EDP

PROPOSED WIND TURBINE (500 KW)

LAND EAST OF BEMERSLEY ROAD, BEMERSLEY, STOKE-ON-TRENT, STAFFORDSHIRE

NOISE IMPACT ASSESSMENT

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NIA/5155/14/4860/V2	30 April 2014	JR	JR	JR

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SECTION 1 INTRODUCTION

1.1 Environmental Noise Solutions Limited (ENS) has been commissioned by EDP to undertake a noise impact assessment for a proposed wind turbine at land east of Bemersley Road, Bemersley Green, Stoke-on-Trent, Staffordshire.

1.2 The proposal consists of the erection of a single wind turbine with 500 kW rated power generating capacity. The exact model of wind turbine is to be determined at a later date, subject to planning permission being granted, as is common convention. Nonetheless, it can be confirmed that the turbine will have a maximum height to hub of 50 metres and to blade tip of 78 metres (above ground level).

1.3 The noise assessment is made on the basis of a candidate wind turbine. Typical 500 kW wind turbines which comply with these physical limitations are summarised in the following table.

Table 1.1 – Candidate 500 kW Wind Turbines

Model	Rated Energy (kW)	Hub Height (m)	Rotor Diameter (m)	Tip Height (m)	Modelled Sound Power Level (dB(A)), including uncertainty, 10 m/s wind at 10 m height
EWT DW 54	500	50.0	54.0	77.0	100.5 dB L_{WA}
Enercon E-53	500	50.0	53.0	76.5	100.5 dB L_{WA}
Enercon E-48	500	50.0	48.0	74.0	101.0 dB L_{WA}

1.4 The proposed wind turbine is to be installed at grid reference **E388869 N354524** (subject to the micro-siting allowance defined in the Planning Statement).

1.5 The nearest noise sensitive receptors (NSR) are:

- NSR1 – Residential dwellings off Bemersley Road, circa 405 metres to the west south west of the proposed wind turbine (hub)
- NSR2 – Residential dwellings off Bemersley Road, circa 410 metres to the west of the proposed wind turbine (hub)

1.6 A site plan illustrating the relative location of the proposed wind turbine and the nearest noise sensitive receptors is contained in Appendix 1 for reference.

1.7 The information reported herein has been based on the wind turbine manufacturer's noise emission data and has been accepted in good faith as being accurate and valid. The Enercon E-48 (500 kW) wind turbine has been modelled as the candidate turbine (as this has the highest sound power level as set out in Table 1.1).

1.8 A glossary of acoustic terms is contained in Appendix 2 for reference.

SECTION 2 ETSU–R–97 ASSESSMENT CRITERIA

2.1 Principles and guidelines for the environmental assessment of wind turbine related noise are given in the report entitled ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms', based on the findings of the Working Group on Noise from Wind Turbines.

2.2 This document describes a framework for the measurement of wind turbine noise and suggests noise limits to offer a reasonable degree of protection to the neighbouring properties, whilst, at the same time, bearing in mind the significance of wind turbine development as a renewable energy source.

2.3 ETSU-R-97 recommends the imposition of noise limits set relative to the existing background noise (except in low noise environments, where lower absolute noise limits apply) at the nearest noise sensitive properties, taking into consideration the variation in both turbine source noise and background noise with wind speed.

2.4 The following table shows the recommended noise limits for wind turbine related noise at the nearest noise sensitive properties in line with ETSU-R-97.

Table 2.1 – ESTU-R-97 Noise Limits for Wind Turbine Related Noise

Period	ETSU-R-97 Lower Absolute Noise Limit dB L_{A90}	ETSU-R-97 Relative Noise Limit dB L_{A90}
Daytime (0700–2300)	35 – 40	5 dB(A) above background noise
Night time (2300–0700)	43	5 dB(A) above background noise

2.5 It should be noted that at low wind speeds (where background noise is expected to be quieter), the lower absolute noise limits apply, until the background noise has risen to within 5 dB of this level (as wind speed increases) wherein the relative noise limits come into force.

2.6 The fixed daytime limits (35–40 dB(A)) are understood to have been chosen such that they offer a reasonable degree of protection to occupants of nearby noise sensitive properties, whilst at the same time not placing unreasonable restrictions on the development of wind turbines. ETSU-R-97 advises that the actual limit chosen should depend on a number of factors, including the number of dwellings in the vicinity of the site.

2.7 The fixed night time limit (43 dB(A)) has been derived from the 35 dB(A) sleep disturbance criteria referred to in Planning Policy Guidance Note 24 (PPG 24). An allowance of 10 dB(A) has been made for attenuation through an open window (free field to internal) and 2 dB(A) subtracted to account for the use of L_{A90} rather than L_{Aeq}.

