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BACKGROUND NOISE MEASUREMENTS FOR WIND FARM DEVELOPMENTS

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1. INTRODUCTION

When assessing the likely impact of proposed wind farms, it has become fairly standard practice to measure the background noise level in terms of LA90,10 min., over the course of 7 days at nearby properties, and then to plot this factor against simultaneous wind speed measurements made at the proposed wind farm; the calculated level of windfarm noise is then compared against the measured background noise level, at any given windspeed i.e. the wind turbine predicted levels for a windspeed of say 8 m/s are compared against the corresponding background noise level. Figure 1 is an example of this approach. This procedure is recommended by The British Wind Energy Association [1]. For convenience this method will be referred to as the "Standard" assessment method in the remainder of this paper.

This method of assessment is adopted on the basis that it is a BS.4142 [2] type approach and that a BS.4142 type approach is the most valid.

It is understood that the DTI working group on wind turbine generator (WTG) noise is at present (April '95) discussing the first draft of its recommendations; it is to be hoped that there will be some clear advice on the assessment of wind turbine noise. In the interim I propose to question some of the assumptions on which the "Standard" assessment method is based, and to examine some of the consequences of this approach, particularly with regard to the use of background noise, and trust that these issues will be addressed in the final DTI report.

2. HOW VALID IS THE "STANDARD" METHOD?

The general principle behind BS.4142 is that people living in an area become accustomed to the prevailing level of noise in that area (the background noise level) and judge any new noises against that level; it is the quieter portion of the ambient noise which they are used to e.g. the gaps in the traffic measured as LA90; the reasoning is that when a new noise appears to be around twice as loud as the preexisting background noise (10 dBA), complaints are likely.

Most industrial noise sources occur during weekdays or week-nights. In addition for most residential areas the background noise (LA90) is mainly dependant on road traffic and therefore does not vary greatly from day to day i.e. the daytime background noise level is probably similar from one day to the next, as is the night-time background noise level. Therefore the concept of a "yardstick" to which residents become accustomed, and judge new noises by, has some meaning.

By contrast in very rural areas there is a significant variation in background noise depending on the weather. Referring to the "Standard" method, is it true to say that residents are accustomed to one background noise when the wind is calm, and judge new noises by this yardstick, and yet are accustomed to a slightly higher level of background noise when the wind is slightly higher and so on? Equally when the wind speed is greater than 15 m/s (gale and storm force winds) do residents have any particular expectations of new environmental noise, when they are probably inside with all windows and doors shut?

If the background noise in a rural area increases by 1 dBA per 1m/s increase in wind speed e.g. 24 LA90 @ 0 m/s ranging to 44 LA90 @ 20 m/s, then, according to the "Standard" method there are 20 different background noise climates against which WTG noise is judged, depending on wind speed.

Minerals extraction sites also vary in the amount of noise produced and are often sited in rural areas, but the background noise levels used in MPG11 [3] assessments are single figure ratings. There is no suggestion in this document that residents in such areas judge new noise by 20 different background noise categories depending on wind strength and hence no suggestion that working cannot take place close to noise sensitive premises, unless the wind induced background noise is above a certain level. A single figure is chosen as the background noise and this is used to assess the impact of the minerals site.

In summary the "Standard" method seems different from the original concept of BS.4142. It is also different from the way that BS.4142 is used in documents such as MPG11 to assess other rural noise sources.

3. NIGHT-TIME ASSESSMENTS AND BACKGROUND NOISE?

There have been a number of applications for wind farm developments at locations along town or city waterfronts. At such locations it is much more likely that night-time WTG operation will have a greater potential for noise impact; for example at the Shoreham Harbour appeal [4] it was found by the Secretary of State that daytime traffic noise levels would effectively mask noise from the windfarm except between mid-night and 6.00 am.

Referring back to the principle behind BS.4142 we should ask how residents can become accustomed to the prevailing background noise level in an area, when they are asleep? At night it would surely be more relevant to consider sleep disturbance as the main criteria rather than excess over background. For example it can be seen that the night-time noise exposure categories of PPG24 [5], and the recently reported DoE suggestions [6] of a criminal offence of night-time nuisance, were chosen on the basis that internal absolute noise levels of more than 35 LAeq should be avoided i.e. sleep disturbance criteria.

