ASPECTS OF NOISE FROM WINDFARM DEVELOPMENTS

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1. INTRODUCTION

One of the results of the Electricity Act of 1989 is that the government now requires each of the twelve regional electricity generating companies to obtain a certain amount of power from non-fossil fuels. This is referred to as the Non-Fossil Fuel Obligation. The additional costs incurred by the generating companies as a result of this obligation are subsidised by a 'fossil levy' charged on energy supplied from fossil sources. Although the Non-Fossuil Fuel Obligation includes both nuclear and renewable energy sources, one of the results is that windfarms have become much more financially attractive to developers.

The siting of windfarms is constrained by various factors, some of which relate to the actual generation process and some of which relate more to local planning issues. Noise and visual intrusion have become two of the most important issues in planning debates and, in some cases, have been major obstacles to the progress of the development.

From the noise point of view, it is not that wind turbines produce high levels of noise but that the existing background noise levels in areas appropriate for windfarm development are often very low. Windfarm development can be completely precluded at locations which are emminantly suitable if the likely noise impact is assessed by comparing predicted noise levels from the windfarm with existing background levels at nearby residencies, as is suggested in British Standard 4142. Whilst it is acknowledged that the use of this standard will, in most cases, protect nearby residents against noise from the windfarm to a very high degree, it should be noted that it is stated in paragraph 1 of BS4142 that it "is not applicable for assessing .... noise in situations where the background noise level is very low, ie. below an 'A' weighted sound pressure level of 30 dB(A)".

2. MEASUREMENT OF BACKGROUND NOISE

As a result of the underlying importance of establishing the background noise levels around potential windfarm sites,

WINDFARM NOISE

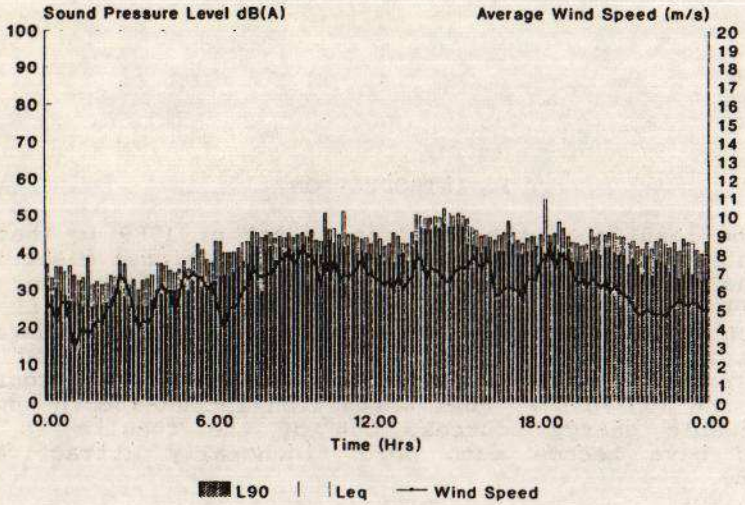

Figure 1 - Background Noise & Wind Speed over a 24 Hour Period

simultaneous measurements of background noise and prevailing windspeed (and direction) are generally undertaken at the nearest sensitive residencies to any development. This enables background noise levels to be compared to predicted noise level at a given windspeed (and direction) in line with the recommendations given in BS4142. In the absence of other nearby noise sources, wind in the trees and around the local topography generally accounts for a significant amount of the prevailing background noise; and background noise from these sources increases with wind speed. It is generally true that the turbines do not make any noise below their cut-in wind speed of around 5 m/s, and that background noise increases at a faster rate than turbine noise with wind speed above this. The point at which the likely noise level from the windfarm is highest in relation to the existing background level is, therefore, at the cut-in wind speed for the proposed turbines.

It is, therefore, important to establish the background noise levels which exist when wind speeds are around the cut-in speed for the proposed wind turbines. Noise which is not generated by the wind tends to vary according to time of day and the only effect of the wind is to change its propagation through the atmosphere. It is, therefore, insufficient to plot background

noise against wind speed without also establishing the pattern of background noise with time. This will go some way towards resolving the scatter on a plot of background noise against wind speed when there are significant noise sources other than those which are affected by the wind. Figure 1 shows how background noise (L_{A90}) varies over a 24 hour period, for wind speeds around cut-in at a residence close to a potential windfarm development.

The wind speeds shown on this graph were measured at a typical wind turbine height of 30m and the averages are shown for the same 10 minute periods as were used for the measurement of L_{A90} and L_{Aeq}. Figure 2 shows background noise plotted against wind speed as measured over a longer period and Figure 3, shows how the scatter on this graph is much reduced when only night-time data (ie. when noise sources independent of wind speed are diminished) is included.