2.8 The noise levels recommended in ETSU-R-97 take into account the character of noise described as 'blade swish', although an appropriate penalty should be imposed for any 'tonal' components in the wind turbine noise emissions.

2.9 ETSU-R-97 states (in Paragraph 25 of the Executive Summary) that '*For single turbines or wind farms with very large separation distances between the turbines and the nearest properties a simplified noise condition may be suitable. We are of the opinion that, if the noise is limited to an L_{A90}, 10 min of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then this condition alone would offer sufficient protection of amenity …. We feel that, even in sheltered areas when the wind speed exceeds 10 m/s on the wind farm site, some additional background noise will be generated which will increase background levels at the property*.'

2.10 ETSU-R-97 states (in Paragraph 24 of the Executive Summary) that '*The Noise Working Group recommends that both day- and night-time lower fixed limits can be increased to 45 dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the wind farm*.'

2.11 It is considered that these types of conditions are suitable for this application.

SECTION 3 CANDIDATE WIND TURBINE NOISE PREDICTIONS

3.1 For the purpose of the calculations, the candidate wind turbine noise emissions have been robustly based on the Enercon E-48 (500 kW) wind turbine. The noise emission data for an Enercon E-48 (500 kW) wind turbine has been provided by the manufacturer and is reproduced in Appendix 3 of this report for reference (Enercon Document SIAS-04-SPL E48 OM 500 kW Rev 1_1-eng-eng.doc),

3.2 The data illustrates that the maximum sound power level (L_{WA}) of the E-48 (500 kW) wind turbine is 100.0 dB L_{WA}. Comparison with an individual test report, and liaison with Enercon, illustrates that this value includes a safety factor over test data ascertained in accordance with IEC 61400-11 (note: 99.4 dB L_{WA} maximum sound power level stated in individual test report). The addition of a further 1 decibel uncertainty provides a modelled sound power level (in accordance with the Institute of Acoustics Good Practice Guide to the application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOAGPG) published in May 2013) of 101.0 dB L_{WA} at a 10 metres per second wind speed at a reference height of 10 metres. In accordance with ETSU-R-97, a tonal penalty is not applicable.

3.3 Of particular importance is the way noise propagation from wind turbines is modelled since this is not covered by the ETSU-R-97 guidance which only deals with assessment of any such predicted noise levels. This issue is covered by the IOAGPG. In summary:

- Atmospheric absorption increases linearly with distance, affecting higher frequency sound more than lower frequency sound and varying with temperature and relative humidity. It is not appropriate to model all the possible variations in temperature and relative humidity so a reasonable worst case is usually assumed. The IOAGPG recommends the assumption of a temperature of 10 degrees Celsius and relative humidity of 70 percent.

- Ground attenuation is caused by the interaction of the direct sound wave from the source with that reflected by the ground which depends, in turn, on the acoustic impedance of the ground between the source and receiver. This is modeled in different ways by different prediction methodologies but all categorize the ground around and between the source and receiver as hard, porous, semi-porous or other variant. The IOAGPG states a soft ground factor (G=1.0) should not be used. Although a hard ground factor of G=0.0 is commonly used, as it will tend to provide robust predictions in most situations, this can over predict noise levels. For consistency, the assumption of semi-porous ground factor of G=0.5 is recommended.

- The IOAGPG recommends that the modelled sound power level should be based on a tested level plus an additional allowance for uncertainty (in this case the modeled sound power level has been taken as 101.0 dB L_{WA} at a 10 metres per second wind speed at a reference height of 10 metres).

- Although the assumed receiver height can have a very small (miniscule) effect on the separation distance between source and receiver and also (similarly miniscule in most cases) on barrier/screening attenuation, it can have a more significant effect on the ground attenuation. The IOAGPG recommends the assumption of a 4 metre receiver height.

3.4 In order to calculate the noise level associated with the operation of the proposed wind turbine at the nearest noise sensitive receptors, the following relationship may be employed:

SPL = SWL – 20 log(r) – 11 – A – 2 dB(A) where:

SWL is the modelled sound power level of the wind turbine (dB(A))

SPL is the predicted sound pressure level at the receptor position (dB(A))

r is the distance to the receptor (in metres)

A is attenuation due to atmospheric absorption, ground effect, barriers, miscellaneous effects

Note: – 2 is the correction from L_{Aeq} to the L_{A90} in accordance with ETSU-R-97.