It would still be necessary to measure night-time noise, to ensure the WTG noise was above the level of the background, because if the background noise at a given wind speed is higher than the WTG noise then no real additional sleep disturbance would occur.

4.THE CONSEQUENCES OF THE "STANDARD" METHOD

If long term background noise levels near noise sensitive premises are to be plotted against simultaneous wind speed measurements at a proposed turbine location then it naturally follows that an anemometer must be located at the proposed WTG site. It would be nonsensical to pay for the installation of an anemometer tower merely for the noise assessment. Once erected it is more cost effective to obtain long term results for the purposes of financial return prediction; the cost of making such measurements can be as high as £5,000.

Therefore adoption of the "Standard" assessment method is likely to result in smaller developers being less able to afford a full planning application even if they are certain of the energy generating capability of the site; For example the famous Brontë Parsonage wind turbine has been successfully producing power for several years and yet the local authority proposed noise criteria [7] requires an anemometer tower on site for the noise assessment, which would not otherwise be required.

By contrast major developers are likely both to have access to in-house anemometry facilities, and to perform such measurements as a matter of routine., so that a "Standard" assessment will tend to discriminate against both the smaller scale developer and smaller scale developments.

Further there are relatively few manufacturers of battery powered produce precision grade sound level meters with the capability of measuring down to <20 dBA, and also which can record for 7 days, and at the same time store the >1000 sets of results, and which can be fitted with a "weatherproof" microphone enclosure.

A typical proposed site might require background noise measurements at 3 locations, so that there are more than 3000 background noise measurements which need to be plotted against 1000 wind speed measurements; therefore the only practicable option requires the facility to download data directly from the sound level meter into a moderately powerful spreadsheet.

This procedure is difficult for most noise consultants to comply with and especially difficult for local authorities to perform; so that they may not be able to undertake their own assessments or to check those of noise consultants.

5. PLOTTING MEAN WIND SPEED vs LA90,10 min.

In order to determine how much energy a site will produce developers (and bankers) are interested in the long term mean wind speed. A fairly normal procedure is for the anemometers to take a wind speed sample every 3 seconds and at the end of 10 minutes to store the arithmetic average of all the samples, their standard deviation and the maximum (gust) value. The mast may be left in position for a year or more. Therefore this data is readily available from developers, and the anemometer equipment normally would not be capable of producing other parameters.

If the background noise in an area is truly wind controlled then the $L90_{noise}$ is produced by the $L90_{wind}$; however the noise consultant is provided with the mean wind speed which may not bear a fixed relationship to the $L90_{wind}$. When the wind conditions are variable the relationship between the two wind parameters will vary, if the wind is constant the two parameters will probably be fairly similar; whilst at some sites a particular configuration of topography and wind direction may mean that the relationship between the two wind parameters varies.

For example, there may be a gust of wind which last for 11% of an assessment period; this would elevate the mean wind speed but would not affect the $L90_{wind}$. Equally a 11% lull in wind speed would dominate the L90 noise but may not greatly affect the mean wind speed.

In addition, the "Standard" method uses 10 minute assessment periods, and it is quite likely that the wind speeds measured at the proposed site will not always correlate with the wind induced noise at the housing. Firstly there is no easy method of ensuring that the time clock on the anemometer coincides with the clock on the sound level meter. Secondly a 5 m/s wind gust will take more than 3 minutes to travel 1km, so that depending on wind direction such a gust will either be at the measurement position 200 seconds before, or 200 seconds after it reaches the anemometer.

It might be thought that if background noise measurements are made over a long enough time and enough points are plotted on the graph then it will "all come out in the wash". However without comparative research, the uncertainties of plotting LA90,10 min. vs mean wind speed cannot be known. It may be that hourly measurements of the L90 plotted against the hourly mean wind speed provides more consistent results, because variations between $L90_{wind}$ and the mean wind speed are smoothed out. With such hourly measurements any timing differences would tend to be smoothed out, and more types of sound level meters could be used to make measurements of hourly readings.

