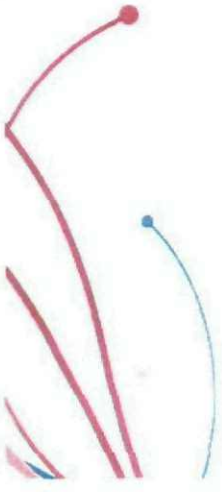
Appendix B

evancewind

Analysis of TR087 MCS noise data for comparison with ETSU guidelines

Issue 04



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1. Introduction

Despite the introduction of the BWEA Performance and Safety standard[1], Evance Wind Turbines Ltd are receiving an increasing number of requests from planning authorities in the UK for noise data for the R9000 wind turbine that is analysed and reported according to the ETSU-R-97[2] standard.

This report uses the certified MCS noise data in the report titled 'Product Certification - Evance R9000 Acoustic Noise Assessment[3]' and applies two different methods of assessment. The first is a comparison of wind turbine noise against a reference background noise (ETSU-R-97[2] page 67) and the second is the simplified assessment method (ETSU-R-97[2] page 66).

The required minimum slant distances (distance from turbine hub to point of interest) for one, two and three wind turbines are reported for both methods.

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2. Procedure

The analysis was based on the measured $L_{A,90}$ noise data and the wind speed measurements at 10m height, as provided in TR087[3].

The following steps have been taken:

- The $L_{A,90}$ values were plotted against 10m height wind speed and a 4th order regression analysis completed on both turbine running and turbine parked sets of data. This is shown in Figure 1.

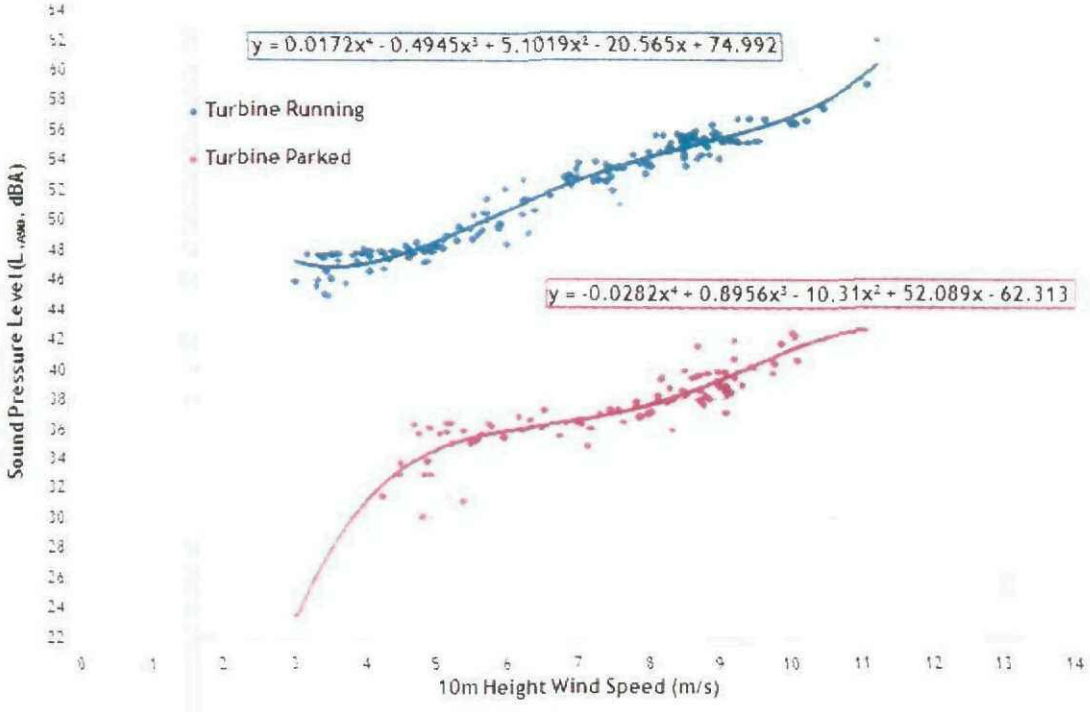


FIGURE 1 - SOUND PRESSURE LEVEL ON THE GROUND BOARD AT A SLANT DISTANCE OF 19.85M (1)

- The background corrected sound pressure levels (i.e. the wind turbine specific noise after the removal of the contribution from the background noise) were plotted at integer wind speed values between 3 m/s and 11m/s. These points were calculated from the turbine running and turbine parked 4th order regression lines. This is shown in Figure 2.

