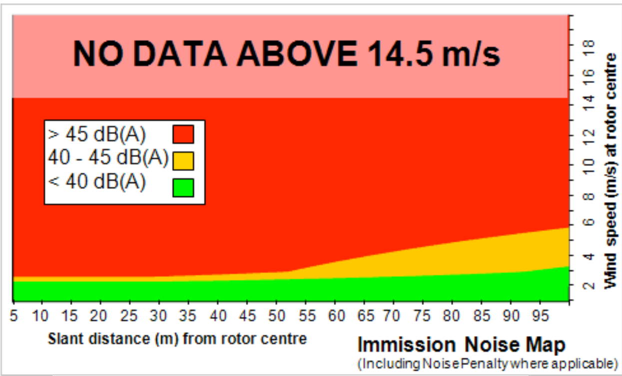

Figure 3 Noise Immission Map

The 45 dB(A) value is used since this is the maximum recommended level for night-time noise outside a bedroom window as given in the WHO Community Noise Guide. It is the free field sound pressure level after façade correction. The 40 dB(A) level is simply chosen as 5 dB less than the 45 dB(A) WHO guide level.

The key objective of the Immission Noise Map is to provide a rapid means (with minimal calculation) of estimating how the noise at a distance compares against the recommended WHO night-time noise level. As can be seen from Figure 3 for the WT 15000, any rotor centre wind speed greater than 6 m/s will result in noise levels > 45 dB(A) within 100 m of the turbine.

The 'No data' panel on the map shows the limit of data collected during the acoustic measurements.

3 PREDICTING THE NOISE FOR A GIVEN (OR PLANNED) INSTALLATION

Due to the variability of wind speeds, local layout and proximity of noise sensitive areas between different sites, an assessment of noise suitability has to be made on a site-by-site basis. Appendix A to the BWEA SWT Performance and Safety Standard describes a simple assessment procedure based on the use of the NOABL wind speed database, as follows:

a) Find the National Grid reference for the proposed turbine location. This can be obtained from an ordinance survey map or from the Postcode if a suitable conversion program is available. Shorten the reference to the NOABL required format; e.g. if the Grid Reference is NS641532, then the NOABL input value is NS 64 53.

b) Use NOABL to get the average annual wind, $V_{avg,10}$ at 10 m height for the location.

c) Assume a Rayleigh wind distribution, calculate the 90% wind (i.e. the wind that is only exceeded 10% of the time), V90,10, for 10 m height as:

$$V_{90,10} = 1.72 * V_{avg,10} \qquad (1)$$

d) Apply a wind correction factor from 10 m height using a power law (in accordance with IEC 61400-2) to get an estimate of wind at the installed rotor centre height, H, as:

$$V_{90,H} = V_{90,10} * \left(\frac{H}{10}\right)^{0.2} \qquad (2)$$

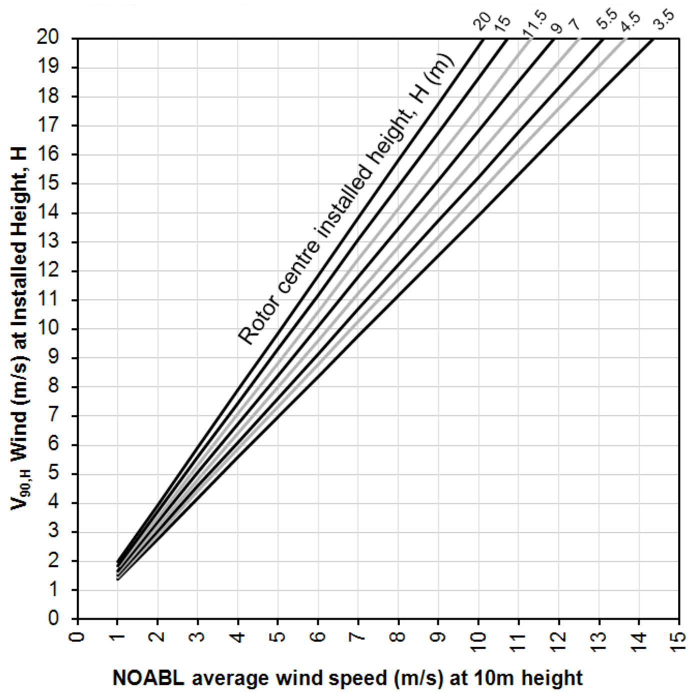

Figure 4 Nomograph for $V_{90,H}$

Figure 4 provides a nomograph to obtain $V_{90,H}$ from a $V_{avg,10}$ rather than by use of equations (1) and (2).

e) Draw a horizontal line on the Immission Noise Map at the V90,H wind speed and read off the distance for the 45 dB(A) and 40 dB(A) values. If the distances are above 100 m (and consequently off the map scale) the values can be calculated for rotor centre wind speeds up to 8 m/s using equations (7) and (8) in the BWEA standard.

