Technical Note

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WIND TURBINE SYNDROME – AN ALTERNATIVE VIEW

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There is a view in many countries that there is something "different" in wind turbine noise, usually considered to be infrasound, that makes people ill even at distances up to 10km. This paper presents the view that there is a simpler explanation and one which many acousticians know about from personal experience. Apart from the level and the character of turbine noise, non-acoustic factors contribute to the annoyance people feel. That annoyance brings stress which produces the symptoms described. The non-acoustic factors are largely attributable to the manner in which wind farms are developed, in particular, governments' dismissal of a few people with a real problem as antisocial.

INTRODUCTION

Pedersen et al. [1] established that wind turbine noise annoys more than most other noise with similar loudness. Some people have put that down to some feature of turbine noise that we do not understand. In particular there is a body of opinion centred mainly round the work of Alves-Pereira and Castello-Branco [2], Harry [3], Pierpont [4] and the Waubra Foundation in Australia [5] that there is some special factor in wind turbine noise that directly causes illness called, for convenience using Pierpont's name, Wind Turbine Syndrome. The most commonly stated culprit is infrasound. A recent paper by Ambrose and Rand [6] suggests that the authors have proved an infrasound link to health effects in part because they were themselves so affected. There is a wide range of symptoms that are claimed to be the effect of turbine noise including sleep disturbance and attendant day time tiredness, headache, tinnitus, memory loss, depression, migraine, dizziness, tachycardia, irritability, loss of concentration, hyperacusis and anxiety. Ambrose and Rand [6] themselves relate that they experienced "*unpleasant symptoms of motion sickness, including ear pressure, headache, nausea, dizziness, vertigo, especially when moving about." They go on to say "We had a sense that the room was moving or slightly displaced from where it appeared. We experienced a loss of appetite, cloudy thinking, fatigue, some anxiety and an inexplicable desire to get outside; similar to motion sickness we have experienced on a boat or plane*." Headlines such as "The Wind Turbine Syndrome has become pandemic [7]" are becoming more common.

I do not think that the proponents of Wind Turbine Syndrome in its various forms have proved their case but this paper does not discuss that. It offers an alternative explanation to the undoubted symptoms people display which are similar to the symptoms that experienced acoustic consultants have observed with many types of noise – that the level and character of the noise are only part of the explanation. The strength of reaction to noise is brought about by non-acoustic factors moderating the perception of noise. One of the conclusions reached by Wolsink et al. [8] in their study of annoyance from wind turbines was that *the amount of annoyance was hardly related to the objective sound level*.

There is no doubt in my mind, from some of the work above and from the author's own experience that there are people who live near wind farms who have the symptoms that have been described above. I also have no doubt (because I have met some of them) that there are some people blighted directly by noise from poorly sited wind farms. But the number of people it is suggested that Wind Turbine Syndrome effects, at distances of up to 10km, cannot be explained simply by the noise level. My view is that there are three factors. First the measured noise level and second the character of the noise – in the case of wind farms mostly the presence of amplitude modulation but sometimes tones. Finally people's perception of the whole development and its implementation and of governments' stated attitude to wind turbine noise. This paper considers primarily the UK approach to wind farm development but many of the comments apply to a greater or lesser extent to other countries.

NOISE LEVEL

The first factor in the effect of wind turbine noise on people is the sound level and, in particular, the sound level relative to the background noise before the development. Some wind farms are simply too close to housing. Although Pierpont [4] does not quote noise levels to which her subjects were exposed, I have no doubt that most of the subjects in her investigation had a genuine grievance related simply to the sound level of the noise. Half were less than 750m away from a turbine and the nearest 305m. In the same way I do not doubt that most of those people who were the subject of Harry's report [3], 70% of whom were less than 750m away, had a genuine grievance related directly to the sound levelof the noise even though again, no noise levels were quoted. Most of these are in rural areas and turbine noise would be up to 40 or even 45dBA compared with a background noise level of less than 30dBA.

The effect of noise in many of these cases, because they were relatively close to turbines was probably exacerbated by amplitude modulation.