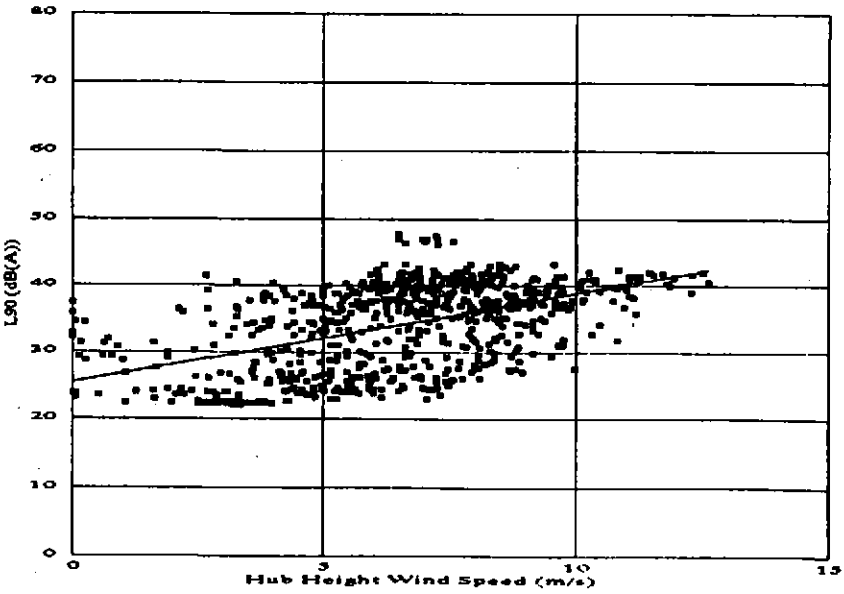

Figure 2 - L90 vs Wind Speed (All Data)

WINDFARM NOISE

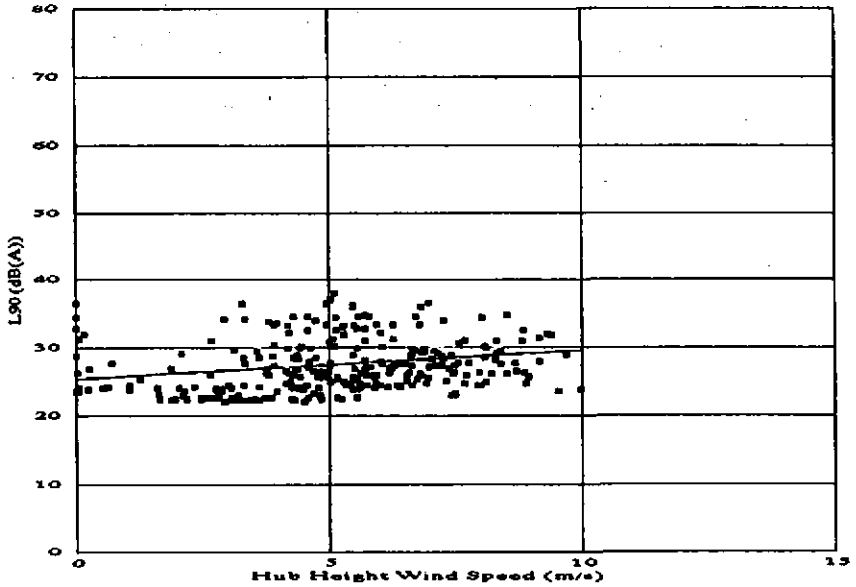

Figure 3 - L90 vs Wind Speed (2300-0700)

3. ASSESSMENT OF NOISE IMPACT

Not only do windfarms tend to be in rural areas where background noise levels are generally low, but they continue to operate during those times when background levels are extremely low (ie. 0100-0500) if wind conditions are correct. Although the use of BS4142 is specifically precluded in situations where background noise level is below 30 dB(A), it is the only document which is available to guide planning officers in establishing the likely noise impact of a potential windfarm development.

The method described in BS4142 for assessing the impact of a new noise source compares the L_{Aeq} from the new source with the measured L_{A90} of the background noise. If the assessment is based on the well being of residents inside their homes, then it pre-supposes that it is possible to hear the contrast between ambient noise levels with and without the new noise source operating. The noise insulation afforded by a typical dwelling renders this comparison meaningless as noise levels below 30 dB(A) will be inaudible under most conditions when

windows are closed. Although it is likely that windows will be open during the summer months, windfarms will not tend to operate regularly at this time due to lower average wind speeds.

On the 5th December 1991 the Department of the Environment produced a draft Planning Policy Guidance Note covering Renewable Energy. This has an annex specifically concerned with wind energy which covers many factors, including noise. Unfortunately, this document contains no specific advice on noise and merely draws attention to the inadequacies of existing legislation (ie. BS4142). It does, however, refer to a further DoE draft Planning Policy Guidance note covering Planning and Noise which was subsequently published on 31st December 1991 and to the Danish draft Statutory Order on Noise from Windmills (1).