6. VALIDITY OF THE "STANDARD" METHOD IN HILLY AREAS

In hilly areas it is usual for wind turbines to be built on the hilltop in the wind, and for housing to be built in valleys out of the wind; therefore housing may be shielded from one wind direction but not another; hence, at any given wind speed, the amount of wind induced background noise will depend on both the wind strength and direction. In addition for some quiet rural areas a source of background noise

may lie in a single direction; for example a river or distant motorway. In such cases wind strength and direction can have a significant effect on background noise

A further consequence of housing being sited down in the valley sheltered from the hilltop wind, is that the wind experienced at the proposed hilltop site is unlikely to be the same as that experienced by valley residents. This disparity has lead to problems at existing wind farm sites i.e. when the wind is from a particular direction the turbines are turning and producing both energy and noise, whilst there is little wind induced background noise down in the valley.

Given the above situation it is possible that for some sites complaints about noise would be valid only for a short period. If there is the further complicating factor of a wind farm built close to the urban fringe, such problems may only occur at night.

As an example of possible short periods of noise impact, there are many villages on the Lancashire side of the Pennines for which a westerly wind is likely to affect both any proposed turbine site and the housing whereas an easterly wind may produce the wind shadow effect described above; the following data was obtained from The Met Office, from their Wilsden site in the Pennines. It is a fairly typical hilltop location in the area and therefore is representative of wind farm sites in the area. The 10 year averages for wind speed and direction from January 1977 to December 1986 were:-

From	**<8m/s @ 10m**	**>8m/s @ 10m**
SW quarter	33%	8%
NW quarter	20%	4%
NE quarter	16%	0%
SE quarter	19%	0%
Total	**88%**	**12%**

On the above figures, it may be that an excess over criterion only occurs when there is a strong wind from the NE quarter, i.e. <1% of the time, is this relevant to any planning decision? and if so how relevant? Or it could be that an excess over criterion occurs during a light wind from the NE quarter, which in the Pennines is more likely to occur during cold winter months when residents are inside with windows and doors shut.

In summary any recommendations on WTG noise impact assessment should adress how often any criteria can be breached, and at what times of day, before the impact should be deemed significant.

Finally in hilly areas and with larger sites there is often more than 1 anemometer mast. Figure 2 shows wind speed measurements from a proposed 60 turbine site in a hilly area. The developers had three anemometers on site. It can be seen that there was a significant difference between the measurements. All the masts were checked and were found to be reading correctly. Under such circumstances which of the traces should be used for plotting the graphs?

7. CONCLUSIONS

Given that the wind conditions in the British Isles are well suited to the generation of power from the wind, it is likely that applications for wind farms will continue at the current rate, if not increase. In addition the lower construction costs of wind farms on less remote sites will mean that applications close to housing are likely to continue, and conseuquently noise is likely to continue as a major issue.

The current "Standard" method of assessing noise impact has many advantages but some questions over its validity and application to typical sites need to be addressed in any guidance which is produced.

In particular research could usefully be undertaken on the following topics:-

1. whether LA90,1hour measurements plotted against hourly mean wind speed data produces significantly different conclusions

2. the length of time over which background noise measurements should be taken. This could be achieved by taking say 8 weeks worth of background noise measurements around various sites and examining the sub-period (e.g. 3, 6, 7, & 10 day) results for significant differences.

3. how residents of rural areas perceive the prevailing background noise both during the daytime and at night.

4. for residents affected by existing windfarms how short a period of "excess" noise they would regard as unacceptable.

It is to hoped that the DTI working party address these matters when making their recommendations.