BS 4142 [9] is a British Standard that has been in existence for over 40 years. It is widely used throughout the UK as an assessment tool for planning purposes. Indeed it is so widely used that hardly any local authority in the country does not use it for some types of assessment and most require it for assessments of developments where a new noise is introduced into an area. In Ref. [10], the authors say "*The result of an assessment carried out to BS4142 would normally be relevant to the deliberations of any court considering whether or not a nuisance exists.*" The principle is simply that the projected new noise is compared with the existing background noise. If the difference is around 10dB or more then complaints are likely and if the difference is 5dB then the situation is marginal.

When ETSU-R-97 [11] – the wind turbine noise assessment method used in the UK – was written, the version of British Standard BS 4142 current at the time said that it was not applicable when background noise levels were below 30dBA. The ETSU-R-97 Working Group interpreted this as meaning that there was some lower limit (30dBA) below which background noise did not matter. In other words they assumed that, in very low background noise levels, people are not sensitive to the margin of the intruding noise above the background noise. It is just as likely, perhaps more so, that the reverse is true. People who live in very quiet rural areas (where wind turbines are often erected) may have a heightened sense of noise. They value the quiet – that is why they live there. It is quite possible to have an external ambient noise level of 25dBA and an external level of 30dBA from turbines, well below the accepted standard, that would easily be heard and might be found by some people in a tranquil area to be annoying. Most other countries adopt standards that are either a fixed limit or contain a fixed limit. It may be necessary, for the development of renewable energy, that such levels of wind turbine noise should be adopted but developers and government should make clear why they are necessary and should not be surprised if residents complain.

AMPLITUDE MODULATION

The second factor influencing reaction to turbine noise is the character of the noise. The dominant characteristic of turbine noise that cannot always be mitigated completely is amplitude modulation. All modern large turbines exhibit amplitude modulation and this has been explained by Oerlemans and Schepers [12] when the observer is close to the turbines and at greater distances in specific directions as due merely to the directivity and Doppler amplification of the noise. Upwind or downwind of the turbine the amplitude modulation reduces quite rapidly with distance but Oerlemans and Schepers has shown that it can project over longer distances in the cross wind directions. This is what is often called "swish".

However, there appears to be another type of amplitude modulation. It is sometimes called "thump" on the basis that some people including Salford University [13] and van den Berg [14] have suggested that it has a faster rise time than the swish described by Oerlemans and Schepers [12]. It seems possible now that this fast rise time is not a feature but that the fundamental difference is that there is a low to mid frequency component (125 to 250Hz) to the amplitude modulation in thump which does not occur in swish [15]. It seems, anecdotally at least, to be penetrating and relentless. The University of Salford Report [13] found that, of the 27 wind farms in the UK about which there had been complaints, four were due to amplitude modulation. In fact the headline figure of four was the result of asking environmental health officers whether there was "enhanced amplitude modulation" not whether there was amplitude modulation at all. Table 2 of the report shows that at least half of the sites where there were complaints had noise that was described with such words as thumping, swishing and so on and so was clearly modulated.

If amplitude modulation is present in the noise at a receiver, the noise is perceived as being more annoying than if the noise has no modulation. It can become impossible ignore the noise which might otherwise be acceptable.

PERCEPTION AND FAIRNESS

The third factor that is critical in understanding the reaction of people to wind farm noise is perception and, in particular perception of fairness. It is the contention of the author that it is this issue of fairness that has become the primary problem with wind farm noise. This might not have happened if developers and governments had paid more attention to the level and to the character of the noise when it was clearly unacceptable at some sites in the early stages of wind farm development.

A number of large surveys of noise annoyance from aircraft were published in the late 1960s and in the 1970s when there was a big expansion of jet aircraft movements. An American study [16] concluded that people who were highly annoyed by aircraft noise had a high fear of aircraft crashing, high susceptibility to noise, felt that there was some misconduct on the part of the airport or airline staff and did not rate the airport as important as most people. The noise level to which they were exposed did not correlate highly with their annoyance. Fields [17] looked at 282 social surveys of environmental noise. He says *Over 50 percent of the surveys found that, after controlling for noise level, noise annoyance increases with a fear of danger from the noise source, a sensitivity towards noise generally, the belief that the authorities can control the noise, the awareness of non-noise impacts of the source, and the belief that the noise source is not important*. In an international study of wind farm noise at 16 locations in three countries in 1993 [8], when not many people actually lived near turbines, it was found that the relationship between noise annoyance and sound level is not strong. Flindell and Stallen [18] state *It is almost universally recognised that noise exposure level never accounts for more than a small proportion of the variance of any outcome variable considered*.