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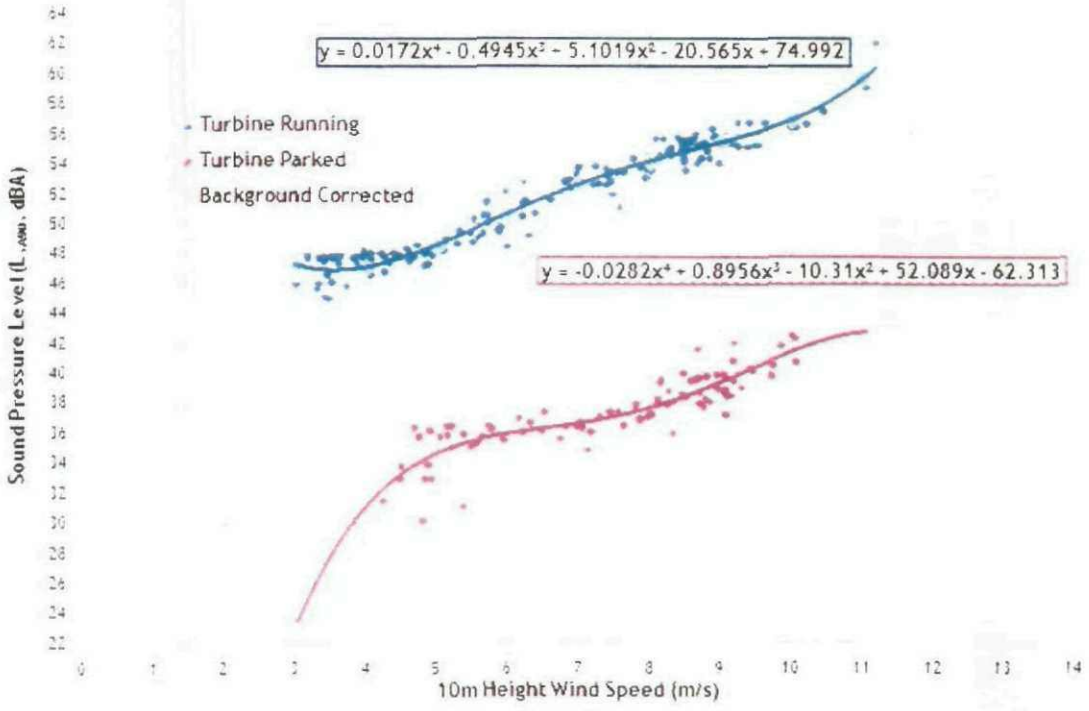


FIGURE 2 - SOUND PRESSURE LEVEL ON THE GROUND BOARD AT A SLANT DISTANCE OF 19.85M (2)

- The background corrected sound pressure levels were used to calculate the sound **power** levels at the corresponding integer wind speeds by applying a -6dB correction for the board reflection and adding +36.9dB to convert from sound pressure at 19.85m to sound power (equation 9 of 61400-11[4]).

- The calculated wind turbine noise levels are summarised in Table 1.

- Using the sound power levels the estimated sound pressure levels at various distances were calculated in accordance with ISO 9613-2[5].

The assumptions made when calculating the sound pressure levels were:

- 1.9dB/km atmospheric attenuation. This is the lowest coefficient listed in [5] and is stated at 10°C and 70% relative humidity.
- The ground between the wind turbine and the receiver is 70% porous, i.e. grass, vegetation, farming land etc, and 30% reflective (conservative in most locations)
- The receiver is located more than 3m above ground level (worst case in [5]).
- There is no screening that would attenuate the noise further. Attenuation due to dense foliage can result in approximately 1dB every 20m [5]).

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3. Results

The calculated wind turbine noise levels are summarised in Table 1.

