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BAILLIE HILL WIND FARM

Precognition of Dick Bowdler

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1 QUALIFICATIONS

1.1 My name is Dick Bowdler. I have been a noise consultant for thirty-eight years. I was one of the original members of the Institute of Acoustics, our professional body, when it was founded in 1974 and I have been a Fellow since 1977. I am also a Chartered Engineer, a Member of the Institute of Physics and chartered physicist, a Fellow of the Chartered Institution of Building Services Engineers and a Member of the Chartered Institute of Arbitrators. Since 1978 I have given evidence at planning inquiries, civil actions for noise nuisance, civil actions for damages in respect of noise induced deafness and appeals against notices served under the Control of Pollution Act 1974 and the Environmental Protection Act 1990. I have previously given evidence at twelve wind farm public inquiries. I have lived and worked in Scotland for 35 years.

1.2 I have been a supporter of wind energy and other forms of renewable energy for over 40 years but I also believe that people have the right to be protected from unreasonable levels of noise. I have been involved in wind farm assessment since I carried out an impact assessment for Scottish Power in 1993. Since then I have examined and reported on about 50 wind farm Environmental Statements on behalf of Local Authorities or objectors. I am currently employed by several local authorities in England, Scotland and Wales to provide an independent assessment of the noise issues in their wind farm applications.

1.3 There have been five Institute of Acoustics wind farm meetings since September 2005. I organised and chaired the first two and have attended two others. I have also attended both International Conferences on Wind Turbine Noise in 2005 and 2007. I have given papers at these meetings on wind farm conditions, background noise and amplitude modulation.

2 BACKGROUND NOISE DATA

2.1 The developer carried out background noise measurements at six locations around the site, though only 5 were used. The methodology is described in the ES and the results are plotted on Figs 9.1 to 9.10 of the 2006 Addendum report.

2.2 The shape of some of the noise curves is not typical. Background noise curves can be considered as being made up of two separate noise sources each consisting of a set of data. The first is a horizontal line consisting of noise that is not wind related. It may be inherent meter noise, streams, road traffic or any other continuous or varying noise other than that associated with the wind. Because it is not wind related the best fit curve for this first set of data must be horizontal. This is shown by the blue line in Fig 3 of my Tables and Figures **CWAG/083**. The second noise source – noise generated by the wind - produces a set of data that is related to wind speed shown by the red curve. The figure shows how these two elements go together to produce the typical, flat-S, best fit curve through the set of data points shown in black. If we compare the developer's curves with these principles we find there is often no significant flattening at low wind speeds or at high wind speeds. Part of the reason for this is that a second order polynomial appears to have been used. However, there are other concerns. Figs 9.1 and 9.2 of the 2006 Addendum, for example, show hardly any correlation of noise with wind speed.

2.3 The wind monitoring mast used for the noise measurements was 10m high and located near Hillcrest. This is not a suitable location. The point of measuring the wind speed and comparing it with the background noise is to relate the wind speed **on the development site** to the background noise **at noise sensitive properties**. This is crucially important because it is the wind speed on the development site – not that at local houses – that determines the noise emitted by the turbines with which we shall be comparing the background noise. The second point of concern related to the location of the 10m mast is that it seems to have been less than 100m from forestry and in the lee of the prevailing winds over the forestry. Both of these factors are likely to result in wind speeds being recorded that were less than they would have been on the open site. This does indeed appear to be the case. A 60m mast was erected before the noise monitoring was completed so there is a period of nearly three weeks when both masts were operating simultaneously. I have taken the wind speeds at 40m and 50m, calculated the wind shear and then calculated the wind speed at 10m on the development site. Fig 4 of **CWAG/083** shows a comparison of the 10m wind speed on the site – in black – and the 10m wind speed at Hillcrest as used by the developer. The wind speeds at Hillcrest are clearly significantly less.

