Groton Wind , LLC
Docket No. 2010-01
August 31, 2010

STATE OF NEW HAMPSHIRE
SITE EVALUATION COMMITTEE

Re: Application of Groton Wind, LLC for Certificate of site and facility to construct 24 wind turbines in Groton, New Hampshire on Fletcher and Tenney Mountain Ridges and operate the same.

RICHARD WETTERER, INTERVENER FROM RUMNEY

Witnesses aand Prefiled testimoney

I have not been able to locate any expert witnesses willing to testify without reimbursement concerning the adverse health effects caused by large scale wind turbines. With adequate funds, I'm sure I would have been able to find numerous witnesses of stature who would have been more than willing and able to do so. Because I have not had the means to hire said witnesses, I hope you will not conclude that I do not take the threat posed by the proposed Groton Wind, LLC lightly. I do indeed still consider the proposed Groton Wind, LLC a grave risk to the health and well being of the people of Rumney.

In place of witnesses I would like to be able to submit a number of scholarly papers on the issue of health effects caused by industrial sized wind turbines. I have already summitted one, "**Public health and noise exposure: the importance of low frequency noise by** Mariana Alves-Pereira and Nuno A. A. Castelo Branco, ERISA-Universidade Lusófona, Lisbon, Portugal, Center for Human Performance, Alverca, Portugal", at an earlier date and hope that that will also be considered in this regard.

At this time I would also like to submit the following: (files sent as attachments)

1). **An Analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents** prepared at the request of Brown County Citizens for Responsible Wind Energy in connection with Public Service Commission of Wisconsin docket no. 1-AC-231, Wind Siting Rules, Carl V. Phillips, MPP PhD, epiphi Consulting Group, cvphilo@gmail.com, 3 July 2010

2). **Monitoring Vibroacoustic Disease**, Nuno A. A. Castelo Branco, Augusto J. F. Martinho Pimenta, José M. Reis Ferreira, Mariana Alves-Pereira

3). **Wind Turbine Noise and Health**, February 2007, by Dr. Amanda Harry, M.B.Ch.B P.G.Dip.E.N.T

4). **NOISE RADIATION FROM WIND TURBINES INSTALLED NEAR HOMES: EFFECTS ON HEALTH** With an annotated review of the research and related issues, By Barbara J Frey, BA, MA and Peter J Hadden, BSc, FRICS

5.) **Do wind turbines produce significant low frequency sound levels?,** G.P. van den Berg, University of Groningen – Science Shop for Physics, Nijenborgh 4, 9747AG Groningen, the Netherlands, g.p.van.den.berg@phys.rug.nl.

6.) **Findings and Rationale – Montville Wind Turbine Generator Ordinance**, 2010

Sincerely,

Richard Wetterer

An Analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents

prepared at the request of Brown County Citizens for Responsible Wind Energy in connection with Public Service Commission of Wisconsin docket no. 1-AC-231, Wind Siting Rules

Carl V. Phillips, MPP PhD
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3 July 2010

Executive Summary

A summary of the main conclusions of my expert opinion, based on my knowledge of epidemiology and scientific methods, and my reading of the available studies and reports, is as follows:

- There is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby. Some of the most compelling evidence in support of this has been somewhat overlooked in previous analyses, including that the existing evidence fits what is known as the case-crossover study design, one of the most useful studies in epidemiology, and the revealed preference (observed behavior) data of people leaving their homes, etc., which provides objective measures of what would otherwise be subjective phenomena. In general, this is an exposure-disease combination where causation can be inferred from a smaller number of less formal observations than is possible for cases such as chemical exposure and cancer risk.

- The reported health effects, including insomnia, loss of concentration, anxiety, and general psychological distress are as real as physical ailments, and are part of accepted modern definitions of individual and public health. While such ailments are sometimes more difficult to study, they probably account for more of the total burden of morbidity in Western countries than do strictly physical diseases. It is true that there is no bright line between these diseases and less intense similar problems that would not usually be called a disease, this is a case for taking the less intense versions of the problems more seriously in making policy decisions, not to ignore the serious diseases.

- Existing evidence is not sufficient to make several important quantifications, including what portion of the population is susceptible to the health effects from particular exposures, how much total health impact wind turbines have, and the magnitude of exposure needed to cause substantial risk of important health effects. However, these are questions that could be answered if some resources were devoted to finding the answer. It is not necessary to proceed with siting so that more data can accumulate, since there is enough data now if it were gathered and analyzed.

- The reports that claim that there is no evidence of health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing prima facie, they do not represent proper scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis.

Personal background/credentials

My name is Carl V. Phillips. I am an expert in epidemiology and related health sciences, as well as scientific epistemology and methodology, and have been retained by attorney Edward Marion, representing Brown County Citizens for Responsible Wind Energy, to provide analysis and testimony in connection with Public Service Commission of Wisconsin docket no. 1-AC-231, Wind Siting Rules.

I earned a PhD in public policy (with an emphasis on economics-based decision making) from Harvard University, completing a dissertation on environmental policy and economics. I then completed the Robert Wood Johnson Foundation Scholars in Health Policy Research postdoctoral fellowship at the University of Michigan. Later I did a second fellowship in philosophy of science at the University of Minnesota. Before I returned to school for my PhD and began my career in public health science, I worked in consulting, primarily analyzing energy and environmental policy issues. Prior to that I earned a Master's in Public Policy from the Kennedy School of Government at Harvard, and *summa cum laude* undergraduate degrees in math and history from Ohio State University.

I spent most of my career as a professor of public health. I currently direct an independent academic-style research institute (a continuation of my university research lab) and a small consultancy. During my career as a professor, I taught at the schools of public health at University of Minnesota, University of Texas, and University of Alberta (Canada), the evidence based medicine program at University of Texas medical school, the University of Alberta medical school, and Harvard's Kennedy School of Government. My teaching focused on two subjects: how to make optimal public policy decisions based on scientific evidence and how to properly analyze epidemiologic data. This subject matter, as important as it is, is generally overlooked in health science and medical education, and students frequently reported that my teaching clarified their understanding of epidemiology, science more generally, and policy decision making for the first time in their educational careers.

My research during my academic career, and continuing in my private institute, has emphasized epidemiologic methods, environmental health, science- and ethics-based policy making, the nature and quality of peer review, and tobacco harm reduction (the main focus of the current institute). My work on epidemiologic methods focuses on recognizing and quantifying uncertainty, recognizing and correcting for biased analyses, and translating statistical results into decision-relevant information. My initial contributions in the area of quantifying uncertainty won several awards in the early 2000s and launched a new area of inquiry in the field.

Epidemiology is the study of actual health outcomes in people, and thus is the only science that can directly inform us about actual health risks from real-world exposures. Related biological and physical sciences often provide useful information about health risks, but they are ultimately trumped by epidemiology because real-world exposures and the human body and mind are so complex that we cannot effectively predict and measure health effects except by studying people and their exposures directly. My background in epidemiology methods, scientific epistemology,

and optimal policy decision-making is the complete background that is needed for being able to evaluate bodies of health science literature and assess their worldly implications. Most people who work in or around epidemiology learn only how to conduct particular types of studies or how to technically interpret individual study conclusions in the simplest possible way, which does not provide the ability to sort out complicated controversies. My study and research have focused on the epistemology of epidemiology, how to understand what the available evidence tells us beyond what the authors of individual studies assert.

My background in environmental economics and environmental health, with an emphasis on energy policy, provides important subject-matter literacy for the current case. I have reviewed the available scientific literature relating to the present case, including previous filings and summary reports and references included therein, as well as other information I felt necessary to find in order to form my opinions.

Summary of my scientific opinions

My main expert opinion in this case is that there is ample scientific evidence in support of the claim that wind turbines sited near residences cause substantial and important health problems for some people living in those residences. This does not mean that we have definitive evidence that there is a problem, but it would clearly be absurd to deny the possibility that there is a substantial problem. Further research could produce results that cause us to change our assessment, but the best assessment based on current evidence is that there is a problem, potentially of great magnitude for the exposed populations.

There is not sufficient evidence to robustly estimate what portion of the exposed population will suffer health problems of a given magnitude (though there is some evidence to allow rough estimates), or to assess much detail about the varying effects based on intensity of exposure. The exact list of diseases being caused by the exposure is difficult to determine, and there is little information to assess whether neurological damage or other physically measurable diseases exist. Nor is there sufficient evidence to assess exactly which of the several candidate causal pathways leads from the existence of the wind turbine to the health outcomes (which bodily systems; primary medium of transmission; nature of the noise and circumstances), and so it is difficult to assess the options to mitigate the effects.

In particular, my scientific analysis is based on the following points, which are expanded upon below:

1. Health effects from the turbine noise are biologically plausible based on what is known of the physics and from other exposures.

2. There is substantial evidence that suggests that some people exposed to wind turbines are suffering psychological distress and related harm from their exposure. These outcomes warrant

the label “health effects” or “disease” by most accepted definitions, though arguments about this are merely a matter of semantics and cannot change the degree of harm suffered.

3. The various attempts to dismiss the evidence that supports point 2 appears to be based on a combination of misunderstanding of epidemiologic science and semantic games. Multiple components of this point appear below.

4. Epidemiology studies could be designed and carried out to provide a much more useful assessment of the existence and quantification of the health impacts of wind turbine facilities.

Biological plausibility

When conducting epidemiologic assessments, it is useful to establish biological plausibility (i.e., that there is an apparent mechanism via which the exposure *could* cause the outcome in question). Such plausibility is not always necessary, and in a some cases major discoveries were made before any mechanism was recognized. But often when an association is observed without identifying any plausible mechanism before looking at the data, it turns out to be a statistical accident or a bias in the analysis. Identifying mechanisms via which an exposure could cause such human health effects does not prove that the particular mechanism is the pathway, nor, of course, does it mean that there are actual health effects.

In the case of the effects of wind turbines, the nature of the observed diseases means that plausible pathways are difficult to identify with certainty. Unlike a case where a particular physical exposure can be shown to lead to a disease, exactly what bodily process to look for is unclear, and there are multiple proposed candidates. But it is clear that the physical effects (noise traveling through the air, noise/vibrations traveling through the ground, and possible flickering light – hereafter just abbreviated as “noise” or just the “exposure”) do reach local residents, and noise does cause health problems under some circumstances.

More important (and presumably the impetus for studying the phenomenon initially) is that people can observe that the noise from the turbines seems to be bothering them, and can surmise that what they are noticing may be causing their diseases (the significance of this point is expanded upon below). It is well established that local residents can hear sound from the turbines under many circumstances and experience flickering light when the line from the sun to a house passes through the range of the blades. Apparently without exception, analyses of the physics of noise from turbines show that the noise reaches houses (though some who report such results argue that it does so only at magnitudes that cannot cause health effects).

Additionally, various studies show that lower level sound and vibrations affect the body via the ear (hearing and vestibular systems), skull, skin, viscera, and other body parts. The favored hypothesis among some who advocate for recognition of the health problems from turbines seems to be effects on the vestibular system. Other authors favor a stress-hormone mediated pathway. Identifying the existence of these possible effects on the body does not mean that the

exposure necessarily causes harm, but it does provide a plausible pathway for the types of harms that are typically caused by accumulated stressors.

Apart from studies of hearing damage, which does not seem to be at issue here, there are several lines of research that indicate that long-term exposure to noise causes health problems. While the literature is mixed, there are enough studies that suggest different health problems result from chronic noise exposure, at least under some circumstances, that it seems very difficult to rule out a particular problem out of hand. One group of researchers has focused on a problem they label vibroacoustic disease, in which substantial tissue effects are observed after long periods of noise-exposed employment (e.g., Alves-Pereira and Castelo Branco, 2004). While it does not appear that the conditions that produce that disease exist in the present case, the existence of such a disease is suggestive of the many not yet understood ways in which long-term exposure to noise can affect the body.

A common result of many studies is that exposure to noise that is not immediately harmful can, over a period of days or months, affect the body in ways other than simply hearing it. My non-systematic review of articles about noise and public health (those wishing to browse that literature can start with the journal *Noise & Health*) suggests that most of them deal with exposures that do not cause acute damage, and few offer a confident assessment of the causal pathways. With the exception of damage to hearing, noise causes problems via mechanisms that we do not fully understand. The significance of this failure to understand the pathways is important: It does not mean we should doubt there are causal relationships just because we cannot figure out exactly how they work. Rather, it means we should be open to the possibility that there are causal pathways beyond our present understanding. For example, there was evidence that immune system failure and oral cancer might be sexually transmitted based on the population statistics alone long before we recognized that the causal pathway from sexual activity to the outcome was a sexually transmitted virus (HIV and HPV, respectively).

<u>Evidence that individuals are suffering disease from wind turbines</u>

There are numerous reports of individuals residing near turbines suffering a collection of similar (across individuals) and plausibly related (as part of the same disease syndrome in an individual) symptoms, including psychological symptoms of general distress (irritability, etc.), failure to concentrate, and depression, as well as symptoms at the border of the psychological and physical, including insomnia, fatigue, headache, and tinnitus. The reported effects are typically described in terms of symptoms, the symptoms being both the sign of the disease and the source of suffering. When such patterns of symptoms occur briefly or are secondary to some more dire (or simply more concretely defined) condition, we do not generally think of them as disease in themselves. However, these can represent a major reduction in well-being and in health even if there are no other known effects. It is possible that some of the problems, particularly if experienced for prolonged periods, could lead to mortality-threatening disease via their effect on blood pressure or other pathways, but it is unlikely such downstream physical manifestations of the stress will be detectable (they will disappear into the random background rates and occur at an unknown time in the future), and so failure to detect them tells us little. But this inability to

measure, and perhaps even to establish, the worst-case manifestations does not diminish the importance of what we can establish and could measure.

There is a small collection of epidemiologic studies of people exposed to wind turbine noise in Europe by Pedersen and colleagues (2004, 2007, 2009, 2010). These studies suggest that some substantial portion of exposed individuals experience harms, some of which constitutes health problems by any modern definitions of health. The studies have various limitations, but they provide a quantification of a nontrivial number of cases. Phipps (2007) also presents a systematic study (which has been misidentified as a case series) that reveals similar results.

Other studies conducted less systematic analyses of exposed populations, providing case series or case studies. Perhaps the most prominent case studies in North America are those reported by Pierpont in her book (2009) and elsewhere. While it has been (correctly) noted that her work was not systematic in several senses, and thus cannot answer some questions of interest, this does not diminish its contribution as a report that these problems exist. Other case reports can be found in various collections (e.g., Harry 2007) and the self reporting of individuals who have wanted to report their own experiences. The latter are completely unsystematic and represent the most biased possible selection, but for this particular disease (for reasons expanded upon below) this does not mean that they provide no useful evidence about the existence of a problem.

Some recent commentators (Colby et al. 2009; Roberts and Roberts 2009) have attempted to dismiss this evidence because none of it is based on the epidemiologic study types that they understand. It is true that other study designs would have told us more, and still could. But dismissing the evidence we have makes little sense given that a huge portion of all knowledge, including formal scientific inference, is based on data that is not from studies designed according to certain preferred approaches. It should be obvious that "does not tell us everything we want to know" does not mean "has no information content". Those making this argument either do not understand scientific inference or are pretending they do not. Claiming that there is no evidence even though there are reports of individuals suffering is akin to claiming that there is no evidence that people get injured as a result of text-messaging while engaged in other activities because, even though the pathway is obvious and there are numerous accidents occurring from some activities, there is often not a "real study" that allows us to make various quantitative estimates.

The most fundamental flaw in that reasoning is that some of the case studies of those exposed to turbine noise actually constitute a quite useful study design, albeit accidentally. The *case-crossover study* (Maclure 1991) is one of the most effective methods for assessing the transitory effect of a transitory exposure (which means in this context: occurring fairly soon after being exposed to turbine noise and disappearing fairly soon once the exposure is removed). This study design is one familiar to all of us in our everyday lives: Impose the exposure at a time when the outcome of interest is absent and see if the outcome occurs; withdraw the exposure and see if the outcome disappears. For example, if you think that a particular food gives you stomach pain, note whether that pain occurs after eating the food but not at other times; avoid eating the food for a while and see if the pains are absent. It is obvious how to translate the resulting

observations into a causal conclusion about the food and the pain. For an even simpler illustration, our usual study design to figure out if a particular switch turns on a particular light is to flip the switch (often three times for some reason) – nothing more complicated is needed. When it is possible to collect case-crossover data, it usually provides among the best possible epidemiologic information. Its advantages include more data (each exposure change serves as an observation, whereas most other study designs produce only one observation per person) and individuals serving as their own comparison population.

For the case of turbines, many of the reports (personal testimonials and collected case series) recount the onset of distress being shortly after with the activation of the turbines – that is, when the person crossed over from being unexposed to being exposed. Moreover, some residents have reported reductions in their health problems under certain conditions (based on wind direction or speed), further supporting the conclusion. Finally, some of those who sought relief from their symptoms through physical (soundproofing) or geographic (moving their home) methods crossed back to unexposed and presumably achieved relief from the disease. While the cause-and-effect pattern might not be so obvious as the light switch experiment (because the appearance and disappearance of symptoms is not quite so immediate), this is fairly compelling evidence.

Several of the case studies reporting residents' exposure to turbines hint at exactly such case-crossover data. Unfortunately, it does not appear that anyone working in this field previously understood the full potential of the case-crossover study, and so did not collect all the possible data about timing and crossing back in the optimal form. But many of those reporting case studies seem to have intuitively understood the importance of observed crossover contrasts (as most people do, with or without formal scientific training). Examples can be found in Pierpont's reports, for example, and it might be possible to mine previously reported case studies for more formal presentation of case-crossover evidence. Failing that, it is relatively quick and easy to collect such data from those already experiencing problems from existing facilities, especially if previous researchers have maintained contact information for their subjects.

The second crucial epistemic consideration is that this exposure-disease combination is quite different from what is typically claimed for noxious facilities. In cases of environmental pollution there is often a fear of slow-developing diseases (especially cancer, for which we cannot even define a time of incidence – i.e., when the disease per se actually started – only of diagnosis) that occur seemingly at random because they have many causes that are impossible to sort out. In such cases, when local residents claim "I got cancer because of the effluent from this factory" the standard response is that it was inevitable that some people near the factory would get some cancer someday, and so it is impossible to make that causal conclusion. To make any such conclusion it is generally necessary to systematically collect enough data on enough exposed cases, as well as on non-cases and an unexposed comparison group, so that statistical comparisons can be made. (The caveat "generally" is meant to recognize the fact that if twenty cases of the same rare cancer were reported among a few hundred exposed individuals we would not actually need to know much more to draw the causal conclusion.) Contrast this epistemic situation with the case of a traumatic injury from a car crash: If following a crash a passenger in

the car has a laceration on his head that he did not have a few minutes earlier, we would not hesitate to say, based on that information alone, that the crash caused the injury. Why? Because head lacerations do not slowly develop from unknown causes, appearing perhaps years later (like cancer); instead they are almost always diagnosed shortly after a causal event occurs. Moreover, we can almost see the causal pathway in the form of the crash causing rapid deceleration which caused an impact between head and something in the car, and it is such impacts that cause trauma.

The case of the various forms of distress caused by wind turbines lies somewhere between the cancer and crash examples, but is rather closer to the latter. While there is contrast with the trauma case in that we cannot see the causal pathway, the particular form of distress that has been observed is not something that often suddenly occurs without some observable proximate cause. This contrasts with cancer caused by chemical exposure, where the chemical insult that triggered it is often invisible and possibly long in the past. The reasonable expectation of a proximate explanation and ability to observe the turbine noise as the ostensible cause make this case more like the car crash than the cancer. Indeed, some commentators who have sought to dispute the claim of health effects from turbine noise have proposed the theory that those suffering health effects after local turbines began operation would have just lost a battle against the siting of the turbines and would be suffering from exhaustion or a sense of defeat from that, and those factors would bring on the symptoms. Others have suggested, somewhat more plausibly, that the cause of the effects is that publicity and local fear about health risks ironically creates the distress. Whatever the merits of the arguments (they could be evaluated with research rather than just asserted), they implicitly acknowledge that most observers agree that onset of the observed health problems generally has an explanation in terms of a recent event.

Moreover, though it is not quite so easy to observe the cause of distress and the resulting psychological and physiological manifestations as it is with the crash and head trauma, a subject's own observations about his own single case are still scientifically informative. This contrasts with most types of cancer, wherein neither the victim nor any clinician or scientist can offer a legitimate conclusion about causation, other than in the form of far-from-certain probabilities derived from statistical comparisons. Someone who claims "this exposure caused my (or this patient's) cancer" is never justified (except for the few nearly single-cause cancers). But if someone claims "this noise is driving me crazy and keeps me from sleeping" we have good reason to believe him. For a more subtle exposure, like low decibel low-frequency noise, the conclusion is less certain than it would be for a loud party next door, but the individual's assessment still has substantial value. This is true even apart from the crossover data that an individual will naturally accumulate (e.g., by spending time away, by changing rooms and other mitigation behavior, etc.), and with that crossover data and common intuition about how to use it the conclusion is even more definitive.

Thus, unlike the case of trying to detect an elevation above some baseline level of a disease that usually has very distant and uncertain causes, which is usually impossible absent formal studies that are designed to do just that, the natural observations in this case are quite compelling.

[Sidebar: This does not appear to have been brought up in the documents associated with this matter, but it might be, so it is worth immunizing readers against a particular common error: mistaking prevalent cases for incident cases. It is imaginable that someone might respond to the points presented here by saying "at any given time, many people are suffering from the collection of symptoms discussed in this context, and most of them are not exposed to wind turbines". That author might go on to argue that therefore we should expect to find many exposed cases purely by coincidence. But such a statement describes *prevalent* cases – i.e., cases that exist at a given point in time – rather than what we observe with turbine exposure, *incident* cases – i.e., cases that begin during the observation period. The distinction is important because many prevalent cases are long-existing diseases which should not be confused with a case that appears shortly after the exposure begins; coincidental cases that become incident the week or month turbine operation begins will be exceeding rare. This does not mean that they might not have some other cause, like the fear or political battle hypothesis that were just mentioned, but mere coincidence is unlikely. Measuring the coincidental occurrence of exposure and disease together, and then assessing whether there are extra cases that are caused by the exposure, is the purpose of most of the complicated statistics used in epidemiology. But the number of coincidental incident cases is very low for the car crash or turbine examples, making the complicated statistics less necessary to merely establish that something occurs (though they are still needed to quantify the risk). But someone who does not understand the difference between prevalent and incident cases might not recognize this.]

Observations about behavior and prices can further support the claim of a causal relationship between turbines and health problems, as well as demonstrate the great magnitude of some of the problems. An apparently nontrivial portion of the residents whose cases where reported in detail, people who had concluded that the turbines were damaging their health, have moved their residence or retrofitted the structure to try to block the noise. These are expensive actions that would not be taken by people who were suffering only minor problems or who had not made every effort to make sure the cause of their disease was indeed the turbines.

Some of the residents attempted to sell their properties and failed to find any buyers at a price they would accept, suggesting that potential buyers anticipated suffering the same problems if they moved near the facility. It might be surprising to see such observations being used as epidemiologic data, but their value should be immediately clear to anyone trying to carry out inference, and who understands more than how to follow a simplistic recipe for how epidemiologic analyses are done. It is theoretically possible that everyone involved (residents, all potential buyers) is so misled about the causes of their health problems that they would upend their lives or waste thousands of dollars in error, and others would fail to take advantage of their error by buying their heavily discounted houses, but economists recognize when there is data like this (called "revealed preference"), it is usually the most compelling evidence available. Of course, there is likely a bias in that those suffering the worst problems are most likely to report their experiences. So once again, case study evidence is not adequate for quantification. But a

systematic study of actions by residents and of the real estate market could offer very useful information.

Summary of what can be concluded from the affirmative evidence

Looking at just the affirmative evidence, then, there is much to support the claim that some people suffer substantial health problems as the result of the externalities from the turbines. At the very least, before considering counter-arguments, any unbiased observer would have to conclude that, at a minimum, substantial health effects are quite plausible, seem to have occurred, and certainly cannot be ruled out without further directed study. To estimate the portion of exposed individuals who experience these problems would also require a more systematic study, as would quantifying the total health impact throughout a population.

The following several sections respond to some of the counter-arguments that have been offered to the conclusion that the existing evidence strongly supports the claim that there is an effect. Many of these are simply attempts to distract readers and do not represent any form of legitimate scientific argument, and so are mentioned briefly to call attention to their lack of legitimacy. Others require a bit more analysis.

Detection or measurement of physiological effects etc. are not necessary for there to be evidence of health effects

Claims have been made that people cannot usually detect the sounds or vibrations from wind turbines at certain distances (e.g., Colby et al. 2009 address this point multiple times and seem to imply it is of great importance), though there are ample counterclaims about people being able to detect the noise. The claims, whether or not they are accurate, have no bearing on whether these exposures affect people's health and well being. Many things we cannot detect can harm us. Though it is not clear that anyone is saying this outright, there is rhetoric that seems to say "the causal pathway does not pass through the most obvious effect of noise – hearing or otherwise detecting it – and this constitutes evidence that there is no causal pathway." But simply eliminating one of the many possible pathways tells us nothing about whether there are health effects, especially when the actual health effects have been observed.

(Aside: For those not used to reading serious analyses of scientific epistemology, it is important to not mistake "even if this were true…" for "this is true" when reading this document. The argument in the previous paragraph is that *even if* we assume there is no detection, it would not be evidence that there is no problem and so that argument is simply unscientific and thus, for immediate purposes, it does not matter whether there is detection. But later, actually making the "even if" assumption could impede further the empirical work or remedies, so it should be recognized only as an inconsequential assumption for a particular purpose, not all purposes. Additionally, *even if*-based arguments should not be interpreted as meaning that the author believes that the claim is true.)

The lack of observable physiological effects associated with (and, in particular, apparently causing) the observed psychological distress is also not a basis for dismissing the evidence we have. The observation of the lack of a known physiologic mechanism may be intended to argue that "the physical phenomenon of noise would have to initially affect people physically [which is true], and we do not fully understand what this effect is [also true], so the health problems are probably not real [a completely unsupported conclusion]". A better conclusion from our ignorance is "it could be useful to do more research to figure out what causes the problems". After all, we do not even fully understand exactly what physical impacts from smoking cause all the heart disease or even lung cancer.

The dismissal of the evidence is sometimes so bald that it seems like parody. Colby et al. (section 4.1.2) go so far as to write "There is no evidence that sound at the levels from wind turbines as heard in residences will cause direct physiological effects. A small number of sensitive people, however, may be stressed by the sound and suffer sleep disturbances." Even if the latter characterization did not comically understate the evidence, these authors, within the space of a two-sentence paragraph, claim there are no physiological effects but note that there are observed cases of turbines causing a physical problem. (One can speculate as to how the authors rationalize this. Perhaps because sleep disturbances may be a manifestation of what are primarily psychological effects they are not counting them, but since they certainly are a physiological manifestation, this makes little sense. Perhaps the authors are trying to gerrymander "physiological" to exclude physical effects that can be measured outside a laboratory; it is not even sufficient to torture the definition to only include effects that can be measured by biomarkers, since sleep loss can be measured by biomarkers if necessary. Or perhaps the crux of the game is found in the word "direct", which is really nonsense since additional intermediate steps can always be inserted into a causal pathway, so the word is inherently meaningless in this context. Whatever the authors thought was a sufficient rationalization, it is clear that they are making great effort to rationalize denying the obvious conclusion, that there is evidence of physiologic effects.)

<u>Psychological diseases are real and very important from a public health perspective</u>
Some commentators have tried to dismiss the reality of the reported diseases because they are primarily psychological. Psychological diseases and those with manifestations on both sides of the psych-physical border – a category that includes stress, depression, and many other ailments – arguably account for the loss of more quality-adjusted life years than purely physical diseases, at least in the West and possibly even worldwide. Most all accepted definitions of individual or public health include psychological health as part of the consideration, and usually refer to an overall state of well being rather than just an absence of particular diagnosed pathology.

It is sometimes tempting for people who do not suffer from addictions, depression, or other psychological or physical-and-psychological diseases to have the attitude that sufferers do not have a real disease and should just snap out of it. There is a substantial literature that documents this dismissive attitude (which in the present case might translate into "sure, I can hear the noise if I think about it, but it is no big deal, so it should not really bother you either"), and argues that

this makes no more sense than telling someone with appendicitis that he is just being negative and should snap out of it. For example, it is difficult for most of us to imagine why someone would have the urge to drink himself into disfunction every day and not even apparently enjoy it, and so tempting to think "all he has to do is realize that this is a bad thing to do and he will quit". But it should be obvious that this is not sufficient and his affliction, however difficult it might be for most of us to empathize with, is quite real.

Some of the attempts to dismiss the importance of the observed health problems are semantic games and belittlement, cheap tactics that are typically used to obscure the lack of legitimate scientific arguments. The term "annoyance" has been adopted as jargon by researchers to refer to certain psychological problems resulting from noise, and has the implication (presumably intended in some cases and not in others) that the causal pathway from noise to disease involves the type of psychological experience that is typically referred to as "annoyance" in natural language. However, it is clear that there is nothing in the use of the jargon that implies that the harm is minor, and indeed the term is used in contexts in which it includes life-destroying harms. But some of those who seek to suggest this suffering is minor appear to be trying to confuse readers based on the natural-language meaning of the word, since in natural language, "annoyance" typically implies a minor harm, a "mere annoyance" that is well below the level that would be considered a disease. But of course adopted jargon does not have its original natural language meaning. Just as "insult" can mean cause of cancer, "annoyance" in this case includes serious physical and psychological symptoms.

Language games like these tend to suggest an attempt to avoid direct discussion of the evidence that there really is a problem: If a writer wishes to claim that the various symptoms are not actually a health problem, he should say so (and explain why most definitions of health say otherwise); if he wishes to say that the health problem is so minor that it should not be called a disease, he should say that (and explain why someone would leave their home over a minor problem). Referring to the effects as "just" annoyance does not constitute an argument that the effects are not disease nor that they are minor.

Similarly, some commentators (see Roberts and Roberts, p.39) have attempted to belittle the disease experience with the phrase "dis-ease", which they implicitly define as including pain, anxiety or physical manifestations thereof. They concede that their construct can often be "undistinguishable from the state of disease as related to morbidity" and then try to argue that it is somehow fundamentally different (rather than reaching the more obvious conclusion that two things that are indistinguishable perhaps should not be distinguished when making policy decisions). They argue that "with physical illnesses, objective measureable [sic] indicators can be obtained through instrumentation testing that is typically absent of human error or influence." This is absurd, both because not all physical illnesses have objective measures (e.g., headache and other pain-defined diseases) and because nothing is ever absent of human error or influence. They then point out that, "Subjective responses to stimuli are much harder to prove or disprove which is why it is very important to supplement a subjective response with an objective assessment", which is reasonable advice, though scientists know that you make the best of

whatever form your data takes rather than declaring the data to be less than one might want and pretending complete ignorance. But they then go on to ignore the non-subjective data that exists, as pointed out below. The rhetoric those authors use is hard to interpret as anything other than an attempt to distract from the evidence.

Another scientifically-invalid bit of rhetoric is to observe that the observed collection of health problems is not a single officially-designated disease, and imply that this makes it somehow less real. Setting aside whether it would be useful for simply parsimony to have something officially defined as "wind turbine syndrome", it is clearly not necessary to have such for there to be a real collection of health problems caused by turbine exposure. The title would not make the phenomenon any more real. Indeed, syndrome-based diseases with primarily psychological symptoms are generally defined based on a systematized (and often only slightly systematized) version of "you will know it when you see it", and definitions are created, altered and dropped over time based on both science and politics. While this does not mean that such diseases are any less important to people's health, it makes clear that the lack of some official designation is fairly meaningless. After all, there is no official disease designation for "injuries resulting from a driver of a subcompact car being hit from the left side by an SUV", but there is certainly a collection of injuries that typically occur from that, and anyone could give it a label.

The most legitimate point that can be mined from claims about the "realness" of the disease is that there are some challenges in dealing with diseases that are subjectively measured (i.e., can only be ascertained and quantified based on the victim's own assessment), especially in a politicized situation. Observing that there is this challenge does not make the diseases non-real. Many important diseases are diagnosed and largely defined based entirely on subjective experience, everything from suicidal depression to a minor headache. To dismiss subjective experiences would be to dismiss the vast majority of what people genuinely care about in the world, as well as many fields of science and medicine. But there are challenges that must be considered.

One challenge in assessing the importance of subjective sources of distress, pain, etc. is that context matters: A minor trauma might cause a pain we just shake off while playing sports but the pain from such a trauma might be completely unpalatable if it occurs while sitting quietly at dinner, and if that pain were inflicted by someone walking by and hitting us on the head we might consider it even more painful and a criminal act. Similarly someone working in a job with a sense of élan (such as training to be an astronaut, as in one of the studies about the effects of noise, but probably for any job someone is happy with or proud of) will likely be more like the sportsman than the person sitting at dinner, and might intentionally downplay the pain or distress. Thus, occupational studies of the effect of noise would be expected to show effects different from – likely less than – those from residential exposure. The challenge is not just that the experiences are different based on circumstance, but that neither is more legitimate than the other. If the subjective experience of the resident at home is different from the worker on the job, it is no less real as a result – a scientific or ethical argument that we should dismiss it for this reason would require ignoring most all pain and similar experiences. Observing that sometimes

people are able to ignore pain or another subjective effect might suggest intervention methods for reducing the impact, but the observation does not in itself reduce the impact.

Sometimes the commentators who seek to dismiss the importance of the health problems appear to misuse "subjective" to mean "psychologically mediated", and thus include all the symptoms typically discussed in the context of turbines. Some of the disease outcomes that have been cited as being caused by turbine exposure are not actually subjective. Loss of sleep, for example, is objectively measured even when measured by an individual (even though he is also the subject, the method of observation – counting up hours that he was asleep – makes him an objective observer of himself). It is actually even possible to objectively measure pain and related sensations – we do so whenever we observe sentient beings other than ourselves endeavor to move away from some stimulus. No one ever knows exactly what another individual is experiencing (that is the essence of subjective symptoms), but we can see when they are reacting in a way that provides convincing objective evidence of distress. Someone moving their home certainly fits this description, a subjective experience with an objectively observable manifestation.

There is no clear way to draw the line between health problems per se and other negative effects that should not be classified as disease. Most everyone would agree that a momentary noise that awakens someone for a few minutes imposes a real cost but the experience does not constitute a disease, while a constant noise that consistently prevents sleep for weeks or months, leading to depression and the many effects of insomnia, has created disease. The point in between that marks the border between disease and other types of costs is arbitrary and not defined. The simplest response to this is that because the difference is arbitrary, it really should not matter for any practical purpose. Inflicting harm on someone is equally unacceptable whether that harm takes the form of "disease" or not. Forcing someone to spend 100 hours dealing with miserable legal proceedings is not appreciably different from causing them to suffer 100 hours of severe flu symptoms.

Politically, it is sometimes the case that harms are considered more important if they can be designated as diseases. For example, instead of recognizing that the aesthetic and minor immediate health objections to involuntary exposure to second-hand smoke can justify bans in indoor public spaces, bans have only been implemented based on claims about life-threatening disease risk. In the present case, many of the above points – whether there is a "wind turbine syndrome", and even whether the effects are disease, "dis-ease" or "annoyance" – are based on the assumption that a harm does not matter so long as it does not have the label "disease". But not only is there no bright line between suffering certain types of diseases and otherwise being forced to suffer a less pleasant life due to ailments, but the same sciences (epidemiology, econometrics) that measure the former inevitably also measure the latter. Certainly from an economics or policy ethics point of view, there is no meaningful difference: A major cost inflicted upon someone's psychological well-being does matter, whatever it is called. Anyone who is attempting to argue that the harms do not represent an official disease and that this affects how we should treat them, should be asked to declare explicitly (as they are admitting implicitly)

that there really are effects that people care about, but they simply should not be called diseases. Only having done this is it proper for them to argue that these effects should be ignored in policy decisions because they are not disease, which is different from arguing that they do not exist or are small.

Heterogeneous effects are to be expected

Some observers might be confused by the fact that some people apparently experience debilitating symptoms from their exposure to turbines, while others may have greater exposure (as measured physically) but no significant symptoms. But this is not at all unusual, and similar patterns can be observed for most any exposure. For example, many heavy smokers never get cancer or suffer any other major disease that is often caused by smoking. There are hypotheses and some data about who is more likely to suffer from exposure to turbine noise, but this could be better informed by further study.

Some observers have had brief exposures to the noise and experienced no adverse effects, and perhaps concluded that the exposure would never bother them. But this does not constitute evidence that no one ever suffers from the effects: The individual in question might be immune while others are not. Or he might be wrong about what would happen if he were exposed longer, since health problems caused by noise exposure tend to be cumulative, as is typical for other exposures that produce stress reactions (social harassment, pain, sleep deprivation, physical restraint) which may seem trivial for an hour but torture after a week. Even exposures for eight hours per day (like workplace exposures) may have quite different effects than exposures that last all day and overnight. Some exposures that people intentionally seek for an hour or a workday-length period (hot weather, loud music, exhausting exercise) cause stress reactions and health problems with unrelenting long-term exposure. The use of low frequency sound as a method of therapy, which at least one group of commentators tried to portray as evidence that such sound is always harmless (Colby et al. 1999, p. 3-17), is actually further evidence that these exposures are difficult to analyze other than via epidemiology because the real-world "dosage" of the exposure matters a great deal (those exposed to the turbines are presumably not sharing in the therapeutic benefits). Thus, observations about the limited effect on some people or of short-term exposure cannot be seen as denying serious effects on some people who experience long-term exposures.

Colby et al. emphasize the empirical observation that the effects of turbines on people depend on personal characteristics (p. 5-2). They do not explain why, but they seem to either find this surprising or want to imply that it is an argument that the effects are less "real". Either of these explanations would suggest that they understand little about epidemiology (a conclusion that is supported in depth below), since anyone familiar with the science knows that the effect of every exposure varies with personal characteristics. Entire sections of the science are dedicated to figuring out how to optimally deal with this fact. Those authors seem to be making the mistake, common among people who do not understand complicated sciences like epidemiology, of thinking that if an outcome has one cause (personal characteristic) then another factor (noise) is not really the cause. In fact, the proper way to think of it (though it takes some getting used to

for non-scientists) is that *both* the noise and the personal characteristics caused the disease (as did a multitude of other factors); if either one of them was absent then the disease would not have occurred. In ethical or policy discourse (as opposed to scientific analysis) we often reduce our list to causes that someone actively brought about (i.e., the causes someone is culpable for, not the ones that simply are). So, for example, a murder is not excused, and is not considered to not be the cause of the death, if his victim would have survived had he been stronger or closer to a hospital – those non-act-based personal and geographic characteristics *also* caused the death, but the murderer is still a cause and thus is guilty.

Health problems are related to negative opinions about the turbines

Some commentators have made the observation that there seems to be a correlation between health problems and a negative opinion about the facilities (see, in particular, Pedersen and Waye, 2004), and have insinuated that the health problems are therefore less real, or perhaps even concocted due to other motives for disliking the facilities. Exactly why even a local resident who disliked the facility would concoct or exaggerate health effects is unclear, given that it is exceedingly unlikely that they could cause any existing facility to be removed, and this has not been explicitly alleged, so I will not address it further.

We should obviously expect to see the observed correlation when data is collected after the turbines are operating (which includes cases where people proactively report their experiences with health problems): Anyone suffering new health problems that they perceive to be caused by the turbines is going to have a negative opinion. The health problems cause the dislike of the facilities, which manifests in hating the sight of them, etc., not the other way around.

Even when disposition data is collected before the turbines start operating, there is still a good chance of causation running from health concerns to disposition. People who recognize, from experience or other self awareness, that they are more likely to suffer health effects from noise pollution are among those who will most strongly object to the siting and have negative feelings about it. Indeed, it seems safe to predict that a larger than average portion of the population with those feelings will be near new facility sites, since they local residents have chosen to live in quiet rural areas. It is certainly the case that local residents will be more sensitive, on average, than people who self-select into noisy occupations (i.e., the people who are the subject of most studies of the effects of noise).

This observation is related to the magnification of the health effects caused by the physical insult that results from fear and possibly frustration. Colby et al. discuss this at length, labeling it a "placebo" effect (and adding the silly neologism "nocebo effect"). Such labeling does not make the health effects any less real or devastating: A cure of a disease by a placebo is still a cure, though we do not fully understand why. In this case, the magnification of the harm due to fear and frustration is actually quite predictable. It does not make that harm less real or important from the individual or public health perspective – it just means that they could be addressed via different interventions. Indeed, if it is the belief of the industry or government that the substantial health effects that have been observed are due to "stress, fear, and

hypervigilance" (Colby et al., p. 4-4) rather than the physical effects of the turbines then they should be promoting interventions to eliminate these phantom ailments via education and counseling. (Note: just broadcasting to people "you are just imagining this and there is no real risk" is well known to have no effect, even when there is little scientific doubt it is true.) If the problems cannot be eliminated this way it would be evidence that either (a) the problems did not really have this "all in their head" characteristic or (b) there is no practical difference between these "placebo" effects and the other effects. The industry's failure to report on successfully intervening in this way suggest that they do not believe their consultants' rhetoric.

Forms of the evidence

Commentators who seek to deny particular health claims frequently resort to insisting there is "no evidence" because the evidence does not adhere to some criterion that they concoct. Liability defendants have demonstrated that it is almost always possible to argue that no study looked at exactly the circumstances of the plaintiff's experience, and therefore no evidence bears on the case. The present case, though not a matter of liability, is quite similar. If we disallow extrapolation of evidence from one situation (population, exact exposure) to another, then we simply have no scientific information about anything. As an exaggerated illustration, all studies took place in 2010 or before, so if we do not allow extrapolation it could be argued that we have no information about what will effect people's health in 2011 and thereafter. Legitimate scientific inference is a matter of figuring out what evidence shows about situations we have not observed, not looking for an excuse to claim that we know nothing relevant.

Sometimes the attack on the evidence takes the form of favoring some study designs over others. It might be that we wish we had a particular type of data, since some studies could tell us more than others. But failure to have the perfect data obviously does not mean we have no data. We simply need to be careful about only drawing the conclusions we can from the data (some people seem to be suffering) and avoid conclusions that are not possible to draw (x% of those exposed suffer some disease).

Another tactic for dismissing evidence is to argue that scientific analyses that are not in a peer reviewed journal are uninformative. It should be obvious that this might be a ground rule for a term paper or a debating club, but is not a good rule for truth-seeking. Very useful information can come in forms that are unlikely to make it into journals regardless of their information content (e.g., a compelling book of case studies will not fit into a journal article, but a barely relevant experiment on mice will likely get published, especially if it can be analyzed in a way that produces the result the researchers prefer). While there is some legitimate concern that enormous amounts of pseudo-scientific claims are written and we need a method for avoiding them, plenty of junk science appears in the peer reviewed health literature. Thus, while it might be that science in health journals is on average better than science that is not in journals, there is no bright line. Peer review does not promise accuracy, since reviewers can almost never assess the actual analysis (they do not have access to the data or the calculation methods, or even know the details of the methods (Heavner et al., 2009). And there are many kinds of useful peer review; the Pierpont (2009) book, the source of much argument in this area, appears to have been

peer reviewed more completely than most papers that appear in journals, and thus the arguments that it should not count because it was not peer reviewed represent either an ignorance of what the peer review process really is or pure rhetorical maneuvering.

Analyses of specific scientific reports

Most of what I have to say about the scientific and pseudo-scientific claims made in scientific reports is addressed above, addressing the substance of the claims. However, there are a few comments that are worth making outside of the context of specific scientific arguments. As I understand from what has been represented to me, and based on my reading of what appears in the literature, the main analyses prepared on behalf of the industry in this matter are the reports by Colby et al. and Roberts. Because these might tend to influence policy decisions, even apart from their specific arguments that are addressed above, I believe it is important to further illustrate the failings of these reports as legitimate health science analysis. While many analysts insist on only writing competing monologues that address opposing arguments only obliquely, if scientists do not directly and explicitly confront scientific errors, non-scientific readers generally have a difficult time determining which of the competing claims is accurate. Thus, it it part of the duty of those offering scientific advice for policy making to explicitly explain why claims that they disagree with lack validity.

It is notable that the Colby et al. panel did not include any population health researchers, even though the question they claim the report addresses is one of population health. Their expertise seems to be limited to the relevant physical sciences and clinical medicine. This explains the dominance of physics-based analyses in the report, discussions that are interesting and informative in some ways, but have very little bearing on question of actual health effects. From the perspective of a population health analysis, those entire sections can be summarized by the following: Turbines make noise; noise often affects people's bodies and health, though in the present case – if it can be established that there are health effects – we have no idea exactly what physical pathway leads from the turbines to the effect. Beyond that, these sections appear to be little more than general background about the technology. More cynically, they might be seen as impressive-sounding filler that might lead the causal reader to think there is a lot more substance to the report than there really is.

Some clinicians are trained and qualified population health scientists, but there is no evidence that those who participated in the Colby panel have such expertise. Unfortunately, it is often the case that physicians who may be quite skilled in their clinical abilities do not recognize that population science requires an entirely different set of skills. (Moreover, in the present case there is something quite curious to a population scientist who has years of experience observing physicians making population science conclusions without understanding the science: Usually physicians can be relied upon to say that if they have seen a case of a disease then the disease exists, and then they often err by over-concluding (about prevalence and especially cause) based on nonsystematic observations. In this case, however, they seem quite anxious to claim that we have seen the cases but they do not really exist, a very un-physician-like behavior.)

Section 4.5 of the Colby report exemplifies the lack of expertise in population health science. It is difficult to make this clear without seeming petty, but this section reads like it was written by someone who took a single class on how to understand epidemiology, and half understood the material. Like most readers of epidemiology, they present statistical significance as the measure of the accuracy of a study. Setting aside the complexities and common errors associated with this concept, they make a huge error: When they invoke it they are talking about a case series where there is no statistic that even could be statistically significant (or fail to be); the concept does not even apply. They go on to characterize "statistically significant" (in this context where it does not actually mean anything at all) as the opposite of the vague concept "simple coincidence" when it actually refers to a fairly technical test of how likely a particular observation is due to sampling error. But "coincidence" mostly invokes the situation where cases that occurred among the exposed population but not because of the exposure (as I use it above), a concept that is quite different from statistical significance or the lack thereof.

(For those who are interested, what the authors seemed to be trying to understand and explain is the contrast between associations (which cannot actually be calculated from the particular data) that have a low degree of statistical robustness – because they quite plausibly could have resulted from random sampling error – versus more robust results that we would not expect to see as a result of that random error alone (a particular technical definition of which is "statistical significance").)

The question of whether "there is a causal relationship between the exposure and the disease" (p. 4-12) is not a matter of whether there are control subjects, as they characterize. Also, they use the word "uncontrolled" to refer to lack of comparison populations, though this is a strange term to use for this (when used in epidemiology, it almost always means the analysis does not include covariates to try to control for confounding or is used to differentiate a purely observational study from a trial/experiment when the investigator controls the exposure). They describe case-control studies in the (admittedly common) naive way – that the comparison is between people with and without the disease, while that is merely the way the data are collected and like most other epidemiologic study designs the comparison is between those with and without the exposure. But they also offer the strange characterization that such studies always match subjects on other variables that might affect the probability of having a disease, which is one option for doing such a study but not the only one. They claim to describe a cohort study (which follows a population to look for new events) but actually use language that betters describes a cross-sectional study (a fundamentally different design which takes a snapshot in time looking for existing ongoing diseases). They imply that the only types of studies that exist are case-control and (the mis-described) cohort, ignoring cross-sectional, the usually favored randomized trial, the critically important case-crossover, and others.

These errors paint a picture of authors who are dramatically overstepping their expertise and hoping that no reader will ever have the expertise to notice and a forum like the present report in which to expose it. But even more important than these failures to understand epidemiologic methods, they fail to understand how to draw scientific conclusions in epidemiology.

In Colby et al.'s conclusions (section 5), even after citing many pieces of evidence that suggest turbines are having health effects, they repeat their "no evidence" claim. They apparently are basing this on the observation that "there is nothing unique about the sounds and vibrations emitted by wind turbines", combined with the claim that "the body of accumulated knowledge about sound and health is substantial". Their logic (they do not explain, so I must infer) seems to be "this is just like other noises" and "we already know everything there is to know about those other noises and they do not cause health problems". The first of these is utter nonsense. While their physics studies many not be able to identify what the relevant differences are, anyone who understands epidemiology knows that similar exposures sometimes have quite different effects. No other exposure is going to be exactly like the noise from wind turbines. Indeed, the "substantial" body of literature that they cite is not really all that impressive, and covers in depth only a few of the many forms of exposure to noise that people experience. In effect they are saying "we would not have predicted, based upon the limited analysis we can do using analogy and extrapolation, that health effects would have been observed, so we are going to insist that they really were not actually observed".

Perhaps this can be attributed to just sloppy presentation of summary points. But deeper flaws in their scientific reasoning can be found. They claim that some quota of studies proves a causal relationship while fewer tell us nothing. Their example is that "multiple case-control studies were necessary before the link between smoking and lung cancer could be proved" (p. 4-12), when in reality the first English language studies (which appeared almost simultaneously) are generally regarded as being quite sufficient for reaching the conclusion. (Moreover, the example is a very poor choice since – as an expert in epidemiology would know – those were the studies at the center of establishing the validity of the case-control study in the first place, so any uncertainty was more about the study design, not its results.) Sometimes a single study is quite convincing, while other times a collection of studies leaves a lot of room for doubt. This is contrary to their assertion that "only after multiple independent-controlled studies show consistent results is the association likely to be broadly accepted".

That last line is wrong at several levels. The first demonstrates their lack of understanding about what we are actually trying to infer (as well as the nature of epidemiology), since the question is not whether the association is accepted, but *causation.* The association is apparent in each individual study, or not. The phrase "independent-controlled" might appear to be jargon from the field, but it actually has no obvious meaning, while "broadly accepted" is a measure of public opinion, not scientific inference. Importantly, no studies ever prove causation – that is not how science ever works. So when Colby et al. denigrate case series data as not being able to "prove that an exposure is really harmful" (p. 4-12) they are saying nothing of substance. What they say that is of substance is that case series "can do no more than suggest hypotheses for further research" which is nonsense. To offer just one clarifying example, continuing on from a previous example, early case studies of tongue cancer cases in young people were sufficient to show that it was not being caused by tobacco use or drinking (on which most geriatric oral cancer was blamed), and later case series of oral cancer that tested cancer tissue for HPV

provided very convincing evidence that that virus was often the cause. Whether a particular study provides useful information about a question is not a simplistic function of the study type. In this case, since the most important question is "does it appear that turbines may be causing diseases", the case series is entirely adequate.

Indeed, this failure to understand what they are analyzing is worth emphasizing. Colby et al. write a (mangled) discourse on what is supposedly required to establish, "prove", or make "broadly accepted" a causal conclusion, when the conclusions of their report are basically that there is no evidence that there is any problem and no reason to do further study. In other words, they lay out (what they claim is) the burden to prove a hypothesis of a particular exposure-disease relationship is true, but then try to use the (claimed) failure as the basis for saying that the hypothesis is false. It is possible that this is calculated misdirection, though my reading of their many failures of scientific reasoning suggest that this elementary error may well be inadvertent. It is really difficult to believe that people who wrote that section have any understanding of epidemiology. And since epidemiology is the core science for understanding human health effects, it seem rather odd that this report is characterized as "an expert panel review" of "health effects".

Similarly, Roberts and Roberts (referred to for convenience as just "Roberts"), though specifically retained as epidemiology experts, demonstrate several failures to understand important principles of the science. Roberts begin by mischaracterizing "confounding", the definition of which is perhaps the main shibboleth for someone's scientist-level understanding of epidemiology. They proceed to report the myth, common to people looking for a legalistic recipe to oversimplify what is really a very complicated science, that case reports can only be used to generate scientific hypotheses and that there is something magical about peer reviewed journal articles, points that have already been addressed. Roberts improve on Colby et al. by correctly describing the cohort study and by claiming that case-control and cohort studies are just the "most common" types of epidemiology study, rather than implying that they are the only types, but they still ignore the other study types (esp. case-crossover) that are particularly applicable in the present case. They go on to report a few particular common methods as if they are the only possible methods (e.g., claiming that cohort studies only ever calculate a relative risk, while other measures like risk differences are often more useful; moreover, they describe the method for calculating only one particular relative risk measure, the risk ratio, as if it is the only choice when another measure, the odds ratio, is also quite common).

Several points like this appear, which might seem arcane to the average reader and might be necessary oversimplifications when talking to a news reporter, but seem difficult to defend in a formal report since accurate descriptions would not be much longer or more difficult. They get a few subtle and tricky points right, which suggests that they really understand some nuances of the science better than they pretend (though some of their errors seem to be based on genuine misunderstanding). This suggests that their mission is to mislead the reader into thinking epidemiology involves simple recipes and excludes more complicated reasoning, so that they can claim (when their chosen simple recipe is applied) that there is no evidence in the present case.

Again, when someone presumes to make up their own rules – and does not expect that their claims about the rules will be met with anyone who can identify their flaws – they certainly improve their chances of winning the argument.

Roberts continue to recite some overly simplistic common claims that are typically invoked by those who wish to deny most evidence. They repeat the claim that "a causal association can only be establish by the evaluation of well designed and executed epidemiologic studies", which sounds good, but the above example about the car crash and head trauma shows that it is often not true. There is no such simplistic rule. Roberts then go on to invoke the "Hill criteria", a classic piece of thinking in epidemiology but one that does not provide the simplistic rules that are typically claimed, and that modern epidemiology (see, e.g., the leading textbook in the field, Rothman and Greenland, or several of my papers) points out as being a problematic way to think about causal inference. (However, since this just seems to be company boilerplate that they cut and pasted into their report, and they make no attempt to link it to their arguments, I will not bother to challenge it in detail.)

It is difficult to believe that Roberts actually believe what they write about the journal peer review process; anyone who has worked in the system knows that it is quite often biased and politicized. They claim that peer review has been the standard since 1665; actually it is primarily a mid-to-late-20th century phenomenon (indeed, because it became a common practice only so late in his life, Einstein famously objected to a journal sending one of his submissions out for peer review, insisting that doing so was a breach of trust). They go on to describe one of the many ways in which peer review takes place, declaring it to be the way that it always works, and present an almost childlike idealization of the process. They have apparently never thought seriously about the process they are opining about; in addition to their errors they do not seem to be aware of the aforementioned point, that peer review basically never actually vouches for the accuracy of the numbers reported in an article (see Heavner et al. 2009 for an explanation of this fairly straightforward point). Nor do they seem aware that in highly politicized arenas like this one, getting the "right" answer – as defined by those who control the discourse – is critical to determining what gets the imprimatur, peer reviewed. Clearly they are writing to try to convince lawyers who have never studied the peer review process about a magical system that does not really exist. It is not clear from reading this report whether they are trying to mislead or are simply ignorant of the reality. Thus, even apart from the specific points about peer review mentioned in the substantive analysis above, these authors' apparent understanding of the process calls into question their understanding of the scientific literature.

This is quite critical, since their approach seems to be entirely premised on a misunderstanding of what constitutes useful scientific literature, and a naive preference for anything that appears in a journal. While they employ a roughly valid method for writing a review of what the literature in journals says, their further conclusion – that what those journals contain is all that science knows – it practiced naivety. If they had concluded simply "we searched some of the available evidence and if one were to consider only that evidence, it would not be sufficient to be sure there is a problem", that would have been valid. (Note the "roughly", however: They do not

explain their methods for excluding some studies they found and apparently never test their search strategy. In particular, it is notable that they do not include Pedersen, van den Berg, et al. (2009), even though the article came out several months before their report. Anyone trying to do a serious review of the literature, rather than just looking for excuses to say there is no evidence, would have known that this research had been done and anticipated the article for inclusion – after all the work of this research group represents a substantial fraction of the highly relevant literature that exists, so there is no excuse for ignoring any of it because of an arbitrary cutoff date or because it does not show up based following an arbitrary, untested search strategy.)

Someone using the Roberts methodology could never legitimately say "there is not sufficient evidence to be sure there is a problem" since they do not attempt to consider most of the evidence, which in the present case exists primarily outside of journals, a fact that Roberts no doubt knew. Moreover, if they evidence that they did not eliminate were really all that existed, the strongest conclusion that could be drawn was "we do not have enough evidence to either establish or rule out that there is a substantial problem". But since this subset of the evidence actually does point to their being some problems, the conclusion should actually be, "to the extent that we can learn much from this body of evidence in isolation, it seems reasonable to conclude that there is some problem" – roughly the same conclusion one should reach when reviewing all the available data.

Roberts' efforts to oversimplify and limit what they recognize as evidence is a reasonable tactic for the defense in a liability situation, wherein the argument "the scientific literature does not clearly establish that X causes Y" is often considered a sufficient defense, and it may be that Roberts were primarily tasked with laying down a liability defense for future tort actions. But making optimal policy requires different epistemology than does making liability awards, and they seem to be trying to obscure this. There are points to quibble with in Roberts' simplistic overview of public health, but since this appears to just be boilerplate that has little to do with the present case, those do not seem terribly important. What is more important is their section on the precautionary principle, which legitimately criticizes extremist interpretations of it, but then tries to imply that since extreme precaution is inappropriate, policy decisions should ignore all suspected health problems until (what they assert as) a burden of proof is met. Tellingly, they did not propose research that would resolve the fundamental questions, but only the research that might support claims like "those claiming health problems are lying for political reasons". After limiting scientific evidence to what they characterize as the most definitive, they declare that there was nothing "demonstrating a link between wind turbines and negative health effects" (even as their report, in multiple places, acknowledges that there are such "links"). But they carefully avoid saying that the studies they reviewed suggest that turbines do not cause substantial health risks, nor even that the available research fails to strongly suggest there is a causal relationship; the exact cautious wording, that a subset of the literature merely does not "demonstrate" it, is rather telling.

<u>Potential for gathering more information</u>

The siting of wind turbine facilities is not a situation where we cannot assess the health effects until we allow exposures to continue to be created, as might be the case with a question like "will novel environmental exposure X cause cancer". The main effects currently at issue have short term manifestations (i.e., we do not have to wait decades for cancers to develop) and there have been sufficient exposures already that information from them could be collected more systematically. The only reason we do not have better information than we do is because no one with the resources to fund the useful studies has done so. Moreover, the needed resources are relatively modest compared to what is devoted other health risks or to what is spent on building turbine facilities. In addition, it is relatively straightforward to sketch the further study that could be conducted and that would provide better information than now exists:

(a) To assess the prevalence of susceptibility (i.e., what portion of exposed people suffer disease) and similar statistics, it will be necessary to systematically collect exposed subjects for study rather than reporting only on those that volunteer or reported health problems. That is, it is necessary to find and query everyone who was exposed (residents living near turbines for some turbine facilities) or a random sample of them if the available population is too large. Subjects who could not be studied would have to be treated as missing data rather than simply left out of the study. This will provide the fraction of those exposed who experienced health problems (and would identify the distribution of specific health problems also). To provide a "denominator" to compare this to the average level of these health problems and thereby estimate how many of the cases were just background coincidence, a non-exposed group would need to be studied. (Population average statistics might be sufficient as this comparison group, but some complications about the period being studied and such might make it easier to just collect individuals for comparison.)