Wind Speed at 10m Height (m/s)	3	4	5	6	7	8	9	10	11
Measured Turbine Noise (L_{90}, dBA)	47.26	47.12	48.65	50.75	52.71	54.26	55.52	57.03	59.75
Measured Background Noise (L_{90}, dBA)	23.06	31.18	34.71	35.96	36.60	37.60	39.25	41.18	42.32
Turbine Noise Corrected for Background (L_{90}, dBA)	47.24	47.01	48.47	50.60	52.61	54.17	55.42	56.92	59.67
Calculated Turbine Sound Power Level (L_{AW90})	78.19	77.95	79.42	81.55	83.55	85.11	86.36	87.87	90.62

TABLE 1 - EVANCE R9000 NOISE LEVELS

Table 2 shows the estimated $L_{A,90}$ sound pressure levels at various slant distances. The values are based on the sound power levels shown in Table 1.

Wind speed at 10m height (m/s)	3	4	5	6	7	8	9	10	11
Slant distance (m)									
60	32.41	32.18	33.64	35.77	37.78	39.34	40.59	42.09	44.84
80	29.87	29.64	31.11	33.24	35.24	36.80	38.05	39.55	42.31
100	27.90	27.66	29.13	31.26	33.26	34.82	36.07	37.58	40.33
120	26.28	26.04	27.51	29.64	31.64	33.20	34.45	35.95	38.71
140	24.90	24.67	26.13	28.26	30.27	31.83	33.08	34.58	37.33
160	23.70	23.47	24.94	27.06	29.07	30.63	31.88	33.38	36.14
180	22.64	22.41	23.87	26.00	28.01	29.57	30.82	32.32	35.07
200	21.69	21.45	22.92	25.05	27.05	28.61	29.86	31.37	34.12
220	20.82	20.59	22.06	24.18	26.19	27.75	29.00	30.50	33.26
240	20.03	19.79	21.26	23.39	25.39	26.95	28.20	29.71	32.46
260	19.29	19.06	20.53	22.66	24.66	26.22	27.47	28.97	31.73
280	18.61	18.38	19.85	21.98	23.98	25.54	26.79	28.29	31.05
300	17.98	17.74	19.21	21.34	23.34	24.90	26.15	27.65	30.41

TABLE 2 - SOUND PRESSURE LEVELS AT VARIOUS DISTANCES FROM THE TURBINE HUB

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3.1. Background Noise Comparison

ETSU-R-97[2] states that the noise from the wind turbine shall be limited to 5dB(A) above the background noise levels with an additional lower absolute limit in the range of $L_{A,90}$ = 35-40dB (day-time) and 43dB (night-time). For this report, the lower limit of 35dB(A) has been assumed.

ETSU-R-97[2] provides an illustration of this based on a representative rural background noise curve, as shown in Figure 3. The figure also shows how the Evance R9000 wind turbine noise level compares to the example curve. The ETSU-R-97[2] document employs this background survey because it provides a good representation of a typical quiet and reasonably sheltered rural location.

