1 REVIEW OF THE HAYES MCKENZIE REPORT

For ease of reference this section will address issues in the report in the same order as they occur in the report. I address only significant issues, which do not include the few trivial typing errors inevitable in a report of this sort.

1.1 Introduction

It is worth noting that the scope of work was solely to measure noise in accordance with ETSU R-97 and to report on whether the measured levels showed compliance with the ETSU R-97 limits determined in the Atkins report.

1.2 Planning Conditions

I have assumed that the planning history and conditions are correctly reported.

Section 2.5 points out that the Environmental Statement submitted as part of the planning application did not contain background noise levels. (I comment on that in my conclusions at the end of this memo). The planning conditions included the following statement :

> *"In relation to those properties for which no background noise measurements have been taken, "Background Noise Level" means the background noise level measured at the property which is most likely to experience background noise levels similar to those experienced at the property in question"*

As background noise levels had not been measured at that stage, the above statement is not meaningful. The net result is, however, that the process of measuring background noise and the conclusions of the Atkins Report were not subject to the same degree of expert review and scrutiny as would have been the case if the report had formed part of a planning application. It is quite possible that the background noise levels at specific residences could be significantly lower than those at the locations reported by Atkins in 2009. Hayes Mackenzie's compliance report uses as its baseline the background noise levels and hence the noise limits set out in the Atkins report. Hayes McKenzie point out that they had not reviewed the measurement procedures and information contained in that report. It is arguable that such a review should have been included in the scope of work instructed by their client.

1.3 Measurements

I can not comment on the description of the receptors as I have not visited the site.

1.3.1 Noise measurements

The measurement methodology, duration, locations and equipment as reported all appear to be in accordance with ETSU R-97 and good practice. Hayes McKenzie is a well established practice specialising in this type of work and their staff are extremely experienced in wind turbine noise measurement. It would be surprising to find any errors of methodology in a report of this type.

I note that the measurements extend to windspeeds of 9.4 m/s at 48 White's Lane and 10.5 m/s at Rustyk House. ETSU recommends requires assessment up to 12 m/s although noise problems specific to these high windspeeds are rare. It is interesting that at 9 m/s, Hayes McKenzie have measured noise levels from the wind turbine and background noise combined which are below Atkins' reported background noise levels. This is probably a result of the way in which Atkins have derived the background noise levels, although it could also be caused by wind noise at the microphones, as I would expect Hayes McKenzie's windshields to be more effective than Atkins' at these higher wind speeds.

As is common for this type of survey, the noise measurements were unattended but the report very properly lists the sources of noise noted during installation and removal of the equipment. At both sites, they report that noise from the turbine was audible ("clearly audible" at 48 Whites Lane). I have discussed this with Mark Craven of Hayes McKenzie who confirms that the noise was not tonal in nature but that it was audible as the "whooshing" noise typically induced by the blades of large wind turbines. This should be audible on the audio recordings which Hayes McKenzie took on the first four days of the survey, but which they have not been required to analyse.

For the avoidance of doubt Mark Craven has confirmed that the turbine shut-downs from 22-31 October were from 02:00 to 03:00 hours. Hence Hayes McKenzie have night-time background noise measurements for these hours which we could compare with those in the Atkins report.

The data was filtered to include only measurements for when each property was downwind of the turbines (+/- 45 degrees). This is reasonable as a worst case assumption ; although it is theoretically possible that some forms of amplitude-modulated noise happen can with other wind directions, this is quite unlikely.

1.3.2 Wind Speed measurements

The accuracy of this type of assessment also relies on the accuracy of the wind speed data, and specifically the calculation of windspeed at a height of 10 metres, which is the reference height used in ETSU R-97. Wind farm operators tend to measure windspeed at hub height, which for a large turbine can be anywhere from 60 to 100m. At any location the windspeed increases with height, and this is known as *Wind Shear.* ETSU R-97 includes in the glossary a formula for wind shear, to allow windspeed at 10 m height to be estimated from measurements at other heights. This is a function of "Ground roughness length" for which some generic estimates are given in ETSU R-97.