(b) Outcome information should be collected systematically (based on ex ante hypotheses) to avoid the risk of finding whatever diseases happen to exist and reporting them as if they were always of interest. This is critical to avoid the potential bias that results from the fact that, for any population with a particular exposure, it is almost certain that *some* set of disease can be found at an elevated level by random realizations alone. The potential for this is the most important legitimate question about the existing evidence, though this does not seem to be understood by some of those who are attacking the evidence. It is theoretically possible that the data collection methods from previous studies were designed as the data was collected, based on what was found, which inevitably creates bias and can easily create an apparent finding where no phenomenon actually exists. Fortunately there is sufficient data already to determine what diseases are likely to occur and thus what hypotheses to consider and data collection methods to design ex ante. To minimize the risk that important results will be dismissed, collected data should include as many non-subjective measures as possible, and perhaps attempt to make some non-subjective measures via instruments other than self-reporting.

(c) Systematic comparison of health outcomes in populations involuntarily that are exposed to other noxious facilities (and thus suffering the general unhappiness, but not the specific physical impacts of the turbines) would help separate diseases caused by the physical exposure from those

caused by general distress. That would help address the claim that many of the health problems result from the general distress of having been rolled over by powerful forces (a characterization that is quite close to the explanation proposed by the industry's own consultants). This would not mean that the some of the health problems are more "real" than others – suffering is still suffering – but it would suggest what portion of them could perhaps be alleviated by means other than just reducing the exposure.

(d) Relevant econometric data would provide a great deal of useful information. Real resource costs suffered by residents to respond to effects of the turbines (retrofitting houses, moving, etc.) are a good quantification of the magnitude of costs that the health effects exceeded (and thus justified the costs). Changes in local real estate values, controlling for other factors, would provide an estimate of the total perceived lowering of quality of life of living in an area as a result of the facility siting. The science cannot easily determine what portion of this is from health effects and what portion is from aesthetic and other impacts but, again, the policy viewpoint might not need to distinguish these: It is not clear that anyone would feel comfortable arguing "yes, these facilities dramatically lower property values, indicating that they do a lot of harm to local residents, but that is just because they are ugly and otherwise bothersome, not because of any formally defined disease, so the cost does not matter."

(e) A study that was designed from the top-down could model how to combine the health and economic analyses and use modern causal modeling methods. In particular, this would allow researchers to proactively properly address potential confounders rather than either ignoring them or using them as an excuse to dismiss the evidence (the frequent claim "aha, I have though of a potential confounder so therefore the conclusions are unsupported").

(f) A new study could collect detailed formal crossover data for individuals who are subject to varying levels of exposure from local turbines due to time of day, weather, and season, as well as physically leaving turbine-proximate residences. This could be combined with physical measurements of exposure, weather data, etc. Existing case study data is probably sufficient to form hypotheses about how disease outcomes change given different periods and types of exposure. People who leave the area entirely could also be followed to see what symptoms reverse, and after how long. It might also be possible to compare the effects of different turbine design details, though the study would have to be designed to assess this specifically.

(g) It would be possible to look for biomarkers of the exposure or health outcomes (e.g., stress hormones) which might help us understand the disease process and how to reduce it.

The crossover analysis would be particularly important for detecting different effects of different levels of exposure. It may not be possible to gather enough data so that comparisons between individuals will allow analysis of how effects vary by exposure detail (characteristics of the person, sound intensity, sound pitch, distance, height, weather, geology, etc.). But it may be possible to learn some of this with good crossover data.

A case for gathering more information before continuing new siting

Based on current standards of public health policy, it would clearly be appropriate to conduct most of the above studies before continuing to site facilities near residences. The studies could be completed fairly quickly based on exposures that already exist, and thus would not create indefinite delay. They could answer many of the questions that are being argued in political fights over siting, but are argued only based on limited observations and competing assertions (as well as obvious confusion about what the evidence shows), rather than the much more complete scientific analysis we could have.

The evidence might show that the magnitude of the health costs is great enough that turbines should only be sited further away from residences than current minimums, or possibly only in quite distant places (on ridgelines, offshore, or on large residence-free tracts of land) or, as explored by Pedersen et al. (2010), in areas that already have more background noise. A similar result might argue for better technology to reduce the exposure, particularly if more could be learned about exactly what characteristics of the exposure seem to cause the health problems. If it is hypothesized that particular facility designs create more problems, and thus technological changes are in order, this could be directly investigated; presumably the industry would have the incentive to point researchers toward comparing the effects of designs they think could be used with lower health effects. Other possible study results would suggest that the problem is serious but limited enough that it is most efficient to proceed but for the facility owners to openly guarantee fair compensation to local residents to compensate residents who suffer major problems. Alternatively, the research might support the claims that all health problems caused by turbines are either quite minor or quite rare, a possibility that is consistent with the existing evidence (however, note the contrast between acknowledging there is a problem but discovering it is quite rare, and thus deciding to proceed with current policies despite the costs versus declaring that there are no important problems and no costs that need to be considered even though the evidence tends to contradict this claim).

This is not a case of demanding that some vague "precautionary principle" be invoked, as in the case of banning useful plastics based on no evidence of any human health effects. The statement is not "we are ignorant and merely hypothesize that something might be wrong, so stop all action until whatever long-term studies are necessary to prove perfect safety" but rather "we have evidence that there are some health problems and we could better understand them fairly rapidly, and since they might be great enough to affect siting decisions, we should do the studies before pushing forward." To put the level of information we have and could get in perspective, there seems to be far more compelling evidence that wind turbines are causing serious health problems than there is evidence that plastics containing bisphenol-A (BPA) or electronic cigarettes (a low-risk substitute for smoking) cause any risks, but U.S. governments are moving to ban both of these despite their huge known benefits. If turbines were a pharmaceutical that was as economically beneficial as turbines are, but there was similar evidence about it causing disease side-effects, it would almost certainly not be approved without more complete study, and there is no way the industry would be able to just say "everything is really fine; please avoid doing any further study."

Our current state of relative ignorance is really more a matter of choice, since further information could be gleaned fairly easily. It is easy to understand why, under some circumstances, further research is not worth doing (Phillips 2001), perhaps because there is no reason to suspect a problem, the research would cost a fortune, or the useful research cannot be done yet. But none of those circumstances apply in this case. Arguing "we do not know enough to be sure we should change anything" is possible – right or wrong, at least someone could make the case. But it is difficult to identify any legitimate basis for arguing "we should avoid learning any more" in a case like this.

Conclusions

In summary, there is substantial evidence to support the hypothesis that wind turbines have important health effects on local residents. If forced to draw a conclusion based on existing evidence alone, it would seem defensible to conclude that there is a problem. It would certainly make little sense to conclude that there is definitely no problem, and those who make this claim offer arguments that are fundamentally unscientific. But there is simply no reason to draw a conclusion based on existing evidence alone; it is quite possible to quickly gather much more useful information than we have.

I admit to being new to this controversy and my studies have been on the content and quality of the reported science, and so there may be something hidden or political that escapes me. I have witnessed other researchers naively wandering into fields I have studied for many years, and being tricked into believing the political propaganda rather than the science. Thus I am aware of the potential limitations of understanding when someone is new to a subject matter. But as someone who specializes in trying to sort out competing epidemiology-related policy claims, I find it difficult to see how the evidence could fail to be adequate to suggest that there is a serious problem worthy of further study. The only apparent scenario that would lead to a different conclusion would be if much of the reported evidence of health problems were basically manufactured (subjects or researchers were overtly lying, or subjects were so intent on being negative that talked themselves into having diseases). But since such a scenario could only be established with further research, so even such a story leaves it impossible to justify the call to avoid further research, other than for the most cynical of motives: trying to suppress unwanted discoveries.

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Monitoring Vibroacoustic Disease

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***Abstract*—Vibroacoustic disease (VAD) is a consequence of long-term (years) exposure to low frequency noise. Since the early 1980's, the ongoing attempt has been to find a non-invasive and reliable diagnostic tool that could simultaneously monitor the evolution of VAD with accuracy. Initially, neurophysiological tests were used, but as the cardiovascular pathology of VAD became evident, echocardiography became the diagnostic tool of choice. Despite the non-invasiveness and the availability echocardiography, the subjectivity of measurement induced by techinicians has deemed it inadequate. Recent evidence indicates that pulmonary function evaluations could provide answers for an accurate and inexpensive tool to monitor VAD.**

***Index Terms*—echocardiography, epilepsy, low frequency noise exposure, pulmonary function tests.**

I. Introduction

VIBROACOUSTIC disease (VAD) is a whole-body pathology caused by excessive exposure to low frequency noise (LFN) (?500 Hz, including infrasound) ?1?. Initially identified among aeronautical technicians, VAD has also been observed in military ?2?and commercial pilots ?3?and aircrew, and in a civilian population exposed to environmental LFN ?4?. Other individuals who were unsuspectingly exposed to LFN have also been identified with VAD ?5?.

LFN exposure induces an abnormal growth of extra-cellular matrices. This is reflected by abnormal thickening of cardiovascular structures ?6?, ?7? and by the appearance of pulmonary fibrosis that has been replicated in LFN-exposed rodents, under laboratorial conditions ?8?-?11?. LFN has also been identified as a genotoxic agent in both LFN-exposed workers ?12?, ?13? and animal models ?14?, ?15?. All lung tumors in VAD patients (7 smokers/3non-smokers) are of the same type of cellularity – squamous cell carcinomas ?10?. In fact, all other respiratory tract tumors (2 glottis 1 smoker/1 non-smoker) are also squamous cell carcinomas. Through electron microscopy, rats exposed to LFN exhibited squamous metaplasia ?11?.

The appearance of symptoms depends on the number of years of occupational exposure, as Table I indicates ?1?. There is a neuro-psychiatric picture that initially involves humoral and behavioral changes: mood swings, increased irritability and aggressiveness, and memory disturbances that are mostly reported by family and friends.

Table 1. Data corresponding to a group of 140 aircraft technicians (selected from an initial group of 306 workers), occupationally exposed to LFN. Exposure time refers to the amount of time it took for 70 individuals (50%) to develop the corresponding sign or symptom ?1?

Clinical Stage	Sign/Symptom
Stage I- Mild (1-4 years)	Slight mood swings, Indigestion & heart-burn, Mouth/throat infections, Bronchitis
Stage II- Moderate (4-10 years)	Chest pain, Definite mood swings, Back pain, Fatigue, Fungal, viral and parasitic skin infections, Inflammation of stomach lining, Pain and blood in urine, Conjunctivitis, Allergies
Stage III – Severe (> 10 years)	Psychiatric disturbances, Haemorrhages of nasal, digestive and conjunctive mucosa [Small nose bleeds], Varicose veins and haemorrhoids, Duodenal ulcers, Spastic colitis, Decrease in visual acuity, Headaches, Severe joint pain, Intense muscular pain, Neurological disturbances

After 4 years of exposure, the individual tends to recognize the existence of memory lapses, mood changes become more pronounced, and a variety of simultaneous ailments can appear. In the advanced stages, neurological disorders include epilepsy ?16?, balance disorders ?17?, and a marked increase in cognitive impairment. The palmo-mental reflex - a

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primitive reflex that is frequently present in several pathologies associated with cognitive deterioration – is a common feature in VAD patients [18]. Facial dyskinesia triggered by auditory stimulus has also been identified in LFN-exposed workers [19]. Psychiatric disorders, such as suicidal tendencies and rage-reactions are some of the most tragic consequences of unmonitored LFN exposure [5]. Respiratory disorders appear within the first 4 years of exposure, and can progress into shortness of breath, and, focal pulmonary fibrosis. This is independent of smoking habits [9].

LFN also affects the auditory pathway. One of the complaints that most instigates suspicion of excessive exposure to LFN is “I hear too much”, or “any noise bothers me, television, music, etc”. This is typical in VAD patients [1]. The ensuing behavior is isolation, unlike the behavior of the hearing impaired who do not seek to avoid social gatherings. In the cochlea of LFN-exposed rats, cilia were seen to fuse with the upper tectonic membrane whereas non-exposed rats lost cilia with the normal aging process [11]. Since cilia are fused, it seems natural that any movement they are forced to have will produce discomfort. It is postulated that this may be the reason why VAD patients have these specific auditory complaints.

The need to monitor VAD is most pressing within occupational settings. The appearance of compulsory early disability retirements among LFN-exposed workers due to the definitive and irreversible lesions caused by LFN exposure is an important issue, especially for occupational physicians [5], [20]. It would be useful to have a medical diagnostic test that could reliably and conclusively indicate if the individual was suffering from VAD, and to what degree.

LFN does not only exist in the workplace. Indeed, many leisurely activities now include a great amount of LFN exposure, such as dance clubs, motorized sports, and boom-cars. To work in LFN environments, it is important to select individuals who, despite possible previous exposures to LFN, have not yet developed any VAD signs or symptoms. Again, a medical device that could monitor the progression of LFN-induced lesions would be very useful for this purpose.

This entire problem is aggravated by the lack of recognition that LFN exists and is an agent of disease [21]. While the debate goes on between lobbyists, politicians and legislators, the need for a reliable diagnostic test that would also reflect the degree of progression of the disease is critical. It is crucial to be able to follow the disease so that its lesions do not develop into irreversible conditions that, ultimately, can lead to early disablity retirements, with all the socio-economical sequelae that this entails.

II. Monitoring VAD

A. Through Psychometric and Performance Tests

In 1980, it was discovered that 10% of the aeronautical technicians employed at an aircraft manufacturing, maintenance and repair facility had been diagnosed with late-onset epilepsy; the expected rate for the Portuguese general population is 0.2% [16], [22]. This finding initiated research which led to the definition of VAD. At that time, it was assumed that these technicians’ pathology was exclusively of the neuropsychological domain. Thus, psychological evaluations and psychometric tests were provided for these individuals. Unfortunately, the dispersion of values, low accuracy, and enormous individual variance doomed psychometric tests as a routine tool for VAD [23]. Nevertheless, psychometric tests did reveal cognitive changes in memory and attention [24]. Hence, a computerized test to evaluate worker performance (PACT) was developed [25], but lack of funding did not allow the expansion of this project.

B. Biochemistry

Hematological, biochemical and endocrine studies revealed a very interesting amount of data but useless for a monitoring tool [26]-[30].

C. Through MRI and Neurophysiology

Given the abnormal neurological findings in these patients, brainstem auditory evoked potentials were provided to evaluate possible nerve conduction disturbances [31]. Results were initially difficult to interpret. The problem was tackled mathematically using multivariate analysis, clustering algorithms, of the distribution of action currents. The results were very interesting: delays in nerve conduction were statistically significantly altered in waves III, IV and V [32], [33]. Despite the encouraging advancements, this methodology did not prove to be a useful tool because the technology is expensive and specialists are required. Moreover, despite the mathematical treatment, dispersion values were still quite large. But the results raised suspicions that the brainstem was being compromised.

Initially, magnetic resonance imaging (MRI) of the brain was proposed as a possible method of viewing the brain lesions responsible for the nerve conduction delays. Brain MRI were carried out, and lesions were observed in the subcortical and periventricular white substance, basal ganglia and brainstem [34]-[37]. These features are common to aging processes, as well as to other pathology, and are considered a risk factor for cardio-cerebro-vascular disease. Similarly, cerebral atrophy and dilation of the Virchow-Robin perivascular spaces were also seen in LFN-exposed individuals, but these features are also common to other pathologies. The study of endogenous potentials and brain-mapping confirmed the existence of significant abnormalities in brain potential amplitude and topography, as is usually seen in the elderly and in degenerative processes. A possible VAD-specific correlation was identified between the latency in N2 and the existence of brain lesions [38].

Despite the magnificence of all this neurological information, no consistent, inexpensive and readily available diagnostic tool had yet been identified.

D. Through the Cardiovascular System

In 1987, an autopsy performed on a deceased VAD patient provided outstanding information about this non-specific, and almost silent pathology [8]. The deceased patient exhibited systemic changes of the extra-cellular matrix, with impressive and peculiar thickening of cardiovascular structures. Thickening of all hollow organ walls was identified (even the wall of kidney cysts), and focal fibrosis of the lung was also observed. Two malignant tumors (kidney and brain) were identified. This patient died due to myocardial perforation, as a consequence of a very small infarct and subsequent cardiac tamponade. Studies revealed the presence of 11 small scars dispersed throughout the myocardium indicating that, over the years, 11 silent ischemic events had occurred.

Based on the findings of cardiovascular thickening, the following years were dedicated to the echo-imaging of these structures [39], [40]. Pericardial thickening proved to be the most consistent feature in echocardiograms of VAD patients, although mitral and aortic valve thickening, as well as mitral valve prolapse, were also very frequent findings [4], [41]. Thickened pericardial structures are common in pericarditis which involves an inflammatory process of the tissues. In VAD, despite increased thickness, there is no inflammatory process, nor is there any interference with normal diastolic heart function.

Skepticism surfaced regarding the true anatomical thickeness of the pericardium. Echo-imaging was not a direct reflection of the actual amount of anatomical thickening. With each individual's consent, VAD patients who were submitted to cardiac surgery for other reasons allowed the removal of a fragment of the parietal pericardium for histological and ultrastructural studies. Extraordinary changes of the pericardial structure were observed [2], [6], [7]. Normal pericardial thickness is <0.5 mm. In VAD patients, pericardial thickeness reached 2.3mm [7]. Today, pericardial thickening in the absence of an inflammatory process, and with no diastolic dysfunction, is the hallmark of VAD [42].

Finally, it seemed that a possible diagnostic technique was becoming available. Echocardiography seemed to be the best tool for monitoring VAD. In commercial aircraft pilots [3] and in a civilian population exposed to environmental LFN [4], echocardiography results were consistent: all revealed pericardial thickening in the absence of an inflammatory process and with no diastolic dysfunction. It was the most frequent finding in LFN-exposed individuals, independent of age, and was directly related to the amount of cumulative LFN exposure.

New problems arose when technician subjectivity began to interfere with the consistency of results. All our echocardiography studies had always been performed by the same cardiologists (not technicians) whose specialty was echo-imaging techniques. No standardized method exists for enhancing the pericardial image in order to evaluate its thickness. Thus, echocardiography became a weak parameter for reliably monitoring VAD.

Given the widespread involvement of the cardiovascular system, the carotid arteries as seen through echo-Doppler imaging techniques, became the object of investigation. For the carotid arteries, the acoustic ultrasound window is larger and the vessels are closer to the surface, and thus far easier to evaluate than the heart. Several studies demonstrated that the carotid arteries in these patients were thickened [43]-[45]. Unlike atherosclerotic plaques, here thickening blanketed the entire vessel walls. The results were very promising, but, in Portugal, echo-Doppler technology is relatively expensive, it only exists in major vascular surgery departments, and since no technicians are available, it is usually the vascular disease specialist that conducts echo-imaging evaluations. So this method for diagnosing VAD is not cheap, and requires expensive human resources. Moreover, carotid thickening was not as frequent a finding as cardiac thickening, nor did it reliably reflective the severity of the disease.

E. Through the Respiratory System

During the 1987 autopsy, the observation of lung fibrosis was not immediately associated with LFN exposure. This patient had worked as an aircraft technician, and aircraft run-up tests were part of his job description. Here, the possibility of fumes and dusts is real and could explain the observation in the respiratory tract. However, when these same lesions appeared in small rodents exposed solely to LFN [46], the autopsy findings were questioned. Since then, subsequent respiratory tract studies in rodents exposed to LFN clearly indicates that the respiratory system is a preferential target for LFN [11].

In order to verify that focal lung fibrosis could be a consequence of LFN exposure, high resolution CT-scan of non-smoker, LFN exposed workers, with and without respiratory symptoms was performed. Both groups revealed focal lung fibrosis and air-trapping that was independent of the existence of respiratory complaints. Pulmonary function tests were all within normal values. Curiously, an increased reaction to metacholine was detected [9]. Although about 10% of the general population exhibit an increased sensitivity to metacholine due to allergic propensities, these individuals had been screened for allergic predispositons. Again, and despite the noteworthy results that were obtained, this did not seem to be the best way to monitor LFN-induced lesions.

The respiratory epithelia - surface of the respiratory tract that is open to the airway - of rodents exposed to LFN is dramatically altered [11]. The amount of cilia is reduced but, more remarkably, some cilia appeared sheared, leaving stems of different sizes. Bundles of sheared cilia were found lying upon the epithelial surface. Another unusual aspect was wilted and shaggy cilia that were long but apparently could not remain upright. Brush cells are common in the respiratory epithelia, however their function is unknown. In the LFN-exposed rodents, these brush cells have an extraordinarily peculiar behavior, in that their constituents fuse, much in the same way that cochlear cilia have also fused [11]. Within the cell body of these brush cells, multivesicular bodies have been identified and associated with neuropeptides [47]. The current working hypothesis has been that the respiratory brush cell mediates a neuroendocrine response. This position is

strengthened by the fact that both cilia and brush cells appear to engage in secretion functions, in both controls and LFN-exposed rodents ?11?. Again, despite the wealth of information gathered, no clear method of monitoring VAD in LFN-exposed workers has been achieved.

III. Ongoing Investigation

The clinical manifestations of the neurological lesions in the LFN-exposed workers that have been studied are extraordinary. In a group of 60 workers with an average age of 42 years, 62% (37) exhibited MRI abnormalities that are normally seen in aging processes ?38?. In a group of 40 workers with an average age of 43 years, auditory evoked potentials and brainmapping demonstrate that all had changes associated with cognitive deterioration, as seen in the elderly and in degenerative processes ?38?. In a group of 60 workers with average age 43 years, 30 exhibited the palmo-mental reflex that is frequently present in several pathologies associated with cognitive deterioration ?18?. In a group of 140 workers, average age 42 years, 57% (80) suffered vertigo or dizziness vs. the expected 2% in the general population ?17?. Auditory-induced facial dyskinesia was observed in 4 patients (37-44 years old) ?19?. All EEGs of this study population were within normal values.

This information taken together with that obtained in the respiratory tract of LFN-exposed rodents has now led to question whether the respiratory reflex might be compromised. Ventilation is extremely sensitive to increasing pressures of CO_2 (PCO_2), and less so to decreasing pressures of O_2. Detection of CO_2 changes can occur through peripheral or medullary chemoreceptors. The index $P_{0.1}$ is a measure of the suction developed at the mouth 0.1 seconds after the start of inspiration. This initial respiratory drive originates in the autonomic (or involuntary) pathway of the neural control of the respiratory function. By rebreathing CO_2, normal individuals would present a minimum seven-fold increase in the $P_{0.1}(CO_2)$ index when compared to normal $P_{0.1}$. If the neural control of respiration is compromised, then a less-than seven-fold increase would be expected in the $P_{0.1}(CO_2)$ index ?48?-?50?.

Within this context, a standard test of measuring the amount of ventilation produced by an increase of CO_2 was employed: closed-circuit, or rebreathing technique. This method is normally used to investigate obstructive pathology, which creates local increase of CO_2 and a loss of respiratory drive. Preliminary results indicate that this ventilation test has, indeed, the potential of becoming the reliable, inexpensive and non-invasive diagnostic tool for monitoring VAD. All VAD patients have been presenting abnormal values for the $P_{0.1}(CO_2)/ P_{0.1}$ ratio, or the $P_{0.1}(CO_2)/ P_{IMax}$ ratio (P_{IMax} is the maximal inspiratory pressure). Formal results will be ready for publication in early 2003.

IV. Final Commentary

A very important issue related to VAD and LFN-induced pathology is the difficulty of finding an adequate control population. Who is *not* exposed to LFN? The younger generations are exposed to LFN since their early teenage years, through the variety of leisurely activities that involve very large amounts of LFN. In urban settings, traffic and public transportation are recognized sources of noise in general, and of LFN in particular. False controls, therefore, abound. Some curious cases of false controls have already been described ?5?. One of the most remarkable instances of false controls in LFN-induced pathology is the Vieques heart study ?51?.

The lack of recognition of LFN as agent of disease and the continued erroneous assumption that noise only affects the ear impedes objective and conclusive scientific results. But this status quo situation is tolerated by many and convenient for a few.

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Wind Turbines, Noise and Health

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THE EFFECT OF WIND TURBINES ON HEALTH.

I first realised there might be a problem associated with wind turbines when I was introduced to a couple living near a wind farm in Cornwall. The distance from their home to the nearest turbine is about 400 meters. They told me about poor sleep, headaches stress and anxiety symptoms brought on when the wind was blowing in certain directions. At times, they told me that they have been so disturbed by the noise that after several disturbed nights sleep, they have sought refuge in a nearby bed and breakfast establishment (far enough away not to be similarly affected by the noise).

Since that meeting I have spoken to and / or corresponded with 39 people living between 300meters and 2 km from the nearest turbine of a wind farm all of whom were suffering from the consequences of the noise coming from the turbines. This disturbance is by no means always there and is worse in certain wind directions.
The cases mentioned below are from several wind farms in the UK with a variety of turbine sizes from the smaller, older turbines to the taller more modern turbines.
However I have had correspondence from people living near wind farms in New Zealand and Australia and have evidence from other sources, (newspapers, journals and papers) of people being similarly affected in France, Germany, Netherlands and the USA.
What this shows is that there is number of people suffering from the consequences of noise from the wind turbines. I'm sure that the cases mentioned here are probably the "tip of the iceberg" and further independent investigation is warranted. The cases are kept anonymous in order to protect the individuals concerned. There is much concern within communities that if one is seen to complain about the noise that if they decide to move away their properties will be difficult to sell and possibly devalued as a result. Therefore they feel that they are in a "Catch 22" situation.

METHOD

All people involved in this survey were contacted either by phone or in writing. Questionnaires were completed for all cases. Questionnaires were sent to people already known to be suffering from problems which they felt was due to their proximity to wind turbines.
The identity of the people questioned has been with held in order to maintain confidentiality. The respondents were from a number of sites in the UK- Wales, Cornwall and the north of England

Example of questionnaire.

1) Name- (preferred but optional)

2) Age 18-30 30-45
45-60 >60

3) Occupation

4) Address and /or postcode

5) Which wind farm is near your property?

6) How far away from your property is the nearest turbine?

7) How long have you been living at this property?

8) Do you feel that your health has in any way been affected since the erection of these turbines?

9) If yes please answer the following:-
Do you feel that since living near a wind turbine/turbines you have experienced excess of the following symptoms (i.e. more than you did prior to living near these structures)?

Headaches	yes	no
Palpitations	yes	no
Excessive tiredness	yes	no
Stress	yes	no
Anxiety	yes	no
Tinnitus (ringing in ears)	yes	no
Hearing problems	yes	no
Sleep disturbance	yes	no
Migraines	yes	no
Depression	yes	no
Other- please specify		

If you have answered yes to any or the above questions, have you approached your doctor regarding these symptoms? If yes please state any tests and/or treatment initiated.

10) Do you feel that your quality of life has in any way altered since living near the wind turbines? Yes no

If yes could you please explain in what way you feel your life has been altered.

RESULTS

	1	2	3	4
Age	45-60	45-60	45-60	45-60
Occupation	Cleaner/ housewife	Retired Ill health	Head chef	farmer
Distance from turbine	400m	300m	350m	400m
Time at property	36 years	3 years	7years	4years
Health altered	Yes	Yes	yes	yes
Headaches	Yes	Yes	yes	yes
Palpitations	No	no	no	no
Excessive tiredness	Yes	No	yes	yes
Stress	Yes	Yes	yes	yes
Anxiety	Yes	Yes	yes	yes
Tinnitus	No	No	no	no
Hearing problems	No	No	no	yes
Sleep disturbances	Yes	Yes	yes	yes
Migraines	Yes	Yes	no	yes
Other				
Approached doctor	No	No	no	no
Altered quality of life	Yes	Yes	yes	yes

	5	6	7	8
Age	45-60	>60	18-30	18-30
Occupation	Housewife	Retired	Electrician	carer
Distance from turbine	300m	300m	300-500m	300-500m
Time at property	2.5 years	2.5 years	6 months	6 months
Health altered	Yes	Yes	Yes	yes
Headaches	Yes	Yes	Yes	yes
Palpitations	No	No	No	no
Excessive tiredness	No	Yes	Yes	yes
Stress	No	No	No	no
Anxiety	No	No	No	no
Tinnitus	No	No	No	no
Hearing problems	No	No	No	no
Sleep disturbance	No	No	Yes	yes
Migraines	No	no	No	no
Depression	No	no	No	no
Other		Thumping in ears		
Approached doctor	No	Yes-Rx with pain Killers-ongoing assessment	No- didn't associate symptoms with the turbines	
Altered quality of life	Yes	yes	Yes	yes

	9	10	11	12
Age	>60	30-45	30-45	30-45
occupation	Retired	candle maker	Retired-nervous Breakdown	Retired-ill health
Distance from turbine	300m	¼ mile	300m	300m
Time at property	4years	10 years	3 years	3years
Health altered	Yes	no	Yes	yes
Headaches	No	no	Yes	yes
Palpitations	No	no	No	no
Excessive tiredness	No	no	Yes	no
Stress	No	no	Yes	yes
Anxiety	No	no	Yes	yes
Tinnitus	Yes	no	No	no
Hearing problems	No	no	No	no
Sleep disturbance	No	no	Yes	yes
Migraines	Yes	no	Yes	no
Depression	No	no	Yes	yes
Other		See comments at end	Stomach upset	
Approached doctor	No	no	Yes-seen psychiatrist-Ongoing review	no
Quality of life affected	Yes	yes	Yes	yes

	13	14
Age	30-45	>60
Occupation	Veterinary nurse and HGV driver	Retired from farming and Teaching
Wind farm	Bears Down	Blean Bowi
Distance from turbine	Too close	1mile
Time at property	19 months	27years
Health altered	Yes	Yes
Headaches	Yes	Yes
Palpitations	No	Yes
Excessive tiredness	Yes	Yes
Stress	No	Yes
Anxiety	No	Yes
Tinnitus	No	Yes
Hearing problems	No	No
Sleep disturbance	Yes	Yes
Migraines	No	No
Depression	No	Yes
Other	No	Emotional turmoil
Approached doctor	Yes- taking sleepers and Headache tablets	Yes-had heart check up
Quality of life affected	Yes	Yes

	15	16	17	18
Age	45-60	>60	>60	45-60
Occupation	Teacher	Retired	Retired	Charity manager
Distance from turbine	700m	650m	650	½ mile
Time at property	26 years	30+	30+years	Bear Down
Health altered	Yes	Yes	No	No
Headaches	Yes	No	no	No
Palpitations	No	No	No	No
Excessive tiredness	Yes	Yes	No	No
Stress	No	Yes	No	No
Anxiety	Yes	No	No	No
Tinnitus	No	No	No	No
Hearing problems	No	Yes	No	No
Sleep disturbance	Yes	Yes	No	No
Migraines	No	No	No	No
Depression	No	Yes	No	No
Other	No	No	No	No
Approached doctor	No	No	No	No
Quality of life altered	Yes	Yes	Yes	No

	19	20	21	22
Age	>60	>60	>60	>60
Occupation	Retired		Retired	Retired
Distance from turbine			700m	700m
Time at property	20years	20 years	25years	25 years
Adverse health affects	Yes	Yes	Yes	Yes
Headaches			Yes	Yes
Palpitations				
Excessive tiredness	Yes	Yes	Yes	Yes
Stress			Yes	Yes
Anxiety			Yes	Yes
Tinnitus				Yes
Hearing problems				Yes
Sleep disturbance		Yes	Yes	Yes
Migraines				
Depression	Yes		Yes	Yes
Other				
Approached doctor			Yes	Yes- doctor referred me to the hospital. After tests the consultant could find nothing wrong with my ears.
Quality if life affected	Yes	Yes	Yes	Yes

	23	24	25	26
Age	45-60	45-60	>60	57
Occupation	Farmer	Farmer	Retired	Retired police officer
Distance from turbines	430m	430m	1000m	1000m
Time at property	5 ½ years	5 ½	30years	30years
Adverse health affects	No	Yes	Yes	Yes
Headaches			Yes	Yes
Palpitations				
Excessive tiredness			Yes	Yes
Stress			Yes	Yes
Anxiety				Yes
Tinnitus		Yes		
Hearing problems			Yes	
Sleep disturbance				Yes
Migraines			Yes	
Depression				Yes
Other				
Approached doctor		Yes- been under a specialist in Furness General hospital for 1 ½ years	Yes	No
Quality of life affected	Yes	Yes	Yes	Yes

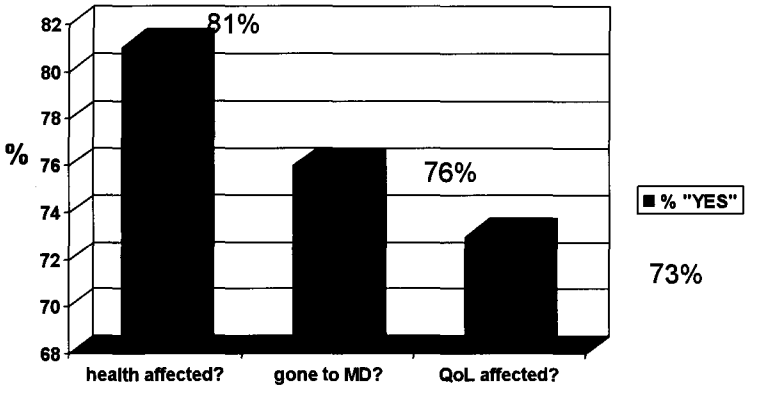
	27	28	29	30
Age	>60	>60	56	79
Occupation	Farmer/ sheep breeder		Pedigree sheep breeder	War veteran
Distance from turbine	½ mile	700m	1/3mile	
Time at property	9 years	33 years	9 years	33 years
Adverse health affect	Yes	Yes	Yes	Yes
Headaches	Yes		Yes	Yes
Palpitations			Yes	
Excessive tiredness	Yes		Yes	Yes
Stress	Yes		Yes	Yes
Anxiety			Yes	Yes
Tinnitus				Yes
Hearing problems				Yes
Sleep disturbance	Yes	Yes	Yes	
Migraines	Yes		Yes	Yes
Depression				
Other			Concentration	
Approached doctor	Yes	No	Yes- have had a 24 hour e.c.g. for investigations of palpitations. Brain haemorrhage 2 years ago.	Yes
Quality of life affected	Yes		Yes	Yes

	31	32	33	34
Age	81	45-60	>60	30-45
Occupation	Retired carpenter	Systems analyst/programmer	Business owner	Retired State registered nurse
Distance from turbine		¾ mile	Less than 1 mile	300m
Time at property	33 years	16 years	16 years	7 years
Health adversely affected	Yes	No	Yes	Yes
Headaches	Yes		No	Yes
Palpitations			No	
Excessive tiredness	Yes	Yes	Yes	Yes
Stress	Yes		Yes	Yes
Anxiety	Yes		No	
Tinnitus	Yes		No	
Hearing problems	Yes		Yes	
Sleep disturbance			Yes	Yes
Migraines	Yes		no	
Depression			No	
Other				
Approached doctor	Yes	Yes	No	No
Quality of life affected	Yes		Yes	Yes

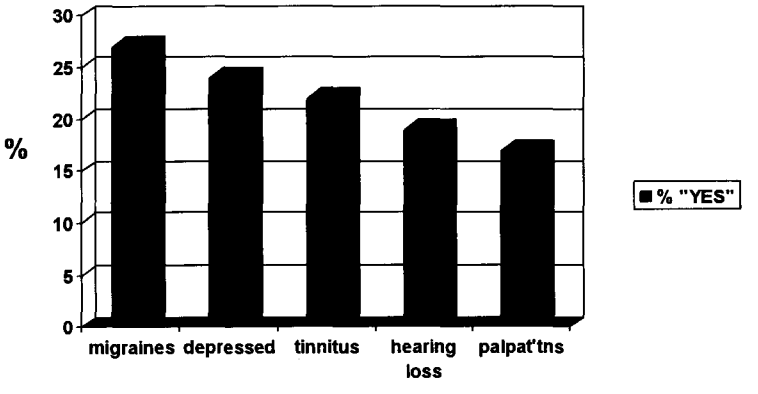
	35	36	37	38
Age	45-60	45-60	45-60	62
Occupation	Retired due to Nervous breakdown	Semi Retired farmer	Semi retired farmer	Retired
Distance from turbine	300m	800m	800m	
Time at property	7 years	11 years	11 years	25 years
Health adversely affected	yes	Yes definitely	Yes	
Headaches	yes	Yes	Yes	
Palpitations		Yes	Yes	
Excessive tiredness		Yes	Yes	Yes
Stress	yes	Yes yes	Yes	
Anxiety	yes	Yes yes yes	Yes	
Tinnitus		Yes	Yes	
Hearing problems		May be		
Sleep disturbance	yes	Yes yes yes	Yes	Yes
Migraines		No	No	
Depression		No	no	
Other	nausea			
Approached doctor	yes	Yes put on antidepressants and anti-hypertensives	Yes	
Quality of life affected	Yes	Absolutely yes	Yes	Yes

	39	40	41	42
Age			45-60	>60
Occupation	Retired phlebotomist	Running own business	Database administrator	Retired farmer
Distance from turbine		600m	3/4mile	1 mile
Time at property	20 years	24 years	7 years	26 years
Adverse affect on health	Yes	Yes	Yes	Yes
Headaches		Yes		Yes
Palpitations				Yes
Excessive tiredness	Yes	Yes		Yes
Stress				Yes
Anxiety		Yes	Yes	Yes
Tinnitus				
Hearing problems				
Sleep disturbance	Yes	Yes		Yes
Migraines				
Depression				Yes
Other	Lack of concentration And irritability		Nausea	
Approached doctor	No	No		Yes
Quality of life affected	Yes	Yes	Yes	Yes

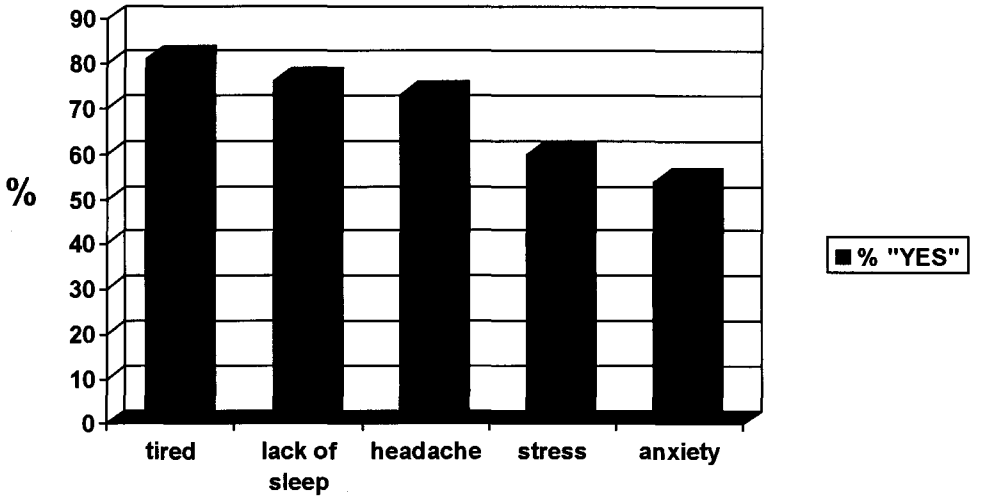
- *Has your health in any way been affected since the erection of these turbines?*
- *As a result, have you gone to see your doctor?*
- *Do you feel that your Quality of Life has in any way been altered since living near the wind turbines?*



Top 5 Self-reported Health Symptoms



Next 5 Self-reported Health Symptoms



ADDITIONAL COMMENTS MADE BY RESPONDANTS

1) I get little sleep when the noise from the turbines is constant in its low frequency noise. I feel so depressed I want to get away and stay away until I know the wind direction has changed.

2) My symptoms are due to lack of sleep when the wind is in the east or northeast

3) I get headaches frequently especially when the turbines are running at a fast rate towards us.

4) I get headaches and thumping in the ears. I also find its continual noise very distressing.

5) Suffer with headaches more and feel tired more so find daily tasks difficult to do.

6) I also find that the sound we get from the farm affects my metal heart valve.

7) I couldn't say whether or not the storbing effect wakes me up but it is impossible to go back to sleep with it there.

8) Constant worry about noise. I feel sick when the turbines are running fast and towards the property. I came here to a rural area for peace after a busy city life. I feel this has been ruined by the turbines.

9) Stressed and extremely anxious as I am constantly disturbed by them when they are turning fast and facing towards me. We are having to live our lives around them due to the constant noise when they are working causing wind pressure throbbing.

10) The strobing even when curtains are closed is "HELL". The noise is a pain. TV blocks it, night and day. Can't sit and read a book or write letters.

11) My plan was to stay here- in my newly converted barn (7 years old) (we farmed here) until I died. We have our own private water supply, a good supply of fire wood, my own painting studio- VERY IMPORTANT TO ME! And a good workshop for my husband; friends nearby, brother and sister nearby. I was born 2 miles away- Now WE HAVE TO MOVE. This move has been forced upon us. We planted 7,000 trees here. Etc.etc.etc.....

12) We will probably have to move, I can see no future for me here.

13) I dare not sleep at home.

14)
Noise disturbance at night –when wind in certain direction, interferes with sleep patterns, causing restlessness. During the day- makes it difficult to stay out of doors for any length of time through excessive thumping sound. Both can cause headaches, anxiety and irritability.

15) Certain wind directions mean excessive noise, like a thrashing machine constantly pounding, making it unpleasant to be in the garden or to have windows open. With strong wind conditions, double glazed windows vibrate and cause an intrusive, almost sub audible interference in some rooms.

16) Tired, disturbed by noise. Feel it as much as hear it. Developers deny there are any problems unless we can prove, but how can we do that?

17) Irritating noise from wind farm in easterly winds. You can almost feel it as well as hear it. It drives you mad over extended periods because of the nature of the noise, not the level per se. Unable to have front doors/windows open when winds are easterly, or use front bedroom if all 7 turbines are in operation.

18) Our quality of life we had before the wind farm came has gone. We no longer control the way we live our lives e.g. if we can work or sit in the garden, or at times, even where we can sit in our own home or get a full nights sleep.

19) I never suffered from any problems before the turbines. I am convinced that living in a continual state of anxiety over the past four and a half years since the noise nuisance started has contributed to my present problems (hypertension and stress). Prior to 1999 I always enjoyed excellent health and rarely visited the doctor's surgery. As my husband and I have been retired since 1994 and our family grown up and living in different areas of the country we do not have any other problems that are likely to cause stress or anxiety.

20) Not being able to choose when I work or sit in my own garden. Not getting full nights sleep. Waking with headaches when the noise is bad and feeling sick. Ears feel like I experience when travelling by plane- feel as if they are swollen inside. I cannot work more than 2-3 hours in the garden when the wind direction if from the east. We cannot see the wind farm from our property but at times the noise is horrendous.

21) My quality of life has been affected by the shadow flicker and the noise

22) I am bothered by the shadow flicker, and the noise while working behind the building.

23) I feel generally off colour

24) As we leave the house, the turbines are always there, menacing, always drawing your attention, depressing, in a beautiful area. Normally I sleep with the bedroom windows closed, if in summer we have a heat wave and the windows are open, I find I am wheezing in time with the turbine noise, it seems to come inside my body. This is an old stone gatehouse south of the site.

25) Quality of life has almost disappeared. No longer able to relax in the garden (when wind speed/ direction cause noise). Glinting and reflection also cause disturbance. Visual dominance is oppressive- extremely angry.

26) Constant sleep disturbance. Unable to work within certain areas, for noise levels, when wind is in certain directions, very stressful.

27) Disturbed sleeping. View blades whishing in the wind. Drawn to blades going round. Little concentration. Ugly to look at. Dominant. Not able to work in yard for long periods of time.

28) Our lives and home have been trashed and must be seen to be believed. We seem to be short tempered, unable to concentrate. Every thing we have such as mattress, duvets, cushions 4" thick, 3 rolls of sound deadening quilt, 3 sheets of corrugated asbestos, blankets, curtains, pillows even floor carpet stacked against the walls to try and keep out the sound. Not the peace I volunteered to fight for.

29) constant noise

30) Constant noise when turbine is facing us and away from us. Sleepless nights which make me irritable. Stress due to husbands anxiety about the turbines.

31) Noise from turbines effects my sleep patterns, I sleep less. I get nausea when the turbines face our home and causes a drumming at low noise frequency. I worry about the turbine blades coming off and killing me

32) Alienation from mainstream community that have the erroneous impression that wind power is a good alternative. Forced to sell property at a reduced rate- that was meant to be our retirement home. Health improved since moving from the property

33) As soon as the wind farm was operating I experienced horrendous continuous noise when the wind was from the east. This was both inside and outside my home. There were many times I had to leave the garden because of the noise. It was like a Chinese water torture, it was a constant pulsating noise. It was almost a feeling of compression as much as noise. I had to move bedrooms at times in order to escape the noise. It imprints on you, if you have had it all day in the garden, it stays with you,

once it's in your head it's hard to get rid of. It's weird. It's a feeling as much as a noise. It's torture.

34) It's an irritating and tiring noise, especially when you have not had any sleep because of it.

35) Even if you shut the window, the noise is still there, but not as much. The problem is, once you get the noise in your head, it's always there, it does annoy you and it is difficult to disregard.

36) The noise is like a whooshing noise. It is intrusive. It keeps me awake- it doesn't affect my husband as much as me but my being awake keeps him awake.

37) Once the noise gets into your head, it also seems to beat at the same frequency as my heart and I find it annoying and am unable to get any sleep- this can go on for nights on end. It's not always the level of the noise, it's the intermittent nature. You think "Oh it's stopped" then it starts up again.

38) If the wind is from the East or the South the noise is horrendous- you can't get away from it. It's inside and outside the house. It's worse at night- I have to bed hop. It's a whooshing, drumming, constant drumming noise. It's annoying. It's frustrating. It wears you down. You can't sleep at night or concentrate during the day. Once it gets inside your head you can't get rid of it. You get up in the morning, tired, agitated and depressed and it makes you short- tempered.

39) Our lives are hell, they have been ruined and it's all due to those turbines.

40) The noise from the wind farm is different and I can't explain why, it just is. All you ever want to do is to get out of the way of it, by whatever means you can.

CONCLUSIONS

I think it is clearly evident from these cases that there are people living near turbines who are genuinely suffering from health effects from the noise produced by wind turbines. These neighbours of turbines clearly state that at times the noise from turbines is unbearable. The developers are usually heard to say that noise is not a problem. Clearly this cannot be the case.
A discussion follows which clearly explains why the characteristic noise from these turbines can be producing the symptoms that are being described above. On searching through the current literature I can find no papers written showing that turbines are harmless, only statements from acousticians giving their personal thoughts. In addition to this some of these acoustic experts have made statements categorically saying that the low frequency noise from turbines does not have an effect on health. I feel that these comments are made outside their area of expertise and should be ignored until proper medical, epidemiological studies are carried out by independent medical researchers.

DISCUSSION

As shown in the case studies, people living near wind farms in the United Kingdom have been complaining of health problems since the construction of the wind farms near their homes. Inquiries reveal that some wind farms located close to peoples residences in Europe, Australia and North America have reported similar problems

The range of symptoms mentioned by complainants includes headaches, sleep disturbance, anxiety, depression, stress, vertigo and tinnitus. People complain of the noise, vibration and shadow flicker (caused by rotation of the blades and the reflection of the sun).

The following seeks to explain why these symptoms and problems could be caused by the wind turbines.

The evidence supplied has been made by a prolonged study of research available worldwide. Some acousticians have expressed the opinion that the level of low frequency noise (in dB (A)) emitted by a wind turbine will not produce health problems. However during my extensive search of the published literature, I have been unable to find any medical evidence to support this opinion.

Although the papers researched are generally not specific to wind turbines they are specific to the type and intensity of noise produced by wind turbines. The noise produced by wind turbines is quite complex therefore our response is likely to be complex also. In addition wind turbines produce a repetitive visual stimulus which goes to reinforce annoyance.

SOUND AND NOISE

Recently the European Union Noise Committee stated that noise is the biggest pollutant and the fastest growing pollutant in Europe.

Noise can be defined as unwanted sound and is commonly associated with annoyance reactions. It is commonly perceived as an environmental stressor and nuisance. Environmental noise is ubiquitous and annoyance is one of the most widely studied adverse reactions to noise. Noise interferes with task performance; cognitive performance modifies social behaviour and causes stress and irritation.

According to the World Health Organisation (WHO), health should be regarded as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity"- WHO 2001. Under this broad definition, noise induced annoyance is an adverse health effect. As with any psychological reaction, annoyance has a wide range of individual variability, which is influenced by multiple personal and situational factors.

WHO also defines noise annoyance as "a feeling of resentment displeasure, discomfort, dissatisfaction or offence which occurs when noise interferes with someone's thoughts, feelings or daily activities- (WHO paper on Environmental noise- Passchier and Verneer 1993.

Noise annoyance is always assessed at the level of populations, using questionnaires. There is consistent evidence for annoyance in populations, exposed for more than one year to sound levels of 37dBA and severe annoyance at 42dBA.

There is no doubt that annoyance from noise adversely affects human wellbeing.

The level of annoyance can only be described by listeners themselves. These descriptions are often fuzzy and not quantified most of the time. In addition to this different people have different subjective responses on the grade of annoyance. There are many theories regarding noise nuisance and many factors are thought to have an influence e.g. the types of noise source, noise energy, frequency, age , previous noise exposure, types of building structures and weather conditions. Subjective annoyance relates not only to the sound level and frequency but also to the physiological and mental factors of the sound recipients.

Field studies performed among people living in the vicinity of wind turbines showed that there is a correlation between sound pressure levels and annoyance but that annoyance is also influenced by other factors such as attitude to wind turbines an the landscape. However noise annoyance from wind turbines was found at lower sound pressure levels than in studies of annoyance from road traffic noise.
This is because the absolute noise level is less important than the character of the noise produced.

Non-auditory effects of noise, can be defined as all those effects on health and well being which are caused by noise exposure with the exclusion of effects on the hearing organ. Non auditory effects include stress, related physiological and behavioural effects and safety concerns. There have been studies showing that aircraft noise can decrease cognitive function resulting in decreased scholastic achievement.

It is obvious that the health issues relating to wind turbines are caused by these non-auditory effects as the sound pressure levels are not high enough to cause an auditory effect (e.g. hearing impairment resulting from excessive noise exposure).

How does noise affect health?

It is generally considered that noise can be an intrusion into daily activities and tasks, causing annoyance. In certain circumstances in certain susceptible individuals this annoyance may lead to a stress response which in turn may lead to symptoms and subsequently illness.
The response to noise probably depends upon the characteristics of the sound, including intensity, frequency, and complexity of
sound, duration and meaning of the noise i.e. whether the noise is perceived as threatening or not.

Alternatively, noise may affect health directly and not through annoyance. E.g. studies show elevated cortisol levels in individuals subjected to; vibroacoustic disease caused by excessive exposure to low frequency noise resulting in abnormal proliferation of extra cellular matrices.

Any severe extreme imposed on the sonic environment has a profoundly destabilizing effect on the individual.
This is evident in both the areas of high intensity acoustic energy and also its complete absence.
Anechoic chambers, which create an environment void of sound, have the ability to produce similar feelings of disorientation and disturbance that are evident with high intensity sound. The silence envelops the individual in a suffocating manner causing both psychological trauma and also physiological disturbance in the form of balance problems and other related body functions. It is clearly apparent that the human organism is in an extremely delicate state of equilibrium with the sonic environment and any profound disturbance of this system will have profound ramifications to the individual

The auditory system is an extremely complex system .Because of the complexity of the auditory and cerebral systems it becomes easy to understand why the issues surrounding noise annoyance/ disturbance and associated health effects is not a simple one.

Studies in USA have shown a relationship between anxiety and vestibular disorders such as dizziness and migraines vertigo. Anatomical and electrophysiological evidence suggests that serotonin modulates processing in the vestibular nuclei in the brain. Therefore a disturbance in the serotonin balance which occurs in anxiety and depression syndromes can cause vestibular problems.

Low frequency noise is also produced from wind turbines. Low frequency sound is predominately the result off the displacement of air by a blade and of turbulence at the blade surface. The low frequencies contribute to the overall audible noise but also produce a seismic characteristic which is one of the common complaints from neighbours when they say that not only can they hear the noise but they can also feel it.
The various parts of the body have a specific natural frequency or a resonance frequency. The human body is a strongly damped system, therefore, when a part of it is excited at its natural frequency, it will resonate over a range of frequencies instead of at a single frequency.
(fig. 1).

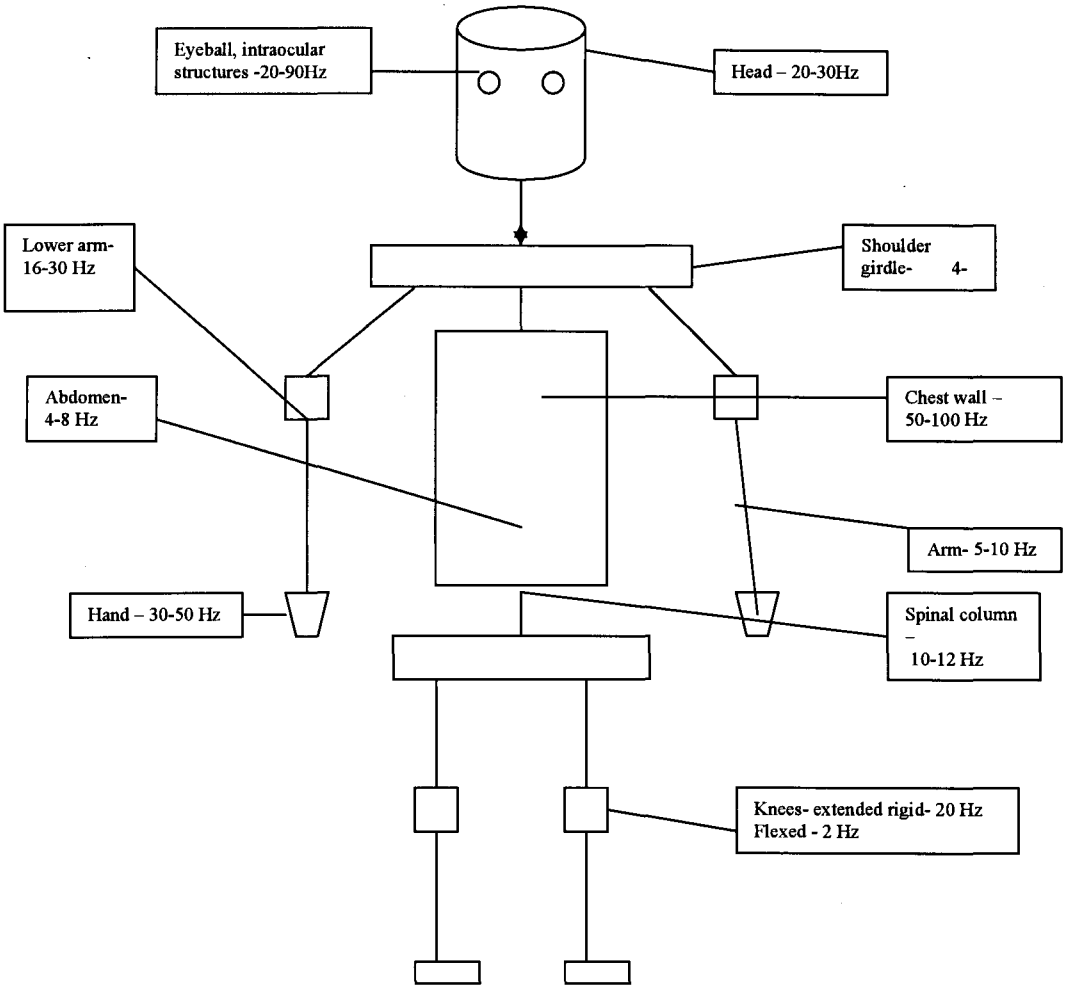
A research paper by G Rasmussen looked at body vibration exposure at frequencies of 1-20 Hz. Part of a table shows:-

Symptoms	Frequency
General feeling of discomfort	4Hz – 9Hz
Head symptoms	13Hz – 20Hz
Influence on speech	13 Hz – 20 Hz
Lump in throat	12 Hz – 16Hz
Chest pains	5Hz – 7Hz
Abdominal pains	4Hz – 10Hz
Urge to urinate	10Hz – 18Hz
Influence on breathing movements	4Hz – 8Hz

Also in the region 60-90 Hz disturbances are felt which suggest eyeball resonances, and a resonance effect in the lower jaw/skull system has been found between 100-200 Hz

Fig. 1

The resonance frequency ranges for various parts of the human body- values taken from the International Standards Organisation –ISO standards 2631



An important contribution to the low frequency part of the sound spectrum may be the result of the sudden variation in air flow the blade encounters when it passes the tower: the angle of attack of the incoming air suddenly deviates from the angle that is optimised for the mean flow. This effect has not been considered important as the blade frequency is of the order of 1Hz where humans' hearing is relatively insensitive. However low frequency modulates well audible, higher frequency sounds and thus creates periodic sound. This effect is stronger at night because in the stable atmosphere there is a greater difference between rotor average and near tower wind speed. In addition to this multiple turbines can interact with each other to further multiply the effect. The effect will be greater for the larger more modern wind turbines.

As wind is variable and not consistent, the nature of the noise produced is also impulsive and unpredictable.

Low frequency noise issues have been researched extensively in Portugal and have been found to cause a complex disease known as vibroacoustic disease. Although this research has been mainly concerned with high levels of low frequency noise, it is felt that over years lower levels of low frequency noise may cause similar problems. It appears that the low frequency noise compromises the mechanotransduction signalling of cells which lead to structural changes of tissues and cells. This damage sustained is dose dependent and it is only in the latter stages that routine medical investigations will become positive. The syndrome can be broken down into various stages:-

Stage 1 - MILD *(1-4 years)* Slight mood swings, indigestion, heartburn, mouth/throat infections, bronchitis
Stage 2 - MODERATE *(4-10 years)* Chest pain, definite mood swings, back pain, fatigue, skin infections (fungal, viral, and parasitic), inflammation of stomach lining, pain and blood in urine, conjunctivitis, allergies.
Stage 3 - SEVERE *(> 10 years)* psychiatric disturbances, haemorrhages (nasal, digestive, conjunctive mucosa) varicose veins, haemorrhoids, duodenal ulcers, spastic colitis, decrease in visual acuity, headaches, severe joint pain, intense muscular pain, neurological disturbances.)

Low frequency noise exposure has also been shown in many studies to interfere with performance and cognitive function in the workplace. The effects are greatest in noise sensitive particularly low frequency noise sensitive individuals. In this group of people salivary cortisol levels are elevated during exposure.