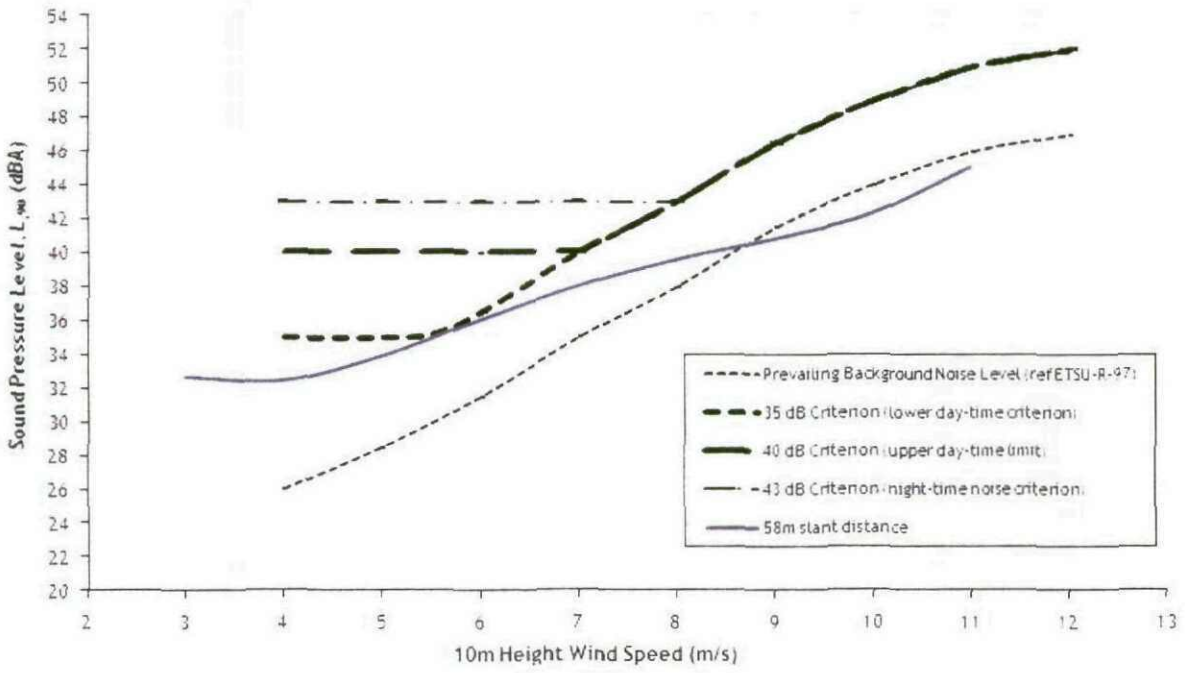


FIGURE 3 - WIND TURBINE AND BACKGROUND NOISE COMPARISON, BASED ON THE EXAMPLE FROM ETSU-R-97

Figure 3 shows that a minimum slant distance (distance from turbine hub to point of interest) of **58m** is required in order to achieve an acceptable noise level across all wind speeds, based on this example.

The normal process defined in ETSU-R-97[2] (which was developed with large utility sized wind farm projects in mind) is to measure the background noise near the proposed wind farm site, rather than use the illustrative background noise curve provided. This would be an onerous undertaking for a 5kW wind turbine. Since much of the background noise at a rural site is generated by the wind itself it is unlikely that the background noise at any rural site would be significantly lower than that in this example.

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Table 3 shows a summary of minimum slant distances for one, two and three wind turbines. It has simply been assumed that the multiple turbines are at the same location. Although clearly this is not possible in practice, such an approach gives an initial indication of the impact of using multiple turbines and will be conservative if the results in the table are applied to the turbine closest to the noise sensitive property. Case by case calculations may be required where such an approach is too crude.

Number of turbines	Slant distance required to satisfy ETSU-R-97[2] 35dB (lower day-time) criterion
1	**58m**
2	**82m**
3	**100m**

TABLE 3 - SUMMARY OF RESULTS FOR 1, 2 AND 3 TURBINES WHEN COMPARED AGAINST THE ETSU-R-97 REFERENCE BACKGROUND NOISE LEVEL

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3.2. Simplified Assessment Method

ETSU-R-97 does provide a simplified method of assessment. It states that If it can be demonstrated that the estimated wind turbine noise is limited to an $L_{A,90}$ of 35dB(A) up to wind speeds of 10m/s at 10m height then this condition alone would offer sufficient protection of amenity without considering the actual background noise at the site under consideration. It is plain that this method is grossly conservative based on real world background noise levels at 10m/s wind speed. However, such an analysis has been completed for illustrative purposes, as described below.

Figure 4 shows that a minimum slant distance (distance from turbine hub to point of interest) of **134m** is required in order for the noise levels to be below an $L_{A,90}$ of 35dB(A) up to wind speeds of 10m/s at 10m height.

A comparison of Figure 3 and Figure 4 reveals how conservative the simplified method is compared to typical real world background noise levels in a rural sheltered location.