This methodology has been found to be unreliable because wind shear is more site-specific than was assumed when ETSU R-97 was written in 1997. Consequently a group of leading experts in wind turbine noise, many of them members of the group which wrote ETSU R-97 and including Malcolm Hayes and Andy McKenzie, published in Acoustics Bulletin a preferred procedure for determining wind shear. This requires simultaneous measurement of windspeed at two heights and a formula for calculating the derived windspeed at 10 m/s from these measurements. In fact this was not a new method – it is referred to on page 85 of ETSU R-97 – but the article expands on and clarifies this method. This preferred procedure has since been widely adopted by noise consultants including Hayes McKenzie and Atkins.

The preferred procedure was published in March 2009 which post-dated Atkins' measurements although it pre-dated issue of their report. The Atkins report states that wind speed data was supplied by their clients SLP, using measurements at 30 metres height which Atkins adjusted to 10 metres using the ETSU method.

The Hayes McKenzie Report states that for their measurements in 2011, wind speed data was obtained from the nacelle-mounted anemometers on the turbines and that this was, again, corrected to the equivalent 10 metre height windspeed using the methodology set out in ETSU R-97. They used the standardised ground roughness length of 0.05m, as that was the basis on which the noise limits were derived by Atkins. The report makes no reference to the more recent preferred procedure.

While using the same methodology might seem consistent with the Atkins measurements, I would query whether this is in fact a reasonable comparison as the wind speed measurements were taken at very different heights – 30 m for the Atkins measurements and more than 60 m for the Hayes McKenzie measurements. Given that in both cases the correction to 10m height was made using an assumed ground roughness length, it is not clear that the two are directly comparable. I would suggest that the more recent preferred method should have been used to establish the wind shear specific to this site, particularly in a case such as this one where noise complaints have been received.

Some calculation of the potential errors resulting from this inconsistency suggest that this could have led to an error of approximately 10% in the calculation of windspeed at 10 m height. Reference to Figures 5 and 6 of the Hayes McKenzie report suggests that this alone would not change the conclusion of their report. None the less this raises the question as to whether it is valid to use the Atkins measurements as a baseline against which to measure the turbine noise as technically speaking, the two are not comparable. There is no discussion of this or other uncertainties or confidence limits in the Hayes McKenzie report.

It is also worth noting that there is no reference to the equipment, calibration, expected precision or reliability of the client's wind speed measurements.

1.4 Results

The essential information is in Figures 5 and 6 of the Hayes McKenzie report. The graphs show a good spread of data for windspeeds 3 – 9 m/s which is the range in which noise problems are most often encountered. Their best-fit curve is a 4^{th}-order polynomial in accordance with ETSU recommendations.. There are a few outliers well above the curve but this is normal and is probably caused by short-term variations in background noise level. Compliance is calculated from the best-fit curve and not from individual data points.

Both curves show compliance with the ETSU noise limits derived from the Atkins report. The lowest "headroom" or "safety margin" at 48 Whites Lane is approximately 5 dB(A) and at Rustyk House it is approximately 3 dB(A). In both cases this occurs around 6-7 m/s windspeed.

It is important to understand that these levels are not corrected for background noise. They are the sum of noise from the wind turbines and of the other sources which make up the background noise. The curves are therefore intrinsically higher than they would be if they showed only the noise generated by the wind turbines. It follows that if the combined (turbine + background) noise is below the ETSU noise limits, the turbine noise level will be further below the limit and in such a case no further analysis is needed. This is apparently the case here, provided that we accept that Atkins measurements as representative of the background noise at these receptors.

If we do not accept that Atkins measurements as a representative baseline, and if the "Quiet daytime noise levels" are lower than assumed by Atkins at windspeeds around 6 m/s, then it is possible that the ETSU-R-97 levels would be exceeded. This is discussed in a later section of this letter.

1.5 Tonality

Mark Craven of Hayes McKenzie has confirmed in conversation that there was no tonal noise either at the residences or closer to the turbines at any time when he was on site. He also stated that complaints from residents described "whooshing" noise and that is also the type of noise that he heard. "Whooshing" is a typical description of aerodynamic blade-induced noise which is broadband amplitude-modulated noise. It is not tonal.

From this information I would concur that tonal analysis is not necessary at this stage. The audio recordings produced on the first four days of the Hayes McKenzie survey could be analysed for tonality at a later stage if required.

1.6 Vibration and Infrasound

While there is a great deal written about this on the internet, much of it is based on confusion between the terms "Vibration", "Infrasound", "Low-frequency noise" and "Amplitude modulation". The "whooshing" noise described is Amplitude Modulation and this is a completely different issue from vibration and infrasound.