For many years research has been carried out using noise as a non lethal weapon. Recently the Israeli army used such a weapon for crowd dispersal. Witnesses describe d a minute-long blast of sound emanating from a white Israeli military vehicle. Within seconds, protestors began falling to their knees, unable to maintain their balance. The technology is believed to be similar to the LRAD — Long-Range Acoustic Device — used by U.S. forces in Iraq as a means of crowd control.

Professor Pratt a professor of neurobiology specializing in human auditory responses at Israel's Technion Institute explains that by stimulating the inner ear, which houses the auditory and vestibular systems, with high intensity acoustic signals that are below the audible frequencies- below 20 Hz, the vestibular organ can be stimulated and create a discrepancy between inputs from the visual system and somatosensory system and the vestibular organ will erroneously report acceleration (because of the low- frequency inaudible sound). It doesn't have to be a loud sound This will create a sensation similar to motion sickness. Such cases have been reported in relation to air conditioning systems.

Work by Fritz van den Berg shows why the characteristics of the noise produced by wind turbines increases and alters at night . He showed that the noise at night can be 15-18dBs higher at night time than during the day because of atmospheric changes (ref. Fritz van den Berg).
Therefore when we are resting in bed at night, the noise from the wind turbines can be at their loudest and most disturbing.

Those people who are disturbed by the noise are often particularly aware of the problems at night. – this statement can be partially explained by lower background noise levels at night, and also the fact that atmospheric stability increases at night giving a greater differential between rotor averaged and near tower wind speed . This explains why the characteristic of the noise emitted from turbines takes on a "beating" character early evening and night-in agreement with the blade passing frequency.

Noise induced sleep disturbance is well known to have adverse health effects and has been studied extensively although not with particular reference to wind turbines. Due to the indisputable restorative function of sleep, noise induced sleep disturbances are regarded as the most deleterious effects of noise.

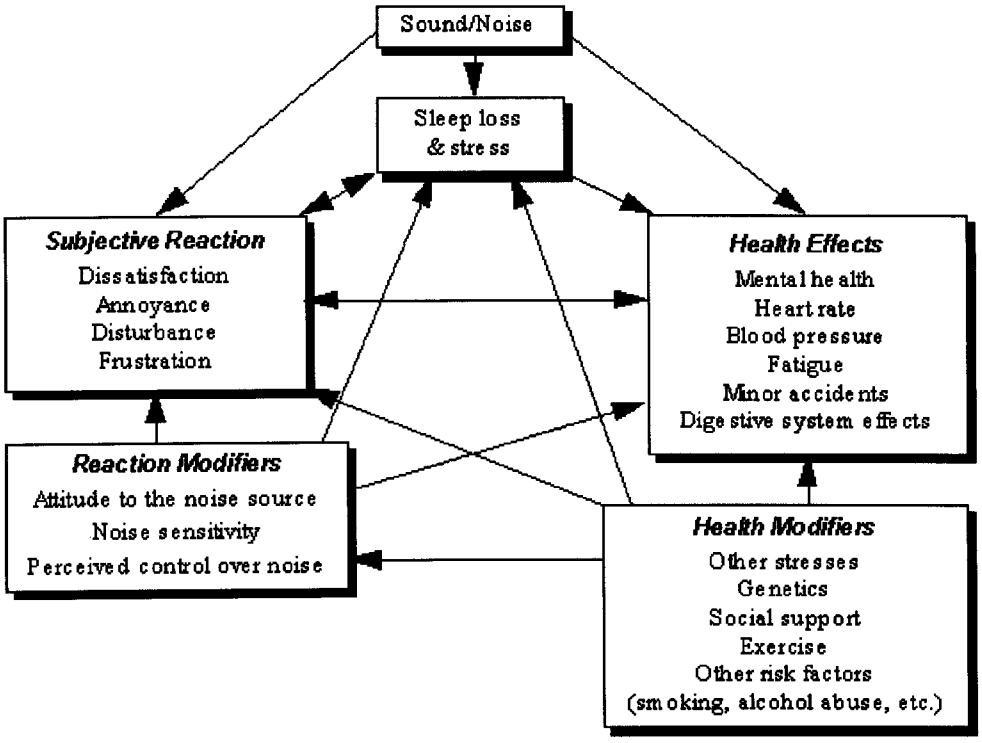
Nocturnal noise disturbance has been shown to disrupt nocturnal cortisol secretion. Nocturnal noise excites areas of the brain such as the amygdyla (functions as the fear centre) and cortical areas (arousal, annoyance and awakening). Noise –even levels below awakening threshold – can induce cortisol secretion. Repeated night time disturbance will result in an accumulation of cortisol levels in the blood. In the long term this can result in long term stress activation.

Several epidemiological studies in patients with primary insomnia found to be at a higher risk of developing major depression in the following years.
It has also been shown that women with increased morning cortisol levels show a higher risk of a major depressive episode within the next 12 months.

Psycho physiological reactions such as effects on heart rate and
respiration rate have been observed during exposure to noise whilst subjects sleep. These have been found to be induced by road traffic noise with levels exceeding 40 dB LA max (both in lab and in field studies). Hardly any habituation occurs during or between nights. Children have higher psycho physiological reactivity than adults. In addition for these types of reactions, the difference between the background noise levels and the maximum sound pressure level is of more importance than the absolute sound level. (Vernet 1983).

The potential adverse health effects are usually classified according to the type of noise. Sudden or impulsive noise appears to create more disturbance than non impulsive noise (Job 1996). Intermittent noise has a greater effect than louder more continuous noise (Westman and Walters 1981). Predictability and controllability are clearly influencing factors in an individual's response to noise and this has been born out by surveys conducted by Eja Pederson in a paper presented in Berlin in Oct 2005.

It has been shown in several studies that depressed people and the elderly have a diminished variability in circadian cortisol levels and a raised morning cortisol in common. (Kern et al in 1996, Van Cauter et al 1998, Deushle et al 1998). It would therefore be likely that the elderly and patients already suffering depression might be more susceptible to noise induced arousals.



However we as humans experience our environment through multi sensory channels e.g. acoustic, visual, proprioceptive, vibrational and psychological and emotional issues.

Therefore all these factors have to be considered when we try to explain why people might be disturbed by wind turbines. When discussing noise with people who are disturbed by turbines, frequent complaints are of vibration leading to an intrusional

and invading noise that they feel they cannot get away from. People say that they can "feel the noise".

I would suggest that several factors are therefore concerned in this annoyance. The "periodic noise" as described previously and the low frequency component. I think that the presence of these two together has an additive effect compounding both. The periodic noise draws the attention to the vibrational component and therefore becomes more annoying than if either were present individually.

In addition to this there is the visual stimulation of the turbine blades rotating- this is particularly disturbing in certain light conditions where strobing occurs, but provide a constant reminder of the presence of the turbines by their movement.

Psychological and social issues must also be considered. E.g. pre-existing psychological problems and also perceptions of having a wind turbine built close to their homes. Most people live in the countryside because they appreciate the quiet and the visual amenity. Therefore reluctance to having a wind farm nearby will exacerbate any problems.

SUMMARY

There are many people living near wind turbines who are suffering from problems with their health.

The noise produced from wind turbines is an extremely complex one and I feel that it is the complexity of the noise and vibration which causes the disturbance.

From my discussions with people suffering from ill health who live near wind farms, it seems that the symptoms suffered can occur up to a mile from the wind farm. Until further independent medical and epidemiological research has been carried out I would suggest that no wind turbines should be sited closer than 1.5 miles away from the nearest wind turbine.

The current UK guidance for establishing a safe distance between turbines and dwellings is the ETSU-R-97. This document was produced when turbines were approximately 20% the size of the currently proposed turbines. The guidelines pay scant reference to low frequency noise and the complexity of the noise profile produced by the turbines.
The continued use of ETSU-R-97 has been publically condemned by Professor FFowcs- Williams and G.P.Van den Berg.

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Appendix 1

Something in the **Wind**

THE SUNDAY TIMES - JANUARY 20, 2002

To some people they are "grotesque"blights on the countryside; to others,graceful machines that offer a welcome alternative to nuclear power and a way of tackling global warming. There are now more than 60 **wind** farms in Britain – the windiest nation in Europe –with 853 [redacted] producing enough power to run 500,000 homes a year. The numbers are set to rise as the government cranks up its drive to generate 10% of Britain's electricity from green energy sources by 2010.
Last week Powergen announced that it is considering building one of the biggest **wind** farms in the world in the Thames Estuary, sinking several hundred [redacted] into a sand bank in a project worth £500m. It comes in the wake of plans announced in December for a huge onshore **wind** farm on the Hebridean island of Lewis.
If the project gets planning permission, 300 [redacted] will be built, eventually meeting 1% of Britain's electricity needs. An increasing number of homeowners therefore have to get used to the prospect of living near the whirling blades. Margaret Gough, for one, cannot stand the sight of the towers that straddle the grassy slopes near her mid-Wales home. When she and her late husband retired to a village outside Aberystwyth 15 years ago, they chose a bungalow which had stunning views – until the Mynydd Gorddu **wind** farm opened several years later. "The reason we bought this property was for the scenery," says Gough. "It was such a beautiful skyline: if I stood in the garden and looked around all I could see was tree- covered hillsides. Now when I look out I can see about eight or nine **wind** [redacted]."

I stand under the turbine in Swaffham in Norfolk [the world's most efficient turbine andat 67m, thought to be Europe's tallest] and you don't know it's turning." Surveys have found that although up to 96% of people say they approve of **wind** farms, about a quarter would not like to live close to one. Householders' main objections are that **wind** [redacted] are "ugly" and they may bring down the value of their properties. Michael Williams, manager of estate agent Shearer & Morris in Aberystwyth, says that unless homes are very close to **wind** [redacted] property prices are unaffected. "I've sold quite a few properties within a mile of **wind** farms without any bother," he says. Nevertheless, some homeowners are fighting back. Martin Wright, Chairman of the Cefn Croes Campaign, is trying to halt the construction of the biggest **wind** farm in Britain. Under the £35m project – already approved by Brian Wilson, the energy minister – 39 [redacted], each 100m high, will be cited at Cefn Croes, near Devil's Bridge in Ceredigion, mid-Wales. Wright says he objects to **wind** farms because he fears that vast swathes of rural Britain will be lost to the machines. "Mid-Wales is full of them," he laments. "The reason I oppose them isn't because I don't want them in my back yard – there's a **wind** farm on the mountain above my house and I can't say it disrupts my life – it's to do with the wider issue of the value of our landscape.

"**Wind** power is a good idea, but the only way it is going to have any impact on our energy needs is to cover the whole country with [redacted]. So unless we are going to go down that path, why bother?
"We are going to ruin some of the lovely wildernesses that have been protected since the war: you can't build bungalows, but you can put up a 100m high turbine. That doesn't seem right."

Archaeologist **Dr Stephen** [redacted], also from Wales, claims he moved because infrasound, sound with a frequency below an audible level, from a **wind** farm made his wife ill. Problems started not long after the Llangwyryfon **wind** farm, 12 miles from Aberystwyth, opened 10 years ago. The [redacted]' house was 350m from three of the 20-plus [redacted] and 650m from six of the machines. "Our initial intention was to stay put, even though we were disturbed by the changes and damage," says [redacted]. "We had been assured the [redacted] would make no noise, but we were so close we could hear the **wind** whistling through them. "We also discovered that not only did they broadcast audible sound, they produced infrasound. It started to make my wife sick." Finally, six years ago, the [redacted] decided to sell their house and move to a new home five miles away.

Dr Peter Musgrove, head of development at National **Wind** Power, which used to own Llangwyryfon, says; "The issue of the infrasound has been looked into in considerable detail and no evidence has been found that it is emitted by the [redacted]." Not everybody objects to [redacted], however. John Theobald and his wife Sue are more than happy to live in the lee of a **wind** farm. Their bungalow overlooks Delabole in Cornwall, the oldest commercial **wind** farm in Britain, which attracts thousands of visitors a year. From their windows, they have a clear view of all 10 [redacted].
"My wife and I are inveterate supporters of renewable energy anyway, but I love them," says Theobald, who runs a woodturning business and a bed-and-breakfast.
"They change colour depending on the weather: some days they look thunderously grey and broody; other days, when the sun goes down, they turn pink and purple.
"Having said that, I don't think anyone would like to live right underneath the tower." "We live about four or five fields away and only occasionally hear the noise from the [redacted] if the **wind** is in the East."
In fact, the noise is diminishing all the time as technology advances.
"Noise is no longer an issue," asserts Peter Edwards, owner of Delabole farm.

Blowing hot and cold: Martin Wright, above, from mid-Wales, fears turbine blight
The Theobalds: see no problems with [redacted]
Source: *The Sunday Times*, 20 January 2002

Appendix 2

Flurry of complaints after wind change

Jul 25, 2005

A wind change at Meridian power company's giant wind farm on the Ruahine Ranges has prompted a flood of complaints from nearby residents.

Residents in the small Manawatu town of Ashurst say that in an easterly there is an intrusive rumble for days on end. They say the windmills emitted a low frequency noise for three days on end, making their lives a living hell.

The Te Apiti windfarm turbines have a steady sound in the prevailing westerly wind but when the wind suddenly, and unusually, turned easterly last weekend Ashurst residents say it bombarded them with noise and vibration.

"On Monday night the rumbling was so bad it sounded like one of those street cleaning machines was driving up and down near the house. In fact it sounded like it was going to come through the house," says Wendy Brock.

Geoff Keall said whether people were inside or outside it had an impact.

The blades on each of the 55 turbines are the size of a Boeing 747 wing and they produce enough electricity to power 45,000 homes.

Tararua District Council says measuring the noise is difficult, but it is concerned for the residents. Spokesman Mike Brown from Tararua District says he believes Meridian is also concerned and they will be talking together to see what can be done to resolve the issue.

But Meridian says it's a small number of people making a big noise about nothing.

Spokesman Alan Seay says they monitor the sound levels at a number of points and the monitoring has shown quite clearly they were well within the guidelines.

There's growing opposition from the public to windfarms.

Previously people have been generally supportive of windpower, but when a power company recently applied to instal a further 40 wind turbines, it attracted objections from more than 250 people.

However, despite the latest complaints windfarms on the Ruahine and Tararua ranges are expected to expand.

Appendix 3

FEATURE: And the beat goes on . . .and on and on

18.02.2006
KATHY WEBB

They call it the train that never arrives. It's a low, rumbling sound that goes on and on ... and on.

Sometimes, in a stiff easterly, the rumbling develops into a roar, like a stormy ocean.

But worst of all is the beat. An insidious, low-frequency vibration that's more a sensation than a noise. It defeats double-glazing and ear plugs, coming up through the ground, or through the floors of houses, and manifesting itself as a ripple up the spine, a thump on the chest or a throbbing in the ears. Those who feel it say it's particularly bad at night. It wakes them up or stops them getting to sleep.

Wendy Brock says staff from Meridian Energy promised her the wind turbines at Te Apiti, 2.5km from her Ashhurst home in southern Hawke's Bay, would be no noisier than waves swishing on a seashore.

"They stood in my lounge and told me that."

But during a strong easterly, the noise emitted by the triffid-like structures waving their arms along the skyline and down the slopes behind the Brock family's lifestyle block is more like a thundering, stormy ocean. Sometimes it goes on for days. And when the air is still, there's the beat - rhythmic and relentless, "like the boom box in a teenager's car".

"It comes up through the floor of our house. You can't stop it."

Mrs Brock says she can feel it rippling along her spine when she's lying in bed at night. Blocking her ears makes no difference.

"It irritates you, night after night. Imagine you've done your day's work, then you go to bed, and there's this bass beat coming up through the floor and you can't go to sleep. You can't even put headphones on and get away from it.

"My older son sometimes gets woken up by the noise. He gets up and prowls around the house."

She tells of other Ashhurst residents who "feel" the sound hitting their chests in the Ashhurst Domain 3km from the turbines. She says one woman is so distressed by the sensation she has put her home on the market.

Not everyone in the village hears the infrasound - Mrs Brock reels off the names of residents wondering what the fuss is all about - but says those who do feel the sound are distressed by it and have nowhere to turn for redress.

There's little point complaining to the Tararua District Council because all it does is record each complaint and forward it to Meridian, and nothing ever happens.

"What are they (the council) going to do to Meridian - fine them, or shut down the turbines?" asks Mrs Brock.

Meridian is dismissive of complaints about noise from Te Apiti.

"Infrasound is just not an issue with modern turbines," insists spokesman Alan Seay.

"We take it very seriously. We have looked into it seriously, but the advice we are getting from eminently qualified people is that it is just not an issue."

Many people claiming to be putting forward scientific argument about noise from turbines "are not qualified in this area of expertise. I have a problem with some of their statements", Mr Seay said.

He asked Hawke's Bay Today for the names of those complaining about noise from Te Apiti.

Asked why he wanted the names, he replied: "There is a group of people there. They are opposed to wind farms per se".

Asked why he thought they were opposed, Mr Seay said "I don't want to speculate. They just are. Possibly for the visual impact."

Meridian had complied with all legal requirements for sound emissions from Te Apiti, and "the people of Ashhurst are very happy to have those turbines there. They have become an icon," Mr Seay said.

Meridian is currently appealing noise restrictions placed on its proposed 70-turbine wind farm at Makara, near Wellington, where some houses will be about 1km away, and downwind of, the turbines.

J ohn Napier lives on the Woodville side of the Te Apiti turbines, about 2km from the nearest one.

When they first began operating, he couldn't believe the roaring noise they made.

"We can hear it in our bedroom at night."

One night, about 2am, he got out of bed to check whether the bedroom windows were vibrating, and about five times since, he has been woken up and thought "they're making a racket tonight".

He doesn't hear the infrasound beat so much. It's mainly "a roar like a train going through a tunnel or over a bridge, but it never stops".

He complained to Meridian about the noise, and the company put a noise meter on his property for a couple of weeks, but wouldn't tell him the results.

"Wind farm companies say noise from turbines is not an issue, but it is an issue all right. I would be very concerned if I lived in Karori (near Makara, in Wellington)," Mr Napier said.

Harvey Jones, who lives in a valley 3km from Te Apiti, says there is an easterly wind blowing across the wind farm about 10 percent of the time. The wind goes across the top of the hill, but the noise from the turbines rolls down the valley. It sounds like a train constantly passing by, and the stronger the wind, the louder the noise. When there's a westerly blowing, he can even hear the turbines in Woodville, 6-7km away.

"Once you get tuned in to it you can easily pick it up," he says.

Mr Jones says the amount of noise generated by the Te Apiti turbines was unexpected, and landowners prepared to put turbines on their land at Te Pohue should think very carefully about the possibility of a repeat scenario.

He predicts disaster for the residents of Makara and Karori.

"They're going to get hammered, but they don't realise."

Steve Griffin, of Te Pohue, is secretary of the Outstanding Natural Landscape Protection Society, formed to oppose two windfarms proposed for his area on the Napier-Taupo road.

Lines company Unison has resource consent to put up about 50 turbines, and Hawke's Bay Windfarms plans to erect 75 turbines nearby.

The landscape protection society is appealing all the consents in the Environment Court.

Mr Griffin, who is "sick to death of wind farms", says the prospect of 128 giant industrial turbines visually

disrupting pristine skyline and covering more than 16km of prominent mountain range near Te Pohue is bad enough. But he and other residents are worried sick about the noise potential - both normal-range and infrasound - from the turbines. Each turbine will have an 80m tower and three 45m blades. They will be 125m high and 90m wide, each taking up the equivalent of 1.5 rugby fields.

They will encircle Te Pohue village and its school, in a valley downwind of the turbines in prevailing winds - and nobody in authority seems to care, he says.

The Government has thrown the doors wide open to wind farm developers, in a bid to meet its Kyoto commitments; there are no national guidelines specific to wind turbines. That stance is unbalanced and unfair, Mr Griffin says.

"Our view is that while wind farms are part of our energy solution, sites must be selected in a socially responsible manner.

"They should not be placed within 5km of schools, hospitals, rest homes, or the private homes of those not involved with a wind farm development."

They should also be kept out of coastal, and recreation areas, and those with high scenic value, he says.

The landscape protection society wants the Government to establish national guidelines for wind farms, and review noise-testing standards to include measurement of low-frequency sound.

Low-frequency sound - sometimes called infrasound - is controversial.

Dr Geoff Leventhall, a noise vibration and acoustics expert from the UK who looked into infrasound at the request of Genesis Power, says "I can state quite categorically that there is no significant infrasound from current designs of wind turbines".

He says "the ear is the most sensitive receptor in the body, so if you cannot hear it you cannot feel it". Engineer Ken Mosley, of Silverstream, has an entirely different view.

The foundations of modern turbines create vibrations in the ground when they are moving, and also sometimes when they are not moving, Dr Mosley says.

"This vibration is transmitted seismically through the ground in a similar manner to earthquake shocks and roughly at similar frequencies.

"Generally, the vibrations cannot be heard until they cause the structure of a house to vibrate in sympathy, and then only inside the house. The effects inside appear as noise and vibrations in certain parts of a room. Outside these areas, little is heard or felt.

"However, the low frequency components of the noise and vibration can cause very unpleasant effects which eventually cause the health of people to deteriorate to an extent where living in the property can become impossible."

Dr Mosley says that wherever wind farms are built close to houses, people complain about noise and vibration.

He quotes a scientist in South West Wales, David Manley, who has been researching noise and vibration phenomena associated with turbines since 1994.

An acoustician and engineer, Dr Manley writes "it is found that people living within 8.2km of a wind farm cluster can be affected and if they are sensitive to low frequencies they may be disturbed".

Two GPs in the UK have researched the health effects of noise and vibrations from turbines. Amanda Harry documented complaints of headaches, migraines, nausea, dizziness, palpitations, sleep disturbance, stress, anxiety and depression. People suffered flow-on effects of being irritable, unable to concentrate during the day, losing the ability to cope.

Bridget Osborne, of Moel Maelogan, a village in North Wales, where three turbines were erected in 2002, is reported as saying "there is a public perception that wind power is 'green' and has no detrimental effect on the environment, but these turbines make low-frequency noises that can be as damaging as high-frequency noises.

"When wind farm developers do surveys to assess the suitability of a site they measure the audible range of noise but never the infrasound measurement - the low-frequency noise that causes vibrations that you can feel through your feet and chest.

"This frequency resonates with the human body, their effect being dependent on body shape. There are those on whom there is virtually no effect, but others for whom it is incredibly disturbing."

Dr Mosley says wind-power generators in New Zealand are aware of such literature on turbine noise and infrasound from all around the world.

"Are they therefore just ignoring what is happening in the rest of the world in the hope that once turbines are up and running, people will quietly endure, or when the noise/vibration situation really starts to damage their health, the community will cut their losses, leave their homes and quietly fade away? Of course, wherever they end up, they must still pay their electricity bills, which is rather like paying the landlord who has evicted you."

The New Zealand Wind Energy Association, which did not return calls from Hawke's Bay Today, acknowledges that turbines produce infrasound, but insists it is so minimal from modern turbines that human beings cannot perceive it. Its website says "there is no evidence to indicate that low frequency sound or infrasound from current models of wind turbine should cause concern."

Infrasound was more of a problem with older turbines, which had their blades downwind of the turbine tower, the association says.

"That caused a low frequency thump each time a blade passed behind the tower."

In contrast, modern turbines "have their blades upwind of the tower, thus reducing the level of this type of noise to below the threshold of human perception, thereby minimising any possible effect on human health or wellbeing".

The association has published excerpts of a report by Dr Leventhall, who suggests that infrasound is a concept that could be classified as pop-science, seized upon by emotionally-overwrought wind farm opponents.

"When a group of residents decides to object to a development, they often support each other with strong emotions, which can sometimes lead them astray. The emphasis on low-frequency noise is an example of this. Over the past 30 years there has been a great deal of confusion and misinformation about low frequency noise, mainly in the popular media. Much of it can best be described as "hot air" but complainants' uncritical acceptance of what they read in unreliable sources has two unfortunate effects:

* It detracts from those people who have genuine low-frequency noise problems, often from industrial exhaust fans, compressors and similar.

* It undermines the credibility of the complainants, who may be harming their own cause in their apparent 'grasping at straws' approach."

Dr Leventhall goes on to say "the rational study of low frequency noise, its effects and criteria for control, has been bedevilled by exaggerations, half-truths and misrepresentations, much of it fomented by media stories over the last 35 years. The result in the UK, and it is probably similar in other countries, is that an incorrect concept - 'low frequency noise is a hazard' - has taken root in the national psyche, where it lies dormant waiting for a trigger to arouse it. The current trigger is wind turbines."

Dr Leventhall says:

* High levels of low-frequency noise are needed before people can perceive it, and the levels must

increase as frequency reduces.

* The ear is the most sensitive receptor in the body, so if you cannot hear it you cannot feel it.

* When there are problems with predominantly low-frequency noise, that is because assessment methods do not cater for it. That leads to the noises being dismissed as not being a nuisance, which in turn leaves unhappy complainants in a distressed state.

Up on the Napier-Taupo road, the printer in Steve Griffin's office is working overtime in preparation for an Environment Court battle. It might be a David and Goliath confrontation, but there's too much at stake to sit back and take it quietly, he says.

Appendix 4

Guantanamo Serenade

Jon Ronson knew from his investigation into US military intelligence that top brass had adopted some strange practices. Jamal al-Harith, the Briton released from Guantánamo in the spring, confirmed it: here, in our second extract from Ronson's revealing new book, he describes the discordant sounds and apparently random music played to him during all-day interrogation sessions, and four psychological warfare experts give their reaction

Saturday November 6, 2004
The Guardian

The more I've delved into the US military's psychological warfare, the more examples of New Age-style, First Earth Battalion tactics I've been noticing in the war on terror. I learned of one fact in particular that struck me as entirely incongruous, something at once banal and extraordinary. It happened to a Mancunian called Jamal al-Harith in a place called the Brown Block. Jamal doesn't know what to make of it either, so he mentioned it to me only as an afterthought when I met him in the coffee bar of the Malmaison Hotel, near Manchester Piccadilly station, one June morning this year.

Jamal is a website designer. He lives with his sisters in south Manchester. He is 37, divorced, with three children. He said he assumed MI5 had followed him here to the hotel, but he's stopped worrying about it. He said that he keeps seeing the same man watching him from across the street, leaning against a car, and that whenever the man thinks he's been spotted, he looks briefly panicked and immediately bends down to fiddle casually with his tyre.

Jamal laughed when he told me this. He was born Ronald Fiddler into a family of second-generation Jamaican immigrants. When he was 23, he learned about Islam and converted, changing his name to Jamal al-Harith: he liked the sound of it. He says al-Harith basically means "seed planter".

In October 2001, Jamal visited Pakistan as a tourist, he says. He was in Quetta on the Afghanistan border, four days into his trip, when the American bombing campaign began. He quickly decided to leave for Turkey and paid a local truck driver to take him there. The driver said the route would take them through Iran, but somehow they ended up in Afghanistan, where they were stopped by a gang of Taliban supporters. They asked to see Jamal's passport, and he was promptly arrested and thrown in jail on suspicion of being a British spy.

Afghanistan fell to the coalition. The Red Cross visited Jamal in prison. They suggested he cross the border into Pakistan and make his own way back home to Manchester, but Jamal had no money, so instead he asked to be put in contact with the British embassy in Kabul.

Nine days later - while he waited in Kandahar for the embassy to transport him home - the Americans picked him up.

"The Americans," Jamal said, "kidnapped me." When he said "kidnapped", he looked surprised at himself for using such a dramatic word.

The Americans in Kandahar told Jamal he needed to be sent to Cuba for two months for administrative processing, and so on, and the next thing he knew he was on a plane, shackled, his arms chained to his legs and then chained to a hook on the floor, his face covered in earmuffs and goggles and a surgical mask, bound for Guantánamo Bay.

In the weeks after Jamal's release, two years later, he gave a few interviews, during which he spoke of the shackles and the solitary confinement and the beatings - the things the outside world had already imagined about life inside that mysterious compound. He said they beat his feet with batons, pepper-sprayed him and kept him inside a cage that was open to the elements, with no privacy or protection from the rats and scorpions that crawled around the base. But these were not sensational revelations.

He spoke to ITV's Martin Bashir, who asked him (off-camera), "Did you see my Michael Jackson documentary?"

Jamal replied, "I've, uh, been in Guantánamo Bay for two years."

When I met Jamal, he began to tell me about the more bewildering abuses. Prostitutes were flown in from the US - he doesn't know whether they were there to smear their menstrual blood on the faces of the more devout detainees. Or perhaps they were brought in to have sex with the soldiers, and some psychological operations (PsyOps) boffin - a resident cultural analyst - devised this other job for them as an afterthought, exploiting the resources at the army's disposal.

"One or two of the British guys," Jamal told me, "said to the guards, 'Can we have the women?' But the guards said, 'No, no, no. The prostitutes are for the detainees who don't actually want them.' They explained it to us: 'If you want it, it's not going to work on you.' "

"So what were the prostitutes doing to the detainees?" I asked.

"Just messing about with their genitals," said Jamal. "Stripping off in front of them. Rubbing their breasts in their faces. Not all the guys would speak. They'd come back from the Brown Block [the interrogation block] and be quiet for days and cry to themselves, so you know something went on, but you don't know what. But for the guys who did speak, that's what we heard." I asked Jamal if he thought that the Americans at Guantánamo were dipping their toes into the waters of exotic interrogation techniques.

"They were doing a lot more than dipping," he replied. And that's when he told me about what happened to him inside the Brown Block.

Jamal said that, being new to torture, he didn't know whether the techniques tested on him were unique to Guantánamo, or as old as torture itself, but they seemed pretty weird to him. His description of life inside the Brown Block made Guantánamo Bay sound like an experimental interrogation lab, teeming not only with intelligence agents, but also with ideas. It was as if, for the first time in the soldiers' careers, they had prisoners and a ready-made facility at their disposal, and they couldn't resist putting all their concepts - which had until then languished, sometimes for decades, in the unsatisfactory realm of the theoretical - into practice.

First there were the noises.

"I would describe them as industrial noises," said Jamal. "Screeches and bangs. These would be played across the Brown Block into all the interrogation rooms. You can't describe it. Screeches, bangs, compressed gas. All sorts of things. Jumbled noises."

"Like a fax machine cranking up into use?" I asked.

"No," said Jamal. "Not computer-generated. Industrial. Strange noises. And mixed in with it would be something like an electronic piano. Not as in music, because there was no rhythm to it."

"Like a synthesiser?"

"Yes, a synthesiser mixed in with industrial noises. All a jumble and a mishmash."

"Did you ever ask them, 'Why are you blasting these strange noises at us?' " I said.

"In Cuba you learn to accept," said Jamal.

The industrial noises were blasted across the block. But the strangest thing of all happened inside Jamal's own interrogation room. The room was furnished with a CCTV camera and a two-way mirror. Jamal would be brought in for 15-hour sessions, during which time they got nothing out of him because, he said, there was nothing to get. He said his past was so clean - not even a parking ticket - that at one point someone wandered over to him and whispered, "Are you an MI5 asset?"

"An MI5 asset!" said Jamal. He whistled. "Asset!" he repeated. "That was the word he used!"

The interrogators were getting more and more cross with Jamal's apparent steely refusal to crack. Also, Jamal used his time inside the Brown Block to do stretching exercises, keeping himself sane. Jamal's exercise regime made the interrogators more angry, but instead of beating him, or threatening him, they did something very odd.

A military intelligence officer brought a ghetto blaster into his room. He put it on the floor in the corner. He said, "Here's a great girl band doing Fleetwood Mac songs."

He didn't blast the CD at Jamal. This wasn't sleep-deprivation, and it wasn't an attempt to induce the Bucha Effect[1]. Instead, the agent simply put it on at normal volume.

"He put it on," said Jamal, "and he left."

"An all-girl Fleetwood Mac covers band?" I said.

"Yeah," said Jamal.

This sounded to me like the tip of a very strange iceberg.

"And what happened next?" I asked.

"When the CD was finished, he came back into the room and said, 'You might like this.' And he put on Kris Kristofferson's greatest hits. Normal volume. And he left the room again. And then, when that was finished, he came back and said, 'Here's a Matchbox Twenty CD.' "

"Was he doing it for entertainment purposes?" I asked.

"It's interrogation," said Jamal. "I don't think they were trying to entertain me."

"Matchbox Twenty?" I said.

I didn't know much about Matchbox Twenty. My research reveals them to be a four-piece country rock band from Florida, who do not sound particularly abrasive (like Metallica and Burn Motherfucker Burn!) nor irritatingly repetitive (like Barney The Purple Dinosaur and Ya! Ya! Das Is A Mountain). They sound a bit like REM. The only other occasion when I had heard of Matchbox Twenty was when Adam Piore from Newsweek told me that they, too (like Metallica and Barney), had been blasted into the shipping containers where detainees were held at al-Qa'im in Iraq. I mentioned this to Jamal and he looked astonished.

"Matchbox Twenty?" he said.

"Their album More Than You Think You Are," I said.

There was a silence.

"I thought they were just playing me a CD," said Jamal. "Just playing me a CD. See if I like music or not. Now I've heard this, I'm thinking there must have been something else going on. Now I'm thinking, why did they play that same CD to me as well? They're playing this CD in Iraq and they're playing the same CD in Cuba. It means to me there is a programme. They're not playing music because they think people like or dislike Matchbox Twenty more than other music. Or Kris Kristofferson more than other music. There is a reason. There's something else going on. Obviously I don't know what it is. But there must be some other intent."

"There must be," I said.

Jamal paused for a moment and then he said, "You don't know how deep the rabbit hole goes, do you? But you know it is deep. You know it is deep."

Subsequently, I talked to Joseph Curtis (not his real name), who worked on the night shift at the Abu Ghraib prison, in charge of the computer network. I asked if he knew anything about the music. He said, sure, they blasted loud music at the detainees all the time. "What about quieter music?" I said, and told him Jamal's story about the ghetto blaster and the Fleetwood Mac all-girl covers band and Matchbox Twenty.

Joseph laughed. He shook his head in wonderment. "They were probably fucking with his head," he said.

"You mean they did it just because it seemed so weird?" I asked. "The incongruity was the point of it?"

"Yeah," he said.

"But that doesn't make sense," I said. "I can imagine that might work on a devout Muslim from an Arab country, but Jamal is British. He was raised in Manchester. He knows all about ghetto blasters and Fleetwood Mac and country and western music."

"Hm," said Joseph.

"Do you think ...?" I said.

Joseph finished my sentence for me.

"Subliminal messages?" he said.

"Or something like that," I said. "Something underneath the music."

"You know," said Joseph, "on a surface level that would be ridiculous. But Guantánamo and Abu Ghraib were anything but surface."

Jamal seemed fine when I met him in Manchester. I asked if he felt at all unusual after listening to Matchbox Twenty and he said no. But one shouldn't read too much into this. There is a very strong chance, given the history of the goat staring and the wall walking and so on that US military intelligence honchos went in for, that they blasted Jamal with silent sounds and it just didn't work.

In late June 2004 I sent an email to Jim Channon and everyone else I'd met during my two-and-a-half-year journey who might have some inside knowledge about the current use of the kinds of psychological interrogation techniques that had first been suggested in Jim's First Earth Battalion manual. I wrote:

Dear ---

I hope you are well.

I was talking with one of the British Guantánamo detainees (innocent - he was released) and he told me a very strange story. He said at one point during the interrogations the MI [military intelligence] officers left him in a room - for hours and hours - with a ghetto blaster. They played him a series of CDs - Fleetwood Mac, Kris Kristofferson, etc. They didn't blast them at him. They just played them at normal volume. Now, as this man is western, I'm sure they weren't trying to freak him out by introducing him to western music. Which leads me to think ... Frequencies? Subliminal messages?

What's your view on this? Do you know any time when frequencies or subliminal sounds have been used by the US military for sure?

With best wishes,

Jon Ronson

I received four replies straight away.

Commander Sid Heal (the Los Angeles Sheriff's Department non-lethals expert who told me about the Bucha Effect): "Most interesting, but I haven't a clue. I know that subliminal messages can be incorporated and that they have a powerful influence. There are laws prohibiting it in the US, but I'm not aware of any uses like you describe. I would imagine, however, that it would be classified and no one without a 'need to know' would be aware anyway. If it were frequencies, it would probably need to be in the audible range or they wouldn't need to mask them with other sounds."

Skip Atwater (General Stubblebine's former psychic spying headhunter): "You can bet this activity was purposeful. If you can get anybody to talk to you about this, it would be interesting to know the 'success rate' of this technique."

Jim Channon: "Strikes me the story you tell is just plain kindness (which still exists)."

I couldn't decide if Jim was being delightfully naive, infuriatingly naive, or sophisticatedly evasive.

Then Colonel John Alexander responded to my email. He remains the US army's leading pioneer of non-lethal technologies, a role he created for himself in part inspired by Jim's First Earth Battalion manual.

Colonel Alexander: "Re your assertion he was innocent. If so, how did he get captured in Afghanistan? Don't think there were many British tourists who happened to be travelling there when our forces arrived. Or maybe he was a cultural anthropologist studying the progressive social order of the Taliban as part of his doctoral dissertation and was mistakenly detained from his education. Perhaps if you believe this man's story you'd also be interested in buying a bridge from me? As for the music, I have no idea what that might be about. Guess hard rockers might take that as cruel and unusual punishment and want to report it to Amnesty International as proof of torture."

Jokes about the use of music in interrogation didn't seem that funny any more - not to me, and I doubt they did to him, either. I emailed him back: "Is there anything you can tell me about the use of subliminal sounds and frequencies in the military's arsenal? If anyone alive today is equipped to answer that question, surely you are."

Colonel Alexander's response arrived instantly. He said my assertion that the US army would ever entertain the possibility of using subliminal sounds or frequencies "just doesn't make sense".

Which was strange. I dug out an interview I'd conducted with the colonel the previous summer. I hadn't been that interested in acoustic weapons at that point, but the conversation had, I now remembered, briefly touched on them.

"Has the army ever blasted anyone with subliminal sounds?" I had asked him.

"I have no idea," he said.

"What's a 'psycho-correction' device?" I asked him.

"I have no idea," he said. "It has no basis in reality."

"What are silent sounds?" I asked.

"I have no idea," he said. "It sounds like an oxymoron to me." The colonel gave me a hard look, which seemed to suggest that I was masquerading as a journalist and was, in fact, a dangerous and irrational conspiracy nut.

"I'm confused," I said. "I don't know much about this subject, but I'm sure I've seen your name linked with something called a 'psycho-correction device'."

Yes, he said, he had sat in on meetings where this sort of thing was discussed, but there was no evidence that machines like this would ever work. "How would you do that [blast someone with silent sounds] without it affecting us? Anybody who's out there would hear it."

How could you blast someone with silent sounds "without it affecting us"? This struck me at the time as an unassailable argument, one that cut through all the paranoid theories circulating on the internet about mind-control machines putting voices into people's heads. Of course it couldn't work.

The thing is, I now realised, if silent sounds had been used against Jamal inside an interrogation room at Guantánamo Bay, there was a clue in Jamal's account, a clue that suggested that military intelligence had craftily solved the vexing problem highlighted by Colonel Alexander.

"He put the CD in," Jamal had said, "and he left the room."

Next, I dug out the recently leaked military report entitled Non-Lethal Weapons: Terms And References. There were a total of 21 acoustic weapons listed, in various stages of development, including the Infrasound ("Very low-frequency sound which can travel long distances and easily penetrate most buildings and vehicles ... biophysical effects: nausea, loss of bowels, disorientation, vomiting, potential internal organ damage or death may occur. Superior to ultrasound ...").

And then, the last entry but one - the Psycho-Correction Device, which "involves influencing subjects visually or aurally with embedded subliminal messages".

I turned to the front page. And there it was. The co-author of this document was Colonel John Alexander.

[1] In the 1950s, helicopters started falling out of the sky, crashing for no apparent reason, and the pilots who survived couldn't explain it. They had been flying as normal and then suddenly they felt nauseous, dizzy and debilitated; they lost control of their helicopters. A Dr Bucha was called in to solve the mystery. What he found was that the rotor blades were strobing the sunlight, and when it reached an approximation of human brainwave frequency, it interfered with the brain's ability to send correct information to the rest of the body.

· This is an edited extract from The Men Who Stare At Goats, by Jon Ronson, published by Picador on November 19 at £16.99. To order a copy for £16.14, with free UK p&p, call **0870 836 0875**. Jon Ronson's three-part television series, The Crazy Rulers Of The World, starts on Channel 4 tomorrow. · Jamal al-Harith is one of four Britons released from Guantánamo in March, after more than two years' imprisonment, who claim they were repeatedly tortured at the camp and, it was announced last week, are suing Donald Rumsfeld and other US military leaders for £6m compensation each.

Appendix 5

Western Morning News

SHATTERED DREAM OF QUIET LIFE

09:00 - 06 January 2004

All they wanted was the good life in Cornwall, and they needed it for the sake of their health - but no sooner had Colin and Kathy Bird fled the city for a modest rural home than their dream was shattered by the noise from wind turbines.

Last year at Christmas the couple booked into B &Bs in Newquay rather than endure sleepless nights in their caravan home at St Eval.

This year they have saved up £1,000 to live in Malta for a month because they cannot bear another winter at home when high winds turn the turbines.

When that noise from the Bears Down wind farm begins, says Kathy,

it's like a "a deep throbbing, or a train that never gets there".

For Colin it's worse. "You never rest your brain, you never get away from them," he says.

What makes it worse for the couple is that they moved to Cornwall to escape the noise of the city.

Colin, 48, had suffered a nervous breakdown when he worked as a car factory worker in Coventry. But he was stirred by warm memories of boyhood holidays in Cornwall. And the couple spent six months each year for three years until 2000 in a rented caravan there, and found it blissfully peaceful.

So they plunged what little money they had into their new life. They bought the neighbouring caravan and moved in one year before the 16-turbine wind farm opened in October 2001.

Their caravan is made mostly of aluminium, which exacerbates the tin can effect.

But they point out that they were there before the wind farm, and they don't have the money to move anywhere else.

Kathy, 43, says: "I did put in a letter of complaint about the plans. I was very concerned about the wildlife - buzzards and peregrine falcons. Then, of course, noise was one of my concerns, but I never realised how bad it would be. At first I thought it was something in the home, but it was the turbines.

"They get to a critical speed, which I believe is 40 knots, and then it disturbs us all the time. It's just as if we're in a box and it's reverberating all the time.

"It's almost like a motion sickness, and it always seems to be worst at Christmas.

"It's the constancy of them that gets to you, it can be for anything like three or four days, it's this deep throbbing."

The couple calculate that they booked into B &Bs four times last

year to escape the turbines. But sometimes they just drive around until the wind dies down.
National Wind Power, which owns the Bears Down site, has paid for double-glazing of the caravan to try to curb the noise effect, but this has had little impact.
Kathy and Colin, like their neighbours, complain of headaches, anxiety, sleeplessness and nausea - 97 per cent questioned by Plymouth GP Amanda Harry complained of one symptom or another.
One neighbour, who asked not to be named, describes the effect of the noise as being like "Chinese water torture".
His home is further back from the wind farm, and better insulated against external noise, but he said: "We get a beating sound, it's like a bus engine sitting parked, and we do get headaches. I understand the need for renewable energy, but the problem is that they do not contribute much. To get the things going they have to use electricity anyway."
To add to his sense of injury, he estimates that the wind farm has devalued his property by 25 per cent. Colin's health has got worse since moving to what he dreamed would be the perfect home for the rest of his days. At first he had no opinion of the turbines' appearance, but now he describes them as being "like ogres looking at you".
So what do the couple want, and how do they see a way out of their nightmare?
Kathy wants the turbines stopped at night so that they can sleep, and "some form of compensation" for their misery and troubles.
Colin explains: "We can't afford anywhere else, so what's it going to be like for the rest of our lives? We came here thinking we'd get peace and quiet for the rest of our lives. And it's beautiful - Cornwall has everything.
"But then this happens - you'd need to be in a Chieftain tank with earphones not to hear those things."
Kathy adds: "We came here to live simply, and we both had to retire early because of ill-health. Colin just needed a very quiet environment, and we'd been here before and had three years of peace and quiet and it was gorgeous.
"But this is systematically ruining our lives - and I just feel that people are not aware of the damage these things are doing to health."
The issue is set to come to the fore with a legal test case in Cumbria where people living between 600-800 metres from the 60-metre turbines in the village of Askham complained of headaches and nausea. Barrister John Campbell is representing three couples at Kendal Magistrates Court in a fight to get wind turbines near their homes declared a statutory nuisance under the Environmental Health Act.

He said: "There are a number of complaints of sleep disturbance, headaches, and migraines that are driving people mad. They say it's a pervasive thump, thump noise from the blades."
He said that if they won the test case, which is expected to take several days, the turbines would either have to be stopped or removed.
Meanwhile, one couple living in a residential caravan near the Bears Down site have saved up £1,000 to go to Malta for a month because they say they cannot cope with life next to the turbines in winter when the winds are high.
In desperation last year, they booked into B &Bs in Newquay at Christmas.
Kathy and Colin Bird took early retirement through ill health from their jobs in Coventry as they sought a quiet life in Cornwall. Then they moved into their caravan in 2000, before the wind farm was built. But Mrs Bird now says: "It's just a throb when the wind is up - it's like the sound of a car going by with the stereo blaring, but it doesn't pass."
Matthew Spencer, chief executive of the South West Renewable Energy Agency (Regen) yesterday disputed whether the noise from turbines was the cause of their health complaints.
He said: "People may perceive that is their problem, but the turbines are not very noisy. Nothing has been proved about the health effects, but I would take these initial findings with a pinch of salt. These are arguments that people who are opposed to wind farms use."
He pointed out that travelling at 40mph would create a noise of 55 decibels at 100 metres while a wind turbine produced a noise of 35 decibels at 350 metres.
He said there was no evidence that the new generation of larger turbines planned for the South West would be a problem. "They are becoming less noisy as they are being developed," he said.
He added that the guidelines for the turbines were that they should not be within 400 metres of people's homes, and that noise had not proved a problem in the eyes of planners.
National Wind Power, which owns and operates the Bears Down wind farm, yesterday failed to respond to a series of questions put by the Western Morning News.

Appendix 6

Western Morning News
WIND TURBINES HAVE EATEN INTO MY VERY SOUL
09:00 - 09 January 2004
Mark Taplin has lived in the shadow of wind turbines for more than a decade. As part of our on-going debate on the issue, he describes how the experience has affected his life
Opposed: Mark Taplin says turbines have ruined his way of life MY world has been overshadowed by the spectre of wind turbines for 12 years, and I have lived with the reality for the past eight years of generating machines spinning their blades 75 metres above my house, the closest a mere 440 metres away. They have imposed themselves on my life and eaten into my soul - small wonder that I feel compelled to contribute to the deluge of column inches that this latest debate has generated. I live in a modest cottage which nestles in a small secluded Cornish valley, surrounded by a few acres that I can call my own.
I came here to pursue my ambition of an Arcadian existence, growing my own fruit and vegetables and indulging in a bit of self taught husbandry.
I was eager to leave behind the smug and affluent rural neighbourhood where I had grown up, and endured the tiresome label of leading "the good life".
I was accustomed to a degree of hardship and was prepared for the vicissitudes of the Westcountry climate. I was not expecting a rural idyll "preserved in aspic". I had a grasp of the commercial imperatives that exerted control over the countryside as the end of the century approached. However, what I was not prepared for was the impact on my life of my nearest neighbours - the wind turbines at Four Burrows.
I am not the first, nor will I be the last, to find the terms "windmill" and "windfarm" misplaced. Wind turbines do not mill grain, nor do they harvest the product of their own endeavours.
Arguably they save some forms of pollution, but are responsible in turn for some negative by-products, from the concrete in their foundations to the tips of their blades, offending many by their very sight and sound. I have always considered myself as one who was aware of environmental issues, and I try to live in harmony with the countryside. But, sadly, the intrusive neighbours on my doorstep have introduced a massive note of discord into my peaceful existence.
Why? Because whatever the individual thinks of them aesthetically, I cannot avoid the noise. I hear them nearly all the time. It is not easy to equate it to other noise sources, and I find the attempts at comparisons trite. The dilemma for one such as me is that the industry has always argued that as the wind picks up speed and the

power output and noise level produced increases, the natural background noise created by the wind will mask any turbine noise. Where this argument falls down, however, is when you find yourself in a comparatively sheltered position on lower ground than the turbines and not buffeted by the wind. Then you hear a great deal more than if you stand up close with the wind rushing past your ears. When small but violent changes in wind direction shear past the turbines, the chomp and swoosh of the blades passing the towers creates a noise, albeit mercifully brief, that beggars belief. It is as if a ghostly steam engine were pumping an abandoned mine working.

But this surprising and unacknowledged phenomenon does thankfully pass as the wind abates, whereas the bane of my life - the "tonal" (mechanical whine or resonance) noise - does not. It is ever present when a turbine is generating at more than mere tickover,

despite the manufacturer's claims.

So, how can I hear tonal noise? It has been so distinct at times that I foolishly assumed everyone would own up and do something about it. Sadly, that is where the technicalities come in, and it boils down to mathematics. The wind industry is better supported than local council environmental health departments, and they were well ahead of the game when they formulated the criteria for establishing tones. It is a loaded issue and not what you might call a level playing field. Whatever I hear, they will claim that it does not qualify as a tone - which means that I am stuck with it. Once you hear tonal noise it follows you around, not in your imagination but because the human ear has a natural habit of homing in on an annoying sound.

But, going back to the beginning, what turned me into an "anti" soon after I found myself thrown on to the learning curve in 1992? Was it the way that the whole thrust of renewable energy development was being hijacked by the wind lobby, the cavalier attitude of a new breed of opportunistic developers, the obscenely generous price support structure offered at that time under the Non Fossil Fuel Obligation and the greedy scramble for another subsidy? Was it the arrogance of politicians who jumped on the green bandwagon, the pressure group zealots who adopted the moral high ground in the name of saving the planet and the naive level of argument from the "better than nuclear, nicer than pylons" brigade? Was it the exasperating lesson of having to teach myself all about parliamentary statements, planning procedures and the technicalities of noise attenuation, which only served to disenchant me, when all the while I would much rather have been getting on quietly with my life? Or was it just a selfish determination to defend my precious green and pleasant Shangri La from industrial machines which threatened to invade my privacy?

I resent the same old stale public relations lecture from the vested interest lobby who do not appear to know how or when to apologise.
I do not warm to those who disregard for the sensibilities of others who can be passionate about preserving a particular landscape that is special to them. I cannot accept that wind turbine generators are benign.
I have contributed to the debate with this account not to seek sympathy, but as a reminder to those of a different persuasion that the route down which wind power development has been driven in recent years can cause very real harm. Noise apart, it has turned me, a potential supporter, against my turbine neighbours and what they stand for.

Appendix 7

Meridian pays family to move

02 August 2005

By LEE MATTHEWS

Meridian Energy has paid an undisclosed sum of money to shift a family from their farm where Te Apiti's wind turbines are located, because noise and vibration made it too difficult to live in their house.

Company spokesman Alan Seay would not say how much the compensation is, as it is a confidential agreement between Meridian and the Bolton family. He understands they will move off their farm and build elsewhere.

He also said the payout is not a surprise, as it had been anticipated in the initial lease agreements with the land owners. It is not part of any of the 20 conditions imposed by the wind farm's resource consent.

"Te Apiti is built on two farm properties. It was recognised right from the start that this family could have issues with noise . . . their house was a only a few hundred metres from the turbines," Mr Seay said.

"The possibility of having to shift was part of the initial lease agreement. These were houses actually in the wind farm, as opposed to neighbouring (houses)."

Meridian has also made a confidential deal with the other farm owners affected. Mr Seay said he understands this has involved building alterations, such as double-glazing windows to reduce noise.

There are no other claims for any kind of compensation for nuisance from Te Apiti, and Mr Seay said he does not anticipate any in future. "This one was made because it was a foreseen situation."

Feedback from the Ashhurst community about Te Apiti has "all" been positive, apart from "one or two vociferous" opponents whom he understands to be working with people objecting to Meridian's proposed Makara wind farm.

"Nimby (not in my back yard) syndrome . . . it's what we've got to expect from some of these groups . . . it's misleading and distorting."

Last November, Ashhurst resident Colin Mahy complained that sun reflection flickering into his house from the Te Apiti turbines was "driving him mad". Meridian had told him to draw his curtains.

Mr Seay said that he had given that advice. "Sun flash is a very momentary thing, it only occurs in certain circumstances and it doesn't last long."

Appendix 8

GWEN's Diary

These wind turbines, they're 76m high, there are three of them, they have a looming presence over the beautiful Teifi Valley, I've been trying hard to come to terms with living within a mile of them ever since they appeared there on Moelfre hill twelve months ago. They don't belong here, they shine in the sunlight, they glow in the moonlight, they stand out stark white against the dark rain clouds, unlike everything else surrounding them they never change. No lichen, no birds encircling them, no ivy creeping up their metallic towers. There is nothing of nature within them ,they don't belong here on Moelfre overlooking the Tivy Valley.

Those living six, ten, fifteen miles and more away from them agree. They can be seen by the inhabitants of many small towns and villages as totally scarring the wondrous outline of the gentle rise from Moelfre to Frenni Fach Frenni Fawr, Foeldrigarn ,Preseli and Caerningly above
Newport. The council planners must have been mad to grant them permission.

I've lived here on my farm now with my husband for twenty six years, I know every nook and cranny of the fifty acres. Our farm is only two miles from the farm where I was born sixty years ago, I grew up looking towards Moelfre and was delighted to be farming within my own community. I've been teaching in local schools, I paint landscapes in a converted shed, I've enjoyed good health, twenty six years of hard but rewarding work, I had planned to spend my remaining days here.

Now I sleep in my outhouse shed, it's not comfortable, I don't want to sleep there, I don't choose to be so far from amenities all night and suffer the sounds of mice within a yard of my head. The trouble is that when I am in the house my heart beat seems to alter, there seems to be a repeated slightly thumping pressure on my lungs. There's a slight throbbing in my head, like a headache without the pain. I feel slightly sick. I know that slightly is a term I've used for all the ailments but it is not a normal state of well being. It makes me feel on edge .When I visit a friend on the other side of the valley that's when I feel normal, and that state of normality suddenly seems the most wonderful feeling on earth. To me this is a tragic turn of events. Compared to the total sum of human misery I admit it might sound trivial. Today we had the fire wood cut up for next winter, here we enjoy our own spring water, my garden, my roses and clematis, and oh the first violets and primroses in the woods. The seven thousand trees we've planted, my studio, this is what our life has been about! Now I feel robbed of all I hold dear, and to complicate the situation my husband is not effected by the turbines, he doesn't like the visual impact but they don't make him ill. The low frequency noise/vibrations from the turbines [not the blades] play havoc with my health.

Where do I go from here? When the company was granted permission for the development the local paper reported that this was a lifeline for the struggling Welsh speaking local farmer who otherwise would have had to leave the land, Hey I'm a Welsh speaking local too, where's my lifeline?
I belong here, those turbines DO NOT.

06/04/03

Diary Tuesday 8th April.

Sat in the gallery yesterday, in Carmarthen, felt well all day. In the evening went to the Teivy Arts meeting, felt well, enjoyed the company and chat. Came home at ten fifteen sat talking to Henning for a while went to bed [the bed in the house, the wind was fairly light] and the throbbing in my head started. Tried to ignore it, listened to the radio, switched it off, throb throb, feeling of anxiety, tried to sleep, but at twelve thirty I reluctantly took a Nytol tablet. Slept.
This morning I went to see my doctor to have a check up to see if there is some physical cause for my disturbed heart rhythm. She examined my heart, all well, felt my pulse rate, all well, lungs, all well, took my blood pressure, 120/80 that's good. Never felt better, She looked up my records for the hearing test in 1992 but there were no specific detailed figures given for the test only the conclusion that this patient had normal hearing. [had the test because I had been suffering from tinnitus that year]
After lunch I sat down in the living room by the window to read, after five minutes I had to move I couldn't stand the heart rhythm and the churning in my head. I tried to override it I really wanted to get on with my book but I could not stay there any longer. The wind is from the south today and the turbines have their backs turned directly at us.
Went outside to do some gardening and took Tess for a walk, it's always better outside. Thought about buying a wooden garden shed to live in, perhaps in the woods.
Back in the house I felt extremely uncomfortable. At five o'clock I baby sat for Lindsay in the old farmhouse until her mother arrived. The noise of the children and telly filled the house so I couldn't compare the two houses for turbine noise.

Wednesday 9th April.

Last night I tried something new, I have a C D of the sound of waves called Ocean Spray, it's called white noise, for relaxation and sound masking. I carried my CD player from the studio up to the bedroom. It's not a portable so it was heavy. The wind was from the south so I knew there would be throbbing in my head. It sounded great,[the sound of waves] I slept quite soon but woke up at five o'clock with a dreadful headache, had to take two soluble aspirins. Wind still from the south and my headache was still with me at ten o'clock. Took more painkillers and kept to our plan of walking on the Preselis.

Three hour walk, beautiful weather, felt great. My mind is going around in circles about what to do in this situation. It's clear that no one else suffers from the same symptoms as me on this farm. There are six adults and three children living here. I really don't want to disrupt everyone else's lives.
Plans: Sell the whole place. Sell only this house; Rent a place and find a tenant for this house; Build a small place for me in some "quiet corner of the farm" if there is such a place; My head is reeling with all the pros and cons. Haven't painted for weeks because of my bed being in the studio. Feel sick again. Trouble is that when I feel ill where can I lie down, in my bedroom? That's where I feel ill.
Later on the wind came from the North, then life gets back to normal again and no way are we going to sell up and move away.

Friday 11th April
North wind, yesterday was no problem to me. What a difference it makes, once the pain has gone there's no need to plan an alternative future for us. Have moved the bed from my studio, I really need to get on with my work. Have moved it to the loft, above another outhouse, I shall sleep there next time the wind is from the south. I'm feeling quite hopeful again that I can live with this once I've learned how to, but in order to make it possible some alterations will have to be made to the loft.
Saturday 12th April
I was far too optimistic yesterday, this is typical of how it goes. Last night was the worst so far. I went to my bed in the house and played the CD of the waves, slept quite soon, CD was on repeat mode. At one forty five am I woke up with the throbbing in my head, really bad, weight on my chest and a distinct pain in my heart. Tried to calm myself, CD was still playing, tried to meditate but was filled with a real sense of panic and felt an urgent need to escape. Too cold to go to the loft so I carried my duvet down to the kitchen which is the furthest room away from the turbines. With the cushions from the settee I made a camp bed but there was no sleep so at six o'clock I dragged it all back upstairs, Got up, had only about three hours sleep.
Shall have to try out the loft tonight, it's the sound of vermin that worries me, and the cold, but nothing could be worse than the way I felt last night.
Sunday 13th April
The loft is as bad as the bedroom. I realized this in the afternoon yesterday when I tried to catch up with some sleep. Spent last night at by brothers' house in the village three miles away. Slept. This is really getting us down, it's taking over our lives. We're now back to selling and moving away, it can't go on like this.
Monday 14th April
Wind from the south again, feel really depressed this morning. Phoned the council about noise pollution, someone will 'phone back today or tomorrow [or never]. I've got to get out of here today, all the symptoms are with me again, Henning is quite sick of hearing about them and I'm sick of suffering them.
Tuesday 14th April,
Wind still from the south, slept in the dining room last night but only after taking a Nytol tablet. Estate agent came out this morning, we'll probably have to move I can see no future for me here. I have to go out today to get some relief from the way I feel.

