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Dear Sir

**NOISE IMPACT ASSESSMENT  
GAIA 11KW WIND TURBINE**

**1.00 INTRODUCTION**

- 1.01 Environmental Noise Solutions Limited (ENS) has been commissioned by Myriad CEG Power Limited to undertake a noise impact assessment for the Gaia 11 kW twin blade wind turbine (GW11) to assess its suitability for possible installation sites.
- 1.02 For reference the GW11 wind turbine is typically mounted on an 18 metre lattice mast, with the blade diameter specified as 13 metres. The wind turbine has a constant rotational speed of 56 rpm, with a cut-in wind speed of 3.5 metres per second.
- 1.03 A glossary of acoustic terms is contained in Appendix 1 for reference.

**2.00 ETSU-R-97 ASSESSMENT CRITERIA**

- 2.01 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.
- 2.02 This document describes a framework for the measurement of wind farm 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 farm development as a renewable energy source.
- 2.03 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.
- 2.04 ETSU-R-97 considers that the  $L_{A90, 10 \text{ min}}$  descriptor should be used for both the background noise and wind turbine noise for assessment purposes. It further states that the  $L_{A90, 10 \text{ min}}$  for wind turbines is of the order of 1.5–2.5 dB lower than the  $L_{Aeq}$  over the same time period.
- 2.05 The following table shows the recommended noise limits for wind farm related noise at the nearest noise sensitive properties in line with ETSU-R-97.

**Table 2.1 – ETSU-R-97 Noise Limits for Wind Farm Related Noise**

Period	Lower absolute noise limit	Relative noise limit
	$L_{A90,10min}$ (dB)	$L_{A90,10min}$ (dB)
Daytime (07:00–23:00)	35 – 40	5 dB(A) above background noise
Night time (23:00–07:00)	43	5 dB(A) above background noise

Note: 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.

- 2.06 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 farms. 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.
- 2.07 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  $L_{A90,10min}$  rather than  $L_{Aeq,10min}$ .
- 2.08 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.
- 2.09 ETSU-R-97 recommends a simplified assessment method for situations where it can be demonstrated that noise limits will be met until quite high wind speeds even if there is no increase in the background noise levels. It is considered that if noise emissions from the wind turbine are limited to 35 dB  $L_{A90, 10min}$  up to a wind speed of 10 metres per second (at 10 metres height), then this condition alone is deemed sufficient to provide an adequate level of protection against noise. Wind speeds in excess of 10 metres per second at a site will generate some additional background noise at the nearest noise sensitive properties, even in sheltered areas.
- 2.10 It should be noted that the National Planning Policy Framework (NPPF) was released on 27 March 2012 and supersedes the Planning Policy Statements (PPS). The NPPF is underpinned by a presumption in favour of sustainable development. One of the 12 core planning principles within the NPPF encourages the use of renewable resources, for example by the development of renewable energy. Whilst it is acknowledged that the NPPF is now the framework for decision-making in the planning process, certain technical aspects of the assessment process will continue to be guided by industry principles within the former PPS.
- 2.11 It is therefore considered that the principles enshrined within PPS 22 'Renewable Energy' will continue to inform the noise impact assessment for wind turbine developments. PPS 22 advises that a well designed wind farm (and equally a single wind turbine) should be suitably located so that any increases in ambient noise levels are kept to acceptable levels in relation to absolute limits or existing background noise when assessed as per the guidance of 'ETSU-R-97: The Assessment and Rating of Noise from Wind Farms'. This is achieved through the selection of the turbine(s) and location(s) to permit sufficient separation distance to noise sensitive properties.
- 2.12 It is therefore considered that, following the publication of the NPPF, ETSU-R-97 remains the most relevant guidance for assessing and rating noise from wind energy development.