3.5 For the purpose of the calculations, the following scenario has been modelled (in accordance with the IOAGPG): a ground factor of G = 0.5 (semi-porous ground); a modelled sound power level of 101.0 dB L_{WA} (which includes appropriate uncertainty); and a frequency spectrum as shown in the following table.

Table 3.1 – Enercon E-48 Octave Band Sound Power Levels

Octave Band Sound Power Level L_{WA} (dB)								L_{WA} (dB)	Uncertainty (dB)
63	125	250	500	1000	2000	4000	8000		
84.2	88.9	90.3	92.3	95.0	91.6	84.3	75.1	99.4	1.6

3.6 On the basis of the above, the noise emissions associated with the proposed 500 kW wind turbine have been calculated at the nearest noise sensitive receptors as detailed in the table below (rounded to the nearest decibel).

Table 3.2 – Predicted Noise Emissions for the Proposed Wind Turbine

Wind speed at 10 m height (includes wind shear correction)	Modelled Sound Power Level (dB(A))	Noise Level at NSR1 dB L_{A90}	Noise Level at NSR2 dB L_{A90}
10	**101.0**	**35**	**35**
ETSU-R-97 Lower Absolute Limits		**35–40 dB L_{A90} daytime 43 dB L_{A90} night time**	

3.7 The predicted noise emissions are worst case as they are based on down wind propagation (i.e. the noise sensitive receptors are down wind of the proposed wind turbine). It should be noted that, under a prevailing westerly / south westerly wind, the noise sensitive receptors would be upwind of the proposed wind turbine and, as a consequence, the predicted noise emissions would be circa 10 decibels lower. For reference, easterly winds, under which the noise sensitive receptors would be downwind of the proposed wind turbine, only occur for around 10 to 15 percent of the year (typically late winter / early spring time) and coincide with cold weather blown across from Scandinavia.

3.8 It is also noteworthy that a wind turbine (different to the candidate turbines considered herein) was previously considered for this site. The wind turbine previously considered would have given rise to noise emissions greater than 35 dB L_{A90} at a 10 metres per second wind speed at 10 metres height. As a consequence, a scoping baseline noise survey was undertaken as part of the site evaluation process.

3.9 The baseline noise survey illustrated that the ambient and background noise levels (in the absence of any wind) on a Saturday afternoon and Saturday early evening (a 'quiet daytime' period as defined by ETSU-R-97) at NSR1 Bermersley Road ranged from 64 to 65 dB L_{Aeq} (due to 600 vehicles per hour on Bemersley Road) and 37 to 40 dB L_{A90} (due to distant traffic), respectively. It is evident that the nearest noise sensitive receptors adjacent to Bemersley Road are not located in a quiet rural area (note: the background noise levels would be significantly higher with a 10 metres per second wind speed at 10 metres height).