Maris [19] wrote that *Based on a meta-analysis of several survey studies, it has been estimated that the effects of acoustical (e.g., the loudness, pitch, predictability) and non-acoustical variables (e.g., perceived control, personality traits like noise sensitivity, and attitudes towards the sound and its source) each account for about one third of the variance in annoyance scores (e.g., Job, 1988; Fields, 1993; Guski, 1999).*

The final 33% of the variance is considered error variance. She carried out research to test this hypothesis which identifies the issue of fairness. Participants are told that they are engaged in a study on effects of sound on people's performance during exams. As part of the experiment, they will take an exam while being exposed to sound. Half the participants are taken through a "fair" procedure in which three types of aircraft noise are described and asked to select the one which they think will cause them least annoyance. The other half are given a "neutral" procedure where they are not asked to choose. In the second test half the participants are given an "unfair" test. They are informed that they will be listening to a 15-min sample of their choice: nature sounds, a radio programme, or aircraft sound. They make their choice of sounds (not usually aircraft) and the experimenter then selects aircraft noise irrespective of the subject's choice and leaves the test booth saying "I have set the computer to aircraft sound." Maris established that when the exposer was unfair, annoyance was higher. In her conclusion she says *A person's evaluation of the sound is affected by the social process between themselve(s) and the operator(s) of the source. The results from the laboratory experiment confirm that the unfairness of the sound management procedure influences the evaluation of the sound. Relative to a neutral sound management procedure, an unfair procedure is found to yield collective excess annoyance*.

So it has been suggested for at least two decades that noise level is only one factor in determining people's reaction to noise.

PERCEIVED UNFAIRNESS IN TURBINE DEVELOPMENT

The stated government policy in the UK and in many other countries is that renewable energy projects should be driven by the private sector and that any environmental or other impacts in applications will be controlled by the planning system. This is a part of the democratic process of the country – the developer on the one side and the planning process representing ordinary people. If there are no objections to a proposal going through the planning system then it will be approved. So objectors to wind farms are doing more than exercising their right, they are exercising their obligation to take part in the democratic process. Only by people objecting can there be any chance of testing whether or not the application meets all the reasonable standards for developments – imposed, after all, by the Government in the first place. Otherwise any development would go ahead however damaging. The author believes that Government and developers in the UK have forgotten this. Ed Miliband, now leader of the opposition in the UK but then minister in charge of dealing with climate change, said in 2009 "Opposition to wind farms should become as socially unacceptable as failing to wear a seatbelt" [20]. In November 2010, RenewableUK – the trade and professional body for the UK wind and marine renewables industries - said that "England stands to lose over £1.3bn in investment that will directly create jobs and opportunities for local companies, funds for community activities and increased business rates for local authorities because of the actions of anti-windfarm campaigners" [21]. Let us look at these two statements. In the first one we have a government minister saying that people who exercise their democratic rights should be made social outcasts. In the second, we have the developers association suggesting that if developers did not have to go through the democratic process they could create more jobs. The author contends that it is these sorts of comments that build up resentment in people who are near wind farms or potential wind farms and the key attitude of authorities that makes people perceive that the system is unfair.

The author observes that people are now so suspicious of developers and government that it seems that even the most benign scheme faces opposition. Some developers – even the most unexpected – insist on confrontation. In the UK the raw noise and wind data is almost always made available by developers to Councils and third parties on request for checking. Sometimes it is put on the planning portal for anyone to download. It is one of the few moves towards transparency that has taken place in the last 5 years. Almost the only exception is St Andrews University, who, when requested for the raw data treated it as a Freedom of Information request and refused it. When it was appealed they turned it down again [22]. It is hardly surprising that people think they have something to hide.

The author observes that the result of all this is that people perceive, rightly or wrongly, that

– their lives will be blighted by these developments,
– they will gain no benefit,
– they pay subsidies in the form of Tax,
– they pay more for electricity,
– developers make all the money.