2.4 The microphone wind shields used were Larson Davis wind shields, Type EPS2107. These are ordinary commercial wind shields with a diameter of about 100mm. On page 84 of ETSU-R-97 it says *Even using the LA90(10min) noise descriptor there is a risk that measured noise levels can become contaminated by the effect of wind noise on the microphone when using the wind shields available commercially. Studies are currently being undertaken to evaluate the constraints on existing measurement systems with a view to offering suggestions for improved windshield design.* In fact this study on improved windshields – "Noise Measurements in Windy Conditions" **CWAG/074** - was published at much the same time as ETSU-R-97. It recommends types of enhanced windshields that can be used, notably on p20. It is over ten years since this information became available so there should be no difficulty in using proper windshields. Indeed the developer's consultants were aware of this by June 2005. In para 11.44 of the ES for Barmoor, **CWAG/081** prepared by the RPS Group, it explains how double skinned windshields were used in the Barmoor survey, quoting the document "Noise Measurements in Windy Conditions".

2.5 A further concern in connection with the background noise measurements and the 10m mast is that there are pieces of wind speed data that are simply missing. It is not that there is no wind speed reading for a period but that the whole set of data including the date and time is missing. For example there are ten periods missing around mid-day on 29th April and there is a whole day missing from about mid-day on 7th May **CWAG/080**. Add to this is the fact that, as admitted by the developer's consultant, the anemometer had to be re-calibrated after the measurements were made and there is little confidence in the whole set of data provided.

2.6 Most of these concerns suggest that the real background noise levels may be less than those provided in the ES and the 2006 Addendum. None of the concerns suggest that the background noise levels might be higher. I bear this in mind in assessing the background noise in the next section.

3 Background Noise Analysis

3.1 In assessing the impact of wind turbine noise we compare the level of the turbine noise with the level of background noise at each wind speed. Turbine noise is stated for a range of wind speeds measured at a height of 10m. Background noise is also stated relative to wind speeds at a height of 10m. So it would appear on the face of it that we are comparing like with like. However, the sound power of the turbine depends on the wind speed at hub height, not at 10m. The sound power output varies even when the wind speed at 10m remains the same because the wind shear changes. On the other hand, the background noise level is much more closely related to the wind speed at a height of 10m.

3.2 When turbine noise levels are measured for noise certification they are done in terms of the Standard BSEN 61400-11 **CWAG/071**. This provides for the wind speed to be stated at a height of 10m. The wind speed is often measured at the hub but sometimes at an intermediate position (such as 50m when the hub height is 80m). In this latter case the procedure is set out in paragraph 8.1 of BSEN 61400-11 in particular the part that begins "Equation (7) uses the following principles". It explains that a correction is first to be made from the wind measurement height to the hub height using the **actual** wind shear. Then a correction is to be made from the hub height to the standard height of 10m using the reference roughness length of 0.05m (which I shall call "standard wind shear"), and applying the formula set out above.

3.3 The developer's consultant has explained this in **BWL86** apparently using exactly the same procedure as I set out above. However, near the top of page 6 of this document he refers to Equation 2 which does not appear in the document. My own analysis of the wind shear from the 50m and 40m anemometers and the subsequent extension to the 70m hub height uses the equation:

$$m = \frac{Log\left({}^{U_1}\!/\!{}_{U_2}\right)}{Log\left({}^{H_1}\!/\!{}_{H_2}\right)}$$

Where:-

m The shear exponent to be calculated
U1 The wind speed measured at the lower height
U2 The wind speed measured at the upper height
H1 The height of the lower wind speed measurement
H2 The height of the upper wind speed measurement

This may be the same one as the developer's consultant has used.

3.4 To emphasis the position the process is shown in my Fig 5 **CWAG/083**. The wind speed is first corrected to hub height using the actual wind shear and then is corrected from hub height to 10m using the standard roughness length of 0.05m. As can be seen, in this case, the correct wind speed at 10m (which I shall call the "standardised wind speed") is 6.9m/s as opposed to the actual wind speed of 6.0m/s. The effect of this is to alter the shape and position of the background noise curves that we see in figs 9.1 to 9.10 of the 2006 Addendum to the ES.