SECTION 4 ASSESSMENT OF RESULTS

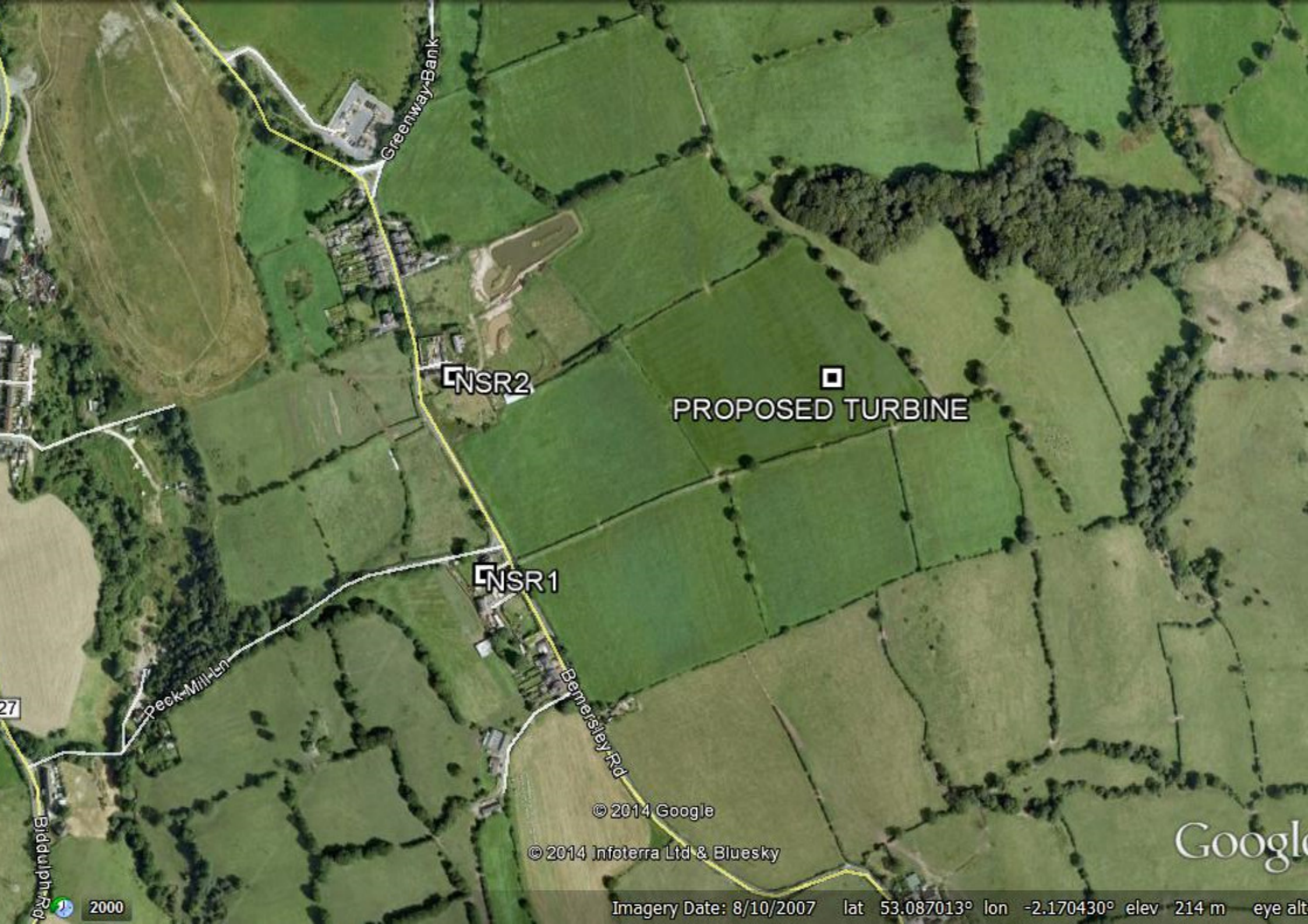
4.1 On the basis of the predicted noise levels detailed in Table 3.2, it is evident that noise emissions at the nearest noise sensitive receptors due to the proposed 500 kW wind turbine are 35 dB L_{A90} up to a wind speed of 10 metres per second at 10 metres height.

4.2 In accordance with the guidance contained in ETSU-R-97, wind turbine noise emissions up to 35 dB L_{A90} at wind speeds up to 10 metres per second at 10 metres height is deemed sufficient alone to provide an adequate level of protection against noise at a non-associated noise sensitive receptor.

4.3 It is therefore considered that noise emissions associated with the proposed 500 kW wind turbine will not cause any loss of amenity to the nearest noise sensitive receptors.

4.4 Considering the separation distances to noise sensitive receptors (over 400 metres), construction and decommissioning noise impacts will be negligible.

APPENDIX 1 ▪ Proposed Wind Turbine Location


Greenway Bank
NSR2
PROPOSED TURBINE
NSR1
Peck Mill Ln
Bemersley Rd
Biddulph Rd
27
© 2014 Google
© 2014 Infoterra Ltd & Bluesky
Google
2000
Imagery Date: 8/10/2007 lat 53.087013° lon -2.170430° elev 214 m eye alt

APPENDIX 2 ▪ Glossary of Acoustic Terms

APPENDIX 2
GLOSSARY OF ACOUSTIC TERMS

Sound Pressure Level (L_p)

The basic unit of sound measurement is the sound pressure level. As the pressures to which the human ear responds can range from 20 µPa to 200 Pa, a linear measurement of sound levels would involve many orders of magnitude. Consequently, the pressures are converted to a logarithmic scale and expressed in decibels (dB) as follows:

$$L_p = 20 \log_{10}(p/p_0)$$

Where L_p = sound pressure level in dB; p = rms sound pressure in Pa; and p_0 = reference sound pressure (20 µPa).

A-weighting Network

A frequency filtering system in a sound level meter, which approximates under defined conditions the frequency response of the human ear. The A-weighted sound pressure level, expressed in dB(A), has been shown to correlate well with subjective response to noise.

Equivalent continuous A-weighted sound pressure level, $L_{Aeq, T}$

The value of the A-weighted sound pressure level in decibels of continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound that varies with time. $L_{Aeq, 16h}$ (07:00 to 23:00 hours) and $L_{Aeq, 8h}$ (23:00 to 07:00 hours) are used to qualify daytime and night time noise levels.