Wasserman and Parnell [23] set out the elements of good noise communication. The list is comprehensive but one element is *Noise communication is successful only to the extent that those involved are satisfied that they are adequately informed within the limits of available knowledge through a transparent process*. They further explain that there is often a lack understanding amongst noise consultants of public perception of noise and the frequent view of consultants that *meeting criteria is an acceptable outcome and will not result in an unacceptable impact* merely perpetuates problems. This seems to be particularly true with wind farm noise where, in the UK, even though ETSU-R-97 does not claim to be a measure of significance, compliance with it is still sometimes translated in an environmental statement as "insignificant impact" even when the turbine noise level might be 45dBA and the background noise 30dBA. Wasserman and Parnell go on to say that no matter how serious a noise is and no matter how much technical detail is used to explain it, the degree of "outrage" (whether people feel that the procedure is fair in effect) is likely to determine much of the public's response. Schomer [24] takes the view that *adjustment for "public relations,". . . . can range from a 5dB penalty to a 5dB bonus depending on the quality of the relations between the noisemaker and the community*. So community engagement from an early stage is extremely important.

STRESS

Pedersen [25] says in a summary of the three surveys quoted above that *Stress was in these studies not directly*

associated with A-weighted sound pressure levels, but with noise annoyance. There was a remarkable consistency among the studies for the relationship between feeling tense or stressed and annoyance. This should however not be taken as evidence for a causal relationship from wind turbine noise to stress, mediated by annoyance. The finding could be explained in the light of Lazarus and Folkman's cognitive stress theory [1984] where an individual appraises an environmental stressor, such as noise, as beneficial or not, and act on behalf of this. An individual already in a strenuous situation possibly appraises the noise as an additional threat to psycho-physiological restoration. As in the present case wind turbine noise can not be controlled by the individual, no action can be taken and the response is manifested as annoyance. Being interrupted in the sleep could possibly further increase the feeling of wind turbine noise as a threat.

What this suggests is that when people near wind farms become annoyed and believe it is because of the noise level it may instead be because of non-acoustic moderating factors. This annoyance then leads to stress. The symptoms of stress are, like the symptoms of Wind Turbine Syndrome, numerous. They are also very similar and, particularly, include headache, dizziness, irritability, loss of concentration, and anxiety [26], to which we can add sleep disturbance and consequent day time tiredness. These stress symptoms are ones that acoustic consultants have observed in people strongly affected by intruding noise of all types and particularly where bad feeling has built up between the resident and the noise maker.

The evidence suggests that illness has not been caused by anything peculiar to wind turbine noise or anything mysterious that we cannot hear or we cannot measure. It has been caused in many cases because it is too loud and has a character that is objectionable. But increasingly, in many countries, such illness could be due to bad project management by developers brought about by an ill thought out procurement procedure and complete lack of any noise management system promoted by government. In a nutshell, a lack of transparency and involvement.

DOES IT MATTER?

Does bad management matter? Governments could just continue to tough it out in the way many do now and essentially ignore the problem. The author believes that it does matter, for three reasons.

- First because it is a public health problem. Not one of enormous scale but nevertheless one which could be avoided.
- The second reason is that it polarises communities. Rural communities that have lived in reasonable harmony for decades are suddenly divided into two camps. Each camp may be stronger knit than before but they no longer talk to each other and sometimes, at the extreme, vandalise each other's property and threaten young people [27]. Facing the problem of climate change, the challenge of the century that ought to have drawn communities together, has instead polarised them.
- The third is that it stifles development. In countries where the development procedure includes close collaboration with local communities **before** the selection of a site and the design of the wind farm, the record of wind energy development is far better, though this will be due to multiple reasons [28].

Nothing in this paper is intended to suggest that people who are made ill by exposure to wind turbine noise are in any way trying to mislead. People who are exposed to wind farm noise and are ill are genuinely ill. Wolsink et al. [8] concluded that, whilst sound level had hardly any effect on annoyance, *This conclusion must not be misunderstood. The fact that sound level is not predicting annoyance does not mean that people are "not really annoyed" when they are reporting it*. The author's recommendation is that much more attention should be paid to the management of the impact of wind farm noise in the community at the planning stage of projects.

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