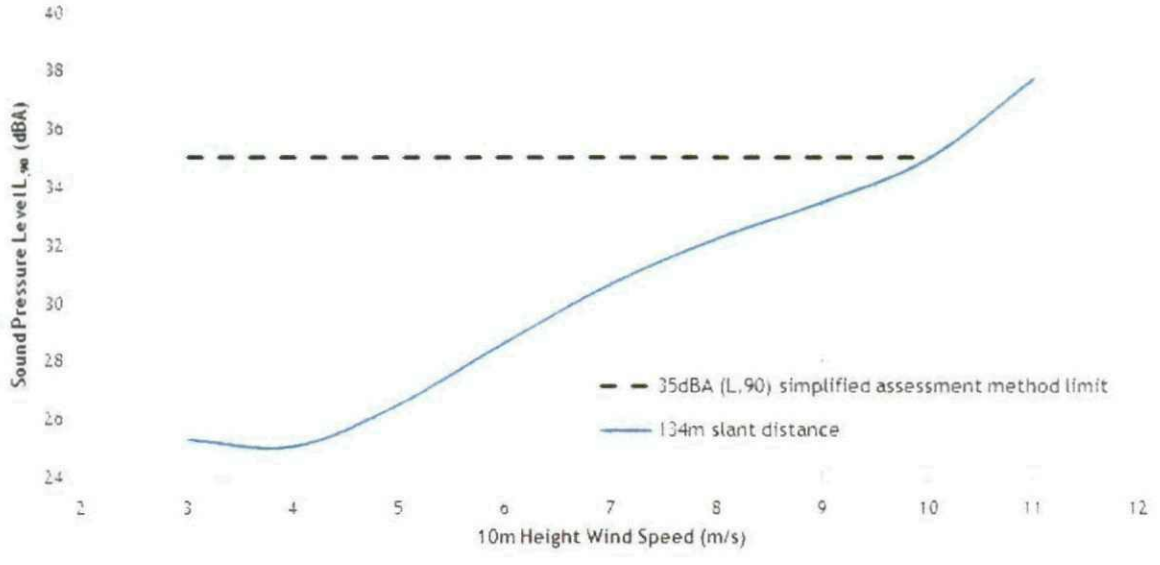


FIGURE 4 - SIMPLIFIED ASSESSMENT METHOD RESULTS

Table 4 shows a summary of the equivalent minimum slant distances for one, two and three wind turbines for noise limits of 35dB, 37dB and 40dB. It has simply been assumed that the multiple turbines are at the same location. Although clearly this is not possible in practice, such an approach gives an initial indication of the impact of using multiple turbines and will be conservative if the results in the table are applied to the turbine closest to the noise sensitive property. Case by case calculations may be required where such an approach is too crude.

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Number of turbines	Slant distance required to achieve an $L_{A,90}$ of 35dB(A) up to wind speeds of 10m/s at 10m height	Slant distance required to achieve an $L_{A,90}$ of 37dB(A) up to wind speeds of 10m/s at 10m height	Slant distance required to achieve an $L_{A,90}$ of 40dB(A) up to wind speeds of 10m/s at 10m height
1	**134m**	**107m**	**77m**
2	**187m**	**150m**	**107m**
3	**227m**	**182m**	**131m**

TABLE 4 - SUMMARY OF RESULTS FOR 1, 2 AND 3 TURBINES

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4. Conclusions

When the Evance R9000 noise levels are assessed using the ETSU-R-97[2] procedure based on the example background noise levels of a quiet rural location provided in the document the result is a required minimum slant distance of 58m.

The document also provides a simplified method of assessment. If the simplified assessment method is adopted the required minimum slant distance would have to be increased by more than double to 134m.

ETSU-R-97[2] was developed primarily for utility sized wind farms, where site specific noise and corresponding 10m height wind speed measurements are appropriate. For a 5kW turbine such an approach is prohibitive, since the costs of such a study would be a significant proportion of the cost of the turbine. This report illustrates that if site specific noise measurements were taken then it is likely that using the ETSU-R-97[2] method would result in required slant distance of the order of 58m. The simplified method of assessment is judged to be overly conservative because even a very open site with no trees is likely to experience background noise levels considerably above 30dB(A) at 10m/s wind speed (which is implied in a 35dB(A) criteria).

5. References

1. Small Wind Turbine Performance and Safety Standard. British Wind Energy Association. 29 Feb 2008
2. The Assessment and Rating of Noise from Wind Farms, ETSU-R-97
3. TR087 v4 Product Certification - Evance R9000 Acoustic Noise Assessment, Nov 2010
4. BS EN 61400-11:2003, Wind Turbine Generator Systems, Part11 - Acoustic Noise Measurement Techniques, 2003
5. ISO 9613-2, Acoustics - Attenuation of sound during propagation outdoors, 1996

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