$L_{A10, T}$

The A-weighted sound pressure level in decibels exceeded for 10% of the measurement period, T. $L_{A10, 18h}$ is the arithmetic mean of the 18 hourly values from 06:00 to 24:00 hours.

$L_{A90, T}$

The A-weighted sound pressure level of the residual noise in decibels exceeded 90% of a given time interval, T. L_{A90} is typically taken as representative of background noise.

$L_{AF\ max}$

The maximum A-weighted noise level recorded during the measurement period. The subscript 'F' denotes fast time weighting, slow time weighting 'S' is also used.

Sound Exposure Level (SEL or L_{AE})

The energy produced by a discrete noise event averaged over one second, no matter how long the event actually took. This allows for comparison between different noise events which occur over different lengths of time.

Weighted Sound Reduction Index (R_W)

Single number quantity which characterises the airborne sound insulation properties of a material or building element over a defined range of frequencies (R_W is used to characterise the insulation of a material or product that has been measured in a laboratory).

APPENDIX 3 ▪ Sound Power Level Data

APPENDIX 3
SOUND POWER LEVEL DATA

Sound Power Level

of the

ENERCON E-48

Operational Mode 500 kW

(Data Sheet)

Imprint

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Revision: 1.1

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Glossary

WEC means an ENERCON wind energy converter.

WECs means more than one ENERCON wind energy converter.

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APPENDIX 3 (CONTINUED)
SOUND POWER LEVEL DATA

ENERCON ENERGY FOR THE WORLD	Sound Power Level E-48	Page 2 of 3

Sound Power Level of the E-48 with 500 kW reduced power

hub height / V_s in 10 m height	50 m	55 m	60 m	65 m	76 m
4 m/s	89.0 dB(A)	89.2 dB(A)	89.4 dB(A)	89.5 dB(A)	89.9 dB(A)
5 m/s	93.3 dB(A)	93.6 dB(A)	93.9 dB(A)	94.2 dB(A)	94.7 dB(A)
6 m/s	97.5 dB(A)	97.8 dB(A)	98.1 dB(A)	98.3 dB(A)	98.8 dB(A)
7 m/s	99.2 dB(A)	99.4 dB(A)	99.5 dB(A)	99.7 dB(A)	100.0 dB(A)
8 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
9 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
10 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
95% reduced power					

Measured value at 500 kW reduced Power	***99,4 dB(A)*** *MBBM M69130/1*

in relation to wind speed at hub height									
wind speed at hub height [m/s]	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Sound Power Level [dB(A)]	95.1	97.9	99.5	99.8	100.0	100.0	100.0	100.0	100.0

1. The relation between the sound power level and the standardized wind speed v_S in 10 m height as shown above is valid on the premise of a logarithmic wind profile with a roughness length of 0.05 m. The relation between the sound power level and the wind speed at hub height applies for all hub heights. During the sound measurements the wind speeds are derived from the power output and the power curve of the WEC.

2. A tonal audibility of $\Delta L_{a,k}$ < 2 dB can be expected over the whole operational range (valid in the near vicinity of the turbine according to IEC 61 400 -11 ed. 2).

3. The sound power level values given in the table are valid for the **Operational Mode 500 kW** (defined via the rotational speed range of 16 – 28 rpm). The respective power curve is the calculated power curve E-48 dated November 2009 (Rev. 2.x).

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6 m/s	97.5 dB(A)	97.8 dB(A)	98.1 dB(A)	98.3 dB(A)	98.8 dB(A)
7 m/s	99.2 dB(A)	99.4 dB(A)	99.5 dB(A)	99.7 dB(A)	100.0 dB(A)
8 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
9 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
10 m/s	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)	100.0 dB(A)
95% reduced power					

Measured value at 500 kW reduced Power	***99,4 dB(A)*** *MBBM M69130/1*

in relation to wind speed at hub height									
wind speed at hub height [m/s]	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Sound Power Level [dB(A)]	95.1	97.9	99.5	99.8	100.0	100.0	100.0	100.0	100.0

1. The relation between the sound power level and the standardized wind speed v_S in 10 m height as shown above is valid on the premise of a logarithmic wind profile with a roughness length of 0.05 m. The relation between the sound power level and the wind speed at hub height applies for all hub heights. During the sound measurements the wind speeds are derived from the power output and the power curve of the WEC.

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3. The sound power level values given in the table are valid for the **Operational Mode 500 kW** (defined via the rotational speed range of 16 – 28 rpm). The respective power curve is the calculated power curve E-48 dated November 2009 (Rev. 2.x).

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