I agree with Hayes McKenzie that vibration and infrasound are most unlikely to be perceptible at the receptors.

1.7 Conclusions on the Hayes McKenzie report

The report concludes that the noise from the wind turbines at Rustyk House and at 48 Whites Lane meet the noise limits set out in ETSU R-97, and hence in the planning conditions, given that these limits were derived from the Atkins report.

If we were to accept the background noise levels in the Atkins Report as accurate and representative of conditions at these two residences, we would reach the same conclusion on the basis of the Hayes McKenzie report.

This does however rely on the Atkins' noise measurements setting a correct and appropriate baseline noise level for this assessment.

2 COMMENTS ON THE ATKINS REPORT

2.1 Measurement locations

The report states that the locations of the two noise monitoring stations were agreed with Waveney District Council. This does not relieve Atkins of their professional responsibility to ensure that the monitoring locations are adequate and representative. I would query whether two noise monitoring stations are adequate for this site and it would be interesting to compare this with the number of sites used for other surveys with similar numbers of potentially affected receptors.

From the photographs supplied, both monitoring stations appear to be surrounded by, and relatively close to, large amounts of vegetation.

2.2 Noise measurements

The measurement methodology and equipment as reported appear to be in accordance with ETSU R-97 and good practice, although I would not expect the standard wind shields used by Atkins to be as effective at high windspeeds as the much larger windshields used by Hayes McKenzie.

The noise measurements were unattended and there is no discussion of the main noise sources contributing to background noise. Atkins do not seem to have taken audio recordings so as to check whether the measured noise levels were affected by atypical sources. Failure to identify any atypical noise sources would tend to result in higher ETSU-R-97 limits.

Most critically, it would appear that the measurements did not cover an adequate range of wind speeds and this is discussed later.

2.3 Wind Speed measurements

The wind speed measurements were provided by Atkins' client SLP. Like Hayes McKenzie, Atkins make no reference to the equipment, calibration, expected precision or reliability of the client's wind speed measurements. It is therefore impossible to judge whether these are likely to be reliable or accurate.

There is a discussion of wind shear measurements, and of the validity of comparison of windspeeds, in section 1.3.2 of this letter.

2.4 Results

The results are shown graphically in Appendix A, and it is immediately obvious in all of the figures A.1 to A.4 that there was very little data at windspeeds between 6 and 9 m/s. In fact for the quiet daytime periods, which tend to be the most critical times, there is no data at all between 6.5 and 8.5 m/s.

At both locations there is a very wide-ranging cluster of data points at low wind speeds – in both cases spread over a range of some 20 dB – with little or no data at medium speeds and some data from 8.5 to 12 m/s.

Atkins have fitted "regression lines" to this data – that is, they have drawn a straight line to achieve a best fit. The assumption stated in the report's Executive Summary and Conclusions is that this should be a "straight line" relationship. This is not, in fact, consistent with ETSU R-97 which requires the use of regression analysis using a polynomial function of up to fourth order, as correctly undertaken by Hayes McKenzie. This can easily be seen by comparing Atkins' Figures A.1-A.4 with Hayes McKenzie Figures 5-6. The latter also show that the windspeeds at which the wind turbine noise comes closest to the assumed noise limits are around 6 m/s, but the Atkins graphs show that there was very little data at those wind speeds from which to derive those limits.

It is surprising that neither report mentions this paucity of data at medium wind speeds and that there is no discussion of the possible errors arising from this.

I therefore consider that the noise limits were derived from insufficient data to set reliable noise limits at some wind speeds, and that the analysis of that data was inadequate.

2.5 Calculation of allowable sound power levels

Section 3 of the Atkins report derives allowable sound power levels for the wind turbines. I have not, at this stage, reviewed these calculations as they are not relevant to the Hayes McKenzie report which only refers to the Atkins report for background noise levels.

It is however interesting to note that in this section, Atkins recommend that at 4 m/s the turbine sound power levels should be 5 dB(A) less than permitted by their derived ETSU R-97 limits, although this is not included in their tabulated criteria in Tables 2.3 and 2.4. They also recommend in Table 3.2 "Conservative" sound power levels of 104 dB(A) at 8 m/s during the night-time.

2.6 Discussion of Atkins' Conclusions

Atkins report Section 4 "Conclusions" states that their analysis shows a reliable relationship between background noise levels and wind speed, and that this is "straight line" 2 dB per m/s during the "quiet day" periods and 3 dB m/s at night-time.