Gwen has now moved and does not live near wind turbines- she says that all her symptoms have settled.

Appendix 9

A) Nick Priest on behalf of 30 families, Chybucca, Allet, Truro, Cornwall, TR4 9DL

..... the only two families who lived near to the Carland Cross wind farm, Newquay, have now moved out because of unsolvable noise problems. At least one home now lies derelict.

Is this positive rural diversification or rural community extinction? The Welsh Affairs Select Committee have recommended that no dwellings should be within 1.5km of a wind farm. There are 30 families within such distance.

(Extract from noise abatement society, July 1997, 'Windfarms certainly do make a noise').

Appendix 10

B) Natalie Gregg, The Courier Mail, Queensland, Australia, 04 Oct 2004

Rural residents in two states can't sleep at night because of noise from a Queensland Government owned corporation's alternative energy plant. Homeowners in Queensland and Vixctoria have all but resigned themselves to the noise of the Stanwell Corp. wind turbines, which they claim have devalued their properties.

Mrs Newman said the throbbing, thumping noise from the generators could be heard at all hours of the day, "It was very frustrating in the beginning and makes us extremely upset, but there is nothing we can do about it." Within 12 months the couple, who are in their fifties, had had enough and they decided to move but they still cannot find a buyer.

Appendix 11

C) Times on Line, 10 Jan, 2004 "wind farms ruin peace, says judge"
Wind farms can ruin the peace of the countryside and destroy the value of nearby homes, a judge has ruled.

District Judge Michael Buckley said that the noise, visual intrusion and flickering of light through the blades of turbines reduced the value of a house by a fifth. He said that the value of a remote house in Marton, in the Lake District, fell significantly because of the construction of a wind farm 40m high turbines, 500 metres away.

Appendix 12

D) Mag. Lotta Nilson, Laholm, Sweden. (lotta.nilson.fsi@swipnet.se)

Wind turbines produce nothing but a nightmare for neighbourhoods; conflicts between former friends and within families, stress, ill health... ... ...I left my home because of a wind turbine placed 650m from my house. One day in November 1998 mine and my neighbour's lives changed dramatically. The wind turbine, totally about 90m high started to rotate for the first time. The noise is a torture. After one year I understood we would not get any help and that no one can or will measure the sound level... ... ...Hundreds of families in my small, former beautiful community on the west coast of Sweden are suffering enormously.

Appendix 13

E) Murray R. Barber, Bradworthy, Devon. 12 July 2005

I understand that Energiekontour A.G. is responsible for operating the Forestmoor wind farm, Bradworthy, Devon. Our home is located 650m from the nearest of three turbines. I wish to complain about noise nuisance created by the wind farm.....

NOISE RADIATION FROM WIND TURBINES INSTALLED NEAR HOMES: EFFECTS ON HEALTH

With an annotated review of the research and related issues

By Barbara J Frey, BA, MA and Peter J Hadden, BSc, FRICS

February 2007
June 2007
www.windturbinenoisehealthhumanrights.com

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Contents

Note: This paper limits its discussion to wind turbines taller than 50m or from 0.75MW up to 2MW installed capacity.

Section 1.0 ABSTRACT

Wind turbines are large industrial structures that create obtrusive environmental noise pollution when built too close to dwellings. This annotated review of evidence and research by experts considers the impact of industrial-scale wind turbines suffered by those living nearby. First, the paper includes the comments by some of the families affected by wind turbines, as well as coverage in news media internationally. The experiences described put a human face to the science of acoustics.

Second, the paper reviews research articles within the field of acoustics concerning the acoustic properties of wind turbines and noise. The acoustic characteristics of wind turbines are complex and in combination produce acoustic radiation. Next, the paper reviews the health effects that may result from the acoustic radiation caused by wind turbines, as well as the health effects from noise, because the symptoms parallel one another. Primarily, the consequent health response includes sleep deprivation and the problems that ensue as a result. In addition, this paper reviews articles that report research about the body's response not only to the audible noise, but also to the inaudible components of noise that can adversely affect the body's physiology. Research points to a causal link between unwanted sound and sleep deprivation and stress, i.e., whole body physiologic responses.

These injuries are considered in the context of Human Rights, where it is contended that the environmental noise pollution destroys a person's effective enjoyment of right to respect for home and private life, a violation of Article 8 of the European Court of Human Rights Act. Furthermore, the paper considers the consequent devaluation of a dwelling as a measure of part of the damage that arises when wind turbines are sited too close to a dwelling, causing acoustic radiation and consequent adverse health responses.

The review concludes that a safe buffer zone of at least 2km should exist between family dwellings and industrial wind turbines of up to 2MW installed capacity, with greater separation for a wind turbine greater than 2MW installed capacity.

Section 2.0 INTRODUCTION

1 Industrial wind turbines produce an intermittent flow of electricity but in the process also produce undesirable noise emissions when installed too close to people's homes, causing environmental noise pollution. (See Section 6.5 of this paper.)

2 Wind turbines located at a sensible distance from dwellings are unlikely to cause environmental noise pollution and health problems. When the State allows priority to commercial interests, the reasonable needs of families and their human rights are extinguished. There are questions of human rights and of industrial and governmental ethics when developers construct wind turbines too close to dwellings, especially when Government decision makers are fully aware that there is a high probability that families may lose the right of respect for their home and private life. In such instances, both the commercial groups and the State are party to the violation.

3 This Review seeks to bring together research evidence in the professional literature that addresses the substantive nature of the problem, both from the acoustical and biomedical perspectives. However, the Review would be incomplete without Section 3, Overview of the Problems – Personal Perspectives, which includes the observations and reflections by those living near wind turbines, as well as reports in the media. The Review also considers the possible infringement of human rights when developers build wind turbines in close proximity to dwellings.

4 Precision in predicting noise levels in homes neighbouring wind turbines has so far eluded the wind industry. As early as 1987, Glegg, Baxter, and Glendinning reported on the problems with predicting noise accurately:

> *'This paper describes a broadband noise prediction scheme for wind turbines. The source mechanisms included in the method are unsteady lift noise, unsteady thickness noise, trailing edge noise and the noise from separated flow … [In] spite of these detailed predictions of the atmospheric boundary layer the noise predictions are 10dB below the measured levels … [The upwind] support tower cannot be ignored, since significant acoustic scattering occurs when the rotor blade is close to the tower. This can be very important subjectively and so a theoretical model has been developed which allows for the increase in radiation due to this effect.'* [Glegg SAL, Baxter SM, and Glendinning AG. The prediction of broadband noise from wind turbines. Journal of sound and vibration 1987; 118(2): 217-39, pp 217-218]

5 In a recent (2006) Report the Dti found further studies of wind turbine noise were necessary:

> *'However, the presence of aerodynamic modulation which is greater than that originally foreseen by the authors of ETSU-R-97, particularly during the night hours, can result in internal wind farm noise levels which are audible and which may provoke an adverse reaction from a listener … To take account of periods when aerodynamic modulation is a clearly audible feature within the incident noise, it is recommended that a means to assess and apply a correction the incident noise is developed.'* [Dti Executive

Summary of the Measurement of Low Frequency Noise at Three UK Wind Farms, contract number W/45/00656/00/00, URN number 06/1412, Contractor: Hayes McKenzie Partnership Ltd, 2006.]

The report states that *'… it may be appropriate to re-visit the issue of aerodynamic modulation and a means by which it should be assessed.'* [p 65]

6 The wind energy industry and its consultants – acoustical engineers – claim that the audible and inaudible noise effects have minimal consequence on humans and that infrasound (0Hz – 20Hz, part of the low frequency noise spectrum), is inaudible and weak and therefore not a human health risk. This review has not found any epidemiological evidence to support these suppositions.

7 As more wind turbines are installed near homes, more communities are affected by these complex sounds. Noise is the human face of the science of sound, and physicians are seeing the results. More people living close to wind turbines – within 1.5km – complain of sleep deprivation, headaches, dizziness, unsteadiness, nausea, exhaustion, mood problems, and inability to concentrate.

Physicians and researchers in the UK, Portugal, Germany, the USA, Australia, and New Zealand, among others, have observed a similar constellation of symptoms.

8 Although acousticians and engineers working for the wind energy industry conclude that audible noise and low frequency noise from wind turbines are unlikely to cause health effects, experts in biomedical research have drawn different conclusions.

9 Indeed, in 2006, the French National Academy of Medicine issued a report that concludes:

'The harmful effects of sound related wind turbines are insufficiently assessed … People living near the towers, the heights of which vary from 10 to 100 meters, sometimes complain of functional disturbances similar to those observed in syndromes of chronic sound trauma … The sounds emitted by the blades being low frequency, which therefore travel easily and vary according to the wind, … constitute a permanent risk for the people exposed to them … An investigation conducted by the Ddass [Direction Departementale des Affaires Sanitaires et Sociales] in Saint-Crepin (Charent-Maritime) revealed that sound levels 1 km from an installation occasionally exceeded allowable limits.'

The report continues:

'While waiting for precise studies of the risks connected with these installations, the Academy recommend halting wind turbine construction closer than 1.5 km from residences.'
[Chouard C-H. Le retentissement du fonctionnement des eoliennes sur la sante de l'homme (Repercussions of wind turbine operations on human health). Panorama du Medecin, 20 March 2006]

10 Warning signs of future problems with new technologies have been overlooked or ignored in the past, much to the detriment of the public's health. One has only to look at the history of asbestos and mesothelioma; tobacco and lung cancer and chronic pulmonary diseases; thalidomide and birth defects; mercury and neurotoxicity; x-rays and fluoroscopes and cancer; lead-based paint and childhood poisoning; and coal miners and black lung, to name but a few. The pattern of medical problems took time to emerge before a pattern of health complaints were observed, followed by epidemiologic studies and public health policy.

11 Human health effects may take years to emerge as a pattern, when the detrimental effects are past correction. As the numbers of wind turbine installations close to people's homes increase, reports of health effects have escalated, from sites across the globe. These problems do not appear to be present where wind turbines are located at a safe distance from homes.

12 This paper brings together research evidence on the characteristics of noise radiated by wind turbines and how that noise affects human health. As this is a public health issue, this paper also presents the advice and policy recommendations of medical and epidemiological experts.

This paper also considers whether as a result of reported health problems, the noise emission components of wind turbines should be regarded as an environmental noise pollution, which is a violation of basic Human Rights.

Section 3.0 OVERVIEW OF THE PROBLEMS: Personal Perspectives

'Britain should be considerably quieter than it is ... unless something is done the situation will soon become intolerable.' **[The *Times*, London, 3 July 1963]**

1 This section of the paper, perhaps more than any other, illustrates that noise is the human face of the science of acoustics. This section presents that essential – but often ignored – side of the equation: the voices of those directly affected by the construction of wind turbines near their homes.

2 In 1966, Dr Alan Bell observed that noise is much more than an occupational hazard:

> *'Noise is a sensory input, devoid of information, that nevertheless demands attention ... it is a public nuisance and a danger to mental and physical health ... The degree of annoyance is not necessarily directly related to the intensity of the sound ... The factors influencing community responses included lack of sleep ... The results of past lack of forethought are aggravated by situations still developing that will certainly create noise problems in years to come ... Even rural peace is often shattered.'* [Bell, A. Noise: an occupational hazard and public nuisance. Geneva: World Health Organization, 1966.]

3 Both the European and British Wind Energy Associations, in their Best Practice Guidelines, state that:

> ***'Wind turbines should not be located so close to domestic dwellings that they unreasonably affect the amenity of such properties through noise, shadow flicker, visual dominance or reflected light.'***

4 But these are only industry guidelines. Planning Policy Statement 22, section 22, says that:

> *'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* [ETSU-R-97, The assessment and rating of noise from wind farms] *for the Dti should be used to assess and rate noise from wind energy development.'*

5 This guidance is scrupulously followed by wind turbine developers and Planning decision makers. Section 4.0 of this paper, Acoustics, addresses the limitations of ETSU-R-97; yet it is interesting to note here that the standards in ETSU-R-97 appear to provide less protection to people than the standards of the World Health Organisation *Guidelines for Community Noise 1999*.

6 ETSU-R-97 and subsequent policies based on that document fail to protect families living near wind turbines, as the following illustrates:

For a fortnight beginning 12 January 2004, complainants and witnesses gave evidence about their experiences living near the Askam, Cumbria, UK, wind turbines. These wind turbines are rather modest compared to the larger turbines of today: seven wind turbines, each 62.5m high.

Prior to the construction, the developers had assured the community that wind turbines near their homes would not create noise or visual disturbances. Background noise prior to the wind farm was as low as 16.5 dB, with a nighttime average of about 19 dB. The readings are now regularly in the middle to high 40's dB.

> *'Eventually the developers admitted everything that we had claimed – but still nothing has been done to resolve these problems to the satisfaction of those people who matter.'* [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

7 On seeking assistance from the local Council, the Askam residents were then informed that *'because of the court case of* ***Gillingham v Medway Council****, the classification of the area had changed with the passing of the planning permission'*. That is, the area where the wind turbines were built had been reclassified as a mixed rural/industrial area; local residents were unaware of this reclassification.

Consequently, their expectations of noise levels were considered *'unrealistically high'* for an industrialised area, according to the local authority. [Brierley, 2006]

8 Indeed, when the Askam residents brought a case against the developer PowerGen (E.oN), the judge eventually ruled against the residents, saying that ***"audibility and annoyance are not to be equated with nuisance."*** [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

9 The following are excerpts of statements of only a few who have lived near wind turbine installations. Some of these families have consequently moved home because they felt it impossible to enjoy a normal family life by remaining.

It is important to remember that some of these statements were written or presented several years after living with the daily, or nearly daily, intrusions of noise and/or shadow flicker / strobing caused by wind turbines.

Please note: In respect for the residents' confidentiality, the authors are identifying the families by number rather than by name.

10 *'Everything changed … when the wind turbines arrived …approximately 700 metres away from our property … At this point we had no idea how this development (windfarm) was to effect [sic] our quality of life and cause so much pain and suffering. Within days of the windfarm coming into operation we began to hear a terrible noise, but didn't know, at first, where it was coming from. As it continued we eventually realised the noise originated from the windfarm. We were horrified. Were we the only ones suffering this noise?*

Would this continue for the proposed length of time the windfarm would be there i.e. for the next 20 years? The noise drove us mad. Gave us headaches. Kept us awake at night. Prevented us from having windows and doors open in hot weather, and was extremely disturbing.'
Member of Family 01

Some time after the wind turbines began operation, this resident learned that other people were experiencing the same problems; they attempted to voice their concerns and their distress:

'From that day, until the present, despite telephone calls, letters to, (and liaison meetings with), the owner, the operators, representatives of the Parish Council, the District Council, the local Planning Committee, the Environmental Health Department and our member of Parliament … nothing has been resolved.'

11 On one occasion, several of the wind turbines were switched off on the morning of one bank holiday, to give this family some relief (this is 4 years on …), but by evening, the turbines were operational, and the noise returned. This resident's statement continues with an anecdote: one of the wind turbine operators who lived several kilometres from the site said

'… quite openly, that he walked his dog on the foreshore … and had identified noise from the wind turbines …over 4 kilometres away from the site.'

Occasionally the family would request that one or more turbines could be switched off so that they could spend time in their garden, but:

*'I found it beyond belief that after almost 4 years we still had to ask for time to work in our own garden and even then to be restricted to 4-5 hours.***'**
Member of Family 01

12 Other witnesses said that even without a view of the turbines, there is an audible impact:

'I cannot come to terms with the thought of this situation continuing for another 15 years. From our property we cannot see any of the turbines, but we can certainly hear them.' **Member of Family 02**

'They were noisy immediately, blades "whooshing" around … if the wind is from the East, or the South, the noise is horrendous. You can't get away from the noise, where can you go? It's all around outside and you get it inside the house as well. It's worst during the night, I have to "bed hop" to get any sleep … but it doesn't work … This noise is like a washing machine that's gone wrong. It's whooshing, drumming, constant drumming, noise. It is agitating. It is frustrating. It is annoying. It wears you down. You can't sleep at night and you can't concentrate during the day … It just goes on and on … It's torture … [4 years later] *You just don't get a full night's sleep and when you drop off it is always disturbed and only like "cat napping". You then get up, tired, agitated and depressed and it makes you short-tempered … Our lives are hell.'* **Member of Family 03**

13 One resident near the wind farm, a mechanical engineer and his family, accepted the developer's assurance that the turbines would not be a noise nuisance. However, when the wind turbines became operational, they began to experience problems with noise. Following this, they then discovered that other families had similar problems. The developer denied that any problem existed:

> *'The wind farm was described as "inaudible", which clearly wasn't true. They also denied the existence of upwind noise, a fact they later retracted and admitted did exist … at one of these meetings Mr --- , of --- , said … that his company was not prepared to take any action to reduce or eliminate'* the phenomenon of shadow flicker. *'Throughout the negotiations with the developer's side, it has been disappointing to encounter the amount of "stonewalling" and intimidation, which culminated in the threat of legal action against us, when our sole intention was to remedy the problems inflicted on us by the presence of the wind farm, which caused the various nuisances.'* **Member of Family 04**

14 Another family living near the wind turbines, who had also been reassured by the developer prior to the installation that noise would not be a nuisance, did indeed experience a 'noise nuisance' when the turbines became operational. At a meeting, a representative of the developer, when asked about the problems with noise, especially after assurances that noise would not be a problem at this site, responded:

> *'… no wind farm was "inaudible". I suggested that any further correspondence publicising wind farms in general should, in future, be correctly worded and not mislead the general public in this way … everything we were complaining about was being aggressively fought against by the developers … My personal feeling is that the residents have been let down by all the parties involved, but specifically by the Environmental Health Department's apparent inability to resolve what is a genuine and distressing sequence of noise nuisances that have gone on now for over 4 years.'* **Member of Family 05**

15 Yet another resident living near the wind turbines, although not visible from his home, found the noise from the turbines disturbing, especially when the wind prevails from the East, which is frequent:

> *'It was like the Chinese water torture, it was constant pulsating noise. I also had to move bedrooms on occasions in an attempt to escape the noise. It's a feeling as much as a noise … It's an irritating and tiring noise, especially when you have not had any sleep because of it.'* **Member of Family 06**

16 The litany continues: One resident, with many years work experience of oil and gas exploration, development, and production, including work as a consultant internationally, questioned the wisdom of installing wind turbines near homes. It was not the technology to which he objected. However, he felt reassured by the developer that the wind turbines would not create a nuisance, and that the developer would safeguard their 'continuing quality of life':

> *'It is not necessarily the noise level per se, but the nature of this noise. It may not be constant. It has lasted some 10 – 12 days without respite, with varying intensity such that even when not present you are waiting for it to re-occur.*

The most apt description is that it is an audio version of the Chinese Water Torture. The noise is such that the noise is felt as much as heard … Developers have been informed … that this noise is making people ill, although I have no experience of this. This, I believe, may be attributable to the low frequency element of noise created by the wind farm. This phenomenon is documented in a report published by DEFRA, where wind farms are confirmed as a source of low frequency noise.'
Member of Family 07

This particular resident was 'appalled' when the signatory of the developer's letter assuring the community that the wind turbines, when operational, would not create a noise nuisance, later admitted to him privately, that:

'There is noise with all wind farms. It is to be expected and you have to live with it.'

'*This confirmed my worst fears that the residents had been misled …'*

17 Apparently, the developer eventually provided attempts at noise mitigation:

'This, I believe, is an admission that noise problems exist … the developers want to dictate the times of day, duration and location of the residencies [sic] that will and will not be affected by noise emanating from their wind farm. This is entirely contrary to the [developer's] letter and the BWEA and EWEA guidelines … It is also contrary to the EHO's mission statement as publicly depicted on their web site.' **Member of Family 07**

18 And from a farming family:

'The noise is a big "Whooshing" noise … I hear it inside my home … If I sit in the garden it's there, not always as it depends really on the wind direction and if the wind is from the west side of my property it is worse … I am not against wind energy, but these are definitely in the wrong place. If only someone had come and looked at it or even if they came today, they would realise what I am trying to say.' **Member of Family 08**

19 One family has since moved away; their home was 680m from the nearest wind turbine.

Another family that has since moved away lived 700m from the nearest wind turbine.

Another family is moving away; they live 800m from the nearest turbine.

Of the other witnesses, distances from the nearest turbines range from 600m to 1000m. One resident, who lives 390 m away, sleeps with the radio on, but this person declined to testify.

20 In a paper known as "The Darmstadt Manifesto", published in September 1998 by the German Academic Initiative Group, and endorsed by more than 100 university professors in Germany, the German experience with wind turbines is described in graphic terms:

'More and more people are describing their lives as unbearable when they are directly exposed to the acoustic and optical effects of wind farms. There are reports of people being signed off sick and unfit for work, there is a growing number of complaints about symptoms such as pulse irregularities and states of anxiety, which are known to be from the effects of infrasound [sound frequencies below the normal audible limit].'

21 In Bradworthy, North Devon, UK, noise complaints lodged to the local environmental health officer after three wind turbines – each 85m high [75m approved, built at 85m] – became operational in 2005, are still unresolved. One resident, who lives as near as 533m to these three turbines, endures

'strobe or shadow flicker entering my Kitchen, Conservatory and Sitting room, all on the East side, when the sun rises in the east, in Autumn and Winter behind the wind turbines. This will last for three months and is NOT ACCEPTABLE … The prolonged flicker causes a headache, affects my eyes and causes disorientation.'

This resident has observed and described the noise at various times of day, in all weather conditions, and rarely is there a lull in the noise, which is characterised, depending upon the strength and direction of the wind, as swooshing, swishing, whining, a constant aeroplane drone, a police siren, and like a spin dryer.

'That shadow flicker would cause problems was denied 3 times in the planning appeal book.' [MH, Bradworthy]

Yet, the developer's Planning Appeal stated:

'Shadow Flicker. As previously stated, this is not considered an issue due to the distance and orientation of the turbines to the nearest dwelling.'

Instead, this property owner explains that the shadow flicker *'actually reaches past my property and over a public highway … 500 metres away is too close.'* [MH, Bradworthy]

22 In a letter to the *Western Morning News,* 16 October 2001, Patrick and Phoebe Lockett, of Wadebridge, Cornwall, UK, wrote:

'We live near the Bears Down windfarm in North Cornwall, where there are 16 turbines between 750 and 1400 metres from our home, and we are subjected to intrusive noise. When the wind direction is south to south-westerly, there is a rhythmic thumping sound which disturbs us and our neighbours, in our homes and gardens, day and night.

We are writing to residents in the areas of North Devon where there are proposed wind farm developments, advising them not to take reassurances from developers at face value.

I quote from a letter we received in October 1998 from National Wind Power's head of operations and technology, John Warren:

"We are 100 per cent confident that there will be no noise problem at any nearby residence."

NWP say that they do not know why the turbines are making this noise. They are monitoring it and tell us they will try some experimental adjustments to the turbine blades. Our only hope is that NWP's investigations will provide a solution to the distressing situation in which we and our neighbours find ourselves.'

23 Two years later, in a letter to the Western Morning News on 15 November 2003, Phoebe Lockett wrote:

'We are still experiencing noise problems with the turbines on Bears Down.'

24 *The Courier-Mail* (Queensland, Australia) reported on 4 October 2005, that a Queensland government-owned wind farm, which began operating in 2000, was creating sleep disturbances and noise problems at nearby properties. Jim and Dot Newman said:

'… the throbbing, thumping noise from the generators could be heard at all hours of the day. It was very frustrating in the beginning and makes us extremely upset, but there is nothing we can do about it.'

After a year, the couple decided to move, but could not find a buyer for their property. The newspaper reported that:

'A number of Victorian residents know exactly how the Newmans feel and are equally angry at Stanwell Corporation.'

Stanwell had assured residents that they would not be disturbed by the turbines.

With two 60m towers standing 750m and 810m from their homes, Keith and Terry Hurst said:

'It was terrible, we had real trouble sleeping and the worst part was we decided to move and it took 18 months to sell the place.' In a 'booming' property market, they lost money selling their house. One real estate agent said that 'it was nearly impossible to sell a property within one kilometre of a wind turbine or a proposed wind turbine.'

25 Stanwell's spokesperson said that:

'… independent experts and noise level monitoring had verified the Toora Wind Farm [as] fully compliant with its operating permit conditions.' (Gregg N. Wind energy not resident-friendly. The Courier-Mail, Queensland, Australia, 4 October 2005.)

26 A common thread runs through these observations by those who live near wind turbines: It is not necessarily only the loudness of the noise; it is also the character of the noise that is disturbing. The wind turbine noise is periodic; intermittent; 'whooshing' or 'swishing'; it interferes with outdoor activities at one's home and with sleep or studying, i.e., it severely disrupts normal family life.

As one of those living near the wind farm in Askam observed:

> ***'You think "Oh it's stopped" – then it starts up again.'***
> (Member of Family 09)

27 In New Zealand, a man may be forced from his home because noise from wind turbines will make his house 'uninhabitable'. After 20 years, it is understandable he is reluctant to leave. However, the nearest of the planned twelve turbines is only 500m from his boundary, and the decibel levels will exceed those allowable, according to the state-owned power company's representatives.

28 In 2005, a family living near the Te Apiti wind farm in New Zealand, had to move house because noise and vibration *'made it impossible for them to stay'*. [http://stuff.co.nz : *Turitea man fears he'll have to go*. 10 November 2006]

Indeed, those living near the Te Apiti wind turbines have first-hand experience with those problems:

> *'… in an easterly there is an intrusive rumble for days on end. They say the windmills emitted a low frequency noise for three days on end, making their lives a living hell.'*

At another time,

> *"… the rumbling was so bad it sounded like one of those street cleaning machines was driving up and down near the house. In fact it sounded like it was going to come through the house,"* said Wendy Brock.

29 According to Meridian, the developer:

> ***'… it's a small number of people making a big noise about nothing.'***

And another Meridian spokesperson, Alan Seay, said that:

> ***'… the monitoring has shown quite clearly they were well within the guidelines.'***
> [Flurry of complaints after wind change. TV1 News, New Zealand, 25 July 2005, http://tvnz.co.nz/view/page/411749/599657]

30 In Nova Scotia, Canada, one family and one wind farm developer have drawn different conclusions from similar noise readings at the family's home. Although the family insists that the noise from the 17 wind turbines – the closest is 400m from their home – has affected their well-being, the developer does not acknowledge any deleterious effects on the family. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

The d'Entremont family complained of noise and low frequency vibrations in their house after the wind turbines began operation in May 2005. The inaudible noise deprived his family of sleep, gave his children and wife headaches, and *'made it impossible for them to concentrate'*. They now live nearby; if they return to their home, the symptoms return.

31 *'But a study released this month by the federal natural resources department, which oversees funding for wind farm projects, found no problems with low-frequency noise, also known as infrasound.'*

The government report concludes that the measurements:

'indicate sound at infrasonic frequencies below typical thresholds of perception; infrasound is not an issue'.

The developer says he was not surprised by the report's findings:

'It essentially says that there's no issue whatsoever with infrasound.'

32 D'Etremont hired his own consultant to record the noise levels at his home:

'Gordon Whitehead, a retired audiologist with twenty years of experience at Dalhousie University in Halifax conducted tests.'

Whitehead's data was similar to that of the government's report. However, as a health professional, Whitehead reaches a different conclusion:

'They're viewing it from the standpoint of an engineer; I'm viewing it from the standpoint of an audiologist who works with ears … The report should read that (the sound) is well below the auditory threshold for perception. ***In other words, it's quiet enough that people would not be able to hear it. But that doesn't mean that people would not be able to perceive it.'***

Whitehead explains that

'… low-frequency noise can affect the balance system of the ear, leading to a range of symptoms including nausea, dizziness and vision problems. It's not perceptible to the ear but it is perceptible. It's perceptible to people with very sensitive balance mechanisms and that's generally people who get very easily seasick.'

33 The developer has acknowledged that some questions remain:

'From our perspective, I think it's really up to the scientific community to really address and research such issues (as low-frequency noise) … I know there is research that points to different directions.' [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

34 In a newspaper article describing the d'Etremonts' situation and the wind power company's position, Michael Sharpe, a Dalhousie University audiologist, said that:

'Even if someone isn't affected directly by low-frequency noise, the constant swoosh of the blades, even at allowable levels, can have psychological effects.

"If the sound is audible and it annoys you, then it can seem louder," says Sharpe who compares it to a dripping tap that can keep someone awake at night.

"As your stress level increases, your awareness of the annoying sound increases as well. As we know, elevated stress levels for a prolonged period of time can have a negative health effect."' [Keller J. Turbines stir up debate. *The Chronicle Herald*, Halifax, Nova Scotia 21 May 2006.]

35 The d'Etremonts are unable to sell their home because of the wind farm. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. *Canadian Press*, 13 November 2006 http://thestar.com]

36 Dr Robert Larivee, a Professor of Chemistry who lives 3000m east of twenty wind turbines – commissioned in 2003 – in Meyersdale, Somerset County, Pennsylvania, USA, wrote to his County Commissioners (2005) after an acoustician measured noise at his property that rose to 75 dB.

'*These levels are much higher than those predicted by the company. There are a number of reasons that may contribute to this. Probably the most significant factor is the topology of the area. Our area has many mountains and valleys …'*

Dr Larivee quotes the US Environmental Protection Agency, which says that

'noise levels above 45 dB(A) disturbs sleep and most people cannot sleep above the noise level of 70 dB(A). Emotional upset, irritability and other tensions, may also arise. Noise contributes to ailments like indigestion, ulcers, heartburn and gastrointestinal malfunction in the body.' [Letter from Dr Robert Larivee, Meyersdale, Pennsylvania, USA, to the County Commissioners http://www.pbase.com/wp/image/39285457]

37 Another resident of Meyersdale, who lives less than one mile from the twenty wind turbines, wrote a lengthy letter on 7 March 2006 to 'Interested Parties'. Karen Ervin felt she had to *'share the realities and impacts'* of living near a wind turbine facility. She calls her situation the "**Human Experimental Factor**", as the community deals with *'the multiple nuisances and issues'* affecting her family, her neighbours, and local adjacent property owners during the two years the wind turbines have been operating:

'Prior to the building of the facility, our neighbors and we were never made aware of the nuisances that occur with a wind turbine facility. The noises emitted from the turbines have definitely changed our style of living. The noises produced from the blades turning on the turbines create a 'threshing' sound within and around our home as well as the adjacent properties …'

'At times it is difficult to fall asleep with the "pounding" of the turbines. One is often awakened by the 'droning' noise of the turbines, finding it most difficult to fall back asleep. The noise becomes so disruptive; one can concentrate on nothing else but the constant droning. During the winter months, the noise is quite unbearable at times, sounding like drums beating constantly in the background. During the summer months, we cannot have our windows open …'

'Advocates for these facilities will often compare this "threshing" noise to the "peaceful" sound of waves beating against the rocks at the seashore; but I

have been to the seashore and it certainly is in no way comparable to the "calming sound" of waves.'

Noise is not the only problem: flicker and 'strobing' are also nuisances. Ms Ervin concludes her letter with this observation:

'This industry without stringent regulations can be truly labelled a "Pandora's Box". Be careful for what is opened, and be prepared for the negative impacts that have occurred and continue to occur with this industry.' [Letter, Karen Ervin, Meyersdale, Pennsylvania, USA, 7 March 2006, www.pbase.com/wp/image/39285457]

38 Yet another resident living near the Meyersdale wind turbine facility, Mr Rodger Hutzell, Jr, and his family experienced

'… noise nuisance issues, specifically when trying to go to sleep at night. The noises are greater during the winter months. The noise appears to correlate to a continual droning sound. When awakened at night, there are times that is impossible [sic] to get back to sleep due to the threshing sounds produced by the wind turbines.' [Letter, Rodger A Hutzell, Jr, Meyersdale, Pennsylvania USA, 13 February 2005, www.pbase.com/wp/image/39285457]

39 In Mackinaw City, Michigan, USA, wind turbines rise 325 feet high, visible from nearby homes. Kelly Alexander's home is ¼ mile away from the nearest turbine. Initially Mr Alexander was in favour of the turbines, especially after the developer's assurances that the wind turbines would not be noisy. Flicker is also a problem, but this was never mentioned by the developer to Mr Alexander or the community.

Once the turbines became operational, Alexander heard

'a constant humming sound inside his home when the turbines are running, whether the windows are open or not. He said the situation was unliveable and all he wants is for things to be the way they were …'

40 **The wind energy company representative said that it *'has lived up to ordinance requirements.'***

Alexander's response was:

'Stop lying about these turbines. Tell people the truth.' [Holland *Sentinel*, 31 December 2002]

41 In September 2002, the Mackinaw *Journal* reported on these turbines. Danny Dann and Kelly Alexander said that the turbines *'were exceeding a 60-decibel noise limit'*, and that ten other immediate neighbours were also concerned about the noise. The Mackinaw City Community Development Director said that they had sought legal advice because they did not have *'anything in our lease agreement to terminate the contract.'*

42 The owner, Bay Windpower, planned to erect at least two more wind turbines in the same area. [McManus S. Turbines still causing a problem, neighbors say. Mackinaw *Journal,* August 29 – September 26, 2002, p 3]

43 In 2004, Dr James LeFanu wrote that *'there have been some interesting comments on the substantial health problems – headaches, anxiety, sleep disturbances'* experienced by those living near wind farms:

> '*The cause seems to be the low-frequency noise generated by the incessant throb of their turbines ("like a concrete mixer in the sky"). "I like to think I know a bit about sound," writes Basil Tate, a recording engineer from Cornwall, "but it always amazes me how my wife can feel low-frequency sounds that are a long way away and be extremely distressed by them." Little wonder that some of those living close to wind farms have been forced to flee their homes.'* [LeFanu J, Dr. In sickness and in health. *Daily Telegraph* 14 March 2004]

44 Unhappily, this is not an exaggeration. Gwen Burkhardt was surprised when Dewi Jones, director of Windjen, which runs Blaen Bowi wind farm in Wales, UK, said:

> ***'There are a lot of wind farms operating in the UK and we haven't come across the complaint before.'*** ['Did turbines make you sick? Journal 18 May 2005, www.thisissouthwales.co.uk]

In her letter to the Journal [1 June 2005], Ms Burkhardt wrote that:

> *'I spoke to you and two of your employees on March 10 this year … I explained to you in great detail about my own illness which was also brought on by the low frequency sound emitting from the very same turbines.*
>
> *It has caused me and my family a great deal of distress and has resulted in us having to move away from the area where I was born and where we have farmed for the last 27 years. Have you just forgotten our conversation? Do you simply not care? … I do remember you sympathising with me and also telling me that you would not like to live near the turbines yourself.'* [Burkhardt G. Complaints are not new. *Journal*, 1 June 2005, www.thisissouthwales.co.uk]

45 In July 2005, Mr Murray Barber wrote to inform Energiekontor AG about the noise problems at the Forestmoor wind farm near Bradworthy, Devon, UK. His family's home, located 650m from the nearest of three turbines, is affected especially during calm days when the noise is very audible.

> *'The noise nuisance caused is irritating, distracting, stressful … We do not understand why it is necessary for all three turbines to be driven at a high speed of rotation in absolute still air.'* [Letter from M Barber to Energiekontor AG, 12 July 2005]

In response, Energiekontor AG informed Mr Barber that:

> ***'The threshold of hearing is considerably lower than these levels, so noise from the turbines will be audible, however, at a level which is considered by the guidelines not to unduly affect amenity.'*** [Letter to M Barber from Energiekontor AG 19 July 2005]

46 In Fenner, New York, USA, when the trees are bare, Wayne Danley's wife 'flees' the living room of their house because of the flicker created by the turbine's rotating blades. Mr Danley lives 900 feet from the nearest wind turbine:

> *'It sounds like a train going through, except the train never comes through … It's too close.'* [Neighbors complain of wind farm nuisances, The Albuquerque *Tribune,* 28 April 2006]

In response, Marion Trieste, publicist for the Alliance for Clean Energy New York, said:

> ***'There's a lot of misinformation, and a lot of inflamed discussion about negative encroachment.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

And according to Laurie Jodziewicz, a policy specialist for the Alliance, **there are complaints about the *'strobe-light effects, but those occur only during certain months of the year and depend on the sun's angle to the turbine blades.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

47 Given the sophistication of engineering design computer modelling, one might presume that these effects could be calculated prior to the construction of the wind turbines. However, Mr Danley had it right: the wind turbine was too close. With appropriate planning and distances between homes and wind turbines, these problems would not only be attenuated, they would cease to exist.

> *"It's not there all the time, but you're always waiting for it … [It's] totally infuriating.'*

The thump-thump-thump 'reverberates up to 22 times a minute,' said Les Nichols, who lives beside a wind farm in Askam, Furness, UK. When seeking permission for the seven turbines, the developers *'guaranteed there would be no noise nuisance.*' (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

48 Yet Bruce Allen, a director of Wind Prospect, the management company for the owner, PowerGen Renewables, said that:

> ***'The wind farm "had not breached its planning requirements. It's a subjective thing – like living beside a busy road." '*** (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

Garrett's article continues:

> Giant wind turbines *'planted on your doorstep … can transform a tranquil neighbourhood overnight into a menacing industrial site … there are no rules about how close they can be to homes.'*
>
> *'The Welsh Affairs Select Committee recommended they shouldn't be less than 1.5 kilometres (0.93 miles) from any house, but developers generally go as close as between 500 metres (1,640 ft) and 600 metres (1,968 ft) …'* (Garrett A. Ugly side of wind power. *The Observer*, Sunday, March 2, 2003)

49 As Phoebe Lockett, who lives near the Bears' Down wind farm in Cornwall, UK, wrote in a personal communication:

> *'There seems to be little known of what noise there may be from wind turbines and very few people who have genuine expertise in this area. The planning guidelines and studies carried out beforehand are, in my opinion, of little use.'*
>
> *'Please let me know if I can be of further assistance, as I do not like to think of others having to go through the same distress.'* [Letter, personal communication, 15 November 2003]

50 Eleven wind turbines, 121m high, have been operating in Taurbeg, Cork, Ireland, since February 2006, where residents *'are anything but happy …'* The noise from the turbines are causing sleepless nights; one resident said the noise was like a *'plane which consistently hovers but never lands.'*

Another resident told the newspaper that *'The thought of another six going up within 500 metres of my front door is just a nightmare … The noise from the windmills kept everybody in the area awake.'*

There were a number of complaints about the inaccuracies of the photomontages produced by the developer during the application process. Residents also suffer flicker, and one person labelled the result *'visual chaos'*.
[Herlihy M. Windmills 'are a nightmare'. The Corkman, 6 April 2006]

51 In the summer of 2006, eight wind turbines with an installed capacity of 16MW became operational at Deeping St Nicholas, Lincolnshire, UK. The noise from these turbines transformed the lives and the livelihood of the Davis family, living in a farmhouse only 907m from the nearest turbine. Jane and Julian Davis, who farm at Deeping St Nicholas and who learned of the development while reading their local newspaper, did not object to the development. They support wind energy and believe that renewable energy sources are essential to preserving the environment.

Although the Davis family cannot see the wind turbines from their home, the noise – both inside and outside their home, and which also caused vibrations within the structure of their home – has had a deleterious impact on their health and sense of well-being. Prior to the wind farm, they had no problems sleeping through the night. Now, when the wind blows from the southeast or the southwest, the noise from the acoustic radiation seriously disturbs their sleep.

> *'They have spent more than 60 nights in the last six months sleeping at friends' houses', and when home, they 'are existing on less than four hours sleep a night and sometimes a lot less.'* [Couple driven out of home by wind farm. Spalding Today (UK) 21 December 2006]

After taking its own acoustic readings, the local Council confirmed the noise problem, and it is investigating the matter further. [Davis J. Personal communication, 19 January 2007]

Local land agents have told them that their property is 'unsaleable'. Although consultants for the developer are evaluating the issue, and the Dti are investigating wind farm noise, that does not alleviate the impact on the family. [Tasker J. 'Wind farm noise is driving us out of our house.' Farmers Weekly 12 January 2007]

As the noise established itself as an ongoing problem, the Davis family learned that developers had used only predicted levels for their home without taking actual baseline measurements. Indeed, background noise most often measured below 20 dB at night (and usually in the range of 14 dB); now noise in the range of 40 dB occurs when the wind shifts to the southeast or the southwest, and on occasion, the noise has measured over 60 dB. [Personal Communication, 19 January 2007]

Quite generously under these circumstances, the Davis family continue to support wind energy but believe that wind turbines must be sited further from homes because the noise level and the impact of the noise cannot be accurately predicted. Jane Davis says that:

> *'More needs to be done if wind power is to become a viable alternative source of energy. It is a national issue and the Government ought to be doing more about this if we need lots more wind power.'* [Spalding Today (UK) 21 December 2006]

The Environmental Statement that accompanied the developer's application said that there would be no noise. [Davis J. Personal communication, 19 January 2007]

Meanwhile, Jane Davis says that she and her family are literally ***'fighting for our lives.'*** [Personal communication, 19 January 2007]

52 These are the voices and concerns of people who are despairing. However, with civic spirit, they speak out to alert others to the realities of living near wind turbines. As Bell noted in his 1966 report on noise for the World Health Organization:

> *'Anti-noise campaigns serve a useful purpose in focusing public attention on the matter; they provoke discussion and are often a stimulus to positive control measures.'*

53 According to Dr Dilys Davies, consultant clinical psychologist:

> *'Noise problems can lead to ill health'*, leaving the person *'more easily disturbed by noise in the future ... There is pressure on the heart, your breathing and whole arousal system. Your muscles tense as you wait for the noise, and if you are not careful you get used to being in that state constantly ...'* [Aitch, I. Keep It Down. Telegraph, 2 December 2006]

54 Many of those affected by wind turbine noise believe that the developers and decision-makers of the State have misled them. One explanation might be that the methodology for calculating the disturbance levels created by wind turbines at nearby homes is woefully inadequate, concentrating almost entirely on audible sound levels while dismissing other noise characters with a 'penalty in the

condition' [Planning Approval], which has produced unreliable information. The consequent release of noise pollution on people's homes produces sleep deprivation and other health injury, and the adverse effects are entirely avoidable.

There appears to be a total 'disconnect' between the experiences of those living near wind turbines and those who have a commercial interest.

55 The natural commercial instinct of developers is to maximise development potential from land, thereby leaving the minimum distance between turbines and homes. This presumes reliability and certainty in determining the physical impacts on families. However, such reliability and precision in calculating the effects does not exist, as the wind energy industry itself notes in its professional literature. (See Section 4.0, Acoustics, of this paper.)

56 It is too easy to dismiss the reports of noise disturbances and flicker effects by people living near turbines. Yet these problems emanate from many people in many countries, living in varied topographies, with one thing in common: they all live in close proximity to wind turbines.

57 It is somewhat hypocritical of public officials to decry the despoiling of the environment on a global basis, while ignoring the despoiling of the environment – including noise pollution – on a local level. At what point will officials and government agencies respond to these issues that involve the genuine – and avoidable – suffering of those living near wind farms? **At the least, further investigation into the health effects is warranted, with a minimum buffer zone of 2km between the nearest wind turbine and any dwelling.**

Section 4.0 ACOUSTICS

Acoustic Radiation experienced by people living near commercial wind turbines

1 In 2004, a small group met to consider the likely cause of adverse health effects reported by families where developers built wind turbines too close to their homes. Prof James Lovelock, retired NASA scientist and Harvard Medical School; Prof Ralph Katz, Chair, Department of Epidemiology and Health Promotion, New York University; Dr Amanda Harry, physician; and Dr David Coley, acoustician, Exeter University, decided the relationship was most likely to be an acoustic radiation of sound characters, which in combination unbalanced the natural function of the human body.

2 The reason for this is that the human ear responds not only to 'loudness', that is, sound pressure, measured in decibels – dB – with which many people are familiar, but also to sound frequency, measured in Hertz (Hz). [WHO Fact Sheet No 258, 2001]. In addition, sound affects the human body itself; even when a sound is 'inaudible' to the ear, the character of the sound may affect the body.

3 While the wind energy industry seeks to dismiss the adverse health effects reported by families living near wind turbines, there is ample evidence from medical research that noise in diverse circumstances can indeed have a negative impact on health. Noise can induce adverse physical and/or psychological symptoms. The qualities of the symptoms are similar to the complaints of those living near wind turbines. The phenomena may be produced intentionally, e.g., in a laboratory or in a specific instance, or unintentionally by the interaction of technical events, as with wind turbines.

4 Military weaponry exists that relies on low-frequency sound to disperse crowds or control crowd behaviour. [The Cutting Edge: Military Use of Sound, The Toronto Star (Canada), 6 June 2005] The effect of low-frequency noise at high intensities creates discrepancies in the brain, producing disorientation in the body:

> *'The knees buckle, the brain aches, the stomach turns. And suddenly, nobody feels like protesting anymore. The latest weapon in the Israeli army's high-tech tool kit.'*
>
> *'The intention is to disperse crowds with sound pulses that create nausea and dizziness. It has no adverse effects, unless someone is exposed to the sound for hours and hours.'* [The Toronto *Star*, 6 June 2005]

5 Hillel Pratt, a professor of neurobiology specializing in human auditory response at Israel's Technion Institute, said,

> *'It doesn't necessarily have to be a loud sound. The combination of low frequencies at high intensities, for example, can create discrepancies in the inputs to the brain.' Such technologies produce 'simulated sickness'.* [Pratt H. Personal communication, 14 March 2006]

In a subsequent communication, Prof Pratt explained that:

> *'… by stimulating the inner ear, which houses the auditory and vestibular (equilibrium) sensory organs with high intensity acoustic signals <u>that are</u>*

> *<u>BELOW the audible frequencies (less than 20Hz)</u>, the vestibular organ can be stimulated and create a discrepancy between inputs from the visual system and somatosensory system (that report stability of the body relative to the surroundings) and the vestibular organ that will erroneously report acceleration (because of the low-frequency, inaudible sound). This will create a sensation similar to sea or motion sickness. Such cases have been reported, and a famous example is workers in a basement with a new air-conditioning system that all got sick because of inaudible low frequency noise from the new system.'*
> [Pratt H. Personal communication, 15 March 2006]

6 Wind turbines create these unintentional acoustic effects via the confluence of their design and operation. Noise, including low frequency noise, are long-standing issues with wind turbine design and operation. The wind turbine interacts with the topography, meteorology, spatial structure of the site, and with other wind turbines on the site. As an example of this unintentional confluence: Wind turbines produce visual flicker and strobe effects at certain times of the day, an effect similar to driving by a stand of trees when the sun is behind them. Acoustic characters and visual characters can combine and induce body 'disharmony'. Dr Bucha first identified this effect in the 1950s, after he was asked to investigate a series of unexplained helicopter crashes.

7 The pilots surviving the crashes reported feeling fine until the sudden onset of nausea and dizziness. During the episode, pilots lost control of their aircraft. Bucha found that when the blades maintained a rotational rate for sufficient time, the resulting strobe effect of sunlight closely matched human brainwave frequencies. The 'Bucha effect' is a seizure-inducing effect of light flashing in high frequency, similar to epilepsy but without being restricted to a small fraction of the population.

8 In "Present Status of Aeroelasticity of Wind Turbines", a report by Flemming Rasmussen and his colleagues at the Riso National Laboratory, Denmark, the authors observed:

> *"The term aeroelasticity is inherited from aeronautical engineering, and applying this with respect to wind turbines also makes an association to the high level of technology. From this perception the wind turbine is a helicopter. The operation of the flexible rotor in the turbulent atmospheric boundary layer is influenced by the control actions involves many of the same phenomena."* [Rasmussen F; Hartvig Hansen M; Thomsen K; Larsen TJ; Bertagnolio F; Johansen J; Aagaard Madsen H; Bak C; Melchior Hansen A. Present status of aeroelasticity of wind turbines. *Wind Energy* 2003; 6(3):213-228]

9 The military has made use of the combination of visual and acoustic characters to control behaviour. A report of the United States Air Force Institute for National Security Studies identifies and describes numerous non-lethal techniques. Among those that pertain to acoustic and/or optical effects on human physiology, several share characteristics with wind turbine noise and visual effects. [Bunker RJ, ed. Nonlethal Weapons. USAF Institute for National Security Studies, INSS Occasional Paper 15, July 1997].

'Acoustic infrasound: very low frequency sound which can travel long distances and easily penetrate most buildings and vehicles. Transmission of long wavelength sound creates biophysical effects, nausea, loss of bowels, disorientation, vomiting, potential organ damage or death may occur. Superior to ultrasound because it is 'inband', meaning it does not lose its properties when it changes mediums such as air to tissue. By 1972 an infrasound generator had been built in France, which generated waves at 7Hz. When activated it made the people in range sick for hours.'

Techniques include:

a. Bucha effect: high intensity strobe lights that flash at near human brain wave frequency causing vertigo, disorientation and vomiting.

b. Stroboscopic device: devices employed against demonstrators that use stroboscopic flashing; same principle as a discotheque strobe. In the 5 – 15Hz range, these devices can cause various physical symptoms and in a small portion of the population may trigger epileptic seizures.

c. Lag time: The physiological time lag that occurs between the time a stimulus is perceived until the body responds. In a healthy, well-rested human, this takes about three-quarters of a second.

d. Sensory overload: A temporary inability of an organism to correctly interpret and appropriately respond to stimuli because of the volume of the input.

10. Although the military examples use acoustic and visual devices that intensify physiological reactions, the noise and visual effects of wind turbines produce similar physiological reactions. Indeed, the physical complaints of those living near wind turbines share symptoms, though fortunately, not at the levels induced by the military devices. Unfortunately, those individuals living near wind turbines experience the adverse effects without remission. Additionally, military use relies upon high dosage over a short time span. Unintentional occurrence, as with wind turbines, produces a small dose over a long time-span with apparent compounding similar effects.

11. Another example of military use of LFN is called SONAR (SO(und) NA(vigation and R(anging). In *"Navy adapts sonar to protect whales"*, The Sunday Times reported on 26 March 2006, that amid evidence that navy sonar was causing whale and dolphin deaths by confusing them so that they would surface too quickly *'that they suffer fatal attacks of the 'bends'*:

'Navy warships are to be equipped with a £2.5m scanning system to spot marine mammals after post-mortem tests linked the death of beached whales to military sonar.

The use of military sonar appears to interfere with the echo-location system the animals use to navigate, leaving them so disorientated they misjudge depths and swim to the surface too quickly.

The low frequency system will operate at long range and the MOD admits it has the potential to be harmful to marine life. Liz Sandeman, co-founder of

Marine Connection, a conservation group, said, "Low frequency sonar can travel for hundreds of miles, yet the marine animal detection system will only work for two miles".'

12. Following the publication 'Noise annoyance from wind turbines – a review' [Pedersen E, August 2003], Pedersen et al published an article in August 2004, 'Living close to wind turbines – a qualitative approach to a deeper understanding'. [Pedersen E; Persson Waye K; Hallberg LRM. Proceedings of InterNoise2004, Prague, 2004]

    The authors state that:

    a. *'Informants annoyed by wind turbine noise perceived the impact of turbines as a serious intrusion of their privacy. The force of the violation experienced was partly determined by the informants' conception of the living environment as a place where audible and visual impact from wind turbines did not belong. Categories increasing or decreasing the intrusion were experiences of not being believed, being subjected to injustice, lacking influence, and being out of control.'*

    b. *'Surprisingly many respondents reported themselves as annoyed by wind turbine noise at rather low A-weighted sound pressure levels (dB), compared to other sources of community noise such as traffic noise … One hypothesis is that wind turbine sound has special characteristics such as amplitude modulations that are easily perceived and that could lead to annoyance even at low sound pressure levels (dB). Furthermore, in earlier laboratory studies where noise from different wind turbines were compared, the most annoying noises were predominantly described by the subjects as "swishing", "lapping", and "whistling".'* [Persson Waye K and Ohrstrom E. Psycho-acoustic characters of relevance for annoyance of wind turbine noise. Journal of sound and vibration 2002; 250(1): 65-73]

    c. *'An interesting observation was that other responses due to wind turbines, such as annoyance of shadows from rotor blades, seemed to interact with the noise dose-response relationship indicating that exposure to noise from wind turbines should be studied within its context'*. [Pedersen E and Persson Waye K. Audio-visual reactions to wind turbines. Proceedings of Euronoise 2003; 5th European Conference on Noise Control, May 19-21, 2003, Naples, Italy, 2003]

    d. In describing the results of interviews with the study group living close to wind turbines, the report says that:

    'For some informants, the exposure reached further, not only intruding their home environment but also into themselves, creating a feeling of violation of them as a person. They expressed anger, uneasiness, and tiredness, disclosing being under strain, using a tense voice and sometimes crying when talking about the impact of the wind turbines.

    To be affected by the turbines to such a high degree, not being able to protect oneself from the intrusion that constantly raised negative emotions was experienced as a serious decline in well-being and life quality.'

13. In their article, 'Aeroacoustics of large wind turbines', Hubbard and Shepherd observe that buildings are affected by noise transmitted by wind turbines:

> *'The transmitted noise is affected by the mass and stiffness characteristics of the structure and its dynamic responses and the dimensions and layouts of the rooms. Minimum noise reductions occur at frequencies near 10Hz, probably because of associated major house structural resonances. This frequency range of low noise reductions unfortunately coincides generally with the frequency range of the intense rotational harmonics.* ***Noises in this low-frequency range will probably not be heard by human observers but may be observed indirectly as a result of noise induced vibrations of the building structure or furnishings.'***
> [Hubbard HH; Shepherd KP. Aeroacoustics of large wind turbines. JASA Journal of the acoustical society of America 1991 June; 89(6): 2496 – 2508, p 2505]

14. In 'Noise induced house vibrations and human perception', Hubbard's research indicates that:

    a. ***'A person inside the house can sense the impingement of noise on the external surfaces of the house by means of the following phenomena: noise transmitted through the structure …*** *vibrations of the primary components of the building such as the floors, walls and windows; the rattling of objects …'*

    b. Addressing the issue of 'whole body perception', Hubbard refers to the ISO Guidelines and says that a noise level outside a building between 55 – 60 dB (around 0.001 rms) in a frequency range of 0.1 HZ – 80 Hz, is the *'Most sensitive threshold of perception of vibratory motion by humans'*.
    [Hubbard HH. Noise induced house vibrations and human perception. Noise control engineering 1982; 19(2): 49 – 55]

15. In 'Do wind turbines produce significant low frequency sound levels?' [2004], GP van den Berg, observes that:

> *'Windows are usually the most sensitive elements as they move relatively easy because of the low mass per area. Perceptible vibrations of windows may occur at frequencies from 1 Hz to 10 Hz when the incoming 1/3 octave band sound pressure level is at least approaching 52 dB; at higher or lower frequencies a higher level is needed to produce perceptible vibrations. As can be seen in figures 1 –3 sound pressure levels above 60 dB at frequencies below 10 Hz occur close to a* ***turbine as well as 750 m distance and further****.'* [van den Berg GP. Do wind turbines produce significant low frequency sound levels? 11th International Meeting on Low Frequency Noise and Vibration and its Control, Maastricht, The Netherlands, 30 August – 1 September 2004. See also Stephens DG; Shepherd KP; Hubbard HH; Grosveld F. Guide to the evaluation of human exposure to noise from large wind turbines. NASA National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia (USA), NASA-TM-83288, March 1, 1982.] [emphasis added]

16. In 2003, the new International Standard for 'Equal Loudness Level Contours' was agreed (ISO 226:2003). In a comparative study with previous curves, Advanced Industrial Science and Technology (AIST) observed:

> *'Between the new and the previous standards, very large differences are recognised up to about 15dB (decibels) for a wide area of frequency region lower than 1KHz (1,000Hz).*
>
> ***A difference of 10dB means a 10 fold difference in sound energy and that of 15dB corresponds to a 30 fold difference (fig 1).'***

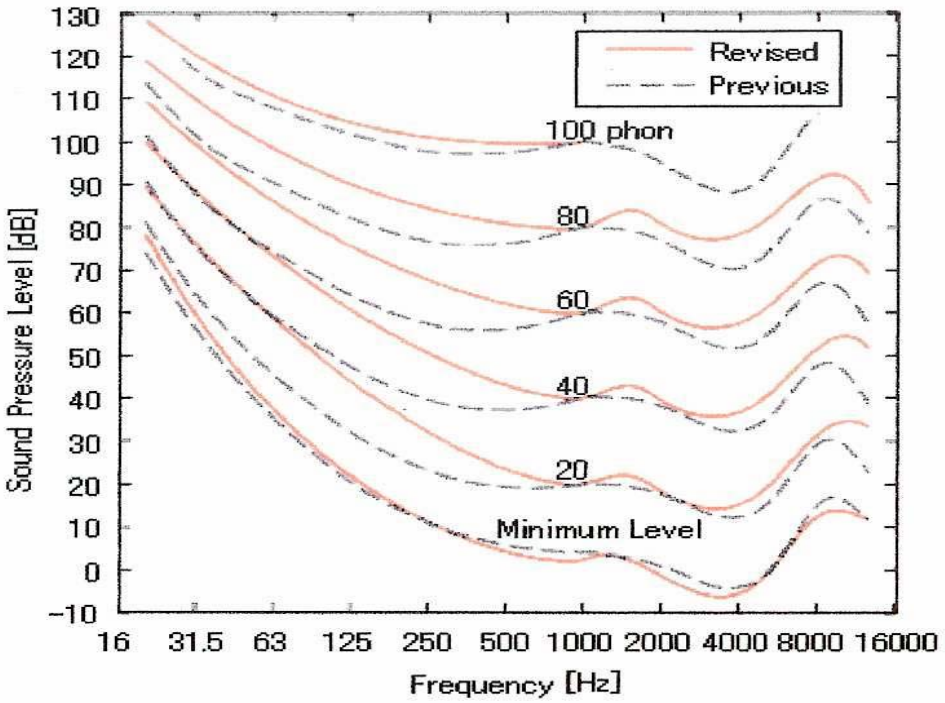


Fig. 1. Comparison between the new and the previous characteristics of equal-loudness-level contours. Remarkable differences are observed in the low frequency range.

Source: AIST. Full revision of International Standards for Equal-Loudness Level Contours (ISO 226), 2003 http://www.aist.go.jp

[Note: The threshold of hearing at about 20 Hz is circa 75dB.]