3.5 When the wind shear is greater than the standard wind shear, the standardised wind speed is greater than the measured wind speed. That means that, if the background noise level is adjusted, each data point on the graph will move to the right. So the effect of increasing wind shear on the graphs – for example on Chart 9.8 in the 2006 Addendum - would be to move the background noise curve to the right. Comparison with the equivalent noise curve on p10 of **BWL/86** shows that the background noise curve has been moved to the left. In fact all the background noise curves in **BWL/86** have moved to the left as compared with the 2006 Addendum. This suggests that the wind shear on the site is less than the standard wind shear not more, as the developer's consultant has suggested.

3.6 I have analysed the same May 2004 data, as the developers consultant has done, for the night time period. The results are in **CWAG/084.** My conclusion from this analysis is that the standardised wind speed is, on average at night, about 1.5 times the wind speed as measured by the 10m mast at Hillcrest. This is also shown in broad terms in Fig 4 of **CWAG/083**. This means that the background noise curves in **BWL/86** ought to be shifted to the right as compared with those in the 2006 Addendum. In fact they are shifted to the left.

3.7 The difference can be clearly seen by comparing the night graphs at Skiall. In Chart 9.8 in the 2006 Addendum the background noise curve passes through 40dB at about 7.2m/s. On the equivalent chart on page 10 of **BWL/86** it passes through 40dB at about 6.6 – it has been shifted to the left. On my Fig 11 in **CWAG/083** the line passes through 40dB at about 8.3m/s – it has been shifted to the right. My contention is therefore that although the correct principles have been used they have been applied incorrectly. The effect is to show background noise levels much higher at any particular wind speed than they should be.

3.8 Using the developer's raw data I have re-calculated the graphs for Stemster, Bardnaheigh and Skiall using the wind data from the main mast – correcting each 10-minute measurement individually and plotting the individual results. These are shown in figures 6 to 11 of **CWAG/083.** It was not possible to make similar corrections to the background noise measurements at Achiebraeskiall and Hillcrest because the background noise was measured before the main mast was erected. I have therefore also carried out an assessment using the background noise data at these locations exactly as supplied by the developer in the Addendum to the ES without any corrections for wind shear. These levels are shown in my Tables 8 and 9.

3.9 It should be noted that although I have corrected for wind shear my concerns set out in section 2 remain with regard to the other aspects of the background noise measurements.

3.10 The allocation of background noise from a measurement position to other locations is not a simple process. The background noise level depends on the degree of shelter that a property has from the wind and the amount of wind noise generating features in the area. Some of the lowest and highest background noise levels are found near stands of trees for example. This is because the trees can act as shelter in some circumstances and as noise generators in others. It is not sufficient to take the background noise level from the nearest place. Accordingly it is my practice to take averages of noise levels at groups of properties as a baseline.

4 TURBINE NOISE

4.1 The propagation path height and the wind speed used in the calculations for modern wind turbines are outside the limits of ISO 9613. Nevertheless it is generally agreed that this standard is an appropriate model for the calculation of turbine noise at noise sensitive properties provided that care is taken in specifying the input parameters.

4.2 In the first place the sound power level of the source needs to be established. This is provided by the manufacturer of the Nordex N80 as 102.6dBA at 8m/s wind speed with a warranted level of 103.5dBA at 8m/s. This latter noise level is the maximum level that the manufacturer warrants that the turbine will produce when measured under the standard test conditions set out in BSEN 61400-11 **CWAG/071**. The warranted levels are calculated from the average of the measurements of the turbine plus the "error" in the measurements. That is to say there is a high degree of confidence that any particular turbine will not exceed the warranted level. I do not significantly disagree with the warranted sound power levels in **BWL/86**.

4.3 The second cause for variation in the predicted noise levels using ISO 9613 is the choice of ground cover and, in association with this, the assumed height of the receiver. Ground cover can be specified in the model at a value between G=0 and G=1. If it is assumed that the ground cover is hard (G=0) then we get the same result irrespective of the height of the receiver. If we take soft ground (G=0) or mixed ground (say G=0.5) then the result varies according to the height of the receiver.