4. NOISE LIMITS

The Planning and Noise PPG, which is designed to replace the existing DoE Planning Circular 10/73, also evades the issue of the assessment of noise impact where background noise levels are below 30 dB(A) but does state that a BS4142 type assessment "may indicate that complaints will occur at a noise level so low that industrial activity is impractical". It suggests that "in some cases local circumstances may warrant setting the level at a higher value, say 40 dB(A)". It also acknowledges that "a balance must be struck between protecting the environment and protecting the economy of an area, albeit at the cost of a slight increase in ambient noise levels". This is in line with guidance contained in the Mineral Planning Guidance note, The Control of Noise at Surface Mineral Workings. This document cites BS4142 as an appropriate standard for assessing noise impact but states that "where there is a very low background noise level, a condition limiting mineral operators to a 10 decibel increase may be unduly restrictive if the resulting noise level is still well below the tolerance levels of most people". It goes on to suggest a night-time nominal limit of 40-45 dB(A) (L_{Aeq}) at any noise sensitive property, while acknowledging that lower nominal noise limits may be appropriate in quiet rural areas.

Noise legislation within the EEC tends to set specific noise limits which use background noise measurements only as an indication of the type of area. In Denmark, specific noise legislation exists which covers noise emitted from wind turbines exclusively. This is contained within the Danish Draft Statutory Order on Noise from Windmills. This specifies what are considered acceptable noise levels within a number of

environments which are expected to be found around a potential windfarm development as follows:-

L_{Aeq} of 45 dB(A) not to be exceeded at outdoor open spaces in the immediate vicinity of neighbouring properties in the open country. Neighbouring properties means all residential buildings other than the private house of the windmill owner.

L_{Aeq} of 40 dB(A) not to be exceeded in the most noise inflicted spot at outdoor open spaces in residential areas and noise sensitive spaces. A noise sensitive space is defined as land used or reserved for purposes of institutions, week-end houses or allotments (these being areas which are required for residents living in high density housing areas).

L_{Aeq} of not more than 45 dB(A) at a distance of 500 metres from the windmill. It is thought that this is to limit the noise radiated from any individual wind turbine.

In Sweden, a draft noise legislation is being proposed to cover noise from wind turbines. It is based upon existing Swedish noise legislation covering industrial plants and a recommended L_{Aeq} of 40 dB(A) is set at neighbouring dwellings downwind of any development. Where the 'experiences of nature' are important then this may be reduced to 35 dB(A). A further penalty will be used should a pure tone exist in the incident noise.

Holland and Germany have no specific legislation concerning noise from wind turbines but set levels of 40 dB(A) (Holland - 24 hr L_{Aeq}, rural) and 35 dB(A) (Germany - Night-time, Pure Residential) respectively for any industrial noise sources.

5. CHARACTERISTICS OF WINDTURBINE NOISE

The noise from a wind turbine is a combination of two distinct types of noise. These are the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise caused by the blades passing through the air. Although the aerodynamic noise from the turbine is broad band in nature, and thus generally un-obtrusive, the mechanical noise is similar to that present in other rotating machinary and is likely to have a tonal quality.

BS4142 states that a 5dB correction factor should be added to the predicted noise level for assessment purposes if the noise contains a "discrete, continuous note". The standard does not, however, provide any guidance as to how to assess the tonal quality from objective measurements carried out in the absence

of being able to listen to the noise under question.

BS7445, Description and Measurement of Environmental Noise, contains a note in Part 2 which suggests that a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5dB or more. It also suggests that if tonal components are clearly audible then a correction of 5-6dB may be appropriate but that, if the components are only just detectable, then the correction should be 2-3 dB.

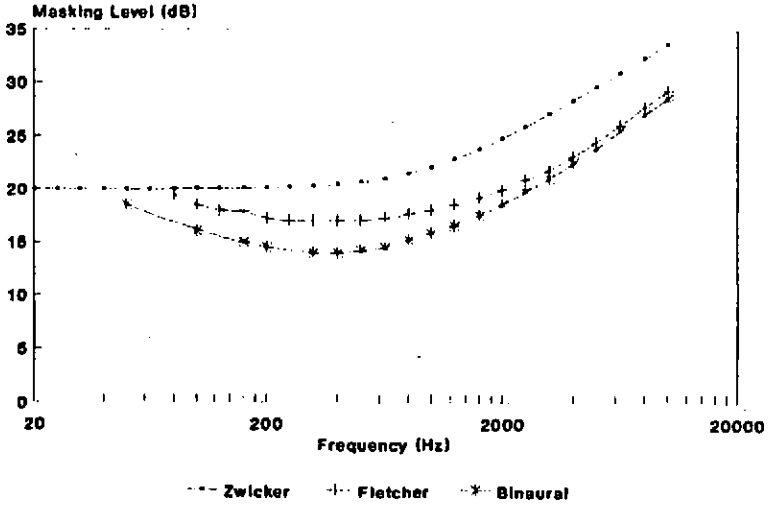

Figure 4 - Threshold of Audibility for Tones in Noise (1Hz B/W)