17. In a report by Dr D Manley and Dr P Styles, "Infrasound Generated by Large Sources", the authors discussed a test conducted near a wind farm in October 1994, using only vibration analysis equipment. Measurements were taken between 0.75 miles and 2 miles downwind of the wind farm at the same elevation:

> '*Wind speed was about 20 knots, and it was possible to hear turbines with a characteristic 'beat' (at about 0.8Hz) ...*
>
> *The blade rotation was usually timed at 43 rpm and therefore the main seismic wave is related to the rotational period of the three bladed machine.*
>
> *All three transducers show (from a typical frequency spectra) that there are odd numbered harmonics of the fundamental blade rotation frequency (0.8Hz, 2.4Hz and 4.0Hz being examples).*

In March 1995 experiments were repeated in eight places, in a location 0.75 miles UPWIND of the wind farm, with a 20 knot wind. The speed of turbine blades was visually measured at 43 rpm. The results clearly show a second harmonic (a higher harmonic) spaced 2.15 Hz …
[Manley DMJP; Styles P. Infrasound generated by large sources. Proceedings of the Institute of Acoustics 1995; 17:239 – 246]

18. Wind turbines radiate noise not only above ground; they also radiate noise below ground. Following his investigations of ground vibration at the Eskdalemuir seismic monitoring facility in Scotland, Professor Peter Styles, in a summary report to the Defence Estate, made these recommendations:

    a. *To 'define an exclusion zone of 10 km within which no windfarm / turbine development is acceptable.'*

    b. *'Between 10 and 50 km the TOTAL permitted windfarm / turbine generated seismic rms amplitude should not exceed 0.25 rms measured at Eskdalemuir' [the recipient]*.

    c. *'This is best illustrated with two hypothetical examples:*

        i. *'A single windfarm of 3 (no.) x 1.8 MW turbines located at 15 km from Eskdalemuir will produce a predicted rms amplitude of 0.20 nm.'*

        ii *'A single windfarm of 17 (no.) x 2.5 MW turbines located at 26 km from Eskdalemuir will produce a predicted rms amplitude of 0.11 nm.'*
        [Styles (Keele University). Summary Report to Defence Estates, 3 March 2004]

    d. '*We have clearly shown that wind turbines generate low frequency sound (infrasound) and acoustic signals which can be detected at considerable distances (many kilometres) from wind farms on infrasound detectors and low frequency microphones.'*
    [Styles P; Stimpson I; Toon S; England R; Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from windfarms: recommendations on the siting of windfarms in the vicinity of Eskdalemuir, Scotland. Keele University (UK), Report for the Ministry of Defence, 18 July 2005]

19. The July 2005 Report by Prof P Styles, et al, "Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Windfarms" commented:

    "When the windfarm starts to generate at low wind speeds, considerable infrasound signals can be detected at all stations out to c 10km. Clear harmonic components which are the second multiple and up of 1.4Hz (the blade passing frequency) can be seen although interestingly and somewhat enigmatically the blade passing frequency itself is not so strongly detected".
    [p 66]

    "We have clearly shown that both fixed speed and variable speed wind turbines generate low frequency vibrations which are multiples of blade passing frequencies and which can be detected on seismometers buried in the ground at significant distances away from the wind farms even in the

presence of significant levels of background seismic noise (many kilometres).” [p 76]

In answer to the question: *“If we have a wind farm of N turbines, how does the seismic amplitude increase as compared to 1 turbine?”*
Answer: *“We have shown it varies as the square root of N and this is to be expected because the turbines are not all in phase and neither are they operating at exactly the same frequency because of the slight possible variations in rotation speed and also wind conditions across the farm. There is also a possible 10% variation in speed (Optislip) which will cause broadening of the spectral peaks . They are quasi-random sources and therefore add as square root of N. Therefore 100 turbines are 10 times as noisy as one, not 100 times.”* [p 77]
[Styles P; Stimpson I; Toon S; England R; Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from windfarms: recommendations on the siting of windfarms in the vicinity of Eskdalemuir, Scotland. Keele University (UK), Report for the Ministry of Defence, 18 July 2005]

‘*The Effect of Windmill Farms on Military Readiness’*, a 2006 report by the US Department of Defense for the US Congressional Committees, supports Styles et al for the seismographic methods and devices used to measure low frequency noise and vibration at Eskdalemuir.

However, the Department of Defense report recommends that the United States modify the approach:

‘Measurements of seismic noise generated by wind turbines that Styles made must be updated to reflect the increased size of SOA wind turbines.’
(SOA = State Of the Art) [United States Department of Defense. The effect of windmill farms on military readiness. Report to the Congressional Defense Committees. Office of the Director of Defense Research and Engineering, US Department of Defense, 2006, p 62]

20. Moreover, Hubbard and Shepherd (‘Aeroacoustics of large wind turbines’, 1991) observe in their discussion on Atmospheric Propagation,

‘Acoustic refraction that arises from sound-speed gradients associated with atmospheric wind and temperature gradients, can cause non-uniform propagation around a sound source.’

In an *‘illustration of the effects of atmospheric refraction, or bending of sound rays, caused by vertical wind sheer gradient over flat homogeneous ground for an elevated point source’*, the rays are bent toward the ground in a downwind direction. That is, the ground can act as a large and effective microphone at low frequencies.

21. The WHO *Guidelines for Community Noise 1999* (S.4.2.1) say that:

“Reverberation times below 1 s are necessary for good speech intelligibility in smaller rooms; and even in a quiet environment a reverberation time below 0.6 s is desirable for adequate speech intelligibility for sensitive groups.”
[Authors’ note: See also Section 3.51 of this Review]

22. Research by GP van den Berg, of the University of Groningen in the Netherlands, examines how wind turbine sound acts in the environment. In 'The Beat is Getting Stronger: The Effect of Atmospheric Stability on Low Frequency Modulated Sound of Wind Turbines' [*Journal of Low Frequency Noise, Vibration, and Active Control* 24(1), March 2005], van den Berg writes:

    a. *'Our experience* ***at distances of approximately 700 m to 1500 m from the Rhede Wind Farm****, with the turbines rotating at high speed in a clear night and pronounced beating audible, is that the sound resembles distant pile driving. When asked to describe the sound of the turbines in this wind farm, a resident compares it to the surf on a rocky coast. Another resident near a set of smaller wind turbines, likens the sound to that of a racing rowing boat (where rowers simultaneously draw, also creating a periodic swish). Several residents near single wind turbines remark that the sound often changes to clapping, thumping or beating when night falls, like a washing machine.'* (p.14)

    b. *'Part of the relatively high annoyance level and the characterisation of wind turbine sound as lapping, swishing, clapping or beating may be explained by the increased fluctuations of the sound [2.21]. Our results in table 2 show that in a stable atmosphere measured fluctuation levels are 4 to 6 dB for single turbines, and in long term measurements (over many 5 minute periods) near the Rhede Wind Farm fluctuation levels of approximately 5 dB are common but may reach values up to 9 dB.'* (p.14)

    c. *'It can be concluded that, in a stable atmosphere, the fluctuations in modern wind turbine sound can be readily perceived. However, as yet it is not clear how this relates to possible annoyance. It can however be likened to the rhythmic beat of music: pleasant when the music is appreciated, but distinctly intrusive when the music is unwanted.'* (p.15).

    d. *'The hypothesis that these fluctuations are important, is supported by descriptions of the character of wind turbine sounds as 'lapping', 'swishing', 'clapping', 'beating', or 'like the surf'.'*

    e. *'Those who visit a wind turbine in daytime will usually not hear this and probably not realise that the sound can be rather different in conditions that do not occur in daytime. This may add to the frustration of residents'.* [See also Persson Waye et al, "Living close to wind turbines – a qualitative approach to a deeper understanding"] (p.15)

    f. *'Fluctuations with peak levels of 3 – 9 dB above a constant level may have effects on sleep quality.* ***The Dutch Health Council ['Effects of Noise on Sleep and Health', pub. No. 2004/14] states that 'at a given L night value, the most unfavourable situation in terms of a particular direct biological effect of night-time noise is not, as might be supposed, one characterised by a few loud noise events per night. Rather, the worst scenario involves a number of noise events all of which are roughly 5 dB (A) above the threshold for the effect in question'.*** [emphasis added]

    g. *'For transportation noise (road, rail, air traffic) the threshold for motility (movement), a direct biological effect having a negative impact on sleep quality, is a sound exposure level per sound event of SEL=40 dB (A) in the*

bedroom [Dutch Health Council]. The pulses in figure 6 have SEL-values up to 50 dB (A), but were measured on the façade. With an open window facing the wind turbines indoors SEL-values may exceed the threshold level.' (p15)

23. GP van den Berg concludes:

    a. *'Atmospheric stability has a significant effect on wind turbine sound, especially for modern tall turbines.'* (p 15)

    b. *'First, it is related to a change in wind profile causing strong, higher altitude winds, while at the same time wind close to the ground may become relatively weak. High sound immission levels may thus occur at low ambient sound levels, a fact that has not been recognised in noise assessments where a neutral or unstable atmosphere is usually implied. As a result, wind turbine sound that is masked by ambient wind-related sound in daytime, may not be masked at night time.* [van den Berg GP. Effects of the wind profile at night on wind turbine sound. Journal of sound and vibration 2004; 277 (4-5): 955 – 970]

    c. Secondly, the change in wind profile causes a change in angle of attack on the turbine blades. This increases the thickness (infra) sound level as well as the level of trailing edge (TE) sound.

    'The calculated rise in sound level during swish then increases from 1 – 2 dB to 4 – 6 dB. This value is confirmed by measurements at single turbines in the Rhede Wind Farm where maximum sound levels rise 4 to 6 dB above minimum sound levels within short periods of time.' (p 15 – 16)

    d. Third, van den Berg notes that *'atmospheric stability involves a decrease in large scale turbulence … As a result turbines in the farm are exposed to a more constant wind and rotate at a more similar speed with less fluctuations. Because of the near-synchronicity, blade swishes may arrive simultaneously for a period of time and increase swish level.*

    Sound level differences ($L_{A\,max} - L_{Amin}$) (corresponding to swish pulse heights) within 5 minute periods over long measurement periods near the Rhede Wind Farm show that level changes of approximately 5 dB occur for an appreciable amount of the time and may less often be as high as 8 to 9 dB. This level difference did not decrease with distance, but even increased 1dB when distance to the wind farm rose from 400 m to 1,500 m. The added 3 – 5 dB, relative to a single turbine, is in agreement with simultaneously arriving pulses from two or three approximately equally loud turbines.' (p.16)

24. In 2001, Casella Stanger produced "Low frequency Noise", a report for DEFRA (Technical Research Support for Defra Noise programme). Section 4 addresses the 'Possible Effects of LFN':

    'As with any noise, reported effects include annoyance, stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep.

Low frequency noise is sometimes confused with vibration. This is mainly due to the fact that certain parts of the human body can resonate at various frequencies. For example the chest wall can resonate at frequencies of about 50 to 100Hz and the head at 20 to 30Hz.' [S.4.1]

25. In England, U.K., decision-makers are guided by the State according to Planning Policy Statement 22 (2004).

    PPS 22 'Noise' states:

    "The 1997 report by ETSU-R-97 for the Dti ***should*** *be used to assess and rate noise from wind energy developments."* [emphasis added]

    (Note: "should" is not a command statement.)

26. There were 14 Members of the ETSU-R-97 Noise Working Group (NWG), including the Chairman from the Dti. Nearly 60% were either from Power companies involved in wind farm schemes, wind energy trade associations, or specialist advisors to wind farm developers. [Preface, p. i]

    Indeed, the following statement appears in the introduction to ETSU-R-97:
    "*While the Dti facilitated the establishment of this Noise Working Group this report is not a report of Government and should not be thought of in any way as replacing the advice contained with relevant Government guidance."* [Preface p.i]

27. ETSU-R-97 states in its Executive Summary that:
    a. *"This document 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 administration burdens on wind farm developers or local authorities."* [emphasis added] [Summary S. 1]

    b. *"The NWG … wind farms are usually sited in the more rural areas of the UK where enjoyment of the external environment can be as important as the environment within the home."* (Summary S. 3)

    c. *" The NWG considers that absolute noise limits applied at all wind speeds are not suited to wind farms in typical UK locations and that limits set relative to the background noise are more appropriate in the majority of cases."* [Summary, S.8]

    d. *"The* ***recommendation*** *of the NWG is that, generally the noise limits should be set relative to the existing background noise at nearest noise-sensitive properties … We have considered whether the low noise limits which this could imply in particularly quiet areas are appropriate and have concluded that it is not necessary to use a margin above background approach in such low-noise environments.* ***This would be unduly restrictive on developments …"*** (emphasis added) [Summary S.11]

    e. *Separate noise limits should apply for day-time and for night-time. The reason for this is that during the night the protection of external amenity*

becomes less important ***and emphasis should be on preventing sleep disturbance.*** *Day-time noise limits will be derived from background noise data taken during quiet periods of the day and similarly the night-time limits will be derived from background noise data during the night"* (night-time is defined as 11pm-7pm)

f. "*The NWG recommends that the fixed limit for night-time is 43 dB(A). This is derived from the 35 dB(A) sleep disturbance criteria referred to in PPG24. An allowance of 10 dB(A) has been made for attenuation through an open window (free-field to internal) and 2dB subtracted to account for the use of LA90.10min rather than LAeq.10min."* [Summary S.23]

g. *"Lower limit"*
Applying the margin above background approach to some of the very quiet areas in the UK would imply setting noise limits down to say 25 – 30 dB(A) based upon background levels perhaps as low as 20 – 25 dB(A). ***Limits of this level would prove very restrictive on the development of wind energy.*** *As demonstrated below, it is not necessary to restrict wind turbine noise below certain lower fixed limits in order to provide reasonable degree of protection of the amenity."* (emphasis added)

28. In contrast, two years after ETSU-R-97, the WHO *Guidelines for Community Noise 1999* set tighter maximum permitted levels for community noise, yet ETSU-R-97, page 20 refers to *"the WHO document Environmental Health Criteria 12 – WHO 1980(14).* Clearly, ETSU-R-97 does not reflect the latest World Health Organisation *Guidelines for Community Noise*.

29. Independent experts researched and wrote the WHO Guidelines for Community Noise 1999. In brief, the Guidelines state:

"In these Guidelines for Community noise only guideline values are presented. These are essentially values for the onset of health effects from noise exposure." (5th paragraph S. 4.1)

"For each environment and situation, the guideline values take into consideration the identified health effects and are set, based on the lower levels of noise that effect health (critical health effects). (6th paragraph S. 4.1)

"In dwellings the critical effects of noise are on sleep, annoyance and speech interference. To avoid sleep disturbance, indoor guideline values for bedrooms are 30 dB LAeq for continuous noise and 45dB LAmax for single sound events. Lower levels may be annoying, depending on the nature of the noise source…." (S 4.3.1 & see also S 3.3 sleep disturbance)

"Thus when assessing the effects of environmental noise on its people it is relevant to consider the importance of the background noise level, the number of events, and noise exposure level independently." (3rd paragraph S 4.1)

"Most problems occur at lower frequencies, where most environmental noise sources produce relatively high sound pressure levels." (S 2.6)

"If noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably." (S 4.3)

"More regular variations of sound pressure levels with time have been found to increase the annoying aspects of the noise. For example, noises that vary periodically to create a throbbing or pulsating sensation can be more disturbing than continuous noise. (Bradley 1994b). Research suggests that variations at about 4 per second are more disturbing (Zwicker 1989)." (3rd paragraph S 2.3.2)

"At night sound pressure levels at the outside facade of the living spaces should not exceed 45 dB LAeq and 60 dB LAmax, so that people may sleep with bedroom windows open. These values have been obtained by ***assuming*** *that the noise reduction from outside to inside with the window partly open is 15 dB."*

30. It may seem that 15dB is a high level of attenuation through the external envelope especially for timber-framed buildings and high glazed areas. However, the guideline for the onset of sleep deprivation is 30dB, reduced if low frequency noise characters are present and further reduced if throbbing/pulsating characters are present – both of which are present for wind turbine noise. This lower figure represents a new base level to which is added the noise attenuation factor for the external envelope, with a window partially open, to give the outside façade level.

    [Note: the 30dB max for a bedroom is a continuous maximum noise level, which is substantially different to the ETSU-R-97 guideline that allows 5dB above background noise.]

31. The importance of an 'in the bedroom at night maximum level' is emphasised by the findings of GP van den Berg. Van den Berg's research reveals that [van den Berg GP. *Effects of the wind profile at night on wind turbine sound*. Journal of sound and vibration 2004; 277(4-5): 955-970]:

    'Since the start of the operation of a 30 MW, 17 turbine wind park, residents living 500 m and more from the park have reacted strongly to the noise; residents up to 1900 m distance expressed annoyance. To assess actual sound immission, long term measurements (a total of over 400 night hours in 4 months) have been performed at 400 and 1500 m from the park. In the original sound assessment a fixed relation between wind speed at reference height (10 m) and hub height (98 m) had been used. ***However, measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference speed in daytime.*** *Moreover, especially at high rotational speeds the turbines produce a 'thumping', impulsive sound, increasing annoyance further. It is concluded that prediction of noise immission at night from (tall) wind turbines is underestimated when measurement data are used (implicitly) assuming a wind profile valid in daytime.'*

32. During stormy weather, the background wind noise sometimes disturbs sleep, but to suffer wind turbine noise in addition (as per ETSU-R-97) is likely to make sleep intermittent if not impossible.

'Many acoustical environments consist of sounds from more than one source. For these environments, ***health effects are associated with the total noise exposure,*** *rather than with the noise from a single source (WHO 1980b.)"* [WHO Guidelines for Community Noise 1999, S.3.8, The effects of combined noise sources]

33. In assessing how a level of below 30 dB is achieved (WHO S. 4.3.1 & S. 3.3), allowance must be made for a window to be open in order to provide ventilation, especially in warm weather. In addition, the sound reduction index of the external wall is only part of the consideration. The construction of the ceiling might only be a 15mm sheet of plaster, some thermal insulation (not sound insulation), a paper-thin vapour barrier, and thin roofing slate. The transmission **loss** through the ceiling or roof is slight.

'The evidence on low-frequency noise is sufficiently strong to warrant immediate concern. Various industrial sources emit continuous low-frequency noise (compressors, pumps, diesel engines, fans, public works); and large aircraft, heavy duty vehicles and railway traffic produce intermittent low-frequency noise. Low-frequency noise may also produce vibrations and rattles as secondary effects. Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general (Berglund et al. 1996).'

'Since A-weighting underestimates the sound pressure level of noise with low-frequency components, a better assessment of health effects would be to use C-weighting.' [WHO Guidelines for Community Noise 1999, S.3.9, 'The effects of combined noise sources'.]

'To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB LA_{eq} *for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB* LA_{eq}*. These values are based on annoyance studies,* ***but most countries in Europe have adopted 40dB*** LA_{eq} ***as the maximum allowable level for new developments (Gottlob 1995). Indeed the lower level should be considered the maximum allowable sound pressure level for all new developments whenever feasible.'*** (WHO S.4.3.1.)

34. It should be noted that:

a The 30 dB LAeq is not variable with external weather conditions – it is a fixed level regardless of external weather conditions and external background noise.

b The nature of the pulsating beat of the wind turbine, together with probable ground vibration, and the low frequency noise character, are clear reasons to support a lower level than 30 dB LAeq, especially at night.

c WHO *Guidelines for Community Noise 1999* does not provide for measurements limited to background noise plus 5 dB as per ETSU-R-97, but clearly states that noise in a bedroom above 30 dB causes sleep disturbance.

d It is possible to conceive of a position where a lightly constructed dwelling with minimal sound transmission loss between bedroom ceiling and the external wall is subjected to an external wall sound of 45 dBA at night. If the WHO 30dBA maximum bedroom level is applied but reduced to reflect the pulsating character and the low frequency character, the actual measurement inside the bedroom, with the window open for ventilation, will be only marginally less than 45 d BA, potentially creating a 15 dBA excess of sound **which is a staggering 30 fold difference in sound energy.** (See S. 4.18 & S. 4.40 of this review.)

35. The WHO Guidelines for Community Noise 1999 are shown on the following chart:

Table 1: Guideline values for community noise in specific environments:
WHO *Guidelines for Community Noise 1999*

Specific Environment	**Critical Health Effects**	**LAeq [dB(A)]**	**Time Base [hours]**	**LAmax fast [dB]**
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility & moderate annoyance, daytime & evening Sleep disturbance, night-time	35 30	16 8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School classrooms & pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoor	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	as low as possible		

The WHO *Guidelines for Community Noise 1999* also examine the acoustic measurement of sound:

'The A – weighting (dBA) is most commonly used and is intended to approximate the frequency response to our hearing system … C – weighting (dBC) is also quite common and is nearly a flat frequency response with the extreme high and low frequencies attenuated. When no frequency analysis is possible, the difference between A weighted and C weighted levels gives an indication of the amount of low frequency content in measured noise.' (WHO S.2.1.2)

'Noise measures based solely on LAeq values do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. It is also important to measure the maximum noise level and the number of noise events when deriving guideline values. ***If the noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably.*** *When prominent low-frequency components are present, measures based on A-weighting are inappropriate. However, the difference between dBC (of dBlin) and dBA will give crude information about the presence of low-frequency components in noise. If the difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed.'* (WHO S.4.3)

36. In August 2006, the Dti (UK) published 'The Measurement of Low Frequency Noise at Three UK Wind Farms' [Report for Dti by Hayes McKenzie Partnership Ltd].The report measured LFN at three wind farm sites in the UK, and although unidentified in the report, these sites are believed to be:

    Site 1: Askam, Cumbria 7 x 0.66 MW wind turbines of 4.62 MW installed capacity, built 1999.

    Site 2: Bears Down, Cornwall 16 x 0.6 MW of 9.62 MW installed capacity, built September 2001.

    Site 3: Blaen Bowi, Carmarthenshire 3 x 1.3 MW of 3.9 MW installed capacity, built July 2002.

37. For the purpose of its Report, the Dti defined low frequency noise sources as between 20 – 250 Hz [S.1.3]. The Dti stated: *'Infrasound is noise at frequencies below the normal range of human hearing, i.e., less than 20 Hz.'* [S.1.2] The report stated that *'noise sources associated with these frequencies are generated by unsteady loading of the wind turbine blade.'*

    Hubbard and Shepherd also make this observation. Their paper, 'Wind turbine acoustics' [NASA Technical Paper 3057, 1990, p 2496], considered three upwind and four downwind turbines. The upwind MODS.B and WWG-0600 machines measured between 60 dB – 70 dB below 20 Hz [p 2499; p 2502].

38. The Dti Report supports the Hubbard and Shepherd measurement of upwind machines:

> *'Measurements of infrasound [below 20 Hz] in the vicinity of wind farms, and confirmed within this study, indicate typical sound pressure levels between 1 – 10 Hz of 60 – 80 dB, which falls well below the normal environmental infrasound levels experienced by all humans.'* [p 12]

39. The Dti Report observes:

> *'The common cause of complaints associated with wind turbine noise at all three wind farms is not associated with low frequency noise, but is the audible modulation of the aerodynamic noise, especially at night.'* [p 3]

In the Report, the Dti does not provide evidence to support this statement as the sole cause of complaints. There is little doubt that audible modulation is a contributory cause, but as Professor James Lovelock, Professor Ralph Katz, Dr Amanda Harry, and Dr David Coley suggested, the "common cause" will be the acoustic radiation of sound characters of which a cocktail strikes the human body, the responses mainly being of a physiological (biologic/medical) nature, producing both short-term and long-term effects.

40. Section 2.10 of this Review noted several examples of public health concerns that emerged only after time, when a pattern of human exposure and adverse response could be observed, e.g., as reflected by the public health history with tobacco, mercury, asbestos, and thalidomide. It is therefore unsafe for the Dti to conclude that there is no environmental noise pollution from wind turbines without first conducting an independent acoustic and epidemiologic assessment.

41. The Dti Report uses the word *"perception"* and as this does not appear to be defined, one has to presume the authors are referring to *"perception of the auditory system"*, i.e., whether a sound is audible. The WHO *Guidelines for Community Noise 1999* states in S.2.1.6:

> *"Sound is a sensory perception evoked by physiological process in the auditory brain."* [That is, the process of 'perceiving' sound is a biologic/ physiologic process.]

42. The Dti Report Conclusions [August 2006] state, on page 66:

> *"Community Noise, WHO 'there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects."*

The Dti report repeats this quotation on pages 2, 10, 46 and 66. However, this quotation is taken from the ***WHO Community Noise Paper 1995*** **and does not appear in the final document of 1999.**

In fact, the WHO *Guidelines for Community Noise 1999* clearly states in Section 3.8:

> ***"The evidence on low frequency noise is sufficiently strong to warrant immediate concern."***

"Health effects due to low frequency components in noise are estimated to be more severe than for community noises in general (Berglund et al 1996)."

43. Other conclusions of the Dti Report on page 66 include:

> *"Infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range."* (Below 20Hz)

There is significant medical evidence that infrasound is perceived by other organs in the human torso with negative health responses. (See Section 5, Health Effects, in this Review). The Dti Report measured at Site 2, Appendix 6C, levels of 40 – 50 dB between 10Hz-20Hz. The UKNA survey (S.4.52) measured 70dB below 20Hz on three wind farms. Both measurements are inaudible to the auditory brain (the ear), yet may medically have an impact on body organs.

44. Another conclusion from the Dti Report on page 66 states:

> *"It may therefore be concluded that infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to health of a wind farm neighbour."*

There is no substantive epidemiological or physiological evidence in the Dti Report to support this conclusion.

The Dti Report does not address the physiological or biological responses of the human body. Acousticians – with experience working as consultants to the wind industry – produced the Dti report, and as acousticians, they focus on acoustic analysis, identifying the sound power levels [dB] down to around the threshold of audibility.

45. The Dti Report considered the 'individual thresholds of hearing', observing that:

> *'Measurements of the equal-loudness contours at frequencies below 20 Hz have been investigated by Moller and Andresen, and Whittle et al.'* (p. 26)

In a comparison of the results of these studies, the '*measurements indicate good agreement between the two papers and indicate a continuing tendency for the contours to become closer as the frequency reduces. Therefore,* ***in the infrasonic range, an increase of the sound pressure level by 10 dB may be perceived as an 8 – 16 fold increase in loudness as compared to a doubling, 2 fold increase at 1 kHz [1,000 Hz]. The result of this change in perceived loudness with change in sound pressure level in the low frequency region is that small changes in the pressure level may be experienced as a large change in perceived loudness****."* [emphasis added] [Moller H; Andresen J. Loudness of pure tones at low and infrasonic frequencies. Journal of low frequency noise and vibration 1984; 3(2): 78 – 87; and Whittle LS; Collins SJ; Robinson DW. The audibility of low frequency sounds. Journal of sound and vibration 1972; 21: 431 – 448]

> ***'Therefore, when infrasound and low frequency are of sufficient level to be detected, then a small change in pressure level above this threshold will quickly become perceived as a large change in loudness which may be considered unacceptable.*** *The experience of the low frequency sufferers within the Salford Study* [Proposed criteria for the assessment of low frequency noise disturbance. Report for Defra by Dr Andy Moorhouse et al, February 2005] *indicated that once the subject has been 'sensitised' to low frequency noise, then only a small increase in pressure level above the hearing threshold is required to be considered unacceptable.'* [Dti S.3.3, p. 27]

46. The Dti Report compares the difference in sound power level (dB) at infrasound frequency, between downwind and upwind wind turbines:

> *'Infrasound noise emissions were identified within a paper by Shepherd and Hubbard* [Physical characteristics and perception of low frequency noise from wind turbines. Noise control engineering journal 1991 Jan/Feb; 36(1): 5 – 15] *which provided field data from a number of upwind and downwind rotor configuration wind turbines. The generation of blade passage frequency (BPF) energy and associated harmonics were found to be more dominant for downwind rotor configurations. This was due to the effect of the supporting tower wake interaction as the blade passed behind the tower and would experience a sudden and significant change to the airflow.'* [Dti S.5, p 32]

However, if one refers to Hubbard and Shepherd's '*Aeroacoustics of Large Wind Turbines'* [JASA Journal of the Acoustical Society of America 1991, figure 8, p 2499], the upwind wind turbines show a similar noise spectra, indicating sound pressure levels (dB) between 60 – 70 dB in the 1Hz – 20 Hz range. This compares with the Dti Report on upwind machines of between 50 – 60 dB in the 6 – 20 Hz range.

47. The Dti Report refers to infrasound noise immissions:

> *'The measured data indicates that wind turbines do increase the level of infrasound acoustic energy within the environment but that this energy is below the perception threshold.'* [Dti p 36]

While the Dti Report provides evidence to support the view that the sound pressure level (dB) when below 20 Hz is below the threshold of audibility, the report provides no evidence to support the view that the noise is below the threshold of human perception. Indeed, a purely acoustics report cannot provide evidence in that regard, because humans **are** physiologically affected by inaudible sound. Inaudible sound affects not only humans, but also animals; e.g., animals retreated from the coastal areas of the tsunami that devastated parts of Asia in 2004, and sonar can affect whales and dolphins. [Mott M. Did animals sense tsunami was coming? National Geographic News, 4 January 2005. See also Section 4.11 of this paper.]

48. In identifying complaints from the three wind turbine sites where measurements were taken, the Dti Report noted: (pages 56-57)

> *'In general, the occupants of Site 1: Location 1 and Site 3: Locations 1 & 2, have described wind farm noise as being most intrusive within the dwellings during the night-time or early morning periods. The occupants have also indicated that the amplitude modulation of the aerodynamic noise is a character that draws their attention to the noise and which makes it readily identifiable when heard within an internal living space. The levels of external noise when the wind farms were considered to give rise to audible noise within the dwellings and specifically identified by the occupants ranged as follows:*

Site 1 Location 1: 38.5 – 41.0 dB LAeq 10 min : 36.3 – 38.7 LA90, 10 min

Site 2 Location 1: 37.5 – 40.2 dB LAeq 10 min : 36.2 – 38.1 LA90, 10 min

Site 3 Location 1: 40.4 – 45.5 dB LAeq 10 min : 39.0 – 39.8 LA90, 10 min

> *'Irrespective of the existing background noise level at the time of the measurements, the external noise levels associated with the operation of the wind turbines meet the requirements of ETSU-R-97 for night-time operations'* – the greater of 43 dB L_{A90} (or background + 5 dB) – *'i.e., noise levels are lower than 43 dB L_{A90}. This level provides protection against the awakening of an occupant, based upon the recordings, where no occupant was noted to awaken due to noise associated with the operation of the wind turbine.'*
>
> *'Measured internal noise levels for the same measurement periods detailed above are as follows:* (page 60)

Site 1 Location 1: 22.7 – 24.6 L_{Aeq} 10 min : 21.8 – 22.5 dB L_{A90}, 10 min

Site 2 Location 1: 27.6 – 36.7 L_{Aeq} 10 min : 25.9 – 30.1 dB L_{A90}, 10 min

Site 3 Location 1: 42.5 – 53.1 L_{Aeq} 10 min : 41.6 – 42.0 dB L_{A90}, 10 min

Site 1, location 1 is within a double glazed conservatory with no windows open.

Site 2, location 1, is within a room with windows open.

Site 3, location 1, is within a room with windows open with the internal measurement location having a direct line of sight down to the stream in the valley below and the microphone placed within 0.3 m of the open window.'

[Authors' note: Compliance with the noise limits based on ETSU-R-97 does not imply that there will be no significant noise impact on local residents.]

49. The following are further examples of measurements forming part of the Dti report Appendix:

For example, Site 1, measurements taken on 16 May 2005, are within the frequency range of 10 Hz – 20 Hz, an L_{eq} dB of between 40 dB – 45 dB 'Low frequency noise audibility external façade', location 1:00:00 – 1:02:35 (figures 1 and 32).

For example, Site 2 measurements taken on 14 June 2006, '*Low frequency noise audibility internal before windows open*', an L_{eq} dB within the frequency range of 10 Hz – 20 Hz of between 40 – 45 dB was measured, Location 1:21:00 – 1:21:15 (figures 1 and 4).

50. This, however, portrays just a small part of the picture. To be useful, all wind turbine acoustic measurements should include the following information. This is because the rotation speed of the blades can be controlled remotely, especially when a noise management scheme is in place. The rotation speed (rpm) has a direct bearing on the noise emission from the wind turbine.

i. Distance of the measured point from nearest wind turbine;
ii. Measured point relative to the wind turbines (array impact);
iii. Wind speed and direction at the hub height;
iv. Actual revolutions per minute of the blades at the time of measurement – as this does not necessarily correlate to wind speed;
v. Difference in altitude between the measured point and the wind turbine;
vi. A definitive description of the terrain; and
vii. A dB(A) and dB(C) measurement of frequency down to 1 Hz.

51. Referring to Site 1, the Dti report [p 81] comments:

> *'It should be noted that the description of the noise by the awoken occupant was that the noise was "intolerable". The range in levels in the 400 – 500 Hz third octave bands was measured to lie between 9 – 10 dB and to be 17 dB above the B.S. ISO 226:2003 Threshold Criterion Curve. In this event,* ***the perceived change in level in this frequency range would be a doubling of the perceived loudness, with levels potentially rising in and out of the Threshold of Audibility.*** [emphasis added] *This would give rise to a sound of a muffled swish that could be described as a heart beat type sound as the sound may only be audible for part of the time, i.e., as the noise associated with the wind farm is aerodynamic in origin and is associated with the rotation of the blades, then this will appear at 3 times the rotational speed also known as the blade passage frequency (bpf). The turbines operate with a rotational speed of 26 rpm, which equates to a blade passage frequency = 78 bpf. This is in the normal range of a heart beat.'* [p 81]

According to 'Measuring Sound', a publication from Bruel and Kjaer, a company that manufactures acoustical measuring and calibrating equipment used by many researchers and industries, when noise levels are too high and no other means of attenuation has worked or is feasible, then:

> *'Shut down the offending machinery. In severe cases, this step must be considered. It is also possible to limit the hours of operation.'*
> [Bruel and Kjaer. Measuring Sound, September 1984 (rev)]

52. In August 2006, the United Kingdom Noise Association (UKNA) published a report by John Stewart, ***'Location, Location, Location'***. This report, believed to be the first produced with input and evidence from both acoustic and medical resources and experts, addresses the cause of the suffering of families when wind turbines have been built too close to their homes:

    'Our own conclusion, after reviewing the evidence … So much depends on the location of the wind farm relative to where people live.'

    The UK Noise Association measured noise levels around three wind farms: Bears Down (October 2005) in Cornwall; Bradworthy (December 2005) in Devon; and Blaen Bowi (October 2005) in Wales. (As previously mentioned it is believed that the Dti took its measurements at Bears Down– its Site 2; and Blaen Bowi – its Site 3.)

53. UKNA summarised its findings of wind turbine noise measured outdoors:

    'At 10 Hz, the noise from the wind farms ranged from negligible (upwind from the turbines) to 75 dB (C) (downwind). Because 'Watanabe and Moller' figures are 'G' weighted and the UK Noise Association used 'C' weighting, only approximate comparisons are possible. But these findings are well within the 97 decibels where it would become a noise problem at 10 Hz, whatever the weighting.'

    'At 20 Hz, the noise from the wind farms ranged from a low of 10 dB (C) (upwind of the turbines) to a high 82 dB (C) (downwind), with the great majority of the results falling in the 40 – 70 dB (C) range.' [p 14]

54. UKNA also tested for low frequency noise indoors. A house close to the Blaen Bowi wind farm was used (p 15):

    "The results we obtained were these:

    '*At 10 Hz, the noise levels ranged from 44 to 48 decibels, well below the levels at which the noise could be heard. At 20 Hz, the noise levels ranged from 40 to 48 decibels, again well below audible levels. At 60 Hz, the noise levels ranged from 44 to 63 decibels, which suggests that low-frequency noise is being heard at times. At 100 Hz, the decibel levels ranged from 42 to 52 decibels, which indicates that the 'swish' sound is being heard, containing low frequency content.' "*

55. The UKNA Report also stated:

    On page 19: *'Conclusions on Noise and Health.*

    Pedersen's arguments are persuasive that the dancing shadows and the rotating blades can significantly add to the annoyance and stress caused by noise from the turbines. The questions being asked by some in the medical profession as to whether this cocktail of effects – the noise, low frequency, rotating blades, the shadows and the strobing – is leading to ill health out of proportion to the noise turbines make, needs serious examination.'

On page 20 - first conclusion: *'Overall Conclusions.*

> *1. Wind farm noise, in common with noise generally, affects different people in different ways, but the evidence suggests there is rarely a problem for people living more than 1 – 1.5 miles from a turbine.'*

On page 21- first recommendation. *'Overall Recommendations.*

> ***It would be prudent that no wind turbine should be sited closer than 1 mile away from the nearest dwelling.*** *This is the distance the Academy of Medicine in Paris is recommending, certainly for the larger turbines and until further studies are carried out.* ***There may even be occasions where a mile is insufficient depending on the scale and nature of the proposed development.****'*

56. The following charts from the UKNA survey confirm the presence of LFN. Using the WHO alternative measure (*Guidelines for Community Noise 1999*, S 2.1.2), *"when no frequency analysis is possible, the difference between A-weighted and C-weighted levels gives an indication of the amount of low frequency content in the measured noise."* The difference in two sample readings at Bradworthy (005 & 007), between A and C weighting was 29 and 30 decibels; at Bears Down (05 & 06), the difference was between 25 and 30 decibels; and at Blaen Bowi (005 & 006), the difference was between 26 and 27 decibels.

BRADWORTHY 05 Wind Direction SW speed 9 – 19 MPH Shielded from Wind

Location Hillside Farm SS 294 135

Microphone – 1Hz

Shielded from Direct Wind

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	07/12/2005 19:53:13
End Time:	07/12/2005 19:56:20
Elapsed Time:	00:03:07
Bandwidth:	1/3-octave
Max Input Level:	140.50

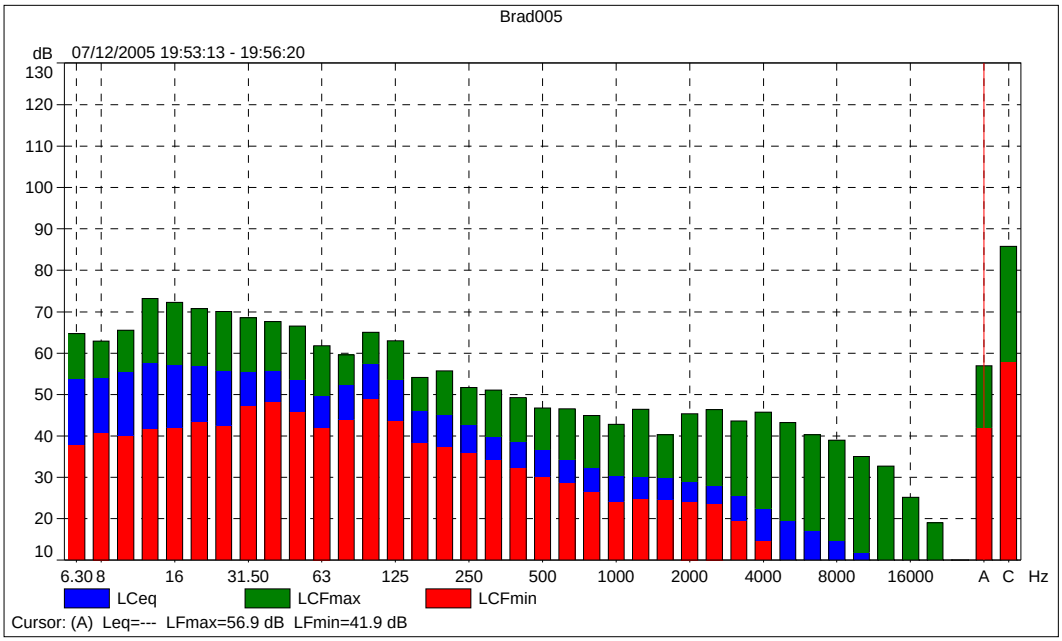
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	None
Sound Field Correction:	Free-field

Calibration Time:	07/12/2005 14:47:11
Calibration Type:	External reference
Sensitivity:	52.78 mV/Pa

Brad005 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	47.7	56.9	41.9
Time	19:53:13	19:56:20	0:03:07				
Date	07/12/2005	07/12/2005					



BRADWORTHY 07 Wind Direction NW speed 9 – 23 MPH Shielded from Wind

Location SS 304 135

Microphone – Normal

Audio File – Track Brad02

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	08/12/2005 11:19:27
End Time:	08/12/2005 11:24:07
Elapsed Time:	00:04:40
Bandwidth:	1/3-octave
Max Input Level:	141.24

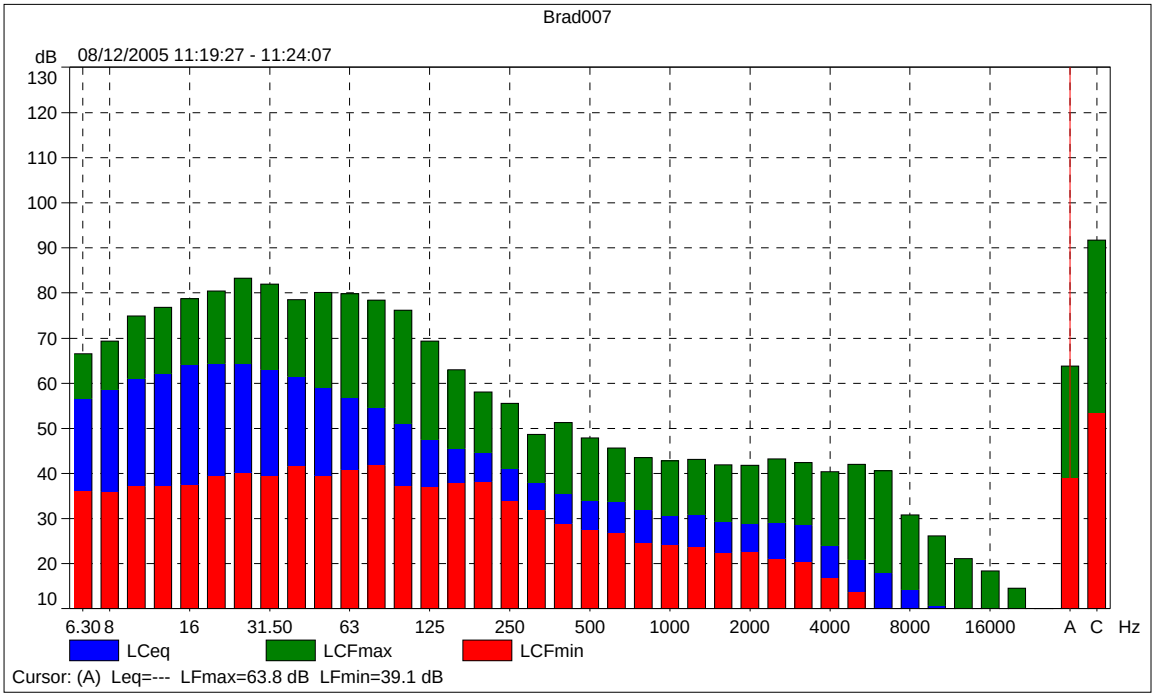
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

Calibration Time:	08/12/2005 09:45:31
Calibration Type:	External reference
Sensitivity:	48.41 mV/Pa

Brad007 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	49.5	63.8	39.1
Time	11:19:27	11:24:07	0:04:40				
Date	08/12/2005	08/12/2005					



BEARSDOWN 05 Location SH 904 685

Wind Speed	12 – 15 MPH
Wind Direction	S
Microphone	Normal

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	07/12/2005 15:22:25
End Time:	07/12/2005 15:24:27
Elapsed Time:	00:02:02
Bandwidth:	1/3-octave
Max Input Level:	140.50

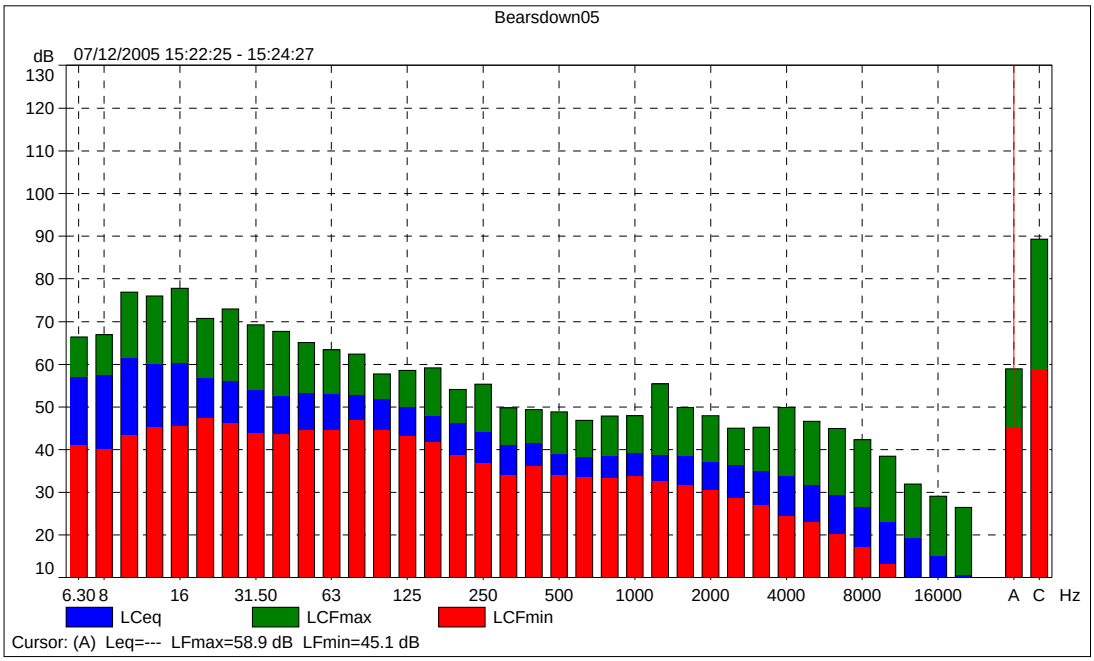
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	None
Sound Field Correction:	Free-field

Calibration Time:	07/12/2005 14:47:11
Calibration Type:	External reference
Sensitivity:	52.78 mV/Pa

Bearsdown05 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	52.6	58.9	45.1
Time	15:22:25	15:24:27	0:02:02				
Date	07/12/2005	07/12/2005					



BEARSDOWN 06 Location SH 904 685

Wind Speed 10 – 18 MPH

Wind Direction S

Microphone 1 Hz

Instrument: 2250
Application: BZ7223 Version 1.2
Start Time: 07/12/2005 15:26:33
End Time: 07/12/2005 15:28:39
Elapsed Time: 00:02:06
Bandwidth: 1/3-octave
Max Input Level: 140.50

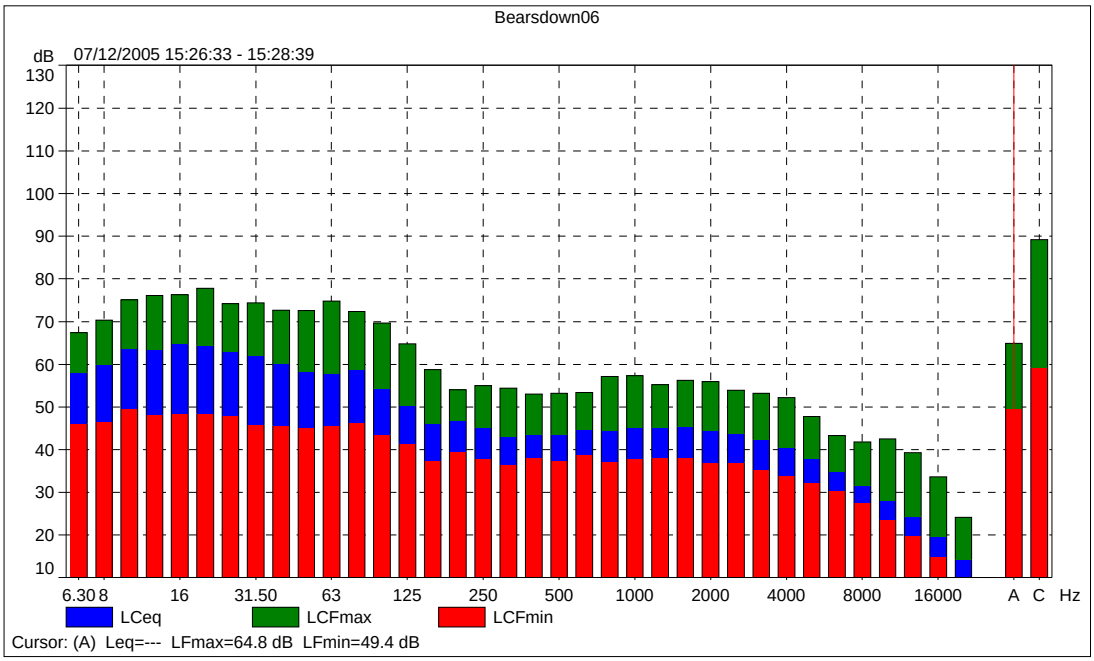
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number: 2505941
Microphone Serial Number: 2508682
Input: Top Socket
Windscreen Correction: None
Sound Field Correction: Free-field

Calibration Time: 07/12/2005 14:47:11
Calibration Type: External reference
Sensitivity: 52.78 mV/Pa

Bearsdown06 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	57.2	64.8	49.4
Time	15:26:33	15:28:39	0:02:06				
Date	07/12/2005	07/12/2005					



BLAEN BOWI 005 No Filter Installed Location SN 32314 BNG 36829

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	01/12/2005 11:55:22
End Time:	01/12/2005 11:57:32
Elapsed Time:	00:02:10
Bandwidth:	1/3-octave
Max Input Level:	140.67

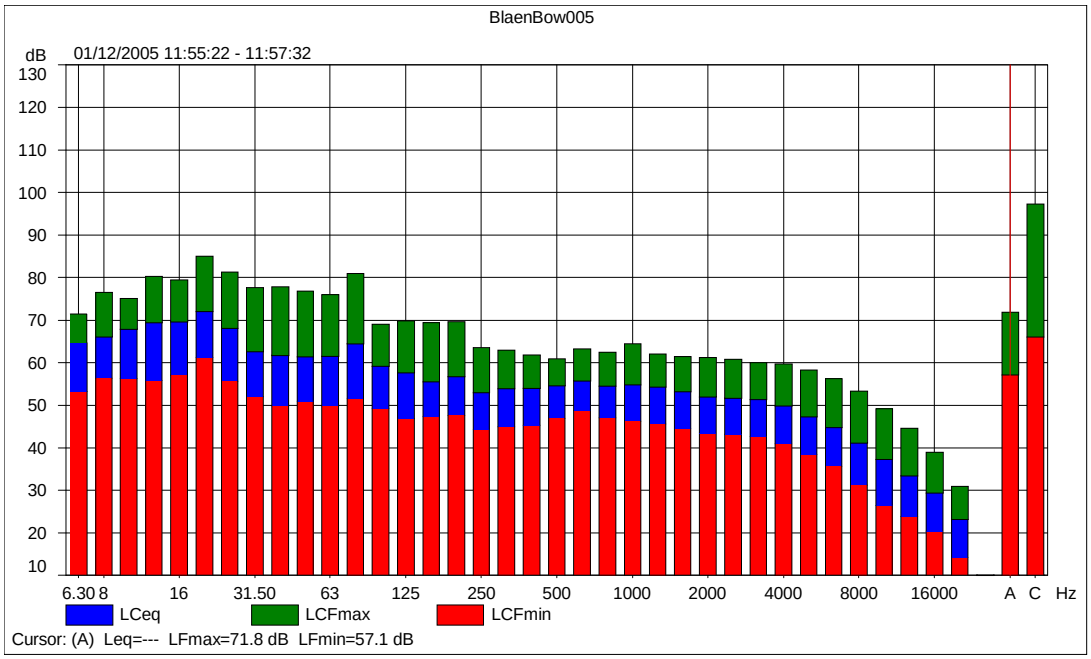
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

Calibration Time:	01/12/2005 10:12:59
Calibration Type:	External reference
Sensitivity:	51.65 mV/Pa

BlaenBow006 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	65.4	71.8	57.1
Time	11:55:22	11:57:32	0:02:10				
Date	01/12/2005	01/12/2005					



BLAEN BOWI 006 Location SN 33081 BNG 35867

Wind Speed 17 – 24 mph

Instrument:	2250
Application:	BZ7223 Version 1.2
Start Time:	01/12/2005 11:55:22
End Time:	01/12/2005 11:57:32
Elapsed Time:	00:02:10
Bandwidth:	1/3-octave
Max Input Level:	140.67

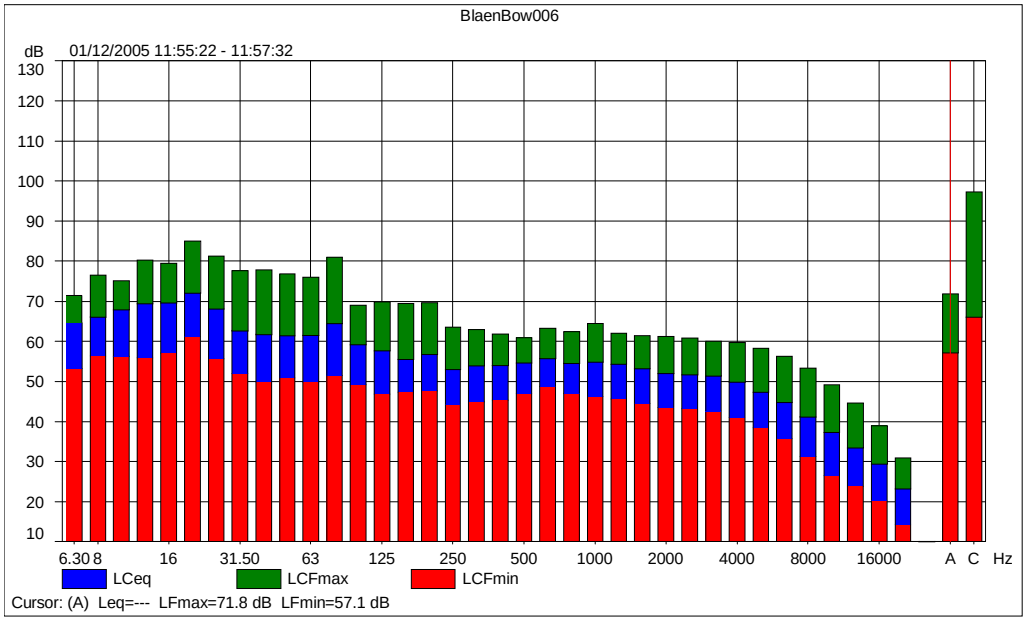
	Time	Frequency	
Broadband (excl. Peak):		FSI	AC
Broadband Peak:		C	
Spectrum:	FS	C	

Instrument Serial Number:	2505941
Microphone Serial Number:	2508682
Input:	Top Socket
Windscreen Correction:	UA 1650
Sound Field Correction:	Free-field

Calibration Time:	01/12/2005 10:12:59
Calibration Type:	External reference
Sensitivity:	51.65 mV/Pa

BlaenBow006 Text

	Start time	End time	Elapsed time	Overload [%]	LAIeq [dB]	LAFmax [dB]	LAFmin [dB]
Value				0.00	65.4	71.8	57.1
Time	11:55:22	11:57:32	0:02:10				
Date	01/12/2005	01/12/2005					



57. The following chart is an analysis of low frequency noise from a DAT tape prepared by Delta, consultants for 'Bonus' of a Bonus 1.3MW wind turbine. The chart formed part of "A Report to Vale of the White Horse District Council"(UK) by Dr G Leventhall, March 2004:

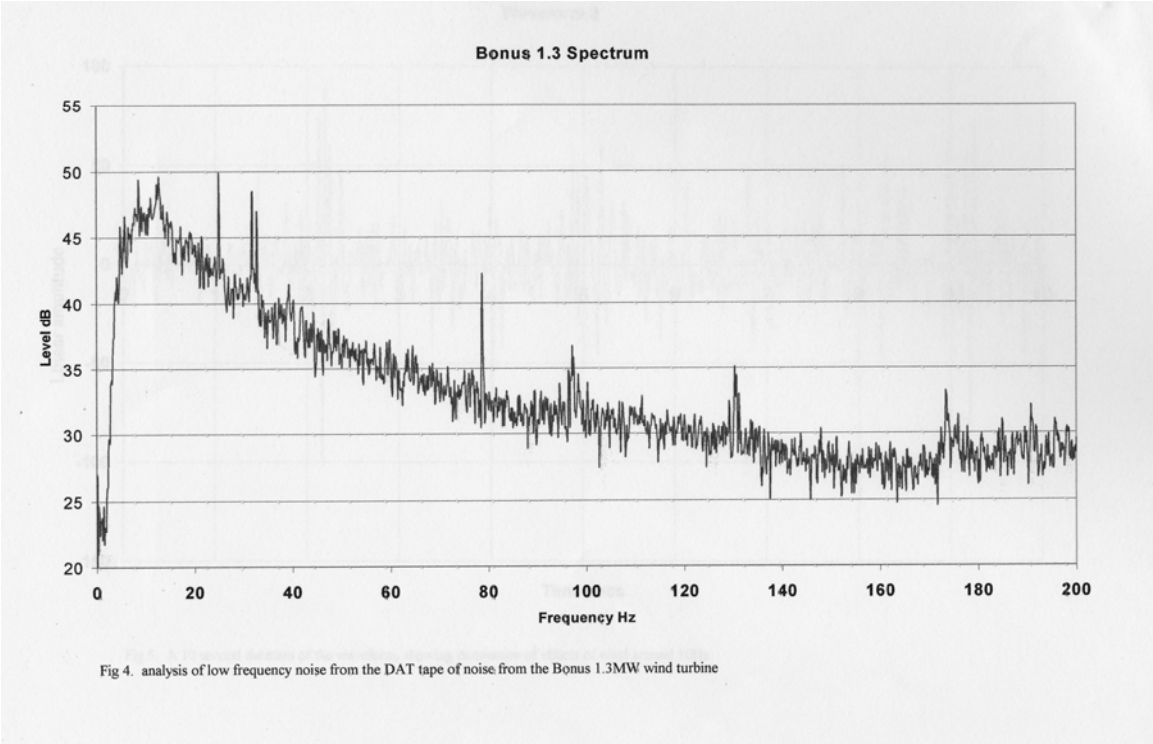


Fig 4. analysis of low frequency noise from the DAT tape of noise from the Bonus 1.3MW wind turbine

It is significant that the noise measurements taken by UKNA correlate with the noise chart in the low frequency noise range, of the Bonus 1.3 MW wind turbine. However, the fall-off at 0Hz – 6Hz is a surprise and may be due to the instrumentation.