4.4 The most accurate methodology has been the subject of a number of studies. A report for the EU in 1998 "Development of a wind farm noise Prediction Model" **CWAG/076** shows on pages 155 and 156 that in most cases, including this one, the attenuation provided by the ground is zero. That is to say, the predicted noise levels will be 3dB less than they would be using hard ground in ISO 9613-2. However, the turbines used to test this model were much smaller than current ones.

4.5 Further work by *Bullmore and others* **CWAG/077** was carried out in 2006-2007. Figs 3d and 4a show noise levels at 754m distance from the nearest turbine with G=0 (hard ground) the measured figures are almost exactly the same as the calculated ones. This can be directly compared with Fig 4c where G=0.5 and the measured figures are 1 to 2dB higher than the predicted ones. The measured values here are made at a height of 1.5m whereas they are compared with the calculated noise level at 4m above ground. The turbine noise levels used are measured ones with no adjustment for uncertainty. In summary, what this paper reports is that good correlation between turbine noise measurements made at 1.5m above ground and calculations can be obtained by using measured turbine sound power levels, G=0 and a 4m receiver height.

4.6 In the interests of establishing common ground in turbine noise calculations, an agreement was reached in February 2009 between seven noise consultants working on wind farm assessments. The consultants were those people on the most recent DTI/BERR Noise Working Group on wind farm noise who represented independent noise consultants on the group. The agreement will be published in the Institute of Acoustics Bulletin in mid-March 2009. The relevant part of the agreement says that *The use of either (a) G=0 together with measured (IEC 61400 11 test) Sound Power Levels or (b) G=0.5 (with a 4 metres receptor height) together with vendor's warranted sound power levels (or measured turbine sound power levels plus an allowance for measurement uncertainty), will generally result in realistic estimates of noise immission levels at receptor locations downwind of wind turbines. Noise immission levels calculated using these combinations of parameters can generally be relied on for the purposes of noise assessment. The assumption of 'soft' ground (G=1) should not be made.*

4.7 This best practice methodology is known to the Developer's consultant RPS Group. In fact they were using it over a year before Bullmore published his research. In their noise section for the Barmoor wind farm proposal in February 2006, **CWAG/081**, table 11.7 shows that they used warranted noise levels (2dBA above measured) and paragraph 11.81 states that *all noise level predictions have been undertaken using a receiver height of 4.0 m above local ground level, mixed ground (g=0.5) . . .* This is exactly the same methodology as that recommended under b) in the agreement described in the previous paragraph.

4.8 In the turbine noise calculations for the Baillie wind farm the developer's consultant in the 2006 Addendum appears to have used completely soft ground (G=1) and a receiver height of 1.5m. The result severely underestimates the real turbine noise. In my Tables and Figures, Table 4, I have set out, by way of example, the turbine noise level at Stemster House using three different methods of calculating turbine noise under ISO 9613. Column A is the method used in the Addendum to the ES. The manufacturers warranted power levels at 8m/s, soft ground and a receiver height of 1.5m have been used, giving a noise level at Stemster House of 37dBA. Column B shows the method used by RPS Group at Barmoor with an addition of 2dB to measured turbine noise levels, G=0.5 and a receiver height of 4m. This gives a noise level of nearly 6dB more than that in the Addendum to the ES. Column C shows the alternative recommended methodology described in (a) of section 4.6 above which uses measured noise level, and G=0. This last is the method I have used for my calculations.

4.9 I know the Barmoor site and there is no reason to treat it any differently from this one. I have therefore calculated the turbine noise levels at sensitive properties on the basis of measured turbine noise levels and hard ground. These levels are shown in my Table 5 **CWAG/083**. As noted above this produces a very similar result to G=0.5 with a receiver height 4m.

4.10 In **BWL/86** the turbine noise level calculations have been revised showing higher noise levels that previously. G=0.5 has been assumed but it is not stated what receiver height has been used. It appears from the results that it may be 1.5m. As I have stated above I do not think this to be appropriate, neither did the RPS Group at Barmoor.