### 3.00 GW11 WIND TURBINE PREDICTED NOISE EMISSIONS

- 3.01 The noise emission data for a GW11 wind turbine is attached in Appendix 2 of this report for reference.
- 3.02 The data illustrates that the apparent sound power level ( $L_{WA}$ ) of the wind turbine varies from 81.7 dB(A) to 87.7 dB(A) under wind speeds varying from 4 metres per second to 10 metres per second (measured at hub height of 18.3 metres). Furthermore, the data illustrates that there is no requirement for the imposition of a noise penalty to account for tonality, thereby indicating that the wind turbine noise emissions are broadband in nature.
- 3.03 In accordance with ETSU-R-97, the  $L_{A90, 10min}$  descriptor has been used for the purpose of this assessment, by applying a –2 dB correction to the predicted SPL at the receptor positions.
- 3.04 Of particular importance is the way noise propagation from wind turbines is modeled since this is not covered by the ETSU-R-97 guidance which only deals with assessment of any such predicted noise levels. This issue was covered by a recent statement on agreed practice by a number of consultants acting for wind farm developers, local authorities and third party groups in an article published in the Institute of Acoustics Bulletin in 2009 (as reproduced in the Hayes McKenzie Partnership Ltd Research Contract 'Analysis of How Noise Impacts are Considered in the Determination of Wind Farm Planning Applications', dated 6<sup>th</sup> April 2011 prepared for Department of Energy and Climate Change). 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. It should be noted that this is covered by the Institute of Acoustics Bulletin Article which 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. In general terms 'hard' ground represents a more conservative approach (higher predicted noise levels) than 'porous' ground (lower predicted noise levels). This is also covered by the Institute of Acoustics Bulletin Article which recommends the assumption of semi-porous ground ( $G=0.5$ ) where manufacturers warranted sound power level data is assumed for the turbine noise level. Where test report data is assumed (as is the case with the GW11), it recommends the use of a ground factor of  $G=0$  (hard ground).
  - 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 Institute of Acoustics Bulletin Article recommends the assumption of a 4 metre receiver height.
- 3.05 In order to calculate the free field equivalent continuous sound pressure level ( $L_{Aeq, T}$ ) associated with the operation of the wind turbine at the nearest NSRs, the following relationship may be employed:

$$SPL = SWL - 20 \log(r) - 11 - A - 2 \text{ dB(A)} \quad \text{where:}$$

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

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

r is the distance to the receptor (in metres)

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

- Note: – 2 is the correction from  $L_{Aeq (10 \text{ min})}$  to the  $L_{A90 (10 \text{ min})}$  in accordance with ETSU-R-97
- 3.06 The noise emission data has been correlated to derived wind speeds at a reference height of 10 metres above ground level (rather than at a hub height of 18.3 metres) by following the procedure detailed in ETSU-R-97. As a consequence, for a wind speed of X metres per second at 10 metres height (as required under the simplified ETSU procedure), the sound power level for X+1 metres per second has been adopted to reflect the increased wind speed at hub height. As a consequence, the sound power level for the GW11 at a wind speed of 10 metres per second at 10 metres height is 88.7 dB(A).
- 3.07 For the purpose of the calculations, a ground factor of  $G=0$  (hard ground) has been assumed, which results in a ground attenuation of –3 dB (i.e. a +3 dB reflection).
- 3.08 In the absence of spectrum noise emission data for the proposed wind turbine at all wind speeds, the attenuation due to atmospheric absorption has been estimated on the basis of the available spectrum noise emission data at 8 metres per second wind speed (measured at hub height).
- 3.09 The noise emissions associated with the GW11 wind turbine (at 10 metres per second wind speed at 10 metres above ground level) have been calculated at the following thresholds (and are reproduced in graphical form in Appendix 3):
- The ETSU-R-97 daytime limit of **45 dB  $L_{A90 (10 \text{ min})}$**  for financially involved receptors occurs at circa **47 metres** separation distance.
  - The ETSU-R-97 daytime limit of **40 dB  $L_{A90 (10 \text{ min})}$**  for non associated receptors occurs at circa **80 metres** separation distance.
  - The ETSU-R-97 daytime limit of **35 dB  $L_{A90 (10 \text{ min})}$**  for non associated receptors occurs at circa **137 metres** separation distance (note: this is also the threshold for the simplified assessment under ETSU-R-97).
  - The ETSU-R-97 night time limit of **43 dB  $L_{A90 (10 \text{ min})}$**  for non associated receptors occurs at circa **58 metres** separation distance.
- 3.10 There are sites where it may be favourable to install 2 no. GW11 wind turbines. The separation distances required between the turbines and nearest non associated receptors to comply with the ETSU-R-97 daytime limit of **35 dB  $L_{A90 (10 \text{ min})}$**  (at 10 metres per second wind speed at 10 metres above ground level) is set out in the following table.