58. In a recent publication [Leventhall G. Infrasound from wind turbines – fact, fiction and deception. Canadian acoustics 2006 Jun; 34(2): 29 – 36], Geoffrey Leventhall, acoustician and consultant to Defra and Dti, writes that:

> *'Infrasound from wind turbines is below the audible threshold and of no consequence.'*

However, Leventhall does acknowledge that wind turbine noise can be problematic:

> *'Low frequency noise is normally not a problem, except under conditions of unusually turbulent inflow air.'*
>
> *'Turbulent air inflow conditions cause enhanced levels of low frequency noise, which may be disturbing, but the overriding noise from wind turbines is the fluctuating audible swish ...'*
>
> A wind turbines' main noise source is produced by the *'repeating sound of the blades interacting with the tower. This is the noise which requires attention, both to reduce it and to develop optimum assessment methods.'* [See also section 4.19 of this paper: Report by Styles et al; report by the US Department of Defense]

59. The suitability of using ETSU-R-97 as a guide for reasonableness is challenged by Dick Bowdler in *'ETSU-R-97: Why it is Wrong'* [July 2005]. The Bowdler Report comments:

    On page 61 of ETSU-R-97, the Noise Working Group stated that:

    > *'During the night one can reasonably expect most people to be indoors and it will not be necessary to control noise to levels below those required to ensure that the restorative process of sleep is not disturbed. A night-time absolute lower limit is therefore appropriate based upon sleep disturbance criteria.'* [ETSU-R-97]

    Bowdler counters this assumption by the Noise Working Group [NWG] with the following:

    > *'What this says is that a turbine noise level inside peoples' houses of just less than the World Health Organisation say is necessary to get back to sleep if you wake up in the night is satisfactory. It seems to me this must be the very upper limit of acceptability, not one that is well balanced. Since then, the WHO has revised its guidance 5 dB lower. So the ETSU night standard is now higher than WHO say you need to get back to sleep.'* [Bowdler, 3.15]

60. On page 62 of ETSU-R-97, the NWG wrote:

    > *'It is also the opinion of the Noise Working Group that there is no need to restrict noise levels below a lower absolute limit of LA90, 10min = 33db(A); if an environment is quiet enough so as not to disturb the process of falling asleep or sleep itself then it ought to be quiet enough for the peaceful enjoyment of one's patio or garden.'* [ETSU-R-97]

    Again, this conclusion relies on presumption; Bowdler responds:

    > *'This is a bizarre statement. It seems that the 33dBA is the 35dB sleep restoration level set out by the World Health Organisation for inside bedrooms at night. They seem to be saying that there is no need for noise levels during the day to be any lower than is necessary to allow you to go to sleep on your patio on a sunny afternoon.'* [Bowdler, 3.16]

    > *'Having suggested that 33dB would be satisfactory because people could get to sleep on their patio – they now say that "This level would however be a damaging constraint on the development of wind power in the UK as the large separation distances required to achieve such low noise levels would rule out most potential wind farm sites" [ETSU-R-97]. There is absolutely no evidence brought forward to justify this.* ***A margin of 2km would normally easily achieve this even with the noisier modern turbines.*** *They argue that "Wind farms have global environmental benefits which have to be weighed carefully against the local environment impact" [ETSU-R-97]. So do many other things. They argue that "Wind farms do not operate on still days when the more inactive pastimes (e.g. sunbathing) are likely to take place" [ETSU-R-97]. The suggestion seems to be that the protection of*

people's amenity does not include protecting them whilst sunbathing in their gardens on a slightly windy day or sleeping on the patio.' [Bowdler, 3.17]

'Then, on page 63 [of ETSU-R-97] there is another leap of credibility: "There is no evidence for or against the assertion that wind farm noise with no audible tones is acceptable up to and including LA90, 10min levels of 40dB(A) even when background noise levels are 30dB or less". This is just nonsense. There most certainly is evidence against this assertion. The 40dB is actually 42dB in BS4142 units. This is at least 12dB above background noise level of "30dB or less" and BS4142 says there are likely to be complaints at turbine levels of plus 10dB. Furthermore there is no argument that BS4142 is not applicable. Even BS4142:1990 (which was current when ETSU-R-97 was written) might easily be applicable here. If the wind speed is 5m/s, the background noise 30dB and the turbine noise 42dB(LAeq) then there is no reason not to use BS4142, it does not exclude itself in these circumstances. ***This noise level is also 12dB more than (twice as loud as) the WHO considers necessary for you to be able to get to sleep.'*** [Bowdler, 3.18]

61. In August 2005, the Renewable Energy Foundation (REF) released a statement that commented on the new report by GP van den Berg, "*The beat is getting stronger: the effect of atmospheric stability on low frequency modulated sound of wind turbines*" [Journal of Low Frequency Noise and Vibration 2005; 24:1-24].

    Prof. Ffowcs-Williams, Emeritus Professor of Engineering, Cambridge University, one of the UK's leading acoustical experts and an advisor to REF said [REF Studies on wind turbine noise raise further concerns, 4 August 2005]:

    'Van den Berg's paper adds weight to the criticisms frequently offered of the UK regulations covering wind turbine noise, ETSU-R-97. The regulations are dated and in other ways inadequate. It is known that modern, very tall turbines, do cause problems, and many think the current guidelines fail adequately to protect the public."

62. "Wind Energy" (published by John Wiley & Sons), a technical bimonthly journal of wind turbine engineering papers, provides evidence that confirms just how imprecise the forecasting of wind turbine performance is:

    a *"Challenges in modelling the unsteady Aerodynamics of wind turbines"* by JG Leishman, Department of Aerospace Engineering, University of Maryland (USA) [Wind Energy 2002;5;85-132]:

    "Such problems include the challenges in understanding and predicting the unsteady blade airloads and rotor performance, as well as predicting the dynamic stresses and aeroelastic response of the blades. Wind turbines are also subjected to complicated environmental effects such as atmospheric turbulence, ground boundary layer effects, directional and spatial variations in wind shear, thermal stratification, and the possible effects of an upstream unsteady, bluff body-like wake from support structure (tower shadow).

    Fig. 1 [in original document] *summarises the various aerodynamic sources that may affect air loads on a wind turbine, which can be decomposed into a variety of mostly periodic and mostly periodic contributions.* ***The net effect***

is that the wind turbine operates in an adverse unsteady aerodynamic environment that is both hard to define using measurements and also to predict using mathematical models."

b "Survey of modelling methods for wind turbine wakes and wind farms" by A Crespo, J Hernandez, and S Frandsen [Wind Energy 1999;2;1-24]:

"*The final report (intensified study of wake effects behind single turbines and in wind power wakes, National Power, London), indicates that the experimental and analytical studies reported (annex) point to significant energy losses in arrays spaced at less than seven turbine diameters. Similarly, turbulence may increase in arrays, sufficiently to cause measurable damage to fatigue and dynamic loads."*

[Comment: In these circumstances, noise characters become more clearly pronounced.]

63. Morris et al further explain the difficulties [Morris PJ; Long LN; Brentner KS. An aeroacoustic analysis of wind turbines. American Institute of Aeronautics and Astronautics: AIAA-2004-1184; 42nd AIAA Aerospace Sciences Meeting, 5-8 January 2004, Reno, Nevada, 2004]:

'Since the wind turbine noise problem is very challenging, only some of the important noise sources and mechanisms are being considered [in this particular study]. *These are airfoil self-noise, the effects of blade rotation, and the propagation of sound over large distances.'*

Their research encompasses *'two aspects of airfoil self-noise ... The first is the relatively low frequency noise generated by deep stall and the second is trailing edge noise. The noise associated with blade rotation includes the effects of blade rotation on the blade aerodynamics, incoming gusts, incoming atmospheric turbulence and wind shear.'*

The authors add that:

'Wind turbines have aerodynamic and aeroacoustic behaviors with unique characteristics that make their prediction more challenging in many ways than already complicated aeroacoustic problems such as rotorcraft or propeller noise.'

Some of the challenges are due to the unpredictable and sudden changes in *'blade / inflow / tower wake interactions.'* Moreover, wind turbine flows are complex, moving through *'a varying atmosphere over an irregular terrain', with 'the blade speed varies linearly from root to tip'*:

'It would be unrealistic to suggest that all aspects of the wind turbine noise problem could be simulated within the framework of a single aerodynamics/ aeroacoustics code. The computational resources required to perform such a simulation will remain beyond the capabilities of available computers for many years.'

(Note: Interestingly, Morris et al use the permeable surface Ffowcs Williams-Hawkings formulation to couple unsteady flow simulations to the radiated noise

field; see item 61 of this section, Acoustics, for Professor Ffowcs Williams's comments on ETSU-R-97.)

The authors further note that:

> *'While discrete frequency noise is certainly an important component of wind turbine noise (especially at low frequencies), broadband noise sources are also very important (especially at the higher frequencies).'*

Additionally:

> *'However, the sound generated by wind turbines, particularly the low frequency components, may propagate large distances through an unsteady, non-uniform atmosphere over an irregular terrain. Atmospheric absorption can also be significant for the high frequency noise components. Thus, for wind turbine applications, sound propagation is an important component of the complete aeroacoustic problem.'*

64. Sezer-Uzol and Long concur with Morris et al and observe that:

> *'... the acceptance of wind turbines by the public depends strongly on achieving low noise levels in application ... Furthermore, the acoustic propagation is of interest at relatively large distances from the wind turbine.'* [Sezer-Uzol N; Long LN. 3-D time-accurate CFD simulations of wind turbine rotor flow fields. American Institute of Aeronautics and Astronautics: AIAA Paper No. 2006-0394, 2006; CFD = Computational Fluid Dynamics]

65. If the measure for setting a noise standard lacks credibility to many professionals, it is understandable why it lacks credibility to those suffering adverse health consequences. If the methodology is inadequate, then an impartial team of experts should redesign the measure. Moreover, until there are newly defined measures that conclusively work beyond reasonable doubt, the old measure should be withdrawn from use immediately and **an immediate minimum 2km zone placed between people's homes and wind turbines**. Greater separation may be necessary in specific circumstances or with a wind turbine of greater than 2MW installed capacity.

66. Moreover, as Paul Schomer noted in 2002 [Schomer PD. For purposes of environmental noise assessment, A-weighting needs to be retired. JASA Journal of the acoustical society of America 2002 Nov; 112(5, pt 2): 2412]:

> *'… for the purposes of environmental noise assessment, A-weighting needs to be retired … A-weighting fails to properly assess multiple noise sources … and it fails to properly assess sound with strong low-frequency content. It performs better outdoors than indoors even though the receivers are indoors. It certainly cannot be used for room noise criteria. A-weighted Leq cannot assess the audibility of sound, and in fact, Leq in fractional octave bands cannot be used to assess the audibility of sounds at low frequencies.'*

[See also WHO *Guidelines for Community Noise 1999*, s.1.2 & s.3.9]

Schomer continues:

> *'There are better measures for all of these functions such as loudness-level rating using ISO 226. At low frequencies, data show some people (about one-third) are "C-weighted" listeners. For all noise, it may be that one model just does not fit all. Experiments show that a majority of listeners make categorical judgments and merely count events based on level with the minority of subjects fitting three other models. There are many ways to clearly move forward but we must give up our A-weighting, it has now reached old age.'*

67. According to Berglund et al [Berglund B; Hassmen P; Soames Job RF. Sources and effects of low-frequency noise. JASA Journal of the acoustical society of America 1996 May; 99(5): 2985 – 3002]:

> *'Low frequency noise is common … as an emission from many artificial sources: road vehicles, aircraft, industrial machinery, artillery and mining explosions, and air movement machinery including wind turbines, compressors, and ventilation or air-conditioning units. The effects of low-frequency noise are of particular concern because of its pervasiveness to numerous sources, efficient propagation, and reduced efficacy of many structures (dwellings, walls, and hearing protection) in attenuating low-frequency noise compared with other noise … Although the effects of lower intensities of low-frequency noise are difficult to establish for methodological reasons, evidence suggests that a number of adverse effects of noise in general arise from exposure to low-frequency noise ...* [p 2985]
>
> *… standards should consider the option of allowing less noise in the low-frequency range since the possibility exists that a stimulus may have an effect even without conscious (auditory) detection. Definitive solutions to these problems would require unethical exposures to low-frequency noise … The balance of probability would appear to favour the conclusion that low-frequency noise has a variety of adverse effects on humans, both physiological and psychological … The evidence provided … warrants concerned action without the potentially extremely lengthy delay that may be occasioned by waiting for definitive proof which may never arise.* [p 2998]

68 Noise from wind turbines combines with visual phenomena such as shadow flicker, which compounds the adverse impact on those living nearby. R Bolton, who is president of a company that develops engineering software, observes in his report on shadow flicker:
[Bolton R. Evaluation of Environmental Shadow Flicker Analysis for "Dutch Hill Wind Power Project". Environmental Compliance Alliance, New York, USA, 30 January 2007]

> *'Large scale shadow flicker is a new phenomenon, not experienced by people on an "industrial scale", with football field sized shadows moving across their home or through their local views. As a new source of environmental pollution extra care is needed when evaluating the long term consequences.'*

For example, on elevated ridges with wind turbines that are 400 feet high, the turbines *'will cast shadows for thousands of feet, well above any vegetative screening'*.

Shadow flicker is not only a day-time phenomenon; night-time flicker is also problematic. Conditions for shadow flicker include moon-lit nights, with the rising and setting of the moon. Moreover, ridgeline wind turbines can cast shadows that *'easily extend 2 to 4 miles'*:

> *'Residents and passers-by (highway traffic) not immediately within the shadow will nevertheless readily observe the shadow flicker ...'*
>
> *'Often numerous wind turbines are sited linearly if placed on a ridgeline and nearby residents will be exposed to numerous shadow flickers simultaneously.'*

That is, all three blades of each wind turbine will create flicker, and the flicker from all the wind turbines will not be synchronised.

According to the UK's Planning Guide for Renewable Energy: a companion guide to PPS22 (2004), *'flicker effects have been proven to occur only within ten rotor diameters of a turbine'*. Meridian Energy, a wind farm developer, recommends that *the 'nearest affected receptors'* to a wind turbine producing shadow flicker, *'should be no closer than 10 turbine rotor diameters'*.

For a wind turbine with a 300-foot rotor diameter, the nearest receptor to shadow flicker should be no closer than 3000 feet.

In New York State (USA), the Department of Environmental Conservation Program Policy provides guidance for the phenomenon of shadow flicker:

> *'A properly sited and designed project is the best way to mitigate potential impacts.'*

The guidance specifies that:

> *'It is the burden of the applicant to provide clear and convincing evidence that the proposed design does not diminish the public enjoyment and appreciation of the qualities of the listed aesthetic resource.'*

Recognising the impact of shadow flicker, the Swedish building authority introduced a rule that the calculation of shadow flicker should be made for the building lot (garden), instead of only the window of a façade.

Bolton concludes that:

> *'... shadow flicker is a serious environmental pollutant that can have significant harmful effects on the welfare of persons subjected to it.*

When coupled with the noise pollution and visual degradation that many residents will be subjected to, it is clear that wind farm turbine setbacks should be increased to a minimum of 3,000 feet from any residence.'
[Bolton R. Evaluation of Environmental Shadow Flicker Analysis for "Dutch Hill Wind Power Project". Environmental Compliance Alliance, New York, USA, 30 January 2007]

69 This Section of the Review, **Acoustics**, provides evidence that the noise radiation from wind turbines is made up of a number of sound characters, which include low frequency noise (0Hz – 200Hz), infrasound (0Hz – 20Hz), vibration, rhythmic pulsation, and tonal qualities. Moreover, the noise combines with visual phenomena, such as strobe effects and shadow flicker, which can act synergistically with the acoustic qualities in the effects on people nearby. A prolonged dose at an appropriate level of any of these characters individually can evoke serious physiological changes in the human body, with health consequences.

Wind turbines emit a cocktail of acoustic characters and are delivered with a rhythmic, pulsating character, all of which can combine to create serious health responses from people if the wind turbines are constructed too close to their dwellings.

The ETSU-R-97 guidelines endorsed by the Dti do not protect families from the sleep deprivation and the consequent health effects where wind turbines are built too close to their homes.

Peter Hadden

Section 5.0 HEALTH EFFECTS

1 Levels of sound, both audible and inaudible (including that in the low frequency range) can have an adverse effect on health, not only psychologically, but also physiologically, with medical consequences. As previously discussed, wind turbines emit noise radiation, both audible and inaudible (including that in the low frequency range). The industry has struggled to accurately predict and control wind turbine noise and its impact on people in nearby dwellings, with inconsistent results. When installed near homes, the noise is not merely a persistent, unremitting nuisance. Whether in the UK, the US, Canada, the Netherlands, Australia, or elsewhere, those living near wind turbines share similar health and medical complaints.

2 Measuring the audibility of noise does not take into consideration that the human body also receives sound characters without the involvement of the auditory system.

3 Merely focusing on audible sound ignores the harmful impacts on human body organs of low frequency noise, vibration, and the whole combination of characters – e.g., pulsations – that act in combination to exacerbate the impact on the body's organs.

4 Acousticians measuring noise near wind turbines do not take into account the physiologic/medical aspects of the effects of noise, as this is not their area of expertise; only those with backgrounds in medicine, the human biologic sciences, and epidemiology can properly study the effects and responses of the human body to wind turbine noise.

5 Moreover, measuring the audibility of a sound, its loudness, and its characteristics does not account for the dose received. Dosimetry is an important part of the equation when considering the effects of noise on human health. Although one may acclimatise to certain noises, wind turbine noise, with its pulsating nature, varying harmonics and low frequency components, does not have a time-limit factor, and continues day after day and year after year, unlike noise at work, e.g., which has a time-limit factor. Because the impact on body organs builds over a long period of time, wind turbine noise is difficult to replicate in laboratory experiments. Moreover, it would be unethical to subject people to extended exposure in the laboratory setting.

6 According to 'Occupational and Community Noise', World Health Organisation Fact Sheet No 258 (February 2001, drawn from the WHO *Guidelines for Community Noise 1999*):

> *'The noise problems of the past are incomparable with those plaguing modern society … the thumps and whines of industry provide a noisy background to our lives. But such noise can be not only annoying but also damaging to the health, and is increasing with economic development.*
>
> ***Health Impact**. The recognition of the noise as a serious health hazard as opposed to a nuisance is a recent development and the health effects of the hazardous noise exposure are now considered to be an increasingly important public health problem.*

- *Prolonged or excessive exposure to noise whether in the community or at work, can cause permanent medical conditions, such as hypertension … (ref WHO Guidelines p XII).*
- *Noise can adversely affect performance, for example in reading, attentiveness, problem solving and memory. Deficits in performance can lead to accidents (ref WHO Guidelines p XII).*
- *A link between community noise and mental health problems is suggested by the demand for tranquillizers and sleeping pills …'*

7 The WHO fact sheet continues:

> Noise may '*interfere with communication, disturb sleep, cause cardiovascular and psycho-physiological effects, reduce performance, and provoke annoyance responses and changes in social behaviour … Many countries have regulations on community noise from rail, road, construction and industrial plants based on emission standards, but few have any regulations on neighbourhood community noise, probably owing to difficulties with its definition, measurement and control. This and the insufficient knowledge of the effects of noise on people handicap attempts to prevent and control the problem.'*

Environment	Critical Health Effect	Sound Level dB(A)*	Time hours
Outdoor living areas	Annoyance	50 – 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	**Sleep disturbance**	**30**	**8**
School classroom	Disturbance of communication	35	During class

Source: Who Fact Sheet No 258, Occupational and Community Noise, February 2001.

The WHO *Guidelines for Community Noise 1999* state that:

> *"The potential health effects of community noise include hearing impairment; startle and defense reactions; aural pain; ear discomfort; speech interference; sleep disturbance; cardiovascular effects; performance reduction; and annoyance responses. These health effects, in turn, can lead to social handicap; reduced productivity; decreased performance in learning; absenteeism in the workplace and school; increased drug use; and accidents. In addition to health effects of community noise, other impacts are important such as loss of property value."*

8 Indeed, the human body does emanate measurable ‘sound’, which can be detected by various testing equipment, as is used for excluding the presence of or for diagnosing disease. For example, in ‘EEG measurement’, G Blundell notes that

The brain operates	Normal activity	13 – 30 Hz
	Relaxed	8 – 13 Hz
	Drowsiness	4 – 7 Hz
	Deep sleep	0.5 – 4 Hz

[See also Hedge, A. ‘Whole body vibration’, Cornell University, April 2002; SafetyLine Institute, Government of Western Australia, ‘Whole body vibration effects on health’, 1998]

9 In the paper, “Human Body Vibration Exposure and its Measurement”, G. Rasmussen looked at body vibration exposure at frequencies of 1 Hz – 20Hz. This chart details some of the findings:

Symptoms	**Frequency**
General feeling of discomfort	4Hz – 9Hz
Head symptoms	13Hz – 20Hz
Influence on speech	13 Hz – 20 Hz
Lump in throat	12 Hz – 16Hz
Chest pains	5Hz – 7Hz
Abdominal pains	4Hz – 10Hz
Urge to urinate	10Hz – 18Hz
Influence on breathing movements	4Hz – 8Hz

10 Rasmussen's 'mechanical man' illustrates these distributions:

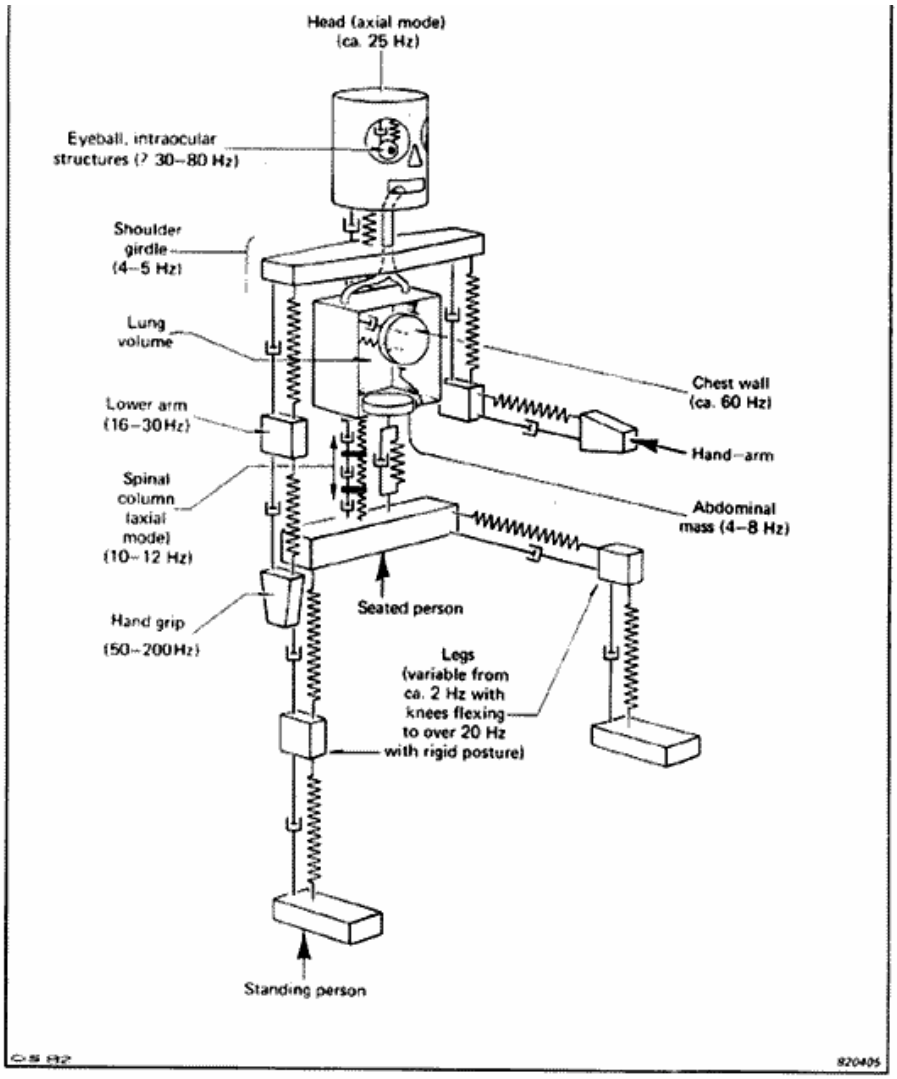


Fig. 1. Simplified mechanical system representing the human body standing on a vertically vibrating platform

Note that the head will vibrate at about 25 Hz and the chest wall at 60 Hz.

> *"Also, in the region 60 to 90 Hz disturbances are felt which suggest eyeball resonances, and a resonance effect in the lower jaw-skull system has been found between 100 and 200Hz."*

11 In "Community Noise Rating" [2d ed, Applied Science Publishers, 1982], the author, Theodore Shultz, wrote that the International Standards Organisation (ISO) had recently (1982) adopted a "Guide for the Evaluation of Human Exposure to Whole-Body Vibration".

In evaluating low frequency noise and vibration, he noted that there are:

> *"… four physical factors of primary importance in determining the human response to vibration: the **intensity**, the **frequency**, the **duration,** (exposure time) and the **direction** of the vibration."*

12 Shultz gives limits for longitudinal (2–axis) and for transverse (x–and y–axis) vibration respectively. Each curve, or boundary, represents a limit beyond which exposure to vibration carries a significant risk of fatigue or impaired working efficiency. Shultz comments:

> *"The 'exposure limit' boundaries are similar in general form to those for fatigue: but they lie 6 dB higher and the boundaries for reduced comfort have a similar form but lie 10dB lower than the fatigue boundaries."*
>
> *"The Standard mentions in a note that the criteria of acceptability in residential contexts, particularly at night, may lie near the threshold of detectability; for frequency bands of greatest sensitivity (4 – 8Hz for longitudinal, and 1 – 2 Hz for transverse vibration), this lies in the vicinity of* ***0.01m/s****, (though it varies greatly in individual circumstances)."*

Merely as a rough guide, the longitudinal acceleration limits for fatigue indicates that for 0.20 rms between 10Hz – 20Hz, the limits of exposure should not exceed 24hrs – 30hrs. For transverse exposure, the limit is only 10hrs. [Authors' note: See also Section 4.18 or this Review]

13 In his coursework description of "Whole Body Vibration", Prof Alan Hedge of Cornell University writes:

> *"Vibrations in the frequency range of 0.5Hz to 80Hz have significant effects on the human body.*
>
> *Individual body members and organs have their own resonant frequencies and do not vibrate as a single mass, with its own natural frequency. This causes amplification or attenuation of input vibrations by certain parts of the body due to their own resonant frequencies.*
>
> *The most effective resonant frequencies of vertical vibration lie between 4Hz and 8Hz.*
>
> *Vibrations between 2.5 and 5Hz generate strong resonance in the vertebra of the neck and lumber region with amplification of up to 240%.*
>
> *Vibrations between 4 and 6Hz set up resonances in the trunk with amplification of up to 200%.*
>
> *Vibrations between 20 and 30Hz set up the strongest resonance between the head and shoulders with amplification of up to 350%.*
>
> *Whole body vibration may create chronic stresses and sometimes even permanent damage to the affected organs or body parts."* [Hedge A. Whole body vibration. DEA350, April 2002, c January 2006]

14 The SafetyLine Institute (Government of Western Australia) notes in its documentation and coursework:

> "*Prolonged exposure to whole body vibration at frequencies below 20Hz results in hyperventilation, increased heart rate, oxygen intake, pulmonary ventilation and respiratory rate.*

Digestive system disease often observed in persons exposed to whole body vibration over a long period of time. Associated with the resonance movement of the stomach at frequencies between 4 and 5 Hz.

Spinal column disease and complaints, perhaps the most common disease associated with long term exposure to whole body vibration, where the back is especially sensitive to the 4 – 12Hz range."

15 One of the most important parts of the body with respect to vibration and shock appears to be the abdomen with the resonance occurring in the 4 – 8 Hz range. The other main resonant effect is found in the head and neck region, with a range of 20 – 30 Hz. Eyeball resonance is similar, with vibration in the range of 25 – 90 Hz. *'The skull itself has a fundamental mode of of vibration in the region of 300 – 400 Hz.'* [SafetyLine Institute of WorkSafe Western Australia, Department of Consumer and Employment Protection, Government of Western Australia. 'Identification of whole-body vibration: Effects on Health', SLI 1998]

16 Another study concurring with these results looked at human body vibration induced by low frequency noise in the range of 20 – 50 Hz:

"*The level and rate of increase with frequency of the vibration turned out to be higher on the chest than on the abdomen."* [Takahashi Y; Yonekawa Y; Kanada K; Maeda S. A pilot study on the human body vibrations induced by low frequency noise. Industrial health 1999 Jan; 37(1): 28-35]

17 Berglund, Hassmen, and Job, in "Sources and effects of low frequency noise", [Berglund B, Hassmen P, Job RF. JASA Journal of the acoustical society of America 1996 May; 99(5): 2985 – 3002] made these observations:

"The setting of the arbitrary lower limit of human hearing determines the lower limit of low frequency noise and the upper bound of infrasound. Such a setting is not a matter of absolutes. The threshold of hearing for tones and frequency bands depends on the loudness as well as the frequency and duration. In this sense, logically, human hearing capacity extends well below the 20 Hz range if one considers a signal that is sufficiently loud. Thus the threshold of absolute hearing extends well into the nominal infrasound range. It has been suggested that at very low frequencies human detection does not occur through hearing in the normal sense. Rather, detection results from nonlinearities of conduction in the middle and inner ear which generate harmonic distortion in the higher, more easily audible frequency range (von Gierke and Nixon 1976). This account does not dictate that the noise is not heard but rather that the method of hearing is indirect, as indeed is the mechanical method of all hearing (i.e. the relevant nerves are fired by changes in other biological structures in the ear, not directly by noise itself)."

"Second, regardless of the process by which a sound wave is detected, it is critical to consider waves which are detected through skeletal bones, the ear, harmonics, tactile senses or resonance in body organs. Detection raises the possibility of subjective reactions such as annoyance, and annoyance

may contribute in complex ways to other biological and psychological effects of the signal (Job 1993, Stansfield 1992.)"

"Third, determination of health and other effects of LFN must consider field data. Real occurrences of low frequency noise will often include considerable energy below 20Hz as well as energy in what is usually considered the LFN range. Thus the arbitrary setting of a cut off at 20Hz is not conducive to analysis of such data."

"The determination of precisely what constitutes LFN is also not perfectly clear in terms of its upper limit. Sound up to 250Hz are sometimes referred to as LFN although others have set the upper limit of the range to 100Hz (e.g. Backteman et al 1983a)."

18 In referring to impulsive noise, Berglund et al commented:

"… impulsive noise generates greater levels of subjective reactions such as annoyance and dissatisfaction than does non-impulsive noise of the same energy level."

The authors referred to the fact LFN travels extended distances with very little energy loss:

"… as the frequency wave is lowered, more of the energy enters the ear, the body and other objects (von Gierke & Nixon 1976). Thus LFN transmission extends into many objects allowing it to set up resonant vibration in our dwellings and our possessions as well as our chest cavities, sinuses, and throat." [Berglund et al]

19 Although within the aircraft industry, in extensive research on vibroacoustic disease (VAD, i.e., LFN-induced pathology), Dr M Pereira found that:

'… when continuous LFN is present in the home it can cause VAD. When pulsating LFN is experienced in the home it can aggravate the LFN induced pathology, either by making particular signs and symptoms more severe or by accelerating the onset of other signs and symptoms.

'Mainstream concepts hold that acoustical phenomena impact the human body through the auditory system. While this may be true for certain regions of the acoustical spectrum, there are other regions of the acoustical spectrum (0 – 250Hz – LFN) where acoustical phenomena impact the human body ***without*** *the involvement of the auditory system.* ***So any study that tries to understand the effects of LFN, as it is perceived by the auditory system is missing the point.'***

20 For those in work environments with extended exposure to large pressure amplitude and LFN (LPALF), e.g., for aircraft technicians, vibroacoustic disease is an occupational health hazard, a disease process that was studied extensively after patterns of health problems were observed.

21 In one study by Castelo Branco et al [Castelo Branco NA, Rodriguez E, Alves-Pereira M, Jones DR. Vibroacoustic disease: some forensic aspects. Aviation, space, and environmental medicine 1999 Mar; 70(3 Pt 2): A145-51], among 236

aircraft technicians, the disabilities manifested themselves after a minimum of 16 years. Disabilities included neurological (34%), psychiatric (9.7%), cardiovascular (6.8%), and osteoarticular (5.9%). Echocardiograms (EEGs) showed 'characteristic changes in pericardial structures', with five pericardial layers instead of three.

Among the study participants, 73% were disabled after an average of 24 years.

22 An important aspect of these studies is the observation that not only can noise have adverse health effects, but also that low frequency noise can adversely impact the human body. This is because, to reiterate, although people perceive sounds and noise via the auditory system:

> ***"Acoustical phenomena impact the human body without the involvement of the auditory system"*** and ***"any study that tries to understand the effects of LFN, as it is perceived by the auditory system is missing the point".*** [M Alves-Pereira]

23 In 2002, Moller and Lydolf [Moller H and Lydolf M. A survey of complaints of infrasound and low frequency noise. Journal of low frequency noise, vibration and active control 2002; 21(2): 53-63] reported on 198 persons who had reported complaints about noise, identified as infrasound and low frequency noise:

> "*Their verbal reports often described the sound as deep and humming or rumbling, as if coming from the distant idling engine of a truck or pump. Nearly all respondents reported a sensory perception of sound. In general they reported that they perceived the sound with their ears, but many mention also the perception of vibration, either in the body or external objects."*

The authors continue:

> *"The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents reported secondary effects, such as insomnia, headache and palpitation. Typically, measurements have shown that existing limits (and hearing thresholds) are not exceeded."*

Moller and Lydolf suggest that there is ample evidence to pursue this research issue further, including the frequencies and levels involved.

24 Research published in 2003 on low frequency and broadband noises and annoyance [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Sliwinska-Kowalska M. Assessment of annoyance from low frequency and broadband noises. International journal of occupational medicine and environmental health 2003; 16(4): 337-43] shows that:

> *"LFN was rated as significantly more annoying than BBN at the comparable A-weighted sound pressure levels. The annoyance assessment of either noise did not depend on age, length of employment or the level of exposure to noise at a current workplace. LFN presents a high risk of influencing human well-being …"*

Indeed, additional studies, most in controlled environments and laboratories, have confirmed their findings.

25 In a 2004 study conducted at the Nofer Institute of Occupational Medicine in Lodz, Poland, the authors wrote [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Szymczak W, Kamedula M, Sliwinska-Kowalska M. The effect of low frequency noise on human mental performance [article in Polish]. Medycyna pracy 2004; 55(1):63-74]:

> *'There is a growing body of data showing that low frequency noise (LFN) defined as broad band noise with dominant content for low frequencies (10 – 250 Hz) differs in its nature from other noises at comparable levels. The aim of this study was to assess the influence of LFN on human mental performance. Subjects were 193 male paid volunteers … LFN at 50 dB(A) could be perceived as annoying and adversely affecting mental performance (concentration and visual perception) …*

26 In another study by this group of 96 men and women, [Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Szymczak W, Sliwinska-Kowalska M. The impact of low frequency noise on human mental performance. International journal of occupational medicine and environmental health 2005; 18(2): 185 - 198], the authors note that:

> *"Low frequency noise differs in it nature from other environmental noise at comparable levels, which are not dominated by low frequency components."* [See also Berglund et al, Sources and effects of low frequency noise, JASA 1996]

Pawlaczyk-Luszczynska et al continue:

> *"Recent investigations show that low frequency noise at relatively low A-weighted sound pressure levels (about 40 – 45 dB) can be perceived as annoying and adversely affecting the performance, particularly when executing more demanding tasks. Moreover, persons classified as sensitive to low frequency noise may be at a higher risk."*
>
> The results of this study *"supports a hypothesis that LFN at levels normally occurring in the control rooms (at about 50 dB(A)) might adversely influence the human mental performance and lead to work impairment."*
>
> These authors also note *that "previous studies on the effects of community LFN (in dwelling rooms) showed that subjects sensitive to this type of noise were not necessarily sensitive to noise in general as measure by noise sensitivity scales … Sensitivity to this special type of noise [LFN] was somewhat different from sensitivity in general."*
>
> *"LFN at relatively low A-weighted SPL (about 40 dB) could be perceived as annoying and adversely affecting the performance, particularly when mentally demanding tasks were executed …"* [see also Persson Waye et al, Low frequency noise pollution interferes with work performance. Noise and health 2001 Oct-Dec; 4(13): 33 – 49]

The subjects *"reported a higher degree of annoyance and impaired working capacity during exposure to LFN … LFN adversely affected performance in two tasks sensitive to reduced attention in a proof-reading task."* [see also Bengtsson et al. Evaluation of effects due to low frequency noise in a low demanding work situation. Journal of sound and vibration 2004; 278(1/2): 83 – 99]

The authors conclude *that "the adverse effect of LFN at 50 dB(A) (compared to reference noise without dominant content of low frequencies) on performance was found in tasks demanding perceptiveness and concentration … Moreover, during exposure to LFN, differences in performance between higher and lower sensitive-to-noise subjects were observed in tasks requiring visual differentiation and selective or continuous attention; the persons categorized as high-sensitive to LFN achieved worse results than low-sensitive ones."* [Pawlaczyk-Luszczynska M, Dudarewicz A, et al, 2005]

27 Subsequent research reinforces the WHO *Guidelines for Community Noise 1999*. Pedersen and Persson Waye [Pedersen E, Persson Waye K. Perception and annoyance due to wind turbine noise – a dose-response relationship. JASA Journal of the acoustical society of America 2004 Dec; 116(4): 3460-70] studied the dose-response relationship of perception and annoyance caused by wind turbines. Their results conclude that:

"a significant dose-response relationship between calculated A-weighted SPL from wind turbines and noise annoyances was found. The prevalence of noise annoyance was higher than what was expected from the calculated dose."

The authors recommend further studies, to include the effect of visual impact.

In their paper, Pedersen and Persson Waye identify a factor that supports the WHO Guidelines in its discussion of sleep disturbance:

This *"wind turbine study was performed in a rural environment, where a low background level allows perception of noise sources even if the A-weighted SPL are low."*

"Wind turbine noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0 – 37.5 dB. This could be due to the presence of amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise. This is also confirmed by the fact that the aerodynamic sounds were perceived at a longer distance than machinery noise."

Although Pedersen and Persson Waye found that "*visual and/or aesthetic interference influenced noise annoyance"*, they also found that *"the influence of noise exposure was still a significant factor for noise annoyance."*

As the authors note:

> *"The high prevalence of noise annoyance could also be due to the intrusive characteristics of the aerodynamic sound … The verbal descriptors of sound characteristics related to the aerodynamic sounds of swishing, whistling, pulsating/throbbing, and resounding were – in agreement with this hypothesis – also reported to be most annoying."*

The extent of the impact of noise is pervasive:

> *"Most respondents who were annoyed by wind turbine noise stated that they were annoyed often, i.e., every day or almost every day. The high occurrence of noise annoyance indicates that the noise intrudes on people's daily life."*

Although their data was not extensive enough to draw conclusions on wind turbine noise and sleep disturbance, based on their observations they recommend that:

> *"... the probability of sleep disturbances due to wind turbine noise can not be neglected at this stage."* [Pedersen and Persson Waye, 2004]

28 There are numerous studies addressing the problems of noise causing sleep disturbance. The noise may be an annoyance but may also trigger physiologic changes that are signs of physiologic (bodily) stress.

29 In an article published in 2004, Griefahn and Spreng [Griefahn B, Spreng M. Disturbed sleep patterns and limitation of noise. Noise and health 2004 Jan-Mar; 6(22): 27-33] note that because of:

> *"… the indisputable restorative function of sleep, noise-induced sleep disturbances are regarded as the most deleterious effects of noise. They comprise alterations during bedtimes such as awakenings, sleep stage changes, body movements and after-effects such as subjectively felt decrease of sleep quality, impairment of mood and performance. The extents of these reactions depend on the information content of noise, on its acoustical parameters, and are modified by individual influences and by situational conditions."*

In context with the described nature of wind turbine noise, Griefahn and Spreng note that intermittent noise "*is particularly disturbing and needs to be reduced*."

30 When the human body responds to stress, there are biological functions activated:

> These functions *"serve an important role in the organism's adaptation to the environment by protecting and restoring the body but may, under certain conditions, also have health damaging consequences."* [Lundberg U. Coping with stress: neuroendocrine reactions and implications for health. Noise and health 1999; 1(4): 67-74] Lundberg writes that *"knowledge about these psychobiological pathways is of considerable importance for the possibilities to prevent and treat environmentally induced ill health."*

31 Further research by Ising et al [Ising H, Babisch W, Kruppa B. Noise-induced endocrine effects and cardiovascular risk. Noise and health 1999: 1(4): 37-48] reiterates that:

> *"Noise has the potential to cause stress reactions. Chronic noise-induced stress accelerates the ageing of the myocardium and thus increases the risk of myocardial infarction."*

The authors note that:

> *"The involved pathomechanisms include acute increase of catecholamines or cortisol under acute noise exposure and an interaction between endocrine reactions and intracellular Ca/Mg shifts."*

Furthermore:

> *"Recent epidemiological studies support the importance of noise as a risk factor in circulatory and heart diseases, especially in myocardial infarction."*

32 As Spreng notes [Spreng M. Possible health effects of noise induced cortisol increase. Noise and health 2000; 2(7): 59-64]:

> *"The auditory system is permanently open – even during sleep … Thus noise causes the release of different stress hormones (e.g., corticotrophin releasing hormone: CRH; adrenocorticotropic hormone: ACTH) especially in sleeping persons during vagotropic night/early morning phase. These effects occur below the waking threshold of noise and are mainly without mental control."*
>
> For example, *"Increased cortisol levels have been found in humans when exposed to aircraft noise or road traffic noise during sleep."*
>
> As a consequence, this imbalance has possible adverse health outcomes. *"The effects of longer-lasting activation of the HPA-axis, especially long-term increase of cortisol, are manifold"*, and include cardiovascular diseases.

Spreng also found that:

> *"Longer lasting activation of the HPA-axis, especially abnormally increased or periodically elevated levels of cortisol ... may lead to disturbed hormonal balance and even severe disease."* [Spreng M. Central nervous system activation by noise. Noise and health 2000; 2(7): 49-58]

33 Wust et al, in their research published in 2000 [Wust S, Wolf J, Hellhammer DH, Federenko I, Schommer N, Kirschbaum C. The cortisol awakening response – normal values and confounds. Noise and health 2000; 2(7): 79-88], state that:

"When measured with strict reference to the time of awakening the assessment of this endocrine response is able to uncover subtle changes in hypothalamus-pituitary-adrenal (HPA) axis activity, which are, for instance, related to persisting pain, burnout and chronic stress."

The HPA axis changes may serve as an indicator *"in subjects exposed to prolonged environmental noise."* The authors looked at four separate studies with a total of 509 subjects to *"provide reliable information on normal values for the free cortisol response to awakening. Corresponding with earlier findings, a mean cortisol increase of about 50% within the first 30 minutes after awakening was observed."*

This reinforces the determination of cortisol levels as a useful tool in identifying physiologic changes that may have clinical significance. *"The cortisol awakening response can be assessed under a wide variety of clinical and field settings, since it is non-invasive, inexpensive and easy-to-employ."*

34 In their review on the acute and chronic endocrine effects of noise [Ising H, Braun C. Acute and chronic endocrine effects of noise: review of the research conducted at the Institute for Water, Soil and Air Hygiene (Berlin, Germany). Noise and health 2000; 2(7): 7 – 24], Ising and Braun cover research results from the early 1980s, during which time:

"... mechanisms of acute noise-induced stress reactions as well as long-term increase of stress hormones in animals and persons under chronic noise exposure were studied."

They note that:
"… habituated noise caused a chronic increase of noradrenaline from the sympathetic synapses under longterm noise exposure at work. Environmental noise exposure (Leq >/= 60 dB(A) caused catecholamine increase if activities such as conversation, concentration, recreation etc. were disturbed through noise."

However, for a sleeping person, *"… traffic noise with only Leq >/= 30 dB(A) and Lmax >/= 55 dB(A) caused significant acute increase of cortisol, which developed into chronic increase if the noise exposure was repeated consistently."*

35 In 2002, Babisch [Babisch W. The noise/stress concept, risk assessment and research needs. Noise and health 2002; 4(16): 1-11] states that:

"In principle, the noise/stress hypothesis is well-understood: Noise activates the pituitary-adrenal-corticol axis and the sympathetic-adrenal-medullary axis. Changes in stress hormones including epinephrine, norepinephrine and cortisol are frequently found in acute and chronic noise experiments."

"Cardiovascular disorders are especially in focus for epidemiological studies on adverse noise effects … The relative importance and significance of health outcomes to be assessed in epidemiological noise studies follow a hierarchical order, i.e., changes in physiological stress indicators, increase

in biological risk factors, increase of the prevalence or incidence of diseases, premature death."

"Magnitude of effect, dose-response relationship, biological plausibility and consistency of findings among studies are issues of epidemiological reasoning."

Babisch identifies the need for further research:

"The cardiovascular risk is a key-outcome in non-auditory noise effects' research because of the high prevalence of related diseases in our communities. Specific studies regarding critical groups, different noise-sources, day/evening/night comparisons, coping styles and other effect-modifying factors, and the role of annoyance as a mediator of effect are issues for future research in this field."

36 Babisch emphasises these points [Babisch W. Stress hormones in the research on cardiovascular effects of noise. Noise and health 2003 Jan-Mar; 5(18): 1-11]:

"Since endocrine changes manifesting in physiological disorders come first in the chain of cause-effect for perceived noise stress, noise effects in stress hormones may therefore be detected in populations after relatively short periods of noise exposure."

Therefore, *"Stress hormones can be used in noise studies to study mechanisms of physiological reactions to noise and to identify vulnerable groups."*

37 Maschke and Hecht underscore the association of changes in stress hormones and sleep disturbances [Maschke C, Hecht K. Stress hormones and sleep-disturbances – electrophysiological and hormonal aspects. Noise and health 2004 Jan-Mar; 6(22): 49-54]:

"Frequent or long awakening reactions endanger therefore the necessary recovery in sleep and, in the long run, health. Findings derived from arousal and stress hormone research make possible a new access to the noise induced nightly health risk."

The author adds that, "*Frequent occurrences of arousal triggered by nocturnal noise"* disturbs the circadian rhythm. *"Additionally, the deep sleep phases in the first part of the night are normally associated with a minimum of cortisol and a maximum of growth hormone concentrations."*

The physical well-being and *"psychic recovery of the sleeper"* rely on the circadian rhythms *"of sleep and neuroendocrine regulations."*

"Noise exposure during sleep which causes frequent arousal leads to decreased performances capacity, drowsiness and tiredness during the day. Long-term disturbances of the described circadian rhythms have a deteriorating effect on health, even when noise induced awakenings are avoided." [Maschke C and Hecht K, 2004]

38 Spreng [Spreng M. Noise induced nocturnal cortisol secretion and tolerable overhead flights. Noise and health 2004 Jan-Mar; 6(22): 35-47] notes that:

> *"repeated noise events (e.g., overflights during night times) may lead to accumulation of the cortisol level in blood."*
>
> *"This fact and the unusual large permeability of cortisol through the cell membranes opens a wide field of connections between stress-dependent cortisol production and the disturbance of a large number of other endocrine processes, especially as a result of long-term stress activation by environmental influences such as environmental noise."*

39 Initial research into low frequency noise in a workplace [Bengtsson J, Persson Waye K, Kjellberg A. Evaluations of effects due to low-frequency noise in a low demanding work situation. J Sound Vibration 2004; 278: 83-99] was tested on subjects using two ventilation noises at 45 dB(A), one with low-frequency noise character. Most of the tasks required of the subjects were routine and undemanding.

> *"The major finding was that low-frequency noise negatively influenced performance on two tasks sensitive to reduced attention and on a proof-reading task, while performance of tasks aimed at evaluating motivation were not significantly affected. The negative effects on performance were not reflected by the subjective reports."*

40 Further research has shown that noise with a low-frequency component also has an effect on cortisol levels. In a work environment experiment with *"exposure to ventilation noise, with dominant low frequencies (low-frequency noise) or a flat frequency spectrum (reference noise)"*, with both noises at 40 dB(A): [Waye KP, Bengtsson J, Rylander R, Hucklebridge F, Evans P, Clow A. Low frequency noise enhances cortisol among noise sensitive subjects during work performance. Life sciences 2002 Jan 4; 70(7): 745-58]

> *"The normal circadian decline in cortisol concentration was however significantly attenuated in subjects high-sensitive to noise in general, when they were exposed to the low frequency noise. This noise was rated as more annoying and more disruptive to working capacity than the reference noise. The study showed physiological evidence of increased stress related to noise sensitivity and noise exposure during work."*
>
> This study demonstrates the *"effect of moderate levels of noise on neuroendocrine activity."*
>
> The authors conclude that *"The impact of long-term exposure to moderate noise levels, and particularly low frequency noise, in the workplace deserves further investigation."*

41 Noise and noise with a low frequency component influence cortisol levels during sleep as well. [Waye KP, Clow A, Edwards S, Hucklebridge F, Rylander R. Effects of nighttime low frequency noise on the cortisol response to awakening and subjective sleep quality. Life sciences 2003 Jan 10; 72(8): 863 – 875]

42 Waye et al studied traffic noise or low frequency noise (LFN) and night-time effects on the cortisol awakening response and subjective sleep quality:

> *"A significant interaction between night time exposure and time was found for the cortisol response upon awakening. The awakening cortisol response following exposure to LFN was attenuated at 30 minutes after awakening. Subjects took longer to fall asleep during exposure to LFN."*
>
> *"This study thus showed that night time exposure to LFN may affect the cortisol response upon wake up and that lower cortisol levels after awakening were associated with subjective reports of lower sleep quality and mood."*

43 The WHO *Guidelines for Community Noise 1999* address sleep disturbance caused by noise:

> *'Measurable effects of noise on sleep begin at LAeq levels of about 30 dB. However, the more intense the background noise, the more disturbing is its effect on sleep. Sensitive groups mainly include the elderly, shift workers, people with physical or mental disorders and other individuals who have difficulty sleeping.*
>
> *Sleep disturbance from intermittent noise events increases with the maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep. Therefore, to avoid sleep disturbance, guidelines for community noise should be expressed in terms of the equivalent sound level of the noise, as well as in terms of maximum noise levels and the number of noise events. It should be noted that low-frequency noise, for example, from ventilation systems, can disturb rest and sleep even at low sound pressure levels.*
>
> *When noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided. For noise with a large proportion of low-frequency sound a still lower guideline value is recommended. When the background noise is low, noise exceeding 45 dB LAmax should be limited, if possible, and for sensitive persons an even lower limit is preferred. Noise mitigation targeted to the first part of the night is believed to be an effective means for helping people fall asleep. It should be noted that the adverse effect of noise partly depends on the nature of the source. A special solution is for newborns in incubators, for which the noise can cause sleep disturbance and other health effects.' (WHO Guidelines for Community Noise, p xiii, 1999)*

44 Physicians, particularly general practitioners who are community-based, are often the first to detect patterns of symptoms described by their patients. Thus was the situation for Dr Amanda Harry, a physician in Cornwall, who in 2003 noted that patients began complaining of poor sleep, headaches, stress, and anxiety. [Harry A. Wind Turbines, Noise and Health. In process for publication, 2007] For example, further discussion with one couple revealed that their health problems coincided with the commissioning of wind turbines, approximately 400 meters from their home. Their symptoms were relieved when they were away from their home, and from the wind turbines. Their symptoms occurred

when the wind blew in certain directions: the noise was sometimes so disrupting that they would go to a nearby bed and breakfast, just far enough away to sleep undisturbed.

45 As a result of her initial clinical observations, Dr Harry investigated further, finding that physicians elsewhere had noted – as had those living near wind turbines have reported – a similar constellation of symptoms. Dr Harry's research included contact and interviews with respondents from a number of sites near wind turbines in the UK – Wales, Cornwall, and the north of England; her international contacts have included among them, France, Germany, Portugal, the Netherlands, and the USA.

Based on her research, Dr Harry concludes that *'further independent research is warranted'*, although she also notes reluctance for those affected to participate:

> *'There is much concern within communities that if one is seen to complain about the noise that if they decide to move away their properties will be difficult to sell and possibly devalued as a result. Therefore they feel that they are in a "Catch 22" situation.'*

46 As a concerned and inquisitive health professional, Dr Harry initiated her own independent pilot study, as she noted a dearth of research on the health effects of wind turbine noise.

The three key areas surveyed by Dr Harry included:

1. *Has your health in any way been affected since the erection of these turbines?*
   -- 81% of the 42 respondents reported that their health had been affected.

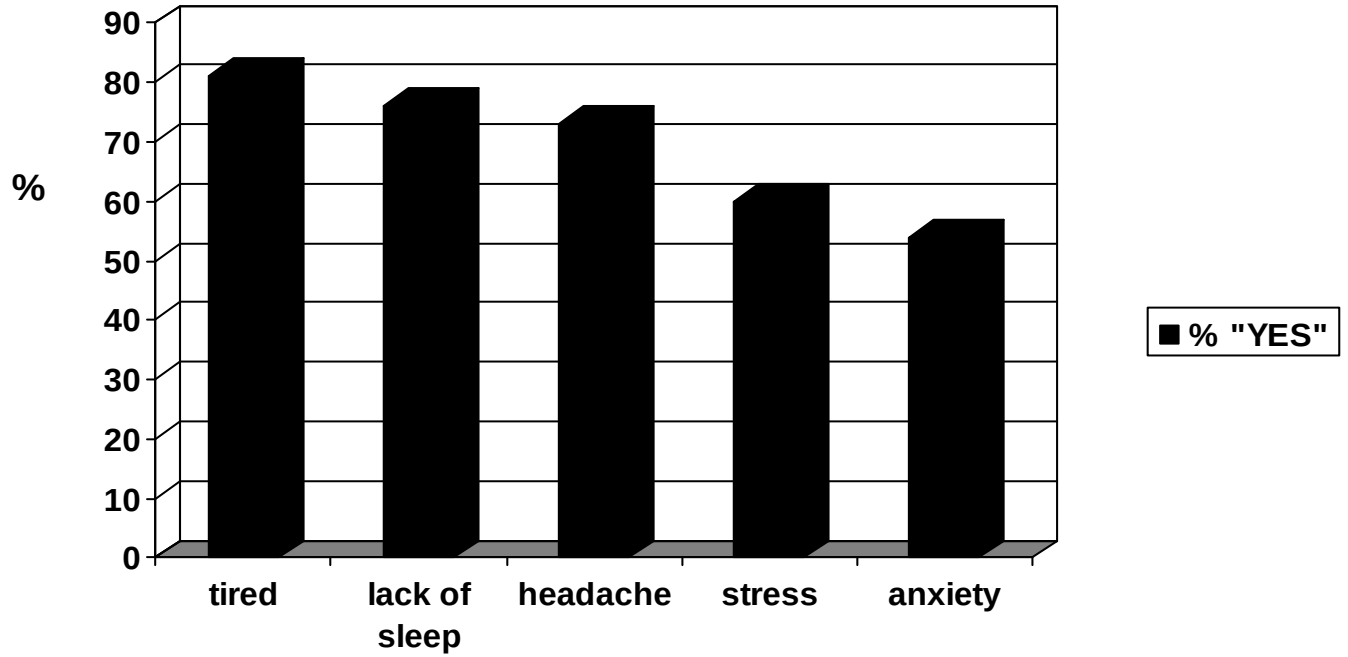
2. *As a result, have you gone to see your doctor?*
   -- 76% of the respondents felt that the effects had been severe enough to initiate a visit to a physician.

3. *Do you feel that your quality of life has in any way been altered since living near the wind turbines?*
   -- 73% of these respondents reported that their quality of life had been adversely impacted.

The following charts summarise the responses by those included in this pilot phase.

Note that 80% of respondents felt that the presence of wind turbines had precipitated at least one symptom that impelled them to visit their physicians.

“Do you feel that since living near a wind turbine you have experienced an excess of any of the following symptoms?”

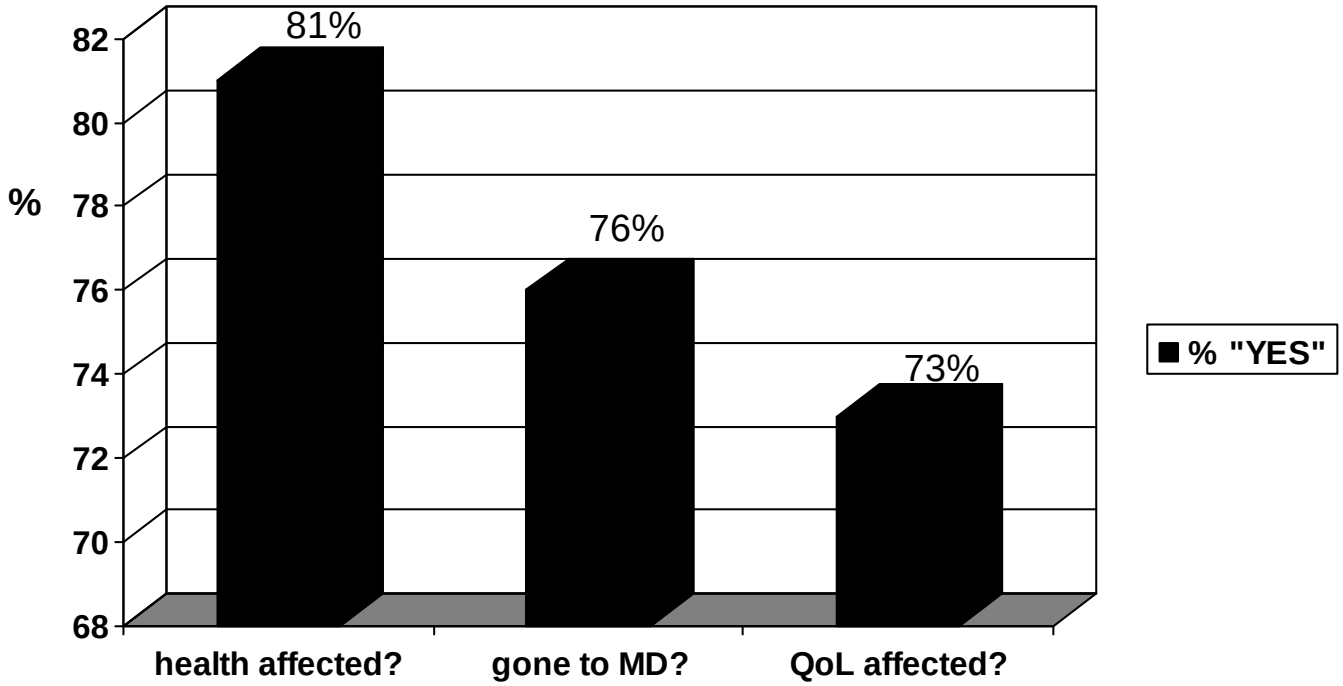


Top 5 Self-reported Health Symptoms

2006 UK Wind Turbine Survey (n = 37)

2006 UK Wind Turbine Health Survey: 3 Key Questions

1. ***Has your health in any way been affected since the erection of these turbines?***
2. ***As a result, have you gone to see your doctor?***
3. ***Do you feel that your Quality of Life has in any way been altered since living near the wind turbines?***



Top 5 Self-reported Health Symptoms

2006 Devon Wind Turbine Survey (n = 42)

47 Dr Harry's inquiries led her to conclude:

> *'There are people living near turbines who are genuinely suffering from health effects from the noise produced by wind turbines. These neighbours of turbines clearly state that at times the noise from turbines is unbearable. The developers are usually heard to say that noise is not a problem. Clearly this cannot be the case.'*
>
> *'Some of these acoustic experts have made statements categorically saying that the low frequency noise from turbines does not have an effect on health. I feel that these comments are made outside their area of expertise and should be ignored until proper medical, epidemiological studies are carried out by independent medical researchers.'*

48 **As a result of her observations and investigation, Dr Harry concluded that wind turbines should be sited not less than 1.5 miles (2.4 km) from the nearest home or residential facility.**

49 The impact of wind turbines on health has commanded the attention of physicians elsewhere. On the basis of patient contacts and research into existing medical evidence, Nina Pierpont, MD, PhD, a physician with a practice in New York State [USA], has suggested that the emerging pattern of complaints by those living near wind turbines is not coincidental. Dr Pierpont supports renewable energy but says that the place for wind energy *'is not near people's homes or near schools, hospitals, or other locations where people have to sleep or learn'*.