In fact there is no reason why this relationship should vary between day and night. At higher wind speeds the noise climate will be dominated by noise from foliage and this will be the same irrespective of time of day. At lower windspeeds other background noise sources such as road traffic will become significant and these are generally lower at night. Hence in both cases the relationship will be a curve rather than a straight line, and the very simplified method adopted by Atkins is simply not correct.

There is a clear discussion of this in Appendix C of ETSU R-97 to which the planning condition specifically refers.

3 CONCLUSIONS

3.1 Technical issues

I have undertaken a technical review of the Hayes McKenzie report and I consider that the noise measurements have been undertaken to a high standard of professionalism and technical correctness. Given their noise data, the wind speed data supplied to them by their client, and the baseline noise levels contained in the Atkins Report, I would reach the same conclusion as they have, which is that the noise levels measured comply with ETSU R-97.

These "Givens" are however questionable. There is inadequate information on the equipment and calibration of the wind speed measurement and it would be helpful to have Hayes McKenzie's evaluation of the reliability and accuracy of that data. Notwithstanding the planning condition, I would also consider it to be good practice to provide a site-specific assessment of wind shear in accordance with the preferred method published in Acoustics Bulletin in March – April 2009. A comparatively large error in wind speed assessment would however be required to reverse the conclusion of the report.

Much more significantly, however, I consider that the baseline noise levels in the Atkins Report, which formed the basis for the Hayes McKenzie assessment, are inadequate. There is insufficient data over a broad range of wind speeds, the way in which that data has been processed is technically incorrect and not in accordance with ETSU R-97. Background noise was measured at only two locations, which seems unusually low for a relatively large number of potentially affected residences, and we have no basis on which to judge whether either of these measurement locations is representative of background noise at the locations assessed by Hayes McKenzie.

3.2 Planning issues

Given the high profile of wind farm noise as a planning issue it is extraordinary that planning consent for a wind farm was granted without a noise assessment.

I understand that planning conditions were imposed by the planning inspectorate. Given that these conditions refer extensively to ETSU R-97, it should be noted that ETSU R-97 itself states that planning conditions would be too complicated to write and instead proposed the use of planning obligations. ETSU even provides a detailed example of such a planning obligation with extensive guidance notes.

The planning conditions are unclear as regards measurement of background noise level, which is of critical importance to the noise assessment. In particular they state that for properties where background noise levels have not been measured, compliance with ETSU R-97 should be assessed against the measured background noise "…at the property most likely to experience background noise levels similar to those experienced at the property in question". This is impossible to assess without measuring background noise levels at the property in question. In any case the "Measured background noise" is defined as being that in the Environmental statement which I understand it does not include such measurements.

The assumption in the Hayes McKenzie report is that in the absence of any other data, the background noise levels are "set" by the Atkins report of April 2009, which post-dates planning consent. In my opinion, however, this report is deeply flawed and would have been challenged had it been submitted with the planning application. Because of the planning history, however, this report was not subject to the level of scrutiny that would be normal for a wind farm planning application in a residential area.

I therefore consider that the only reliable way to measure whether noise levels comply with ETSU R-97 at specific sites would be to use measured background noise levels at those sites. They need only be measured at and around the windspeeds at which complaints occur. I note that Hayes McKenzie have some night-time background noise data at both locations and a first step would be to analyse this, along with the relevant wind speed and direction data.

3.3 Other considerations

ETSU R-97 allows noise levels from wind turbines which are significantly above the background noise level. It is therefore possible for wind turbine noise to be clearly audible, annoying or even a nuisance at residences while still complying with ETSU R-97.

As you know, compliance with planning conditions is not a defence against action under Section 80 or 82 of the Environmental Protection Act. While the defence of Best Practicable Means applies, it is possible that a court might judge it practicable for the turbines to be operated in a lower-noise mode or indeed to be turned off at certain windspeeds. I understand that some turbines are already subject to similar controls over shadowing and flicker at certain speeds and times of day.

Best Practicable Means would not, of course, be a defence against a private action for nuisance and I understand that there is at least one other such case to which we could refer for a precedent. This would require quite a high standard of technical evidence including, I suspect, detailed measurement and recording of Amplitude-modulated noise in complainants' houses and gardens.

Adrian James