Minimum distance to nearest GW11	Minimum distance to furthest GW11
140 metres	510 metres
150 metres	300 metres
160 metres	240 metres
170 metres	215 metres
180 metres	200 metres
190 metres	190 metres

## APPENDIX 1 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  $\mu$ Pa 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  $\mu$ Pa).

### 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 2 SOUND POWER LEVEL DATA FOR GW11 WIND TURBINE

Melton Mowbray, Gaia-Wind Turbine Noise Performance Test

HM: 2064/R1 – 19/02/09



### 6. Results

#### Measured Noise Levels

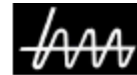
- 6.1 1-minute average measured  $L_{Aeq}$  Noise data was plotted against the reference height wind speed for operational noise periods and separately for background noise periods. All noise data has been filtered such that any 1-minute period that was affected by specific extraneous noises such as aircraft, vehicles, rainfall, and any other anomalies have been removed from the assessment.
- 6.2 Appendix C shows the measured total noise and measured background noise at the microphone position, plotted against the wind speed at rotor centre height for both days. After the removal of data as described above, the data base of the first survey consists of 100 and for the second survey of 191 wind speed – noise data pairs for total measured noise.
- 6.3 As required by [1], a linear regression line was plotted through the measured  $L_{Aeq}$  turbine data and through the measured background data at the reference position, as shown in Appendix C.
- 6.4 The equation obtained for the regression lines of the data of both measurement days was used to determine the turbine and background noise levels at each integer wind speed. The measured total noise levels were corrected for the influence of background noise as described below.

#### Calculation of Sound Power Level

- 6.5 The methodology prescribed by [1] was used to calculate the sound power level of the turbine under test. A summary table detailing the steps is shown below in Table 3.

**Table 3: Calculation of Sound Power Level for all measured data ( $R_1= 28.9$  m)**

Reference height wind speed (m/s)	4	5	6	7	8	9	10
Total Noise Level (dB $L_{Aeq}$ )	48.1	49.2	50.3	51.4	52.5	53.6	54.7
Background Noise Level (dB $L_{Aeq}$ )	39.1	40.7	42.3	43.9	45.5	47.1	48.7
Difference Between Total and Background Noise (dB)	9.0	8.5	8.0	7.5	7.0	6.5	6.0
Background Corrected Sound Pressure Level, $L_{Aeq,c,k}$ (dB $L_{Aeq}$ )	47.5	48.5	49.6	50.6	51.6	52.5	53.5
Apparent Sound Power Level, $L_{WA,k}$ (dB $L_{WA}$ )	81.7	82.7	83.8	84.8	85.8	86.7	87.7



### 1/3 Octave Band Data

6.6 The four 1-minute average periods closest to the reference wind speed of 8 m/s for each measurement day have been used to calculate the energy average 1/3 octave band spectra between 20 and 10 kHz as measured at the Reference Position. The linear, A-weighted and C-weighted results are shown in Appendix D. The data has been corrected for the influence of background noise as described in [2].

### Tonality

6.7 The tonality assessment was carried out with the method according to ISO 1996-2: 2007 [3] Annex D, as suggested in [1].

6.8 The turbine is declared tonal if any 1/3 octave band is higher than its adjacent bands by:

- 15 dB in the low frequency bands (50 to 125 Hz)
- 8 dB in the mid-frequency bands (160 to 400 Hz)
- 5 dB in the high frequency bands (500 to 10000 Hz).

6.9 For the assessment four 1/3 octave band spectra from the first measurement day and four 1/3 octave band spectra from the second measurement day, closest to the wind speed of 8 m/s at rotor centre height, were used.

6.10 The tonal analysis was carried out for the linear, A-weighted and C-weighted 1/3 octave band spectra of the total noise measured at the microphone reference point as shown in Appendix E.

6.11 Based on the 4 spectra being closest to the reference wind speed of 8 m/s at rotor centre height from the measurement on 21/11/08 and 16/01/2009 respectively, the Gaia-Wind turbine is not found to be tonal.

6.12 This assessment is valid for the reference point, where the noise measurement took place and describes the noise character for the proximity of the wind turbine only.

**APPENDIX 3  
PREDICTED NOISE LEVELS FOR GW11 WIND TURBINE (10M/S WIND SPEED AT 10M HEIGHT)**