The use of narrow band frequency analysis is, however, the preferred method of establishing the presence of significant tonal components within the noise spectrum. It is likely that any piece of rotating machinary will contain discrete tones but it is not clear at what point they become prominent over the broad band noise. The masked thresholds for tones in noise can be obtained from published values of critical bandwidth (ie. Zwicker et al. (2) or Fletcher (3) whereby the difference between the tone and the spectral (1 Hz bandwidth) level of the noise just required to mask it is given by 10*Log(Critical Bandwidth). There is, however, a difference of about 3dB

between masking values obtained using the Zwicker and the Fletcher critical bandwidths caused by the different methodologies used to obtained the data. There is also a 'binaural' masking curve from Fletcher, cited in French & Steinberg (4), and the differences between these are cited in Figure 4. Even if definitive thresholds could be agreed, it is not clear how much the tone can exceed the masked threshold before it becomes significant.

6. NEED FOR A SPECIFIC STANDARD

A need has been identified for specific guidelines on permitted levels of noise around windfarm development sites. Since the strict application of BS4142 precludes almost all developments of this sort in rural areas, various compromises have been developed by the local authorities concerned. At present, these consist of a mixture of variations on BS4142 which base the permitted noise levels on differing functions of the background level measured under specific conditions.

It is considered that these compromises neither completely protect local residents from the effects of wind turbine noise, nor allow the developers to construct sites which are practical to run. A need for renewable energy sources has been established by the government and, as a result, an absolute standard should be set, as for the construction of new roads, which specifies achievable noise limits at any residence affected by noise from a windfarm site. This should take into account the following:

1) Regulations in various countries in the EEC for noise limits from industrial developments.

Of particular interest are the noise limits in Denmark which have been drawn up specifically for windfarm developments and which limit the noise to a level of 40 dB(A) at the most noise inflicted spot at outdoor open spaces in residential areas, under specific operational conditions.

2) Recommendations contained in BRE Digest No. 226 and DoE Circular 10/73 on acceptable internal noise levels.

The BRE digest contains the maximum recommended L_{Aeq} sound pressure levels which are considered acceptable within a dwelling when new residential development is to be undertaken near an existing constant noise source. These recommendations are of the form of internal L_{Aeq} levels of between 30 and 40 dB(A) for bedrooms and between 40 and 45 dB(A) for living areas. The DoE circular 10/73 suggests 40 dB(A) as a "good

standard" of noise within dwellings with windows closed.

3) Recommendations contained within the DoE Draft Planning Policy Guidance Note, Planning & Noise.

This suggests that exterior noise levels lower than 42 dB(A) between 2300 and 0700 need not be considered as a determining factor in granting planning permission for new housing developments near to existing "transportation and mixed noise sources".

4) Sleep Disturbance Criteria

The European Communities Commission (5) considers that a night-time Leq level of 30-35 dB(A) or below, within buildings, does not affect sleep. The Organisation for Economic Cooperation and Development (6) recommends (internal) levels of 35 dB(A) during the period of getting to sleep and the World Health Organisation (7) recommends an internal level of about 35 dB(A) during the night.

5) Pure Tone Penalty

A criterion for a pure tone penalty should be established which takes into account the presence of tones in the overall noise from the turbines. Particular account should be taken of the Nordic Method for evaluating tonal content, described in a report (8) published by the Lyteknisk Institut in Denmark, as this has been used in conjunction with the Danish Draft Statutory Order on Noise from Windmills in the development of windfarm sites in that country.

7. CONCLUSIONS

Existing legislation in the UK leaves planning officers poorly equipped to deal with planning applications by windfarm developers. In the absence of any specific guidance for the quiet, rural areas where windfarm development is currently taking place, the potential annoyance to residents is likely to be assessed using British Standard 4142. Application of this standard will protect the few residencies surrounding these isolated sites to a very high degree but is also likely to preclude the development of economically viable windfarm sites in most cases.

A number of different factors including existing legislation in the EEC, especially in Denmark and Sweden where specific standards exist for windfarm developers, have been examined and suggest that noise limits of between 35 and 45 dB(A), together

with criteria for the assessment of tonal content, should be set at any dwelling affected by the development. If this kind of standard were adopted in the UK, it would take into account the needs of the developers, the needs of the local residents and the global requirement for renewable energy sources.

8. REFERENCES

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