5 SETTING THE STANDARD

5.1 PAN 56, Planning and Noise – **CD24** is the key Scottish guidance for planners with regard to noise. It says of wind turbines in paragraph 34 that *Good acoustical design and siting of turbines is essential to ensure there is no significant increase in ambient noise levels as they affect the environment and any nearby noise-sensitive property*.

5.2 PAN 45 "Renewable Energy Technologies" – **CD23 –** also contains guidance about wind farm noise. It quotes the first paragraph of the Executive Summary of The Assessment and Rating of Noise from Wind Farms (ETSU-R-97) – **CWAG/070** - as saying that it *describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or planning authorities.* PAN 45 goes on to say that *The report presents a series of recommendations that can be regarded as relevant guidance on good practice.* The ETSU method compares the predicted noise from turbines with the background noise or, where background noise is low, with a fixed noise level.

5.3 Scotland is not unique in respect of having two parallel tests for wind farm noise. There are similarly two tests in England and in Wales.

5.4 In England Para 22 of PPS22 says *Renewable technologies may generate small increases in noise levels (whether from machinery such as aerodynamic noise from wind turbines, or from associated sources – for example, traffic). Local planning authorities should ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels. Plans may include criteria that set out the minimum separation distances between different types of renewable energy projects and existing developments. The 1997 report by ETSU for the Department of Trade and Industry should be used to assess and rate noise from wind energy development.*

5.5 In Wales the noise guidance is set out in TAN 8 in Paragraphs 2.14 and 2.16 of Annex C.

> *Well designed wind farms should be located so that increases in ambient noise levels around noise-sensitive developments are kept*

to acceptable levels with relation to existing background noise. This will normally be achieved through good design of the turbines and through allowing sufficient distance between the turbines and any existing noise-sensitive development. Noise levels from turbines are generally low and, under most operating conditions, it is likely that turbine noise would be completely masked by wind-generated background noise.

ETSU-R-97 "Assessment and Rating of Noise from Wind Farms" describes a framework for the measurement of wind farm noise and gives indicative noise levels calculated to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or planning authorities.

5.6 Although ETSU-R-97 is sometimes used exclusively to assess wind farm noise this is clearly not correct. At paragraph 28 of his Decision on Rossie Farm Wind Farm, Auchtermuchty (Ref P/PPA/250/675) **CWAG/078** the Reporter said *My main conclusion on noise is that, subject to some reservations about AM, the ETSU-R-97 standards would be met. To that extent, the proposal would therefore be acceptable from a noise point of view. However, as the appellant acknowledged, under some conditions, during both the day and night, the turbines would result in noticeable increases in noise levels at a large number of properties. This is not relevant in terms of ETSU-R-97 – which is concerned with acceptability, not audibility. However, when people who are opposed to wind farms are able to hear, as well as see, the turbines, I believe that that can increase the impact on residential amenity. Given the close proximity of the turbines to a large number of houses, particularly in Auchtermuchty, I attach some weight to this issue.*

5.7 Accordingly there are two tests that need to be applied to wind farm noise levels in order to assess the impact of the proposal. They are not mutually exclusive. I will deal with these in the next two sections.

6 INCREASE IN AMBIENT NOISE

6.1 The first test of ambient noise has not been considered by the Developer. Tables 6 and 7 of my tables and Figures, **CWAG/083,** show the difference between the turbine noise level measured with the property broadly downwind of the turbines and the background noise level now. The tables show ambient noise measured as LA90. Table 6 shows increases in noise level of up to 12dBA during the day and Table 7 shows there are increases up to 18dBA at night.

6.2 However these comparisons use the average of the three highest background noise locations measured. If I use the background noise levels measured by the developer at Hillcrest and Achiebraeskiall as shown in Tables 8 and 9 then the increase in noise levels during the day is up to 17dBA (Table 10) and at night it is up to 18dBA (Table 11).