50 As Pierpont notes, wind farms are *'large industrial installations' that produce 'large scale, industrial noise'*. [Pierpont N. Wind Turbine Syndrome: testimony before the New York State Legislature Energy Committee, March 7, 2006] Pierpont summarises the constellation of symptoms as 'Wind Turbine Syndrome'; these symptoms include:

1. Sleep problems. Noise or physical sensations of pulsation or pressure make it difficult to go to sleep and cause frequent awakening;
2. Headaches. Headaches increase in frequency or severity;
3. Dizziness, unsteadiness, nausea;
4. Exhaustion, anxiety, anger, irritability, and depression;
5. Problems with concentration and learning; and,
6. Tinnitus (ringing in the ears).

> *'Chronic sleep disturbance is the most common symptom. Exhaustion, mood problems, and problems with concentration and learning are natural outcomes of poor sleep.'*
>
> Pierpont also notes that *'Deciding whether people have significant symptoms is not within the expertise of engineers or specialists in acoustics ...'* Moreover, *'not everyone near turbines has these symptoms ... there are differences among people in susceptibility. These differences are known as risk factors ...'*

51 Pierpont mentions several risk factors:

1. Sensitivity to low frequency vibration, which is highly variable in people, and poorly understood [lack of research].

2. Pre-existing migraine disorder – migraines are not merely severe headaches. Migraines are a *'complex neurologic phenomenon which affects the visual, hearing, and balance systems'*, and can affect motor control and consciousness. Many people who experience migraines have heightened sensitivity to noise and to motion.

People rely on the input from three sources in order to maintain balance: the eyes; the 'stretch receptors in joints and muscles'; and 'balance organs in the inner ear'. To maintain balance, two of these systems must be working in agreement. If not, *'one feels both ill and unsteady'*, as with vertigo or seasickness.

> *'Wind turbines impinge on this system in two ways: by the visual disturbance of the moving blades and shadows, and by noise or vibration impacting the inner ear.'*

3. Age-related changes in the inner ear – *'Disturbing the inner ear disturbs mood, not because a person is a whiner or doesn't like turbines, but because of neurology.'*

Pierpont continues:

> *'Data from a number of studies and individual cases document that in rolling terrain, disturbing symptoms of the Wind Turbine Syndrome occur up to 1.2 miles from the closest turbine. In long Appalachian valleys, with turbines on ridge-tops, disturbing symptoms occur up to 1.5 miles away. In New Zealand, which is more mountainous, disturbing symptoms occur up to 1.9 miles away.'*

52 As with other health professionals and those other professionals and organisations who have scrutinised the health effects of wind turbine noise, **Pierpont recommends a minimum setback of 1.5 miles (2.4 km) of wind turbines from people's homes, schools, hospitals, and similar institutions**, while also urging appropriate epidemiologic studies and analysis of clinical data by qualified, independent medical researchers.

53 Indeed, the medical research literature supports the clinical observations of Drs Harry and Pierpont, as well as those by researchers such as Pedersen, Persson Waye, Berglund, and van den Berg. Moreover, as already mentioned, the symptoms described by those living near wind turbines coincide with those symptoms described in the broader literature examining noise and its health effects. Those living near wind turbines complain not only of noise, but also of the character of that noise (impulsive, pulsating, periodic), as well as the impact and synergy of the 'visual noise' of wind turbines, i.e., the shadow flicker and strobe effect from the motion of the blades.

54 Earlier research in the area of headache and migraine showed that patients with tension headaches or migraine are more sensitive to light (photophobia) and

sound (phonophobia) than those who are not prone to headaches. Those who are prone to tension headache or migraine are more sensitive to light and noise even during the intervals between headache occurrences. (Those with cluster headaches are more sensitive during headache, but not during remission.) [Drummond PD. Sensitivity to light and noise in tension-type and cervicogenic headache. Cephalalgia 1998; 18: 303]

Drummond also states that:

> *'Mechanisms that normally suppress photophobia are disrupted during the headache-free interval as well as during migraine. The persistence of phonophobia in various forms of headache implies that a similar process modifies sensitivity to sound ...'*

55 Many who live near wind turbines complain of headaches and migraines (new onset of problem or exacerbation), e.g., as with more than 70% of Dr Harry's respondents. (See also Section 3.0 of this paper, Overview of the Problems.) Indeed, researchers have studied phonophobia and photophobia (including flicker) and their association with headache and migraine, which may help explain some of the clinical symptoms shared by those living near wind turbines – although epidemiologic studies are clearly urged.

Moreover, researchers have also noted that learning can be affected by noise; for example, Wolach and Pratt found that:

> *'Processing was prolonged when the distracter items were phonological.'* [Wolach I; Pratt H. The mode of short-term memory encoding as indicated by event-related potentials in a memory scanning task with distractions. Clinical neurophysiology 2001 Jan; 112(1): 186 – 197]

56 Between 70% – 83% of migraine patients are phonophobic during an attack, and 76% remain more sensitive between attacks. Headache patients – both tension-type and migraine – were hypersensitive to sound both with and without pain. [Vanagaite Vingen J, Pareja JA, Støren O, White LR, Stovner LJ. Phonophobia in Migraine. Cephalalgia 1998; 18: 243-249]

Furthermore, Vanagaite Vingen et al found that:

> *'... the results of the questionnaire study refute the argument that anxiety about provoking attacks is the main cause of the increased sensitivity to sound outside attacks.'*

57 Researchers have also studied how trigger factors acquire the capacity to precipitate headache. In one study [Martin PR. How do Trigger Factors acquire the capacity to precipitate headaches? Behaviour Research and Therapy 2001; 39: 545-554], participants were exposed to validated trigger factors:

> *' "visual disturbance" (flicker, glare and eyestrain) induced by a very bright, stroboscopic light'*:
>
> *'The headache sufferers experienced more visual disturbance and head pain in response to the stimulus than the non-headache individuals.'*

Martin concludes that *'more research is needed urgently to clarify the processes by which trigger factors acquire and lose their capacity to precipitate headaches'* – some studies recommend avoidance of triggers, while others recommend desensitisation.

58 In 2003, McKendrick and Badcock analysed flickering stimuli between migraine attacks. [McKendrick AM, Badcock DR. An analysis of the factors associated with visual field deficits measured with flickering stimuli in-between migraine. Cephalalgia 2004; 24: 389-397] In this study, the authors measured flicker perimetric performance in a broad group of migraine sufferers and found that:

'The migraine groups showed significantly lower general sensitivity across the visual field and higher incidence of localized visual field deficits relative to controls.'
(Note: The most severe migraine sufferers, those on preventative therapy, were not included in this study.)

The authors also suggest that *'there is some contribution of both migraine frequency and cumulative migraine history in determining general sensitivity to flickering stimuli across the visual field.'*

In addition, the authors found *'a weak, but statistically significant, correlation between decreased generalized sensitivity and increased migraine frequency. Abnormalities in cortical neuronal function that increase susceptibility to migraine, thereby resulting in more frequent attacks, may manifest as decreases in generalized visual sensitivity ...'* This implies *'... some cumulative effect of migraine on visual processing'.*

59 It is not only migraine sufferers whose attacks may be triggered or exacerbated by light or noise. One study looked at headaches triggered by negative affect or by noise, analysing physiologic responses,

'including 'headache intensity ratings, forehead electromyographic activity, heart rate, blood pressure, and temporal pulse amplitude (TPA).' ('TPA is thought to be a measure of arterial distension caused by the passage of the pressure pulse.') [Martin PR, Todd J, Reece J. Effects of Noise and a Stressor on Head Pain. Headache 2005; 45: 1353-1364]

The authors note that physiologic changes occur during an episode of headache:
'... both stressor and visual disturbance could trigger headaches. The stressor was associated with increases in blood pressure, heart rate, and temporal pulse amplitude (TPA), while visual disturbance was associated with increases in blood pressure only.'

One group of subjects, the Stressor group, was given highly difficult anagrams to solve, accompanied by failure feedback to create anxiety and mood change. Another group of subjects was exposed to a 'Noise Challenge', a white noise that resembled a loud and un-tuned television set. As the authors observe, those exposed to the Noise had an aversive response.

A third group, exposed to both Stressor and the Noise Challenge simultaneously, rated noise levels as higher than the group exposed only to the noise, even though the noise levels were identical.

The authors found that *'79% of subjects exposed to noise developed a headache.'*

> Significantly**: *'Increased headache ratings occurred during the noise challenge relative to the control condition and continued through the recovery period even though the noise was no longer present.'*** [emphasis added]
>
> Moreover, while 'Negative Affect' (those exposed only to the Stressor of the anagrams) was not associated with physiologic changes when compared to controls:
> *'The Noise Challenge led to elevated TPA [Temporal Pulse Amplitude].'*

60 Martin, Todd, and Reece note that in a previous study, Martin and Teoh had found that visual disturbance as a trigger for headache was also associated with physiologic changes, specifically increases in blood pressure, heart rate, and TPA. [Martin PR, Teoh H-J. Effects of visual stimuli and a stressor on head pain. Headache 1999; 39: 705-715]

Martin, Todd, and Reece conclude that:

> ***'... none of the physiological changes associated with headache induction were in terms of muscle tension – all were in terms of cardiovascular variables.'*** [emphasis added]

61 Martin, Reece, and Forsyth looked more closely at headaches and noise exposure and sensitivity. Headache sufferers most commonly report stress, anxiety, glare, and noise, as triggers; negative affect, visual disturbance, hunger, and noise are experimentally validated triggers. [Martin PR, Reece J, Forsyth M. Noise as a trigger for headaches: relationship between exposure and sensitivity. Headache 2006; 46: 962-972]

In this study, the authors consider whether those who suffer headaches should endure short exposure to triggers to desensitise themselves to the trigger (hypothetically), although this might lead to increased sensitivity (again, hypothetically).

The authors used Noise for their study as it is commonly cited as a trigger for headache, and it has been experimentally validated. The 'white noise' consisted of multiple frequencies similar to an un-tuned television set, at high intensity (but with no threat to the auditory systems of the participants).

The authors conclude:

> *'Through the study, headache patients reported that they found the noise stimulus more aversive and it resulted in reports of more pain, than non-headache patients ... For individuals who do not suffer from regular headaches, the analyses strongly supported the avoidance theory ... However, for individuals who do suffer from regular headaches, the results were less clear-cut.'*

Significantly for those who live near wind turbines and suffer headaches, the authors observe:

> *'In the 'very long' noise exposure condition, the non-headache group showed further desensitization beyond the 'long' exposure condition whereas the headache group showed sensitization relative to the 'long' exposure condition.'*

However:

> *'The findings from individuals who suffer from regular headaches do not provide clear guidance as to whether avoidance or exposure to trigger factors is a better strategy from the perspective of desensitization/sensitization.* ***The data hint at the possibility that for the trigger factor of noise, 'long' exposure may be helpful but 'very long' exposure may be unhelpful.*** *This paper has argued for the potential benefits of exposure to triggers* ***but it seems likely that exposure at too high a level will be counterproductive.****'* [emphasis added]

62 On 17 January 2007, The Planning Inspectorate dismissed an appeal to allow two wind turbines at Penpell Farm, Par, Cornwall, near Lanlivery, UK. The Inspector cited these four as among the most significant considerations:

i. The impact upon the landscape, a nearby World Heritage Site, ancient monuments, and listed buildings;
ii. The impact on the quality of life, including the visual and noise effects on those who would live near the wind turbines;
iii. The impact upon the local economy, including tourism, recreation, and a local day centre for the disabled;
iv. The benefit of the proposal to meet Government, Regional, County, and local policy aims for renewable energy.
(emphasis added)

However, critical issues also revolved around the health concerns for a boy with severe autism, who lives with his family in a home that would have been one of the nearest to the wind turbines, as well as the health concerns for the attendees of the day centre for the disabled.

The Inspector concluded that the young man would face serious difficulties adapting to the presence of the wind turbines, which would then have serious consequences and hardship for the family, who are the caregivers:

> *'... there is likely to be harm, and that these are exceptional circumstances that carry some weight as a material consideration against the appeal proposal.'*
> [The Planning Inspectorate, Bristol. Appeal Decision, by RD Hiscox. Appeal ref: APP/Q0830/A/05/1189328, Penpell Farm, Par, St Austell, Cornwall, PL24 2SA, 17 January 2007]

63 It appears that those living near wind turbines and experiencing sleep disturbance, headache, migraine, and/or anxiety and the accompanying physiologic effects are enduring adverse health effects outside their sphere of control. To reiterate the advice of health professional organisations, e.g., the French National Academy of Medicine; health professionals, researchers, and reports such as UKNA's *Location, Location, Location*, **wind turbines should be sited no closer than 2km to a place of residence (with some recommending even greater separation, i.e., 2.4 km)**.

64 Indeed, after learning about Dr Harry's pilot study, media reports of noise problems from wind turbines, and research on the adverse effects of noise on health, Prof Ralph Katz, Chair of the Department of Epidemiology and Health Promotion, New York University (USA), expressed concern that wind turbines had been constructed in close proximity to homes without research into their potential effects on health.

> *'No one knows the prevalence of health syndromes where there are pockets of people living next to turbines, so what would be the effects where there are clusters?'*

In 2004, Prof Katz recommended a two-year moratorium on wind turbine construction near dwellings in order 'to allow for a multi-disciplinary team of scientists to research all the health and environmental concerns.' [Young N. Wind power debate blows near and far. Western Morning News, 23 January 2004] A two-year moratorium would give epidemiologists enough time to gather and analyse data in order to determine if there is a causal link, although research beyond two years may be required. Moreover, this would avert needless adverse health impacts and an additional burden on the National Health Service in 15 to 20 years time. [Katz R. Personal communication, 3 February 2007]

65 According to Deepak Prasher, Professor of Audiology at the Ear Institute of University College London:

> ***'Noise not only annoys, it causes stress that can have an impact on our health and well-being. It can lead to anxiety, sleep problems, communication difficulties, even cardiovascular and immune changes, of which, the individual is usually unaware.'*** (emphasis added)
> [Prasher D. Widex Noise Report: traffic noise in England 2007. University College London (UK) and Widex, January 2007, www.widex.co.uk]

66 Wind turbines are not only a matter of renewable energy policy, but also – and no less significantly – a matter of public health policy.

The World Health Organisation's Guidelines for Community Noise 1999 included these recommendations:

> Governments should "*include noise as an important issue when assessing public health matters and support more research related to the health effects of noise exposure.*
>
> *Municipalities should develop low-noise implementation plans.*
>
> *Governments should support more policy-relevant research into noise pollution*
>
> *Development of continuous monitoring systems for direct health effects in critical locations.*
>
> *Development of instruments appropriate for local/regional surveys of people's perceptions of their noise/sound environments.*
>
> *Procedures for evaluating the various health effects of complex combined noise exposures over 24 hours on vulnerable groups and on the general population.*

65 The WHO report also recommended further research related to direct and/or long-term health effects:

> *Identification of potential risk groups.*
>
> *Studies of dose-response relationships for various effects.*
>
> *Studies on the perception of control of noise exposure, genetic traits, coping strategies and noise annoyance as modifiers of the effects of noise on the cardiovascular system, and as causes of variability in individual responses to noise.*
>
> *Knowledge on the health effects of low-frequency components in noise and vibration.*
>
> *Studies on the influence of noise-induced sleep disturbance on health, work performance, accident risk and social life.*
>
> *Development of a methodology for the environmental health impact assessment of noise that is applicable in developing as well as developed countries.*
>
> *Studies to assess the effectiveness of noise policies in maintaining and improving soundscapes and reducing human exposures.*

66 Thus, the evidence strongly supports those who complain of adverse health effects when living within close proximity of wind turbines, particularly the impacts from noise and shadow flicker/strobe effects. Their symptoms parallel those found in other areas of research into the physiologic and medical impact of noise on people. Various noise characters, low frequency noise, infrasound, and shadow flicker, all delivered with a pulsating character, over a prolonged period, pose health risks when developers site wind turbines too close to homes.

Section 6.0 HUMAN RIGHTS

1. Landowners have many rights pertaining to their property, but there are legal restrictions, requirements, and liabilities. A property related activity that produces an environmental pollution escaping onto a neighbour's property, causing a mischief and health problems, may trigger an interference with Article 8 of the European Human Rights Act, enacted in the UK as The Human Rights Act 1998. In the UK, a liability may arise in Tort (Rylands v Fletcher). The Environmental Protection Act 1990 (Part 3) may trigger a Statutory Nuisance. This Section of the review looks at the European Community Human Rights Act as a measure of acceptability of the level of violation and in particular considers its application to the UK.

2. In a speech to the Human Rights Lawyers Association in London on 29 September 2006, Lord Falconer of Thornton, Constitutional Affairs Secretary and Lord Chancellor, said:

   > "*We in government will campaign passionately and defiantly for human rights for everyone in Britain. Because we believe it is the foundation of both our security and our prosperity.*"
   >
   > *"It (Democracy) is an acceptance of the values of equality, tolerance and freedom. We are all equal. We are all entitled to have our individual freedoms protected. We can only safeguard our democracy and our freedoms by the rule of law. Those values must be protected and given effect by law." The freedoms set out in the European Convention on Human Rights reflect those values. They are not the property of lawyers."*

3. In discussing UK Government departments' responsibilities, the Lord Chancellor said:

   > *"In essence this involves ensuring an individual's human rights addresses the issues of possible infringement, justification and proportionality."*

4. Environmental Pollution becomes significant when the pollution threatens or affects people's health. The UK is party to many Policy initiatives that give a high priority to environmental issues. For example, Article 37 of the European Union's Charter of Fundamental Rights provides:

   > *"A high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured in accordance with the principle of sustainable development."*

   These principles are based on Articles 2, 6, &174 of the EC Treaty.

5. Increasingly, noise is recognized as a serious environmental problem. For example, EC Directive 2002/49/EC states: "*Whereas: (1) It is part of the Community Policy to achieve a high level of health and environmental protection, and one of the objectives to be pursued is protection against noise. In the Green Paper on Future Noise Policy,* ***the Commission addressed noise in the environment as one of the main environmental problems in Europe."***

The Human Rights Act and Environmental Pollution.

6 There are two areas of the Human Rights Act 1998 that particularly address Environmental Pollution:

i) Article 8, Right to Respect for Private and Family Life

a) Everyone has the right to respect for his private and family life, his home and his correspondence.

b) There shall be no interference by a public authority with the exercise of this right except as in accordance with the law and as necessary in a democratic society in the interests of… the economic well-being of the country for the protection of disorder or crime, or for the protection of health or morals, or for the protection of the rights and freedoms of others.

7 Article 8 is a Qualified right, i.e., it can be interfered with if the interference is justified. The interference:

i. must be **lawful** (e.g., decisions that the planning acts allow);
ii. must serve one of the **legitimate aims** in Article 8 (2); and,
iii. must be **proportionate**.

The **Legitimate aims** under Article 8 (2) include:

i. National security,
ii. Economic well-being,
iii. Prevention of disorder or crime,
iv. Protection of health or morals,
v. Protection of rights and freedoms of others, e.g., the right of a developer to develop his own land and the right of a neighbour to be protected from noise nuisance, and,
vi. Protection of environment and the interests of the community.

Proportionality must consider:

i. Is the interference the minimum necessary to achieve the legitimate aims being pursued?
ii. Has a fair balance been struck?
iii. Interference with a human right must go no further than is strictly necessary in a pluralistic society to achieve its permitted purpose; or more succinctly, must be appropriate and necessary to its legislative aims.

8. **ii) Article 1 of the First Protocol, Protection of Property.**

a) Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law.

b) The preceding provisions shall not in any way impair the right of the State to enforce such laws as it deems necessary to control the use of property in accordance with the general interest or to secure the payment of taxes or other contributions or penalties.

i. Article 1 of the First Protocol is a qualified right;
ii. Property and possessions include land, rights, planning permissions, licences and goodwill (business);
iii. Everyone is entitled to peaceful enjoyment of his possessions;
iv. Prevention of development may infringe the right;
v. Diminution in value of property may be relevant; and,
vi. Justification for interference:

a. must be lawful,
b. must serve one of the legitimate aims in the Article, and,
c. must be proportionate.

9. Are there circumstances when a wind turbine, or a cluster of wind turbines, will be a violation of the Human Rights Act? The European Court of Human Rights is the final arbiter of this question, but there are a number of important considerations of fact that should be addressed, and Case Law provides a lead as to how the Court might consider the question.

Evidence supports the proposition that wind turbines create environmental noise pollution, posing a serious health risk to families where wind turbines are built too close to their homes.

10. **Section 3** of this Review, **"The Overview of the Problems",** reviews the nature of the impacts on people's lives where wind turbines are built too close to their homes.

The common complaints in response to the noise of wind turbines include: sleep deprivation, fatigue, depression, insomnia, headaches, inability to concentrate, agitating – frustrating – annoying (no escape, infrequent remission, unpredictability of noise), all of which trigger more serious health problems.

11. **Section 4** of this Review, **Acoustics,** reviews research and reports on acoustic radiation from wind turbines. The papers reviewed indicate that UK acousticians working in the wind industry seem to have concentrated their studies upon audible sound. The research and reports confirm that it is the combination of audible sound, infrasound, and vibration, in a pulsating character, that appear to trigger serious reported health problems in those families living near wind turbine installations.

The health problems appear to be aggravated when at certain times of the year strobing light and shadow flicker from the rotating blades projects at the same pulsation rate as the noise. The UKNA report, ***Location, Location, Location*** [August 2006], which considered both acoustic and medical advice, concluded:

> ***"It would be prudent that no wind turbine should be sited closer than 1 mile away from the nearest dwellings. This is the distance the Academy of Medicine in Paris is recommending, certainly for the larger turbines and until further studies are carried out. There may even be occasions where a mile is insufficient depending on the scale and nature of the proposed development."***

Wind turbines located too close to dwellings will cause environmental noise pollution.

12. **Section 5** of this Review, **Health Effects**, reviews research and reports on Health. The medical research included in this section is international in scope; most of the citations were retrieved via the databases of the US National Library of Medicine (The National Institutes of Health, Bethesda, Maryland, www.nlm.nih.gov), with additional citations from the major engineering and biologic science databases, e.g., Web of Science. These resources are among the most comprehensive and authoritative available, and articles were published in peer-reviewed journals.

Among the findings of the effects of noise on health, sleep deprivation emerges as a significant factor, which is likely to trigger more serious medical conditions. Some of the physiological changes may be cumulative or irreversible, which can have critical consequences not only in terms of individual health, but also in terms of community health, when the source of the problem is community-based.

The Courts appear to acknowledge that health, as a state of physical, mental and social well-being, is a precondition to any meaningful privacy or intimacy, and inseparable from it. The Courts also recognise that sleep deprivation is a serious condition to the extent that it might be considered as an element of inhuman and degrading treatment under Article 3. In ***Ireland v The United Kingdom,*** the Court held that: *"…holding the detainees in a room where there was a continuous loud and hissing noise …"* constituted inhuman and degrading treatment.

13 The cause of the violation is shown but the **Legitimate Aims, Article 8 (paragraph 7 above)** need to be considered:

i) **National Security**:
The National Security of a country is not going to be impacted if an onshore wind farm is not built. In fact, it may be argued that because the flow of electricity from a wind farm to the National Grid is not in the control of the Nation, but subject to the control of the weather, in a National emergency the supply of electricity from an onshore wind farm can never be relied upon. Furthermore, electricity flowing to the National Grid from a wind farm is neither secure nor reliable in delivery.

14 ii) **Economic Well-being**:
The viability of the National Economy will not be impacted if an onshore wind farm is not built. The National Audit Office have questioned the viability of the ROC (Renewable Obligation Certificate), introduced by the State, which provides the attractive financial investment returns to onshore wind farm developers; moreover, the system is not providing value for money to the consumer. [National Audit Office, Auditor General, HC624 Session 2002-2003. The New Electricity Trading Arrangements in England and Wales, 9 May 2003; also NAO HC 210 session, 2004-2005, 11 Feb 2003] Many argue the introduction of ROCs has been an important influence in stimulating rising electricity prices to consumers, which in turn contributes to increasing inflation which is not in the economic well-being of the country. [Refer also to

Renewable Energy Foundation (REF) The Oswald Research, 2006; also REF submission to the Yelland Wind Farm, Devon, Planning Appeal, 2 April 2006]

In 2006, Professor James Lovelock captured the attention of the international community with his book on global warming, 'The Revenge of Gaia'. On page 83, he comments:

> *'According to the Royal Society of Engineers' 2004 report, onshore European wind energy is 2 – 5 times, and offshore wind energy over 3 times, more expensive per kilowatt hour than gas or nuclear energy. No sensible community would ever support so outrageously expensive and unreliable an energy source were it not that the true costs have been hidden from the public by subsidies and the distortion of market forces through legislation.'* [Lovelock J. The Revenge of Gaia: Why the Earth is Fighting Back – and How We Can Still Save Humanity. Allen Lane (Penguin), 2006]

The Dti Report "Our Energy Challenge 2006" refers to the work of Prof David Simpson in his April 2004 report for the David Hume Institute. The Paper: *"Tilting at Windmills: The Economics of Wind Power" (No. 65)*, states:

> *"At the present time the cost of generating electricity from wind power is approximately twice that of the cheapest alternative conventional cost."*
>
> *"But projections by Government advisers, using relatively optimistic assumptions, show that even by the year 2020 a generation portfolio containing 20% wind power will still be more expensive than a conventionally fuelled alternative."*
>
> *"No matter how large the amount of wind power capacity installed, the unpredictably variable nature of its output means that it can make no significant contribution to the security of energy supplies."*

There is no evidence to show that onshore wind power makes any real contribution to the economic well being of the UK. If all the onshore wind turbines in the UK were shut down, there is no evidence that this shut down would have any impact on the National economy.

15 iii) **Prevention of Disorder or Crime**:
This is not influenced by wind farm developments.

16 iv) **Protection of Health and Morals:**
Wind farms built too close to peoples' homes are unlikely to have any impact on peoples' morals, but they do create very real health problems as set out in **Section 5**, **Health Effects**.

Section 4, of this Review**, Acoustics**, contends that the use of guidance ETSU-R-97 fails to protect families where wind turbines have been built too close to their homes, noting that The World Health Organisation's upper limit for bedroom noise at night offers greater protection to people, family life, and amenity. In considering whether a scheme will be a violation of the Human Rights Act, it is necessary for the decision-maker to seriously consider the advice of The World Health Organisation on standards for Community Noise, as its maximum noise levels are designed to limit noise impact on health.

The WHO limits bedroom noise at night to a **combined (total)** noise level of 30dB, and the level is reduced when low frequency content is present and reduced even further when pulsating noise is present. On windy nights, it is the total noise, including background noise, that enters the bedroom, and that should not exceed the maximum level. The difference in approach between ETSU and WHO probably accounts for much of the sleep deprivation described in **Section 3** of this Review, **Overview of the Problems**.

17 In deciding the status of ETSU-R-97 in terms of the Human Rights Act, it is important to remember that the membership of the Committee that produced the ETSU report in 1997, appeared weighted towards members working in or for the wind industry. This may account for the Committee's recommendation of the high level of environmental noise pollution that would have to be suffered by neighbouring families. While admitting the importance of preventing sleep deprivation, the ETSU Committee recommendation was instead weighted at a level that the Committee felt would not restrict the development of wind energy. As a result, it would seem that the Committee tipped the balance disproportionately in favour of wind farm developers over the impact on community quality of life and the protection of the health of people living nearby.

18 Case law has shown that the violation is the key factor; and if the State has a 'bylaw' that fails to provide adequate protection, then the State remains liable.

The Minutes of the new ETSU-R-97 Noise Working Group, (Committee formed by the State and chaired by the State), dated 02 August 2006, fails to mention any discussion on:

1) The need to comply with The Human Rights Act
2) The World Health Organisation ***"Guidelines for Community Noise 1999"***
3) The Report from the National Academy of Medicine, France (March 2006)
4) The Report by the United Kingdom Noise Association ***"Location, Location, Location"*** (Aug 2006).

Evidence shows that families suffer sleep deprivation and other health problems when wind turbines are built too close to dwellings; this is indicative of the State failing to provide adequate health protection. Interference to this extent is not justified.

19 v) **Protection of Rights and Freedom of Others**:
Clearly, the site owner has the right to develop his land in accordance with the provisions of the County and Local Development Plans under the Town Planning Acts.

However, apart from arguments of a Town Planning nature, the landowner has to recognize that the neighbours also have rights. The development of land that creates an environmental noise pollution, which escapes onto a neighbour's land, may create a violation of the Human Rights Act 1998, as well as an infringement of The Environmental Protection Act, and the nuisance might be classed as a strict liability in Tort ***(Rylands v Fletcher)***.

20 Regarding a wind farm, it is incumbent on the site owner to produce a layout design that prevents or limits to reasonable levels the environmental pollution entering the neighbours' properties, which is most likely achieved by ensuring a suitable distance between the noise source and the neighbours' properties.

The landowner may argue that the State has set Guidance on the level of noise pollution that the State believes is at an acceptable level to neighbours. However, compliance with these Guidance levels may not satisfy the Human Rights Act. The status of the Guidance is worth considering:

> Planning Policy PPG24: Planning & Noise – General principles (2), states:
> *"The Planning system has the task of guiding development to the most appropriate locations. It will be hard to reconcile some land uses, such as housing, hospitals and schools, with other activities which generate high levels of noise but the Planning system should ensure that, wherever practicable, noise sensitive developments are separated from major sources of noise (such as road ... and certain types of industrial development). It is equally important that new development involving noisy activities should, if possible, be sited away from noise sensitive land uses."*
>
> Planning Policy Statement 22 (2004) S.22 'Noise', states:
> *"Renewable technologies may generate small increases in noise levels … Local Planning authorities* ***should*** *ensure that renewable energy developments have been located and designed in such a way to minimize increases in ambient noise levels … The 1997 report by ETSU for the Dti* ***should*** *be used to assess and rate noise from wind energy developments".*

The use of the word "**should**" – rather than the phrase 'will be used' – allows the decision maker to use ETSU-R-97 together with any other relevant considerations.

21 vi) **Protection of the Environment and the Interests of the Community.** The attempt to reduce one form of pollution (carbon) by the creation of a new pollution (noise pollution) and visual pollution is not credible. (Visual pollution is mentioned because many will argue that a fixed, motionless, wind turbine standing in a field is unlikely to provoke much interest. The moment the blades start to rotate, the structure captures the eye and it has the ability to mesmerize or distract some people.)

22 A wind farm does not create new jobs, as one engineer can service a number of wind farms. Rural areas depend mainly on agriculture and tourism as the key employment. Countryside Tourism, by its very title, is supported by people seeking solitude, walking, and a contrast to urban and suburban living. Tourism customers will not find solitude and unspoilt rural landscape where wind farms have industrialised the area. Although some wind farm developers make a token financial contribution to a community, this is 'de minimus' compared with the potential loss in property values resulting from the environmental pollution and industrialisation created by the wind turbines. [The Small Business Council. UK Energy Policy: *The Small Business Perspective and the Impact on the Rural Economy*. Report by Whitmill C for the SBC, February 2006] (See also this paper's **Appendix on Property Values**)

23 Referring again to the Report from The David Hume Institute (S6.13), Prof Simpson commented:

> *"Because of the cost of providing additional stand-by generating capacity, it is unlikely that wind power will ever account for more than 20% of electricity generation through the National Grid. That being the case, its development can make no substantial contribution to an overall reduction in carbon emissions."*

The Dti acknowledges that wind turbines require separate balancing power provided by conventional power stations, in order to balance the flow of electricity to the National Grid. Nuclear power is not suitable because of its slow response time. Conventional power, therefore, provides balancing power in the form of gas, oil, or coal. In the UK, it is normally gas (methane). The construction of onshore wind farms with high volatility in supply of electricity require near similar (MW) balancing power. This has the effect of increasing demand for methane. The transportation of methane has inherent issues, since the leakage is about 4% by volume. **Methane is 24 times more destructive as a greenhouse gas than carbon dioxide**. [Lovelock J. The Revenge of Gaia, 2006, pp 74-5]

24 Having in mind the similar MW capacity 'balancing power' will be constantly fired up, demanding methane gas of which about 4% by volume will disperse into the atmosphere, it is difficult to comprehend how onshore wind farms can be considered as protecting the environment – especially when the noise pollution is added to the equation.

25 Many local communities support the production of renewable energy, but they do not support the creation of environmental pollution as an acceptable consequence. Onshore wind turbines built in sparsely populated, wide-open spaces, around the world, cause few noise problems. However, schemes proposed in well-populated areas are those most likely to evoke a huge swell of community objection. In the final equation, the excessive environmental noise pollution escaping onto neighbouring property, plus the visual pollution from the constant rotation of the blades nearby, plus the reliance on back-up balancing power fuelled by methane gas, balanced against a small saving in carbon (using the National power balance rather than coal as the carbon measure), shows the cost imposed on neighbouring families is not justifiable.

Case Law

26 The European Court of Human Rights has made it very clear that environmental considerations may involve a breach of Article 8, even after allowing a margin of appreciation to the State.

27 In ***Lopez Ostra v Spain*** (1994) 20 EHRR 2777:

> *S.51 Naturally, severe environmental pollution may affect individuals well-being and prevent them from enjoying their homes in such a way as to affect their private and family life adversely, without, however, seriously endangering their health.*
>
> *S.58 Having regard to the foregoing, and despite the margin of appreciation left to the respondent State, the Court considers that the State did not*

succeed in striking a fair balance between the interest of the town's economic well-being – that of having a water treatment plant – and the applicant's effective enjoyment of her right to respect for her home and her private and family life.

28 In ***Guerra & Others v Italy*** (1998) 26 EHRR. 3577:

S.58 The Court considers that Italy cannot be said to have " interfered" with the applicants private or family life: they complained not of an act by the State but of its failure to act. However, although the object of Article 8 is essentially that of protecting the individual against arbitrary interference by the public authorities, it does not merely compel the State to abstain from such interference: in addition to this primary negative undertaking, there may be positive obligations inherent in effective respect for private or family life.

S.60 The Court reiterates that severe environmental pollution may affect individuals well being and prevent them from enjoying their homes in such a way as to affect their private and family life adversely …The Court holds, therefore, that the respondent State did not fulfill its obligation to secure the applicants' right to respect for their private and family life, in breach of Article 8 of the Convention.

29 In ***Fadeyeva v Russia*** (June 2005) ECHR 55723

S.64 The applicant alleged that there had been a violation of Article 8 of the Convention on account of the State's failure to protect her private life and home from severe environmental nuisance arising from the industrial activities of the Severstal steel-plant.

S.132 The Court finds the following. The State authorized the operation of a polluting enterprise in the middle of a densely populated town. Since the toxic emissions from this enterprise exceeded the safe limits established by the domestic legislation and might endanger the health of those living nearby, the State established that a certain territory around the plant should be free of any dwelling. However, these legislative measures were not implemented in practice.

S. 133 It would be going too far to state that the State or the polluting enterprise were under an obligation to provide the applicant with free housing, and, in any event, it is not the Court's role to dictate precise measures which should be adopted by the States in order to comply with their positive duties under Article 8 of the Convention. In the present case, however, although the situation around the plant called for a special treatment of those living within the zone, the State did not offer the applicant any further solution to help her move from the dangerous area. Furthermore, although the polluting enterprise at issue operated in breach of domestic environmental standards, there is no information that the State designed or applied effective measures which would take into account the interests of the local population, affected by the pollution, and which would be capable of reducing the industrial pollution to acceptable levels.

S 134 The Court concludes that, despite the wide margin of appreciation left to the respondent State, it has failed to strike a fair balance between the interests of the community and the applicant's effective enjoyment of her

right to respect for her home and her private life. There has accordingly been a violation of Article 8.

30. In ***Moreno Gomez v Spain*** (16 November 2004) 4143/02
In this case, the applicant had lived in a residential quarter of Valencia since 1970. In June 1996, the City Council approved a bylaw on noise and vibrations. Article 8 of the bylaw says that in a family residential area (such as the one in which the applicant lives) external noise levels were not to exceed 45 dBA Leq between 10pm and 8am. Article 30 of the bylaw defines 'acoustically saturated zones' as areas in which the large number of establishments, activity of the people frequenting them and passing traffic expose local residents to high noise levels and cause them serious disturbance. The applicant was exasperated by the situation, which prevented her from sleeping and resting and caused her insomnia and serious health problems.

S 57 The present case does not concern interference by public authorities with the right to respect for the home, but their failure to take action to put a stop to third-party breaches of the right relied on by the applicant.

S 60 In view of its volume – at night and beyond permitted levels – and the fact that it continued over a number of years, the Court finds that there has been a breach of the rights protected by Article 8.

S 62 In theses circumstances, the Court finds that the respondent State has failed to discharge its positive obligation to guarantee the applicants right to respect for her home and her private life, in breach of Article 8 of the Convention.

31 The above Cases reveal how the European Court of Human Rights has considered breaches of Article 8 where the root cause of the issue is an environmental pollution. A loss of a view that has triggered a loss in property value has not, in itself, been considered a breach of Article 8 and Article 1 of the First Protocol. This was shown in the Case of ***Lough & Ors v Secretary of State and Bankside Developments***, July 2004, in the UK Court of Appeal, before Pill LJ, Keene LJ, and Scott Baker LJ. The Appellants were objectors to a development proposal that had been permitted following a Planning Appeal. The Appellants submitted that the Inspector had erred, it was claimed, in failing to consider three of the complaints made by the Appellants: loss of a view, interference with television reception during the construction of the proposed building and the diminution in value of 15% to 20% in the properties. The Court of Appeal upheld the previous Court's decision that there was no breach of Article 8. The Court found the creation of a diminution of value as a separate and distinct breach of Article 8 and Article 1 of First Protocol was not proven.

32 However, diminution in value has been an important consideration when noise pollution is the interference: In ***Dennis and Dennis v Ministry of Defence*** (2003) EWHC 793 (QB), Mr Justice Buckley found an interference with the Convention rights of the Claimants whose enjoyment of their home (and its value), Walcott Hall, was impaired by the noise of overflying Harrier jets during pilot training exercises from nearby RAF base at Wittering. Also in ***Hatton v UK*** (2003) 37 EHRR 288, the Court had to consider, in the context of Article 8, the level of noise caused by night flights at Heathrow Airport and its effect on nearby residents.

In S.96:

> *Article 8 protects the individual's right to respect for his or her private and family life, home and correspondence. There is no explicit right in the Convention to clean and quiet environment, but where an individual is directly and seriously affected by noise or other pollution, an issue may arise under Article 8.*

33 The **Hatton** judgment also clarifies the nature of the State – or regulatory authority's "positive obligations" to regulate private parties and the balancing exercise it is called upon to perform.

> *S118: It is clear that in the present case the noise disturbance complained of were not caused by the State or State organs, but that they emanated from the activities of private operators. It may be argued that the changes brought about by the 1993 Scheme are to be seen as a direct interference by the State with the Article 8 rights of the persons concerned. On the other hand, the State's responsibility in environmental cases may also arise from a failure to regulate private industry in a manner securing proper respect for the rights enshrined in Article 8 of the Convention. As noted above (S98), broadly similar principles apply whether a case is analysed in terms of a positive duty on the State or in terms of an interference by a public authority with Article 8 rights to be justified in accordance with paragraph (2) of the provision…The question is whether, in the implementation of the 1993 policy on night flights at Heathrow airport, a fair balance was struck between the competing interests of the individuals affected by the night noise and the community as a whole.*

34 Mr Justice Buckley in ***Dennis & Dennis v MOD*** **[2003]** made a further point on "proportionality". The decision established an important principle in domestic law in relation to proportionality and compensation. First, he found that the evidence of severe noise nuisance and consequent loss in value of the estate established an interference with both Article 8 and Article 1 of the First Protocol. In these circumstances, he held that a fair balance would not be struck in the absence of compensation.

> "*I believe it is implicit in the decision **S v France**, that the public interest is greater than the individual private interests of Mr and Mrs Dennis but it is not proportionate to pursue or give effect to the public interest without compensation for Mr and Mrs Dennis … in my view, common fairness demands that where the interests of a minority, let alone an individual, are seriously interfered with because of an overriding public interest, the minority should be compensated."*

35 Without an acceptable scheme for compensating those directly or seriously affected by the noise and economic loss, a proposed development of wind turbines cannot be said to achieve a fair balance, as per ***S v France***. As a consequence, if there is a violation of Article 8, it follows there is most likely to be a violation of Article 1 of the First Protocol, and it is submitted that the damage will flow from the escape of the environmental noise pollution plus an element of value directly attributable to the visual pollution (flicker/strobing).

36 **Justification for Interference**

Once an interference with the families' Convention rights is considered likely, the question is then whether that interference can be justified in order to avoid a violation of the Convention right. To justify the interference it must be shown to be "in accordance with the law and … necessary in a democratic society" in the interests of one of the recognized categories listed in Article 8(2) or in the public interest under Article 1 of the First Protocol. It is accepted that if the decision makers for the State approved the development by granting a Planning permission, in accordance with the Town and Country Planning Act, it would be in accordance with the law. However, the development may not satisfy other elements of justification.

37 The interference might be "necessary in a democratic society" only if:

a) It was in response to a pressing social need; and,
b) It involved no greater interference than required to address that need (this is the proportionality principle).

38 It is difficult to see how a wind farm development satisfies any of the Article 8(2) social need categories: "national security, public safety, the economic well-being of the country, the prevention of disorder or crime, the protection of health or morals or for the protection of the rights and freedoms of others".

39 The stated purpose of most wind farm developments is to promote renewable energy in order to reduce carbon emissions and thus protect the global environment. Conceivably this could involve protecting the rights or freedoms of others, but it would be a weak claim and not sufficient to justify interfering with an individual's valuable rights of privacy under the Article 8.

Moreover, it could be argued that the wind turbine developer could attain the same goal of reducing carbon emissions, with an increased buffer zone between homes and the wind turbines. Thus, the developers' and communities' needs would both be met.

Other options might include using smaller wind turbines, fewer wind turbines, controlling blade rotation speed, and turning them off at night.

40 Whether onshore wind turbines satisfy the "public interest" requirement of Article 1 of the First Protocol is a separate question. It is arguable that the wind turbines do not satisfy primary Government Energy Policy and are therefore not in the public interest.

41 Government Policy, as set out in the Energy White Paper [Dti. *Energy White Paper: Our Energy Future: Creating a Low-Carbon Economy*. Dti: London, 2003], strives to maintain the ***"reliability of energy supplies***" (S. 1.18.) and states that ***"reliable energy supplies are fundamental to the economy as a whole and to sustainable development. An adequate level of energy security must be satisfied at all times in both the short and long term futures."***

42 The national importance of reliability in energy supply is taken forward in *"Our Energy Challenge"*, the Dti consultation document issued in 2006. The State set several goals for the country's energy supply:

a. *"To maintain the reliability of energy supplies."* [p 11, S.1]
b. *"The Regulatory framework must give high priority to reliability."* [p 32, S.2.2.2, Reliable energy supplies]
c. *"Maintaining the reliability of electricity supplies will require very substantial levels of new investment …"* [p 50, S.3.1., Looking ahead]

The key feature of onshore wind generation is its total unreliability in the supply of electricity. Furthermore, because the Dti 2006 document is a major review of UK energy policy, within its 72 pages, there is little mention of onshore wind power, which demonstrates just how insignificant it is to the State as a future electricity-generating source.

43 Furthermore, in his report, *"Power to the People"*, Professor MA Laughton noted the innate unreliability of wind as a secure source of energy:

> *"… a more detailed examination of one aspect is necessary, namely that concerning the interaction of random, intermittency of supply with security, bearing in mind that security of electricity requires continuity of power delivery, not energy."*
>
> *"Large weather systems, particularly high pressure windless systems, can cover most of the country, as seen during the January 2003 cold spell for several days and again during the subsequent July heatwave. At such times the contribution from any wind … are severely curtailed."*
> [Laughton MA. Power to the People: future-proofing the security of UK power supplies. ASI Adam Smith Institute, London 2003]

44 The unreliability of electricity supply and flow from wind turbines is further emphasised in the following reports:

a) *"An Engineering Appraisal of the PIU Energy Review"*, The Royal Academy of Engineering for the Energy Minister, August 2002; and,

b) *"Energy at the crossroads, The Chemical Engineering Contribution to the UK Energy Debate"*, The Institution of Chemical Engineers for the Energy Minister, September 2002.

45 The generation of electricity from wind turbines depends entirely upon the weather. Because this resource is uncontrollable by man, the electricity flow is unreliable and unpredictable. In failing to provide a reliable and secure electricity supply, wind turbine generation thus does not comply with Government Energy Policy.

46 It is however necessary to recognize that the Dti Energy Review [2006] supports offshore wind farms because firstly the wind offshore is more reliable than onshore wind, thereby producing substantially higher effective electricity generation. Secondly, an array of several hundred wind turbines linked to a central collecting pod on the seabed can feed electricity by a single cable to the shore, where a hydrogen generation plant could be located. With a large hydrogen storage capacity, this hydrogen plant would then generate electricity by burning hydrogen in a controlled, reliable, and sustainable form supplying electricity directly to the National Grid. This combination only then meets the National Policy for the reliability and security of electricity supply, i.e., the source of electricity supply is from hydrogen storage.

47 It is also necessary to recognize that the Dti Energy Review supports onshore solace wind turbines serving an industrial unit, commercial premises and small communities. This works because the amount of electricity generated is 'de minimus' and destined for direct commercial consumption. This system allows the National Grid to act as provider of balancing power to the industrial/commercial user without disruption to the network supply.

48 Wind turbine developers often argue that wind turbines are State Policy. It has not been possible to find documentation to support this proposition. It may be more correct to say that State Policy takes the form of setting targets for renewable energy generation and that industry's response to meeting these targets is the wind turbine as it is available technology. Furthermore, the State has set targets in the form of 'installed capacity', and apparently it matters not to the State that in some locations, actual electricity production on an annualised basis is merely circa 24% of installed capacity. While State Policy clearly identifies 'reliability' and 'security' of supply as critical objectives, wind turbines will not satisfy this Policy. The EU Court of Human Rights might wonder at the remoteness of wind turbines from fulfilling Policy.

49 There is **no justification** in allowing wind turbines to be built so close to peoples' homes with the result that they fail to meet the noise limitations set out by the World Health Organisation *Guidelines for Community Noise 1999*, a consequence of which is to create serious health damage and a likely violation of the Human Rights Act 1998.

50 In considering the question of Tort, it is a well established principle of UK law that if a landowner collects something onto his land that is likely to do mischief if it escapes onto adjoining land; then if it does escape, the landowner is liable for the damage ***(Rylands v Fletcher)*** (L.R.1. Ex 265, 279 – 80):

> "*The person who for his own purposes brings on his lands and collects and keeps there anything likely to do mischief if it escapes, must keep it in at his peril, and if he does not do so, is prima facie answerable for all the damage which is the natural consequence of its escape.*"

51 In the House of Lords, Lord Cairns added that in order for the Rule to apply, the defendant's use of the land must be "non-natural". P James on Law of Torts points out:

> *"The Rule applies to things likely to do mischief if they escape, e.g. water, gas, electricity, fumes, rusty wire from fencing, explosions…. To give liability there must be an escape from the premises/land."*

52 The owner of land operating a wind turbine to generate electricity is performing an industrial activity by installing the turbines, collecting the wind, using the wind to manufacture electricity, and discharging the wind (and the resulting wind vortices) over his land. During the manufacturing process, the wind changes its form, velocity, and character, and collects sound characters of its own and in combination with the design and engineering of wind turbines, creates environmental pollution. Over distance, the pollution dissipates and within large sites, the pollution dissipates before leaving the land boundaries. However, on small sites in well-populated areas, the pollution will still be present when the wind – and the resulting wind vortices created by the wind turbines – enters a neighbour's property, mischief is likely to occur with consequent damage to health. The liability may be a strict liability under the Rule of ***Rylands v Fletcher*** and not covered by indemnities or insurance cover. Cases that are more recent include: ***Bottomley v Todmorden***, High Court 2003, and ***Transco v Stockport Metropolitan Borough Council***, House of Lords 2003.

53 Others have noted that perhaps the wind farm developers' contractual indemnities are qualified by the requirement of proof of negligence and based upon strict liability under ***Rylands v Fletcher***, which would mean that in such circumstances liability falls on the landowner.

54 The failure of the State to properly protect the health of people from environmental noise pollution that is a consequence of development permitted by the State, is not justified.

55 This section considered the application of the EU Human Rights Act, Article 8 and Article 1 of the First Protocol, to the physiological and medical suffering of families caused by a decision by the State that allows developers to build wind turbines too close to homes. The weakness of the Human Rights Act is exposed by the fact that decision makers of the State rely on the argument 'balance in favour of the State', to justify serious violations of family to the right of respect for private and family life. Yet applying the dictum of Justice Buckley (S.6.34), if the State considers wind turbines are public policy, then the 'minority' interest should be compensated. If wind turbines are not State policy, then decision makers may be challenged when they use the 'balance in favour of the State' to justify giving an approval that risks a violation of basic Human Rights.

The UK Lord Chancellor has said that:

> *"We in Government will campaign passionately and defiantly for human rights for everyone in Britain. Because we believe it is the foundation of both our security and our prosperity."* [S. 6.02]

On 10 May 2006, The British Consulate, New York, sent an email entitled, *"UK Elected to UN Human Rights Council"*. The last paragraph states:

> *"The UK remains committed to striving for the highest standards of human rights both at home and around the world. We are committed to fulfilling the detailed pledges we made as part of our election campaign to promote and protect human rights in the UK and globally. We will play the fullest part in making the new Human Rights Council a success."*

It is for the reader to judge the evident disparity between the words and the deeds of the UK State when it permits developers to build wind turbines too close to dwellings. The disparity might possibly be explained by the enthusiasm of Departments of State to achieve renewable energy targets set by the State, and in order to achieve those targets, treat the Human Rights Act as an obstacle to circumvent.

Peter Hadden

[Note: Sentences emboldened within quotations are the author's emphases.]

Section 7.0 CONCLUSION

The environmental noise pollution from wind turbines built too close to dwellings causes serious discomfort, and often health injury, to families. Oftentimes those affected did not object to the construction, accepting the developer's assurances that noise would not be problematic.

Section 4 of this Review, **Acoustics**, explores the research on noise radiation from wind turbines. Locating wind turbines close to families demands a precision, accuracy, and certainty of acoustic prediction and calculation that is just not available to the wind energy engineers and acousticians. The ETSU-R-97 Noise Working Group (UK) concluded that it would be too restrictive on wind farm developments to provide the protection necessary [i.e., to prevent sleep deprivation].

The challenges in designing a predictive model for wind turbine noise are complex. Factors include the very nature of wind turbine design itself, e.g., the rotation of the blades through the air, each passing the tower rhythmically, creating a characteristic pulsating sound as well as a vortex of air; moreover, there is an interaction among the turbines, so the placement of each turbine within an array can influence noise emission. Other factors include the constantly changing atmosphere and wind speed, temperature, and terrain. Noise, particularly low frequency noise, travels not only seismically but also airborne over terrain. On occasion, the local geography can act like a giant microphone. Thus, when wind turbines are located too close to dwellings, their noise may have an adverse impact on residents, because the methods and models used to predict wind turbine noise have distinct design limitations.

The result is an adverse impact not only to quality of life, but those who live near wind turbines may also suffer adverse health effects. Research links noise to adverse health effects, e.g., sleep deprivation and headache. Sleep deprivation itself may lead to physiologic affects, such as a rise in cortisol levels, a sign of physiologic stress, as well as headache, mood changes, and inability to concentrate. Initial research into the health impact of wind turbine noise (including the 'visual noise' of shadow flicker) reveals similar findings. Indeed, while many studies in work environments or laboratory simulations confirm these responses, those living near wind turbines endure continuous, long-term exposure.

Thus, the personal and media reports, emerging clinical evidence, and published research combine to offer urgent and compelling reasons for Government to reconsider policy on wind turbine developments. Several reports offer guidance, including the World Health Organisation *Guidelines for Community Noise 1999*; the UK Noise Association's report, *Location, Location, Location* (2006); and the statement by the French National Academy of Medicine (2006).

These are also compelling reasons for the Government to seek expert independent medical advice and epidemiologic research to assess the health impacts in order to prevent additional injury and to redress the injury to those already affected. Indeed, to express this more forcefully: The question the Government must address is whether they – the Government – are prepared to knowingly subject its people to substandard conditions when these could easily have been avoided, e.g., by following the level of health protection advised by the World Health Organisation *Guidelines for Community Noise 1999*.

Although the Government may conclude that they must wait for the scientific evidence to unfold, this approach ignores those many families – and those who will unfortunately and inevitably follow – who are experiencing genuine distress, and whose predicament could so easily have been avoided.

As this is a matter of public health policy, proceeding with wind turbine developments and applications that violate the public's health may also be a violation of the Human Rights Act by the landowners, the wind turbine developers, and the State.

The Review addresses the issue of Human Rights in Section 6. Although European States have 'Bylaws' or 'Guidances' and the United States has 'Ordinances' that provide guidance to Planning decision makers, in the final analysis it is contended that the responsibility of the decision maker is not merely to seek compliance with a Bylaw/Guidance/Ordinance in arithmetical terms, but also to establish beyond reasonable doubt that the families' right to respect for their homes and their private lives is not violated. If the State decides that the public interest in building wind turbines is greater than the individual private interest, then the violation is not proportionate without compensation for the individual (S6.34).

RECOMMENDATIONS:

- The Government would be prudent to institute an immediate and mandatory minimum buffer of 2km between a dwelling and an industrial wind turbine, and with greater separation from a dwelling for a wind turbine with greater than 2MW installed capacity.

- There is a need for a multidisciplinary team of experts – independent of the wind energy industry – to assess clinically and to investigate epidemiologically, the health impacts on people where industrial wind turbines have been located too close to their dwellings.

- Governments are appealing to the social and ethical conscience of commerce to become carbon neutral and mitigate the effects of global warming. In an appeal to the ethical and social conscience of bankers and investment institutions, we recommend that before providing finance to wind turbine developments that are near family homes, the Investors should demand from the developers a Guarantee Bond that unreservedly guarantees that the operation of the wind turbines will not violate the families' right to respect for their homes and private lives. This would be a prudent caution to take in order to lessen the risk of potential environmental and medical claims at some future time.

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APPENDIX – PROPERTY VALUES

1. INTRODUCTION

This Appendix provides global evidence of the negative impact of wind farms on residential property values where the wind turbines are built nearby.

The valuation of a residential property is what it will fetch in an open market sale. The value will depend upon a number of factors and not least will be the number of potential buyers in the market for that type of property in that location. More than one buyer is likely to trigger a bidding-up situation. Wind farms are normally built in rural locations, therefore apart from accommodation size, important influences on value will often be the view, the peace and serenity, and a rural environment.

It is established that in many rural locations a wind farm will reduce the value of properties located nearby; but as the distance between wind turbines and dwellings increases, the valuation impact is lessened and the prospect of consequent health problems reduced. A part of the loss in value will be attributable to the loss of a quality view. However, a substantial apportionment of the loss in value flows directly from the environmental noise pollution and indeed the consequent health impact that flows directly from the environmental noise pollution. A further smaller part of the loss will be attributable to the rotation of the turbine blades, which in certain circumstances will cause strobing light/shadow flicker, which again can have health repercussions. In a high value area of the country, the potential valuation impact is likely to be higher.

It is important to establish the part of the valuation loss that directly flows from the environmental noise pollution as this, in most instances, will reflect the property damage resulting from the escape of the noise pollution. In a well-populated rural area the cumulative financial damage, the loss imposed on the community, will substantially exceed the 'de minimus' public interest that will be served from the wind farm. The following are samples of reported property devaluations from three continents.

2. U.K.

Case A

TURBINE PLAN CUT VALUE OF OUR HOME BY A THIRD

Western Morning News (Plymouth) 9 December 2004

"A Westcountry farming couple have seen the value of their home slashed by a third since controversial plans were submitted to build three giant wind turbines in one of the region's beauty spots, it has been revealed.

Richard and Lynne Lethbridge say they discovered the devastating news after deciding to sell the home their family has farmed from for decades, because of the plans for the turbines.

Two independent agricultural valuers, which visited the large four bedroom bungalow in East Allington last week, both concluded that since the planning application for the turbines at Goveton was submitted earlier this year, the price of the Lethbridge's near £500,000 home had fallen by £165,000.

NPower's plans, which have been submitted to South Hams District Council, are for three generators, each 100 metres high, to be built on land off the A381 between Kingsbridge and Totnes, next to the turning for Goveton.

Mrs Lethbridge, 57, whose property is the closest to the proposals at just 540 metres away from the development, said she had envisioned living in the area with her husband Richard, 58, for the rest of their lives. But she said that it looked extremely likely they would have to move on. "If the plans go through we will have to sell," she said.

"We're upset because it's detrimental to our health and we are so close that we would hear them and to me it would also be a great eyesore. We decided to have the house valued with a view to selling because we're concerned about our livelihood. Richard is a farmer and has been all his life and for the last 15 years or so I've been a farmer's wife. His parents have been here for over 60 years and he was born here and built the home we are in at the moment on the same land in the early 1970s. I thought we would live here all of our lives and this would then go to our family. We would not have thought of moving but we feel we are being forced out because of this. Mrs Lethbridge said the only way the family would consider staying at their home would be if the plans did not go ahead.

"When we found out about the application we realised it was just 540 metres away. It's too close to us. If the plans go ahead we will move. I don't think anyone could change our minds, which is really sad. Her husband Richard added: "I don't really want to leave here, but the noise will be a big problem and with the health issues and the loss of view it will be too much. It doesn't matter how much compensation we would get, if any, because it would be the view and the way of life we would lose."