Note: This procedure provides a conservative estimate since in Step d) it does not further reduce the wind strength seen by the turbine due to local obstructions and hence errs on the side of the general public rather than the turbine manufacturer. If there are buildings or other obstructions in the vicinity of the turbine then further wind weighting factors (site factors as defined in MCS standard MIS 3003) can be applied to account for wind-shadow effects. This, in general, will lower the $V_{90,H}$ value seen by the turbine and result in closer allowable slant distances.

4 ASSESSING THE NOISE IMPACT

Two fundamentally different approaches to the assessment of likelihood of complaint are common:

- Assess a noise level based on its **absolute value** compared to the WHO community noise guide levels; basically against a maximum allowable night-time noise level of 45 dB(A)
- Assess noise levels using BS 4142 on their **relative difference** to the local background noise

The view taken by the wind turbine industry, and as described in the widely accepted ETSU-R97 approach, is that the WHO guide levels form a lower acceptance limit and that the BS 4142 approach would only be applied in situations where the WHO guide levels were exceeded.

Consequently, the BWEA simple assessment approach is based only on the WHO guide level. Once the 45 dB(A) and 40 dB(A) distances are obtained in Step e) of Section 3 above, compare these distances with the slant distance to the nearest noise sensitive location(s) for the planned installation.

In general, any noise sensitive location(s) that lie in the red region are unlikely to be given planning permission since they exceed the WHO night-time guide level. Locations that lie in the green region would generally be acceptable since they are well below the WHO night-time guide level. Locations that lie in the amber region may or may not be acceptable depending on factors such as national or local planning legislation.

4 EXAMPLE

Before looking at a specific example it is worth noting that the default prediction for the Immission Noise Map is only for slant distances up to 100 m. This is because atmospheric noise propagation effects are negligible at distances below 100 m and, consequently, the prediction of free field sound pressure level can be made with a high degree of certainty using a simple hemispherical spreading noise model.

However, as can be seen from Figures 1 and 3, the map for the WT 15000 is largely red. The following example uses an Immission Noise Map for distances up to 400 m as this shows more of the noise features of the turbine including the change in gradient in the curve at the start of the speed-limited region at 10 m/s. Extending the prediction up to distances above 100 m is prone to added uncertainty due to the above mentioned propagation effects but is made here (map provided by TUV NEL) to show indicative levels.

Consider a site where the NOABL wind was 4 m/s at 10 m height and a turbine to be installed at 15 m rotor centre height with the nearest noise sensitive location being 280 m away.

Application of equation (1) gives $V_{90,10}$ = 6.9 m/s and equation (2) $V_{90,H}$ = 7.5 m/s.

When plotted on the turbine's Immission Noise Map, Figure 5, this gives approximate slant distances of 140 and 250 m for 45 and 40 dB(A) respectively.

Any location closer than 140 m would see noise levels in excess of 45 dB(A) and any location further away than 250 m would see noise levels less than 40 dB(A).

Hence in this example the noise sensitive location at 280 m would only see noise levels less than 40 dB(A).

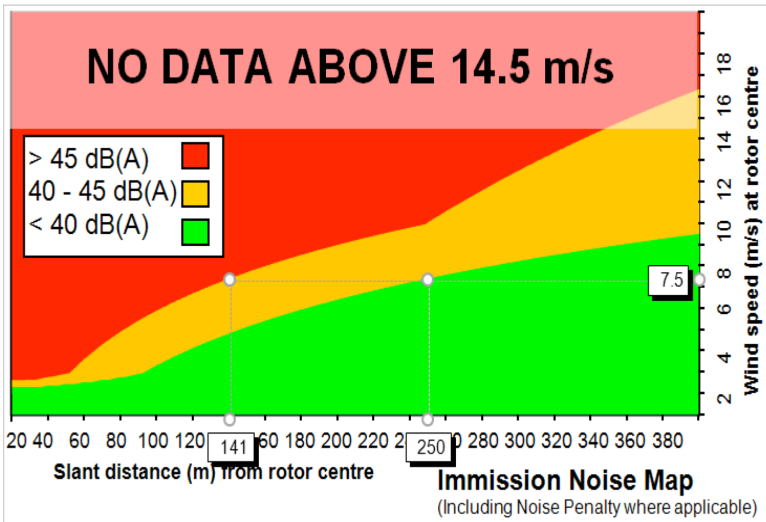

Figure 5 Example for $V_{90,H}$ =7.5 m/s

If an estimate of the noise level at a given distance is required, equation (A.2) in the BWEA standard can be used for rotor centre wind speeds up to the start of the speed-limiting region.