6.3 Para 2.4 of BS8233 **CWAG/079** says that an increase of 10dBA is a doubling of loudness. Some properties will therefore have noise levels from the turbines four times as loud as the present background noise level. Bearing in mind my concern about background noise data generally this is the best case rather than the worst.

7 ETSU-R-97

7.1 ETSU-R-97 limits turbine noise to 5dB above the average background noise level or to a fixed lower limit where background noise is low. It provides a range of minimum noise limits at low wind speeds to be applied during the day between 35dB and 40dB. At night the limit is 43dB though Highland Council has adopted 38dB to allow for changes in the WHO advice for sleep disturbance. In 9.4.2 of the Addendum to the ES the developer has accepted that this site requires the day time level of 35dB and night time level of 38dB. If the background noise levels set out in Tables 2 and 3 of my Tables and Figures are representative of the real background noise then comparison with my Table 5 of turbine noise levels shows that the properties at Stemster House, Bardnaheigh, Hillcrest, Achiebraeskiall and 6 Skiall (11 in all) fail to meet the day time standard and that the same properties plus Old School House, Boulfruach and 5 Skiall (15 in all) fail to meet the night time standard.

7.2 If, on the other hand, the background noise levels set out in Tables 8 and 9 of my Tables and Figures are representative of the real background noise then comparison with my Table 5 of turbine noise levels shows that Stemster House, River Cottage, Bardnaheigh, Hillcrest, Old School House, Achiebeg, Shebster Garage, Mackay Terrace, Achiebraeskiall, Old School Achreamie, Glendower, Boulfruach, Skiall, Marlyn, 1-3 Skiall, 6 Skiall, 5 Skiall and 4 Hallam all fail to meet the day time standard. The same properties with the exception of the Old School Achreamie and 1-3 Skiall also fail to meet the night time standard.

7.3 This is a massive failure to meet the noise standard that is already far less protecting of amenity than almost any other standard for noise. If another turbine were chosen then the levels would almost certainly be even higher. The noise level of the NEG Micon NM80 for example is 103.5dBA at 8m/s. Even if all the turbines could be run at reduced power all the time such that the sound power could be reduced by 3dB there would still be a major failure to meet ETSU-R-97 day and night. Additionally, if I am correct in that the background noise data is too high then there will be an even greater failure.

7.4 For most noise generating developments local authorities are not willing to permit a lower standard of amenity for any property merely because there is some financial connection with the developer because the purpose of protecting amenity is to protect it for anyone who might live in the property in the future. For example, if a farmer wanted to install a grain drier on his land then the local authority would normally require that noise from the installation would have to meet a particular standard. This standard would apply to all properties including, for example, agricultural tenants of the landowner. In an exceptional circumstance I believe it might be argued that the farmer himself might be permitted a higher noise level – though I have never come across such a case.

7.5 Nevertheless ETSU-R-97 permits a higher level of noise at properties where the **occupant** has a financial **involvement** in the development. Financial involvement implies a direct continuing involvement in the finances of the development such as a landowner might have. It is not the same as a financial interest. It is not as stated in 10.3.4 of the 2004 ES *where the owner/occupier has a financial stake in the development*.

7.6 People with a financial **interest** might include shareholders, local communities who have been promised money, people being paid for a licence to run cables across their land or any others who might benefit from the success or suffer from the failure of the development. None of these people can have a significant involvement in the project. For financial **involvement** to be applicable the person must play an active and direct part in the development.

7.7 In order for a property to be categorised as "Financially Involved" it is necessary for the Inquiry to know the form of that involvement so as to come to a proper conclusion as to whether it applies each case. For the developer to be required to put an argument to support the increased limit for those financially involved is no different from the developer having to put an argument to the Inquiry for the use of an upper day time limit of 40dB rather than 35dB. A mere assertion that this is the correct standard to be applied is not sufficient.

7.8 In any case, even if every property were classified as financially involved, three properties at Bardnaheigh, one at Hillcrest and two at 6 Skiall would still fail the much higher ETSU-R-97 test available for financially involved properties.