8. REFERENCES

[1] THE BRITISH WIND ENERGY ASSOCIATION, "Best Practice Guidelines for Wind Energy Development", BWEA November 1994

[2] BRITISH STANDARDS INSTITUTION, "Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas" BS.4142:1990

[3] DEPARTMENT OF THE ENVIRONMENT AND WELSH OFFICE "The Control of Noise at Surface Mineral Workings", MPG11 HMSO 1993

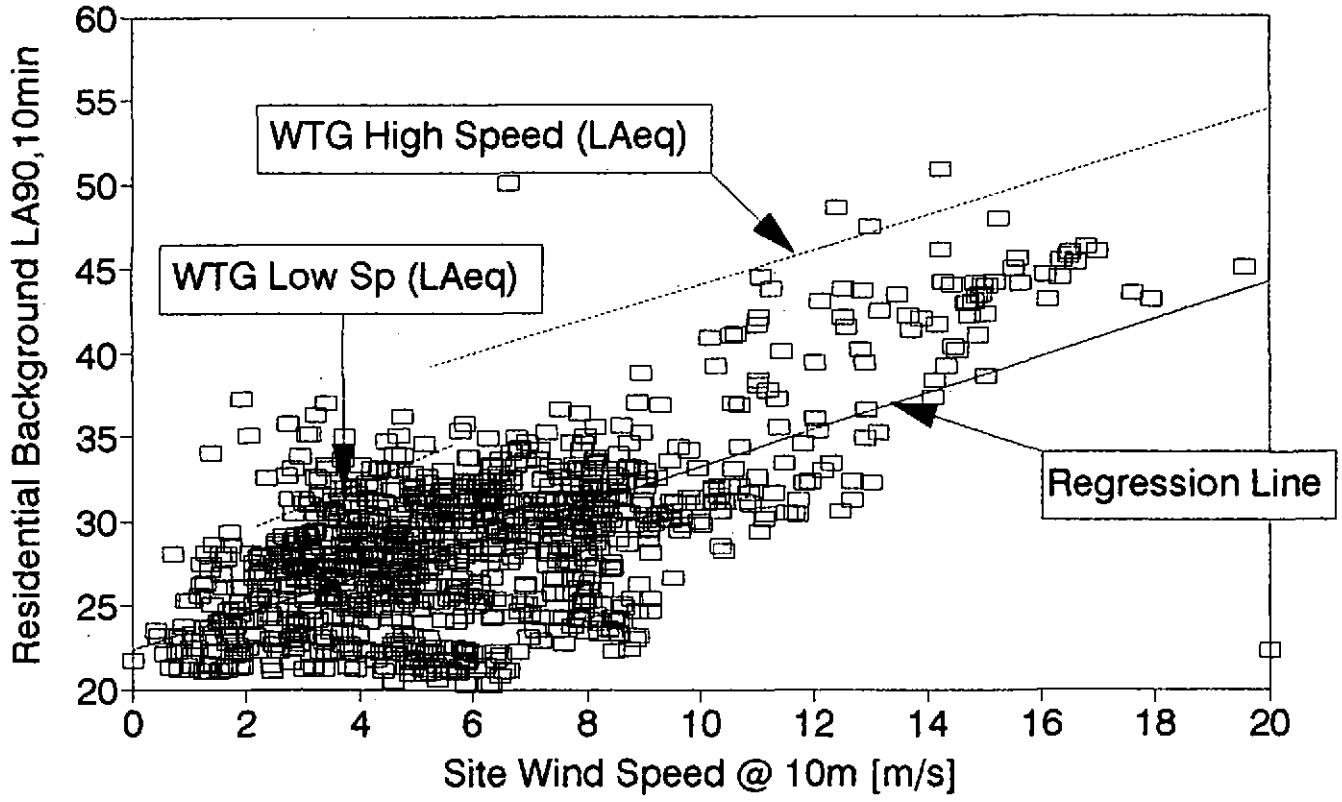
[4] GOVERNMENT OFFICE FOR THE SOUTH EAST "Appeal by The Shoreham Port Authority", APP/F1420/A/93/224812 & APP/Y3805/A/93/224813 - 14.2.95.

[5] DEPARTMENT OF THE ENVIRONMENT "Planning and Noise", PPG24 HMSO 1994.

[6] ENVIRONMENTAL HEALTH NEWS "Five Councils to pilot DoE Noise Proposals", EHN Ltd. Vol.10 No.13 13.3.95

[7] A WALMSLEY "Assessment of Noise from Wind Turbines - Recommendations to Bradford M.B.C. Planning Committee", Directorate of Housing & Env. Protection 7.10.94

Figure 1
House in Isolated Forest



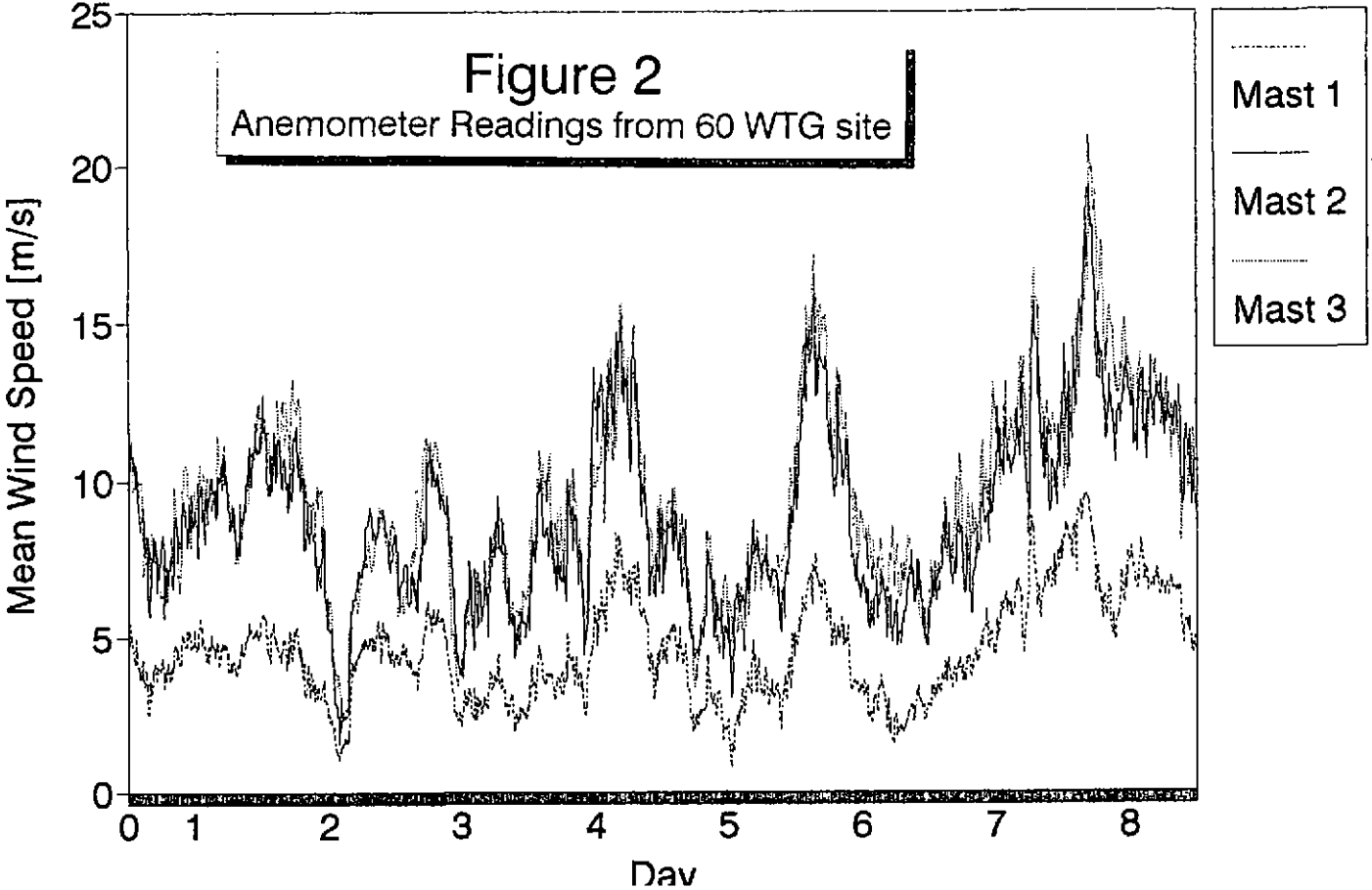


Figure 2
Anemometer Readings from 60 WTG site
Mean Wind Speed [m/s]
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
Day
Mast 1
Mast 2
Mast 3