Case B

In a survey of its members in November 2004, **The Royal Institution of Chartered Surveyors** issued 1942 questionnaires and received 405 responses, of which 20% (81) had dealt with transactions affected by wind farms. The Report stated:

"Actual effect:

-- there are negative influences on the values of residential properties, though a sizeable minority report no impact on prices.
-- nowhere is it considered that wind farms positively affect residential property values …."

"The regional results vary from 44% of surveyors in Wales reporting that residential property values are lower as a result of wind farm developments to a high of 77% in the South West."

"Conclusions:

The three main reasons for this negative impact on property values are the visual impact after completion, the fear of blight and the proximity of residential property to a wind farm development"
The negative impact of wind farms on property values appears to decline over time. This may suggest that the impact lessens as wind farms become more established."

The last conclusion appears tentative and there is no evidence in the report to support this view.

Once the zone of pollution falls in value its lower relative position to other nearby similar but unaffected properties becomes established. From this new relationship of property values, the market residential property inflation will apply to the polluted zone, but in some locations, it may be argued that the pollution is sufficiently severe that a lower inflation level will apply.

A simple example:

Consider similar properties, one in village A valued at £460,000 and a second in village B valued at £460,000. A wind farm is built close to the property in village A decreasing the price the property would fetch in a sale to £280,000. The property in village B is unaffected. After 5 years of 6% compound property inflation, the village A property will rise in value to £374,700 but the house in village B will have risen in value to £615,580, a loss to the house in village A of £240,880.

Some might argue that the rise in value of the house in village A represents a recovery from the initial impact of the wind farm. Others will contend the damage in terms of financial loss remains with the property.

Case C

WINDFARM BLOWS HOUSE VALUE AWAY

Westmorland Gazette, 9 January 2004

"Barry Moon and his partner, Gill Haythornthwaite, live in the shadow of the wind turbines at the controversial Ireleth windfarm near Askam. When they bought Poaka Beck House in 1997, the couple were unaware the arrival of the windfarm was imminent. Previous owners, David and Diane Holding failed to tell the prospective buyers in spite of the fact that they had vigorously opposed the initial application for the wind farm in 1995.

District Judge Buckley decided that this amounted to material misrepresentation and ordered the Holdings to pay compensation of 20% of the market value of the house in 1997, £12,500 plus interest, because of damage to visual amenity, noise pollution, and the 'irritating flickering' caused by the sun going down behind the moving blades of the turbines 550 metres from the house."

Case D

In a letter to a client about the effect of wind turbines on property values, dated May 1998, Estate Agent **FPD Savills** [Norfolk Office] concluded:

"Generally, the higher the value of the property the greater the blight will be... As you go up the value scale, buyers become more discerning and the value of a farmhouse may be affected by as much as 30 per cent if it is in close proximity to the wind turbine."

Case E

PRICES FALLING

Lynwen Evans, Cambridge News, 11 April 2005

"I would like to put my statement to you loud and clear in response to your article "properties not hit by wind farm" (News, April 5).

I for one am in the same position as lots of people in the UK at this moment with the wind farm growing in popularity.

The first thing I did when the news got out about the proposed wind farm, was invite an estate agent to value my property. You can imagine my response when I was told that the value of my "basic three-bedroom bungalow" was going to drop £45,000.

With that, I had a discussion with one of the farmers involved in this wind farm, and she herself told me that they have had their property valued, and yes, it will lose value, but of course the land will gain value because of the wind farm.

One of the villagers put their property on the market as soon as the news came out. They had three people interested, until they were told there was a proposed wind farm. At that, they all pulled out.

These estate agents don't like admitting that there is a fall in property values. Needless to say, they themselves will be out of pocket.

Two of the villagers went into an estate agent asking about the prospects of selling properties in the villages concerned, only to be told that "these areas are now a no-go area!"

It's time devaluation is made known, everyone should know of what's going to happen to all that they have worked for.

Lampeter
Ceredigion
Wales
http://www.cambridge-news.co.uk/news/letters/2005/04/11/529e6c57-a1ec-428b-ad0c-855515b543cc.lpf

Case F

In a letter to the ***Brecon and Radnor Express and Powys County Times,*** 27 July 1995, Mrs Moores of Bucks wrote:

"My mother lives in Wales within sight of a wind factory. For two years we have been trying to sell her house as she is old and frail and wishes to buy a place near us in Bucks ... So be warned – it seems that once a wind factory is built within sight of your home , the value drops considerably. We have been forced to drop nearly to half the original price and have still not sold."

Case G

The Managing Director of Bradleys, (Chartered Surveyors), wrote the following letter in November 2004, to the Denbrook Valley Action Group, which is opposing wind turbines in Mid Devon.

"Dear Sirs
Thank you for your e.mail dated 3rd November 2004, with respect to a proposal to develop a site of 10 or more (approximate) 300-400 foot wind turbines in the Denbrook Valley between Spreyton, Bow and North Tawton.

You have requested that I comment on various matters with respect to this proposed development.

There is no doubt that no added value would be brought to a property sited within the locality of such a development.

It is likely that properties sited within the locality of such a development will be devalued , although the amount of devaluation will depend heavily on not just the proximity but also on individual matters affecting the uniqueness of each property such as spoiling the view or being affected by noise pollution. If, for example, a wind turbine is only 300 metres away from a property it may be in such a position that it cannot be heard or seen. But another property, say 800 metres away could be in full view of the turbine and also subject to its noise pollution.

Under certain circumstances it would be possible for a property within 600 - 800 metres to be devalued by some 30%, property within 1 mile possibly 20% and property within 2 miles possibly 10%. It is important to stress that each individual property would be affected in a different way.

Although it is conceivable that a property within 600/800 metres of such a development would be un-saleable there is no doubt that the property could be significantly devalued, and no doubt its marketability adversely affected.

It should be taken into account that the area in question is one of high desirability and high value and one of the most important reasons for this is its beautiful mid Devon countryside location. Therefore the area around the proposed development would be significantly affected.

With regard to the two comments that "there is no evidence of a general devaluation of local property prices caused by a wind farm", and "the lack of

a house price affect is also confirmed by the Royal Institution of Chartered Surveyors who state that there are no studies that suggest an affect either way", these comments are not actually saying that property prices are not being devalued, they are only stating that there are no studies which have been carried out with regard to the price affect.

I would also point out that any Chartered Surveyor carrying out a valuation on a property in the West Country, where in the proximity there are features such as electricity pylons, radio masts and wind turbines, then there will be a comment in that report that it could affect value, marketability, and/or resaleability.

Yours sincerely
BRADLEYS SURVEYORS

Case H

In a letter of 22 October 2003, South West Estate Agent J Carslake of **Kivells Estate Agents**, Holsworthy, wrote to a client advising:

"It is the case that a wind turbine within sight or sound of a residential property will affect the value of the property detrimentally. The affect on value would, in my opinion, be up to 50% of ordinary open market value, but it is difficult to provide proof of this."

"It is certainly also the case that the threat of a windfarm close to a property can make it un-saleable (I have a case in Bradworthy for example) and would certainly assert that the marketing becomes much more problematic when a wind turbine is situated within sight or sound."

Case I

Evidence of reduced house prices as a direct result of the threat and/or presence of wind turbines can be found on the website of the **Mynydd Llansadwrn Action Group (Wales)** [http://www.turbineaction.co.uk/wind-turbine-facts.htm#refs]

"In May 2005, a local resident near Brechfa reported in the Carmarthen Journal that:

"Our property, in the middle of the proposed TAN8 site (Strategic Area G) had a firm offer of £318,000. One week later our prospective purchaser, who incidentally knew about the turbines and had no problem with them, said they would do us a favour and 'take it off our hands at a big financial risk - for a reduced £250,000 which was higher than the 40 per cent we could expect to get, being near turbines!' "

Case J

Surveyor and Valuer Gareth Scourfield inspected a number of properties in July 2005 near a proposed development of 10 wind turbines at Esgairwen Fawr, Lampeter Wales.

In his report entitled *'Report on a sample of properties inspected near a proposed wind farm at Esgairwen Fawr, near Lampeter, Ceredigion'* (July 11, 2005), he wrote:

"The proposed development also towers over houses in Mydroilyn village. Given a sample of properties inspected and reported as above [i.e., in his Report] *this represents an immediate loss of £1,528,000 for the 8 properties mentioned, let alone all those which may be affected by the turbines, both by seeing them and hearing them."*

Case K

Giant blades are slicing prices

Sunday Telegraph, 17th October 2004, House and Home supplement, page 2

[Excerpts from article by Ross Clark]

Homeowners on the damp expanses of Romney Marsh in Kent have long had to contend with the presence of Dungeness nuclear power station, asking themselves what would happen if it blew its top. Rather less might they have suspected that they would one day find themselves cursing the nuisance posed by "green" renewable energy. Last week, the DTI began an inquiry into plans for a wind farm whose 27 turbines will spread over 1,000 acres of the marsh and stretch into the sky 370ft.

Much of the recent debate over wind farms has revolved around whether they lower the value of nearby properties. Until earlier this year, the British Wind Energy Association (BWEA) maintained that wind farms do not affect values - in fact, the association listed this as one of the "top 10 myths about wind farms" on its website.

In January, however, came the case of Barry Moon, who won £15,000 in damages against the previous owners of his four- bedroom home at Marton, near Ulverston, Cumbria. The vendors had failed to warn Moon about plans for a wind farm on a nearby hill. After hearing evidence from chartered surveyors, the judge made an award on the basis of a 20 per cent reduction in value of Moon's home due to the visual impact of the turbines and the annoying, low-frequency hum. "I've lived a similar distance from the M3 as we live from the wind turbines," says Moon, "but this was a lot worse. What is irritating is the way the whooshing keeps increasing and decreasing in magnitude."

While the Moon case established in law for the first time that a wind farm can lower the value of a home, it did nothing to help homeowners win compensation from the builders and operators of wind farms.

What residents can do is ask the environmental health officer at their local authority to measure the sound produced by the turbines and declare a statutory noise nuisance. As a result of measurements taken by Barrow District Council, Moon managed to persuade Powergen, the operator of the wind farm,

to install a noise management system, which shuts down three of the turbines when the wind is coming from a certain direction.

Three other couples, who live within half a mile of the turbines, had a less happy experience. In January, they took Powergen to Kendal Magistrates Court to win a noise abatement order - and lost. "We were told that our evidence lacked specificity, even though we had 26 recorded cases of noise nuisance," says David Brierley, a former policeman who wasn't named in the case, but who helped the residents compile their evidence.

"The noise management system doesn't work. I live 1,000m south of the wind farm and my wife, who is asthmatic, gets very distressed when the wind is coming from the north because she can feel her breathing trying to synchronise with the thump of the blades."

If the experience of Cumbrian homeowners is anything to go by residents within a mile or so of the proposed Romney Marsh wind farm will have an uphill struggle selling their properties from now on.

Kyle Blue, a Penrith estate agent, runs a protest group objecting to a proposed 27-turbine wind farm at Whinash, Cumbria. In May, the Advertising Standards Authority (ASA) upheld a complaint against him by the BWEA for claiming, on the group's website, that the wind farm would affect property values (the ASA indicated it would have been happy with <u>might</u> affect property values).

Yet when his company auctioned Bretherdale Hall, a semi-derelict farmhouse half a mile from the proposed turbines; it fetched £200,000 - £80,000 less than its valuation before the plans for wind farms were announced.

Another nearby property, a freshly restored £340,000 farmhouse, found a buyer who said the wind farm wouldn't bother him because he was keen on renewable energy. "Then, he went away, did some research and changed his mind," says Blue. The house remains unsold.

<u>Case L</u>

In May 2000, Estate Agents Russell Baldwin & Bright, Brecon in Powys, wrote the following to letter a client:

> *"Further to our telephone conversation last week I confirm that I have withdrawn your property from the market.*
>
> *As discussed since the proposed Wind farm planning application was published enquiries for your property have fallen off dramatically. It is obviously very disappointing that this situation has arisen after such a promising response to earlier marketing which resulted in an excellent number of viewings. There is however, little point in continuing to market your property as any serious purchaser will be immediately put off by the prospect of a nearby windfarm.*
>
> *On a more general note I have a prospective purchaser at Merthyr Cynog having serious doubts over its proximity to the proposed site.*
>
> *I will keep the file pending until planning application is resolved at which time I trust we will be able to re-market the property."*

3. AUSTRALIA

Case A

HOUSE VALUES DECLINE WITH TURBINES
CLOUDS GATHERING OVER WIND FARM PLAN

The Australian, January 9, 2006, by Natasha Robinson

The picturesque fields of Foster North, in Victoria's South Gippsland, have become a battleground with farmers and residents divided over a proposal to build a massive wind farm. Farmers who will benefit from the 125m turbines being built on their land are pitted against their neighbours who bitterly oppose the 48-turbine, 2000-hectare Dollar Wind Farm project. And as state governments grapple with energy demands amid a looming coal crisis, it is a fight likely to be played out in communities around the country.

Victoria's Government had "ridden roughshod" over the Foster North and Dollar communities in refusing to give their council a say on whether the proposal went ahead, Federal Environment Minister Ian Campbell said yesterday. The Victorian Government made its decision before Christmas on the project, planned for the northern side of the South Gippsland Highway at Foster North and Dollar. It is yet to publicly announce if it approved the wind farm. Premier Steve Bracks has pledged to source 10per cent of the state's energy from renewable sources by 2010. The Dollar Wind Farm project was previously the work of a New Zealand-owned company but the project was sold last year to Australian company AGL. The proposal is now with Senator Campbell, who will consider if it poses national environmental concerns.

In Frank and Theresa Cicero's quiet, winding, street in Foster North, local opposition to the wind farm -- which will see a turbine built 800m from their bush retreat -- is easy to find. Almost every property in their street, apart from those of the farmers on whose land the turbines are being built, is for sale.

'I've watched my husband work all his life to build this home," Mrs Cicero said. "We've never had loans, we've always worked and saved. And now we find everything that we've put in here, it's all worth nothing.'

The Ciceros had their home valued at $410,000 before the wind farm was taken into account. Afterwards, the estimated value dropped to $270,000. They have not received one offer for their property in two years. They say if the turbines are erected, they will have to cope with an incessant sun flicker, noise, and a viewing platform.

A spokeswoman for the Victorian Government said it was a complex issue and the Government understood that the community had concerns.
*Web link: http://www.theaustralian.news.com.au/common/story_*

Case B

In **'Research of property devaluations'**, the author, Eleanor Tillinghast (Green Berkshires, Inc, Massachusetts, 2004), reports:

"In a vacation area near the Toora wind power plant in South Gippsland, Australia, a real estate agent told a news reporter that the 12 turbines were 'definitely' having an impact on values. 'If they are near the property, buyers are staying away,' Wesfarmers Landmark Leongatha agent Glen Wright said. 'If I had to put a figure on it, I would say (a reduction of) 25 to 30 per cent on the going value.'

Another real estate sales manager had major difficulties selling a property near the Toora plant. 'I would have shown 50 or 60 people through that property and I would say half of those wouldn't even look at the place once they realize it's in the vicinity of wind turbines,' Bruce Falk said. 'And half of the other 50 per cent were concerned about *resale so they offered 20 per cent less than the price the owners would accept'*
In another part of southwest Australia, John Denham, who had leased his farm for eight turbines, found that their presence hindered his efforts to find a buyer when ill health forced him to sell the land."

4. Denmark

In Denmark, Erwin Thorius, president of the National Association of Neighbours to Wind Turbines, said recently that '*people living near windmills found it impossible to sell their homes'*.

A study in Denmark about 10 years ago found that housing prices decreased near wind power plants, ranging from about US $2,900 at that time for a one-turbine facility to US $16,800 for a 12-turbine site. [Tillinghast, 2004]

5. Germany

Case A

The Darmstadt Manifesto (1 Sept. 1998), signed by more than 100 university professors in Germany, states:

"Falling property values reflect the perceived deterioration in quality of life – not just in areas close to the turbines, but even all over Schleswig-Holstein. More and more people are describing their lives as unbearable when they are directly exposed to the acoustic and optical effects of wind farms. There are reports of people being signed off sick and unfit for work …"

Case B

FIGHT AGAINST WIND POWER

Olympic and World Champions have got together: they demand that Wind Power Stations be Built Away from Riding Stables

"Riders, friends of the riding community and owners of equestrian and breeding businesses are anxiously watching the encroachment of wind power installations over the landscape both in the Lander and throughout the country as a whole - chief among them Judith and Klaus Balkenhol. They want to prevent wind power stations from creeping even closer to riding stables. The signatories of the Memorandum are particularly concerned that equestrian businesses which will be affected are not consulted during the application process. The construction of wind power stations close to such establishments puts into jeopardy the livelihoods of numerous businesses and endangers many jobs. Constructions in the open countryside threaten not only trekking but also recreational riding. Noise and flicker from the turbines do considerable harm to horse and rider and endanger them equally. It is not for nothing that a statutory separation was made compulsory over 200 years ago between windmills and open roads, otherwise the horse shies ("spooks"). The effect of breeding means that there is now a considerably greater number of highly sensitive horses." (Quote from the Memorandum).

The riding community demand a separation of 2,500 - 3,000 metres [2.5 - 3.0 kilometres] between horses and windfarms.

All sensible people are in favour of alternative energy. But when these wind mills – which may be environmentally but not visually friendly – shoot out of the ground like mushrooms right before your very door, then it is quite a different matter. They are particularly unloved by horse people because the noise the blades make at various times and at various volumes, drives the horses wild, at least in the case of sensitive types such as dressage horses. Klaus Balkenhol, former Federal (German) trainer and now a national US team trainer, has himself now experienced this. The wind turbine which is 1 km away from his stables at Rosendahl in Munsterland often irritates the horses he is training to such an extent that any sensible work, to say nothing of hacking in the vicinity of the turbine, is out of the question.

A further 6 turbines are now being planned – something that Balkenhol discovered only by accident. "The Americans are not willing to train under these conditions," Balkenhol's wife, Judith said. "The (US National) team has made that clear to us.

The equestrian establishment, which lies in the shadow of the wind mills, is up for sale, "only at half the price, at the most, of what we invested in it."

A petition signed by numerous top German riders and 17 thoroughbred studs is expected to draw the attention of the authorities to the dangers and damage caused to riding establishments by wind installations. Not only competition riders but recreational riders as well, find little joy in riding beneath the whirlwind. "And all the time Munsterland advertises its ideal conditions for riders," said Judith Balkenhol.

6. New Zealand

TURITEA MAN FEARS HE'LL HAVE TO GO

The Daily News Watch, New Zealand, by Helen Harvey, November 10, 2006

A Turitea man says he will be forced from his home because Mighty River Power told him noise from wind turbines in the reserve will make his house uninhabitable.

Mark Nicholls has been living in his slice of paradise for 10 years. He has 20 hectares of native bush, 13ha of pasture, which he farms, and a view to die for. It is so private that he can bathe on his veranda.

He doesn't want to move, he said. "It's hard to achieve what I have here on my budget."

He first heard the news 12 months ago that four wind turbines from the proposed Mighty River Power/Palmerston North City Council wind farm would be 500m from his boundary.

The state-owned power company's representatives told him the noise from the turbines would make his house uninhabitable, he said.

In city council documents on the wind farm, it said that at 500m from a turbine, the accepted standard of noise should be between 40 and 50 decibels.

The report, presented at the infrastructural well-being committee on October 18, said 40 decibels is equivalent to that of a public library and a loud radio would be 70 decibels. An Ashhurst family had to leave their house last year because noise and vibration from the Te Apiti wind farm made it impossible for them to stay.

Mr Nicholls said his life has been on hold for a year and he is angry that an SOE (Mighty River) and a city council (he lives in the Tararua district) can destroy his idyllic rural paradise.

"Mighty River Power has made a lot of noise that in the fullness of time they will discuss a relocation package. This has been going on for 12 months."

He has asked the energy company what is happening, because he wants to get on with his life. "(They say) talks will take place in due course when the final location of the turbines has been established," he said.

"When you are told you can't live in your property, it changes your life. It's being told your life is going to change, but there is no qualification, no time frame. I don't know where I'm going to be in six months' time, one year's time. I can't plan. I feel that it's frustrating that one's life can be put on hold, not just mine, but my family's as well."

7. U.S.A.

Case A

Potential lessors get warning letters about turbine plan

Several residents oppose wind project in Cherry Valley
by Tom Grace Cooperstown News Bureau [New York, USA] 03/30/05

The attorney for residents opposed to wind turbines in Cherry Valley has sent warning letters to those who might lease their land for the project. The letters are intended to dissuade prospective lessors from participating in the project, said the writer, lawyer Peter Henner of Clarksville.

In the event the project, under consideration by Reunion Power of Montvale, N.J., goes forward, lawsuits may be filed. Henner said Tuesday that his clients want to be in the position of having warned their neighbors in advance.

Among the recipients of a letter from Henner is Daniel Wightman of Portlandville. His property east of the village of Cherry Valley is under active consideration by Reunion.

In a letter dated March 23 and provided to The Daily Star, Henner wrote to Wightman:

"I represent Raymond J. and Susan C. Rivard, Andrew and Kathleen Minnig, Linda VanSchaick, Philip and Leila Durkin, Patrick Shearer, Lynae Quimby, Steven and Angela Witham, Mark and Eliza Oursler, Diana Wells, Roy J. Hall and Paul Petersen, who own property that is in close proximity to your property in the town of Cherry Valley."

"It is my understanding that you are considering leasing a portion of your land to be used for the construction of wind turbines. Because these turbines may have an adverse impact upon my clients, I am writing to you to warn you that my clients will hold you responsible for any damage to their property that may result from these wind turbines."

Henner wrote that the windmills might cause his clients' property to depreciate, in which case, they "may have little choice but to commence an action to recover for the diminution in value of their property. They may also hold you liable for any adverse impacts, including the diminution of the quality of life that may result from the wind turbines."

Even if the windmills are built out of sight of his clients' homes, they may sustain a loss if the turbines can be heard from their residences, Henner said."

http://www.thedailystar.com/news/stories/2005/03/30/win5.html

Case B

Wind farm opponents speak out
More testimony set for tonight

By Mike Johnston, Kittitas Valley News [Washington, USA]
12 January 2006

Opponents of the Kittitas Valley Wind Power Project dominated Wednesday's second hearing on the wind farm proposed for 12 miles northwest of Ellensburg. They said the damage to scenic views from the wind turbines can't be lessened and will reduce property values.

Horizon has applied for up to 80 turbines ranging in height from 250 to 410 feet high, but company officials say they will only build 64.

The Desert Claim project, proposed by EnXco USA Inc. and centered eight miles north of Ellensburg, planned 120 turbines.

Slothower said those factors include conflicts with an increasing number of rural residences being built nearby and the subdivision of land for future homes and recreation, damage to the scenic views and others.

Colleen Anderson of Peavine Road, a real estate agent with Coldwell Banker-Kittitas Valley Realty, said she has compared average land sales near the wind farm with overall average county land sales involving parcels ranging from three to 20 acres. The sales took place in the last six months.

Anderson said land sales near the project area averaged $66,038, but the average countywide sale price was $126,223, a difference of $60,185. She also said lands for sale near the project area linger on the market longer.

'Based on this information,' Anderson said, 'it is my professional opinion that real estate values are adversely affected by the wind farms.'

She called on the two commissions to deny the project.

http://www.kvnews.com/articles/2006/01/12/news/news02.txt

Case C

The Wayward Wind

by Jon Boone, Silver Lake, New York, USA, 19 June 2006

"Do you believe industrial facilities stretching many miles across your landscape, with 105 spinning sky-scraper sized structures creating a cascade of noise are not going to negatively affect property values for those in the neighborhood, as the wind industry maintains a government study proves? One of the most validated real estate precepts is that prominent natural views and historic scenery have premium value, and intrusions restricting those views erode value …

There are few windplants in the world, let alone the United States, with turbines over 400 feet tall placed so prominently near a resort community …

Independent inquiry in Britain, Denmark, and New England suggest the likelihood of significant property devaluations. In his June 10, 2005 direct testimony before the Wisconsin Public Service Commission, Kevin Zarem, an appraiser, estimated that residential property near a proposed windplant "will likely be in the 17% -- 20% loss range." And this is based solely upon visual impact. He did not assess potential loss due to wind turbine noise, motion, or shadows.

Russell Bounds, one of Garrett County's leading realtors in large property transactions … has already lost sales in the area of proposed windplants. Mr. Bounds testified in a PSC hearing that, over the last several years, he has had at least 25 people who expressed interest in buying land in the area targeted by wind developers. However, when he advised them about the plans for wind facilities, not one of those people expressed further interest."

… I have seen contracts which require land owners and encourage neighbors to sign a "memorandum of non-disturbance easement agreement," which absolves the wind company from liability for what the owners might regard as wind turbine-related nuisances."

Case D

Hearing for a proposed wind turbine development in Maryland, in 2006,

The panel heard the testimony of Russell Bounds, Railey Realty, McHenry, Garrett County, Maryland, a licensed estate agent and property appraiser. The following is taken from his recorded testimony at the hearing.

'In 2004, Mr Bounds' sales totaled more than $15,000,000; his volume of sales has averaged about $12,000,000 per year. His work in Garrett County covers mountain or acreage properties in a place of natural beauty. In his testimony, Mr Bounds was asked if had visited areas where wind turbines are in place:

"Yes. I have been to sites in nearby Pennsylvania, experienced the visual impact near the turbines and heard the noise impact from various distances … I do not know the markets in West Virginia or Pennsylvania very well. If we were to move those turbines to Garrett County, however, value would be impacted. Any time you take a thing of natural beauty and you insert industrial development there is an adverse impact on what the property offers. It not only devalues but quite frankly, from my experience in Garrett County anyway, it may render the property unsaleable."

Mr Bounds had viewed properties with the turbines at a distance of three miles to "very close by." Asked "What effect, if any, has the wind turbines had on the special characteristics of properties that are nearby the wind turbines?", Mr Bounds responded:

"Within the view shed it ruins the horizon. The closer you get to the turbines the greater the visual impact. Those people who are looking for the natural views of the mountains find they are diminished or no longer exist. The turbines not

only have a visual impact but, also impact the quality of life. The ones that I visited were very noisy. They impact a country setting with a rather large industrial wind plant that takes away from anything I would call heritage views, peace and quiet."
Mr Bounds answered "Yes," when he was asked if he had heard from people living near wind turbines and if they had told him about any problems:

"The primary complaint is noise. Second is the visual impact of the turbines. Going into the house and closing the door eliminates the view. It does not eliminate the sound. The constant drone cannot be escaped … Their greatest concern is the substantial loss of value of their property. They do not believe they can sell without substantial loss and cannot afford to sustain the loss and move."

When asked if the noise had any substantial impact on the use of the property, Mr Bounds replied:

"Yes. It takes away the enjoyment of their property. It doesn't allow them to sleep at night."

"It takes a property of substantial value and takes away all of the characteristics that are the strengths of that property. The visual impact takes away value. The noise takes away value. The property owners complain that the wind turbines take away value and there is no way for them to escape."

Mr Bounds testified that he knew of property transactions in Somerset, Pennsylvania that were sold for substantially less than their prior sale price because of the proximity and impact of wind turbines. Mr Bounds continued,

"Two properties specifically that sold for substantially less than their original purchase price because of the nuisance issues that were created by wind turbines. The parcels adjoin property with wind turbines. (The deeds of the properties were presented as exhibits.) Somerset Windpower, LLC purchased the property of David Ray Sass for $104,447.50 and sold it to Jeffrey A. Ream for $65,000 … Keith and Billie Sarver sold their property to Somerset Windpower LLC for $101,049.00. Shortly thereafter it sold for only $20,000."

'Another property -- unimproved, was purchased for $12,600 only a few years earlier, The house was five years old when sold for $67,000, at about the same time as the other houses were sold. Mr Bounds noted that, "the property appears to have been sold for less than market value of the same home not located in proximity to the wind turbines. The wind turbines clearly had an adverse impact on the value of nearby properties."

Mr Bounds also replied that he had heard the wind turbine noise himself:

"It was not what I expected. When you are right underneath, it doesn't seem to make much noise, just a swish. Further away from the structure the noise is more noticeable. It seems that it can echo through a hollow or a valley. Sometimes homes that are closer might not have the same noise impact as homes that are further out. I understand the noise changes day to day depending upon which way the wind is blowing and how the blades are

positioned. Some days it may be noisier than others and some days it might not be as noisy."

With his research and professional expertise, Mr Bounds concluded:

"That property values of the natural and scenic properties within one-half mile and probably within a mile of the wind turbines will be negatively impacted. I cannot judge for certain how far the serious negative impact will extend. The visual impact and the noise impact will substantially diminish special attributes of a mountain view, scenic view, natural setting and peace and quiet. Undeveloped properties will be rendered un-developable. Some parcels may be rendered un-saleable. The visual impact beyond a mile will likely adversely impact value. The sound impact will apparently vary outside one mile but, if the results of the study attached as Exhibit 9 are correct, the value of some properties outside one mile will be adversely impacted by the noise."

Case E

In Michigan, David Maturen, a real estate appraiser and Kalamazoo (Michigan) County Commission, wrote the following letter to the Michigan Wind Working Group, 9 September 2004:

MATUREN & ASSOCIATES, INC.
Real Estate Appraisers – Consultants
1125 E. Milham Avenue
Portage, Michigan 49002
269-342-4800

DT: September 9, 2004

TO: Michigan Wind Working Group
c/o John Sarver, Energy Office

RE: Impact of Wind Turbine Generators on Property Values

First of all I wish to thank you for including me in your email distribution list relative to the proceedings of the Wind Working Group. I have an interest in the topic as a Kalamazoo County Commissioner concerned with land use and regulation and as real estate appraiser interested in the issue of external obsolescence (loss or depreciation to property value from outside the property boundary). That economic obsolescence can come from adverse (nuisance) impacts such as visual (loss of viewshed), blade flicker (strobe effect), noise, ice throw from blades in winter, and other environmental impacts from ancillary installations. I am not aware of any plans to put a wind farm in the vicinity of any property that I own, so I have no personal interest one way or the other in this matter, other than wanting the rights all parties to be respected and protected.

I understand that you have as an item of discussion at your September 9, 2004 meeting the issue of property values. I have had some experience with research on this matter. Unfortunately, I have a prior commitment that day and will likely not be able to attend your meeting. Perhaps your committee is already aware of these valuation issues and studies, but I think that they are important to note in the context of promoting wind farms in our state.
As the Vice Chair of the International Right of Way Association's Valuation Committee, I had the opportunity to moderate a session at our International Education Conference in Philadelphia this June. I invited the authors of the two most often quoted studies on the issue of wind farms and property values. Fred Beck of the Renewable Energy Policy Project (REPP) and Dr. David Tuerck of the Beacon Hill Institute at Suffolk College both

presented the findings of their respective studies. Both studies are available on the internet: www.repp.org and www.beaconhill.org.

The REPP study, The Effect of Wind Development on Local Property Values, is a 78 page report which was published in May 2003. They studied 10 areas of the country. The study surveyed assessed values and properties within 5 miles of a wind farm and showed no diminution in value to those properties due to the presence of the wind farms. Critiques have been made regarding the methodology used in that study.

The Beacon Hill Institute issued an initial 53 page report in October 2003 - Blowing in the Wind: Offshore Wind and the Cape Cod Economy and a follow up 34 page report in March 2004 - Free but Costly: An Economic Analysis of a Wind Farm in Nantucket Sound. The studies focus on Nantucket Sound in Massachusetts relative to the Cape Wind Associates proposed 130 wind turbine generator (WTG) offshore wind farm. The 2003 study projected 1) a small decline in tourism resulting in a loss of 1,173 to 2,533 jobs and 2) a decline in property values of 4.6% (10.9% for waterfront property) or $1.35 billion and a concomitant loss in tax revenue to the area of $8 million. Criticisms of that report have also been made.

The Tennessee Valley Authority (TVA) study on a proposed wind farm in Tennessee consisting of 13 to 16 WTGs reviewed literature on the issue. Appendix F of the study cites several studies on wind farms and their impacts. Among those are:

1. The April 1996 Danish study: Social Assessment of Windpower – Visual Effect and Noise from Windmills – Quantifying and Evaluation. It concluded that 13% of people living near windmills considered them a nuisance. Property values showed a loss in housing prices from $2,900 (for one WTG) to $16,000 (for a 12 unit wind farm).
2. The ongoing study in Wisconsin thought to be done in 2003. My conversation with Steve Brick of the Energy Center of Wisconsin indicated that as of this Spring their study was not finished.
3. The TVA study does mention the value of a viewshed as a percentage of the value of improved property at 8% in Fairfax, Virginia and a South Carolina analysis regarding vacant lot premiums of 147% for an ocean view, 115% for a creek or marsh view, and 39% for a golf course view.

The 2002 Strutt & Parker study of the Edinbane Windfarm on the Isle of Skye notes that the proposed 41 turbines would have a major impact on the locality. They estimated that nearby property values would decline by over $1 million. They also note at 6.18 of their report that "In Germany, Estate Agents report diminution in values of between 20% to 30% for properties in sight of wind farms. We understand that FPD Savills have reported similar levels of depreciation for properties in Norfolk."

The report of the Township of Lincoln Wind Turbine Moratorium Committee, Kewaunee, Wisconsin (2000 to 2002) notes that the Town of Lincoln building inspector compiled a list of home sales. The list compared the property's selling price as a function of the distance to an existing 22 WTG farm in the area. His conclusions were 1) Sales within 1 mile of the wind farm prior to the installation were 104% of the assessed values and properties selling after the wind farm introduction in the same area were at 78% of the assessed value.

Anecdotal evidence from real estate agents near Victoria, Australia indicates a 20% to 30% decrease in property values for homes near WTGs.

A court case referenced in the February 14, 2004 edition of the Daily Telegraph (UK) refers to a house near Askam in the Lakes District. The buyers were not informed of the pending installation of 4 WTGs which were 360' tall and 550 yards from their new home. No mention was made in the seller's disclosure form, despite the fact that the seller had protested the proposed wind farm installation to the local government indicating a large loss in value to their property. The court, after listening to chartered surveyors (appraisers) for both sides, concluded that the property had suffered a 20% decline in value.

The above listing is not exhaustive, but a brief mention of studies that discuss the impact on communities and nearby property values by WTGs.

Is the "jury" still out on the impact of WTGs on property value? Yes, though there do appear to be several indications that a loss in value to neighboring properties is real possibility. Can any state agency conclude that wind farms do not have the potential for causing a nuisance and devalue nearby properties and cause a "taking"? No. Whatever report the Wind Working Group comes up with, it should be informational only, include the differing opinions that are out there, not be used to usurp local land use authority in regulating WTGs just like any other land use nor to deny property owners their rights. In our quest for "energy independence" for our society in general, let us not forget the potential for economic loss to individuals as an unintended consequence. We should be prepared to compensate adjacent owners for any property rights (value) taken as a result of the introduction of wind farms.

Sincerely,

David C. Maturen, SR/WA
Certified General Real Estate Appraiser
Kalamazoo County Commissioner

Case F

"Wind turbines don't make good neighbors : some problems of wind power in the Berkshires"

By Eleanor Tillinghast, Green Berkshires, Inc., Massachusetts, May 14, 2004

Here in the U.S., at a public meeting on Enxco's proposal for a wind power plant in Lowell, Vermont, a realtor trying to sell a farm near the site told Mr. Zimmerman that his claim that land values won't decrease is 'ludicrous.' Don Maclure said that when he tells people interested in buying the farm about the proposed project he never hears from them again.

Other realtors are similarly skeptical. "They say there will be no effect on property values. That is absolutely incorrect," said real estate agent Roger Weaver of Kittitas County, Washington. "There is no way wind farms won't affect property values in the Kittitas Valley. In a tremendously scenic area like the valley, the view is a major consideration in what people want."

Mr. Weaver explained that people from Puget Sound are purchasing country lands for homes while still working in Puget Sound. "They want a beautiful place to live and retire," he said. "Wind farms will have a real negative effect on the property values because the scenic views are a big deal, a real big deal to these people."

As part of a study of the proposed Cape Wind [Massachusetts] project, 45 real estate professionals operating in towns around Nantucket Sound were contacted and asked about anticipated effects of the wind power project on property values.
49% of realtors expect property values within the region to fall if the Cape Wind power plant is erected.

501 home owners in the six towns that would be most affected by the Cape Wind project were also surveyed. 68% said that the turbines would worsen the view over Nantucket Sound 'slightly' or 'a lot'.

On average, they believed that Cape Wind would reduce property values by 4.0%. Those with waterfront property believed that it would lose 10.9% of its value. The study concluded that, based on the loss of property value expected by home owners, the total loss in property values resulting from the construction of Cape Wind would be $1.35 billion, a sum substantially larger than the approximately $800 million cost of the project itself.

As the study noted, any reduction in property values would, in turn, lead to a fall in property tax collections in the affected towns; the drop in these tax collections would be $8 million annually. If the tax rates were raised to maintain revenue, this would shift some of the property tax burden off waterfront residents (whose property values would fall the most) and on to the (less affluent) island residents.

In the home owner survey, in response to the statement: It is important to protect an uninterrupted view of Nantucket Sound, 76% strongly agreed, 18% somewhat agreed, 3% were neutral, 2% somewhat disagreed, and 1% strongly disagreed.

It's worth noting that of the home owners surveyed, 94% did not have homes with a view of the Sound. 76% were not members of a conservation or environmental organization. Regardless, their main reasons for living in the area were the 'beauty of the region,' 'the beaches,' and 'the ocean views.'

Comment

In the various reports included in this Appendix, it is clear that individuals from rural communities within the three Continents considered in this **Appendix** are experiencing or are likely to experience economic loss through the potential or actual impact of wind turbines located close their homes.

The continual economic survival of rural communities depends both on 'old' and 'new' wealth creation. Many rural communities have enjoyed economic growth and social benefits from the influx of 'life style' families, young and old, who have brought with them wealth and economic opportunity to their chosen new communities. 'Life style' families are often seeking the pleasures of rural life and unspoilt countryside, away from the commercial and industrial development that is characteristic of our towns and cities. The devaluation of assets such as property by rural industrialisation is likely to deter further migrations to the countryside, and over time, this will inevitably reduce new economic injection into these areas.

State development-control decision-makers, who allow the industrialisation of rural settlements, with the consequent environmental pollution, are likely to trigger a slide back into rural economic deprivation as the lifetime savings of people living in these communities are eroded by the devaluation of their properties.

Peter Hadden

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Do wind turbines produce significant low frequency sound levels?

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Summary

Wind turbines produce low frequency sounds, but it has not been shown this is a major factor contributing to annoyance. Sound from wind turbines involves several sound production mechanisms related to different interactions between the turbine blades and the air. Low frequency sound is predominantly the result of the displacement of air by a blade and of turbulence at the blade surface.

An important contribution to the low frequency part of the sound spectrum may be the result of the sudden variation in air flow the blade encounters when it passes the tower: the angle of attack of the incoming air suddenly deviates from the angle that is optimized for the mean flow.

This effect probably has not been considered important as the blade passing frequency is of the order of one hertz where human hearing is very insensitive. This argument however obscures a very relevant effect: the low blade passing frequency modulates well audible, higher frequency sounds and thus creates periodic sound. This effect is stronger at night because in a stable atmosphere there is a greater difference between rotor averaged and near-tower wind speed. Measurements have shown that more turbines can interact to further amplify this effect.

The effect is confirmed by residents near wind turbines who mention the same common observation: often late in the afternoon or in the evening the turbine sound changes to a more 'clapping' or 'beating' sound, the rhythm in agreement with the blade passing frequency. It is clear from the observations that this is associated to a change to a higher atmospheric stability. The increased annoyance has not been investigated as such, although there are indications from literature this effect is relevant. It is of increasing relevance as the effect is stronger for modern (that is: tall) wind turbines.

Introduction

Modern wind turbines have electric power outputs up to 2 MW (increasing now to 5 MW) and have turbine heights of 80 to 100 meters (increasing to 120 m). In the European Union, producing 74% of the wind power in the world, by the end of 2002 23 GW has been installed, and this should increase to the European target of 40 GW for 2010, but already a capacity of 90 GW has been forecasted for that year [1]. As a result of this growth an increasing number of people are living near (projected) wind parks and have reason to inquire and perhaps be worried about their environmental impact. Visual impact, intermittent reflections on the turbine blades as well as intermittent shadows (sun behind rotating blades), and sound are usually considered potentially negative impacts.

Wind turbines are also suspected to be a cause of low frequency noise, affecting people living nearby. This has been brought forward in the United Kingdom where opponents of wind parks state "current recommendations for noise evaluation near wind turbine sites completely exclude the measurement of low frequency sound" [2]. In a reaction the British Wind Energy Association denies this and accuses the other party "to misunderstand technical information, but be happy to use the material in inappropriate ways. One example of this is their persistent misuse of material on noise". [3].
Yet, a recent review for the British Department for Environment, Food and Rural Affairs states: "Infrasound exposure is ubiquitous in modern life (…..) common in
urban environments, and as an emission from (…..) air movement machinery including wind turbines (….). The effects of infrasound or low frequency noise are of particular concern because of its pervasiveness (…..) compared with other noise." [4]. Also, according to a project proposal from the Swedish Kungl Technical Highschool "there is a risk for low frequency sound from the large wind turbine farms that are planned both in Sweden and in other European countries" [5]. So, those who link wind turbines with low frequency sound are in expert company. But, does it affect nearby residents?
This paper explores the nature of (low frequency) wind turbine sound and explains why low frequencies may be relevant and not relevant at the same time, depending on perspective.

Sources of wind turbine sound
There is a wealth of information on the nature, cause and power of turbine sound. A review resulting from a research programme of the European Union is given by Wagner *et al* [6]. A concise overview of the three sound source mechanisms relevant to this paper will be given here, preceded by an introduction on wind aeroacoustics.

If an air flow is smooth around a (streamlined) body, it will generate little sound. For high speeds and/or over longer lengths the flow in the boundary layer (between body and main flow) becomes turbulent. As this leads to rapid velocity *changes* this will cause more sound with frequencies related to the rate of the velocity changes. A typical size for this turbulence is the boundary layer thickness.
As is the case for aircraft wings or propellor blades, a wind turbine blade is driven by lift generated by the air flow and performs best when lift is maximized and at the same time drag (flow resistance) is minimized. Both are determined by the angle of attack: the angle between the incoming flow and the chord (line between front and rear edge) of the blade. When the angle of attack increases from its optimal value the turbulent boundary layer grows in thickness and turbulence strength, decreasing power performance and increasing sound level. For an increasing angle of attack this eventually leads to stall: a dramatic reduction in lift.
Also, the atmosphere itself is turbulent over a wide range of frequencies and sizes. Atmospheric turbulence energy has a maximum at a frequency that depends on height and atmospheric stability; for wind turbine altitudes this frequency is of an order of magnitude of once per minute (≈ 0.01 Hz), and the associated eddy (whirl) 'diameter' is of the order of magnitude of a several hundreds of meters [7]. Eddy diameter and turbulence strength decrease at increasing frequency and vanish because of viscous friction when they have reached the size of a millimeter.
Turbulent flow is the dominant cause of (audible) sound for modern wind turbines. There are several mechanisms whereby the sound actually is produced.
1. When a blade moves through the air, the air on the forward edge is moved sideways moving back again at the rear edge. So for a periodically moving blade the air is periodically forced, leading to 'thickness noise'. Normally this will not lead to a significant sound production.

However, when a blade passes in front of the turbine tower, it encounters a wind that is influenced by the tower: the wind is slowed down and is forced to move sideways around the tower. This means that quite suddenly the angle of attack changes and lift and drag change abruptly. The change in mechanical load will increase thickness sound at the rate of the blade passing frequency f_B (f_B is the turbine rotation frequency multiplied by the number of blades). As the movement is not purely sinusoidal, there are harmonics with frequencies $k \cdot f_B$ where k is a (small) integer. As f_B typically has a value of approximately 1 Hz and harmonics may occur up to 10 - 20 Hz, this sound is in the infrasound region. Another consequence is that high frequency sound will also increase abruptly because of increased turbulence due to the sub-optimal angle of attack, creating the typical swishes superimposed on the constant noisy sound of a wind turbine.

2. Because of atmospheric turbulence there is a random movement of air superimposed on the average wind speed. The contribution of atmospheric turbulence to wind turbine sound is named 'in-flow turbulence noise' and is broad band sound stretching over a wide frequency range.
   For turbulent eddies larger in size than the blade this may be interpreted as a change in the direction and/or velocity of the incoming flow, equivalent to a deviation of the optimal angle of attack. This leads to the same phenomena as in 1., but changes will usually be less abrupt.
   For turbulent eddies the size of the chord length and less, effects are local and do not occur coherently over the blade. When the blade cuts through the eddies, the movement normal to the wind surface is reduced or stopped, given rise to high accelerations and thus sound.
3. High frequency sound is due to several flow phenomena at the blade itself or in the turbulent wake behind a blade ('airfoil self-noise'). It increases when induced turbulence increases, *e.g.* because of higher speed or of irregularities (scratches, dirt, insects) on the blade surface. It is essentially broad band sound, but if the turbulence can lock into a fixed length (such as a slit or cut parallel to the trailing edge), a specific frequency can become prominent, resulting in tonal sound.

Sound originating from the generator or the transmission gear has decreased in level in the past decade and has now become irrelevant if considering annoyance for residents.

Measured wind turbine sound spectra

In the summer of 2002 wind turbine sound has been recorded in and near wind park Rhede on the German-Dutch border. The park has a straight row of ten ca. 300 m spaced turbines parallel to the border and a less regular, somewhat uneven spaced row of seven turbines appr. 400 m behind the first row. Each turbine is 100 m high (hub heigth) with a blade length of 35 m, and produces nominally 2 MW electricity. It proved that the sound level, determined by the rotation speed of the turbines, depended on atmospheric stability and was not well predicted at evening and night hours by the usual reference wind speed measured at 10 meter altitude [8].

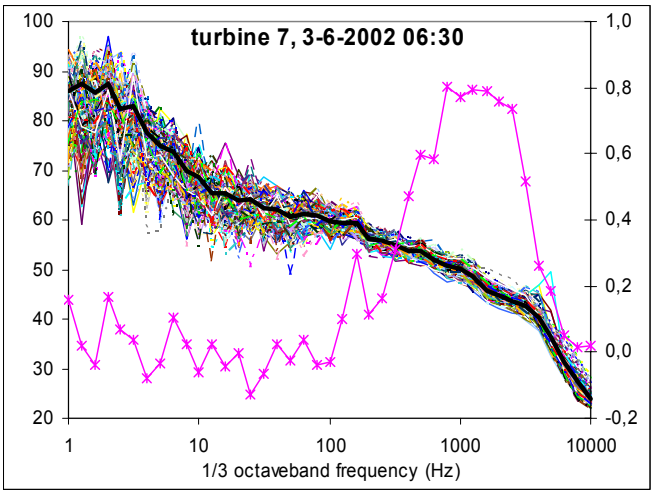
In figure 1 1/3 octave band spectra of the recorded sound have been plotted. The sound was recorded on a TASCAM DA-1 DAT-recorder with a precision Sennheiser microphone. The sound was then sampled in 1-second intervals on a Larson Davis 2800 frequency analyzer. The frequency response of the measurement chain is within 3 dB for frequencies above 4 Hz. From 1 to 4 Hz the frequency response is not accurately known (this has never been a necessity in our work). The spectra were determined from recordings (appr. 5 minutes each) taken with the microphone just above a hard surface at ground level at 100 m from two different turbines (plotted levels are measured Leq minus 6 dB correction for coherent reflection against the surface), and from a recording 1.5 m above a paved terrace and 2 m in

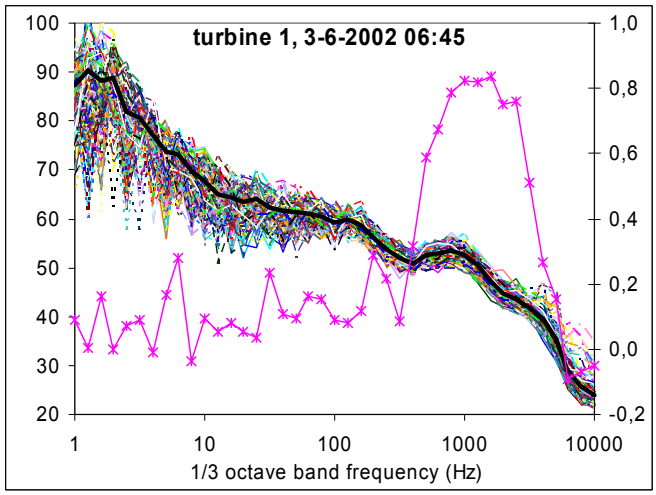
front of the façade of a dwelling at 750 m distance from the nearest row of turbines (measured Leq minus 3 dB correction for incoherent reflection at the façade).
In each part of figure 1 200 spectra (spaced 1 sec) as well as the energy averaged spectrum have been plotted. Also the correlation coefficient σ between all unweighted 1/3 octave band levels and the overall A-weighted sound levels has been plotted for each 1/3 octave band frequency. It is clear from the spectra that most energy is found at lower frequencies. This does not imply it is relevant for hearing as human hearing however is relatively insensitive at low frequencies. Indeed, the correlations show that most audible energy near the turbines is contained in the 1/3 octave band levels with frequencies from 400 through 3150 Hz (where σ > 0.4). For the sound at the façade this is one octave lower (200 - 1600 Hz) because higher frequencies were better absorbed and now contribute less to the sound energy as they do near the turbines.

In figure 2 thirteen more detailed 1-second 1/3 octave band spectra have been plotted from the sound on the façade (see figure 1). Although the bandwidth should be taken smaller to detect the harmonics of the blade passing frequency f_B = 1 Hz, the first harmonic at 2 Hz is clearly visible. A more detailed spectrum form a single turbine is given by Betke *et al* [9].

In figure 3 the three average spectra from figure 1 have been repeated, and the median hearing threshold for otologically selected young adults (according to ISO 226 [10]) has been added as well as the hearing threshold for the best hearing 10% of this group (10 percentile) which is 7 to 8 dB below the median level. It is clear that the sound below appr. 20 Hz must be considered inaudible for even well hearing people, even when one stands close to the turbine. Sound levels above the low frequency range but below appr. 1000 Hz are dominant with respect to audibility.
From figure 3 it is clear that sound levels at 100 m from a turbine (the two upper spectra) and at a location 750 km away from the first row of turbines are of comparable level at infrasonic frequencies; in fact the level differs only 4 dB. Although at the larger distance the sound level of a single turbine decreases, this is counterbalanced by the fact that more turbines contribute. At higher frequencies the same is true, but at increasing distance more sound energy is lost because of absorption.
The spectra in figure 3 are divided in three regions. For frequencies below 10 Hz the sound is dominated by thickness noise associated with the blade passing frequency (and harmonics). Then, in the higher infrasound region and upwards, where the level falls less steeply, in-flow turbulence is the dominant sound producing mechanism. Gradually, at frequencies above 100 Hz, airfoil self-noise is becoming the most dominant source, declining only at high frequencies of several kHz.

Impulsiveness
Wind turbine sound is not usually considered to be impulsive, as it has a more or less constant level due to the essentially random nature of the sound production mechanisms. Although there are periodic audible swishes, these are no equal to ‘real impulses’ like hammering or gun shots.
However, in a stable atmosphere the periodic swishes are louder than in daytime and residents use words like clapping, beating or thumping to describe the character or the sound. In the case of the Rhede wind park, the beating can be heard clearly at distances of at least up to 1 km and at night one can use it to determine the rotational speed of the turbine. So perhaps wind turbines can produce impulsive sound, but only in specific atmospheric conditions: the atmosphere must be stable. To understand this we must understand the implications of a stable atmosphere with respect to wind, the matter driving wind turbines.





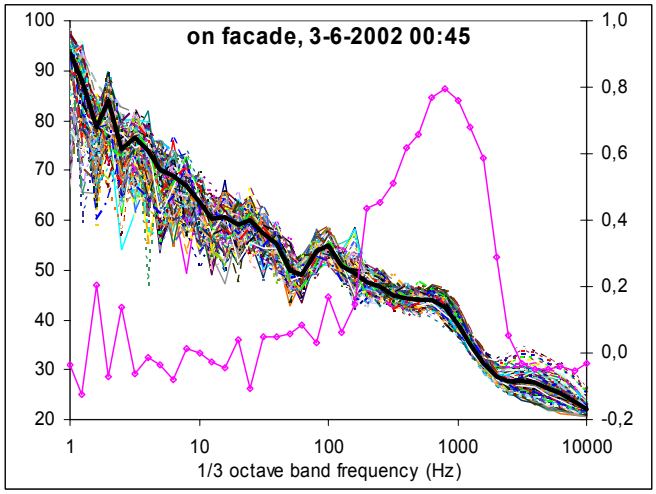


Figure 1:
left axis (in dB): 200 consecutive, unweighted and 1 second spaced 1/3 octave band levels (thin lines), and average spectral level (thick line) near two turbines and near dwelling;

right axis: coefficient of correlation (line with markers) at each 1/3 octave band frequency between all 200 1/3 octave band levels and overall A-weighted levels

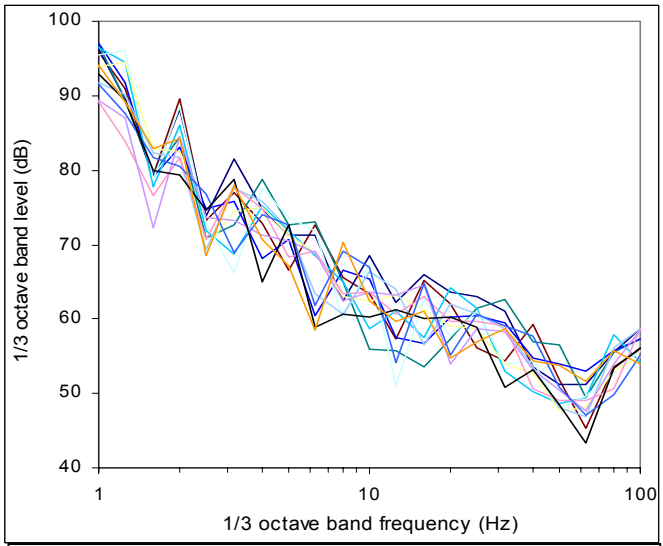


Figure 2:
13 unweighted, 1 second spaced 1/3 octave band levels near a turbine

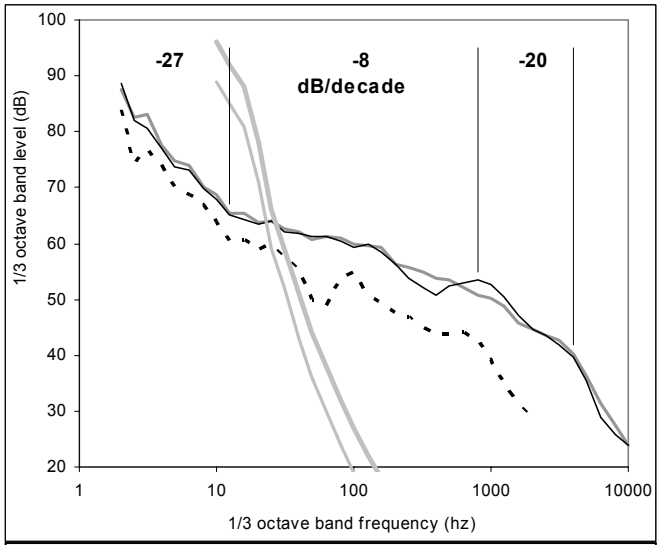


Figure 3: regions in 1/3 octave band spectra near turbines (grey and thin black line) and dwelling (dotted line) with average spectrum slope in dB/decade, and 10 and 50 percentile hearing threshold level for young adults

The wind speed v_h at height h in the atmosphere can be written as:

$$v_h = v_{ref} \cdot (h/h_{ref})^m \quad (1)$$

where v_{ref} is the wind speed at a reference height h_{ref} (usually 10 m). The exponent m depends upon atmospheric stability. For a neutral atmosphere, occurring under heavy clouding an/or in strong winds, air buoyancy dominates thermal effects and m has a value of appr. 0.2. In an unstable atmosphere, as is usual in daytime (if not neutral), m has a value of appr. 0.1. In a stable atmosphere m should theoretically reach values up to a maximum of $\frac{1}{2}\cdot\sqrt{2}$, describing a parabolic wind profile corresponding to laminar flow. Our Rhede measurements yielded values of m up to 0.6 [8]. A sample from data from the Royal Dutch Meteorological Institute KNMI [11] shows that indeed this theoretical maximum can be reached: in ten out of twelve midnight half hours (averages over 0:00 – 0:30 GMT) of each first night of the month there was a temperature inversion in the lower 120 m, indicating atmospheric stability. Of these in six cases the temperature increased with more than 1 °C from 10 to 120 m height and the exponent m (calculated from (1): $m = \log(v_{80}/v_{10})/\log(8)$) was 0.43, 0.44, 0.55, 0.58, 0.67 and 0.72 (we expect to do a more thorough analysis on more data to obtain statistically relevant long-term results).
In the following text we will use a value m = 0.1 for an unstable atmosphere and m = 0.6 for a stable atmosphere. These values will be used for altitudes between 10 and 120 m. It is probable that the wind profile above 120 m will not follow formula (1), as eventually a more or less constant wind speed (the geostrophic wind) will be attained, perhaps, in a stable atmosphere, after a decrease when the top of a 'low level jet' at about 100 m height has been reached. Because of this, the optimal height for a windturbine from an energetic point of view wil probably be about 100 m.

Effects depend on wind turbine properties (such as speed, diameter and height). We will use typical dimensions of a modern 1.5-2 MW wind turbine: hub height 80 m, rotor diameter 70 m and rotational speed increasing with wind speed to a maximum value of 20 rpm.

Now there are two reasons why the periodic swishes acquire a more impulsive character in a stable atmosphere relative to an unstable or neutral atmosphere.
1- Rotational speed will be determined by a rotor averaged wind speed, but the difference in wind speed between the upper and lower part of the rotor increases. Suppose the wind speed at hub height is v_{80} = 8 m/s. Then in daytime (m = 0.1) the wind speed at the lowest point of the rotor would be v_{45} = 7.6 m/s, at the highest point v_{115} = 8.3 m. The difference in wind speed over the rotor of 0.35 m/s causes a change in angle of attack of only 0.25° (both plus or minus relative to average value). A very slight vertical tilt of the rotor can offset this. In nighttime (m = 0.6) however, at the same wind speed at hub height, v_{45} is 5.7 m/s and v_{115} 9.9 m/s, so the difference in wind speed over the rotor and the change in angle of attack are now 6 times as large: 2.1 m/s and 1.5°, respectively. As a consequence there will be more airfoil self-noise.
A further effect is that there is a greater mismatch between optimum and actual angle of attack when the blade passes the mast (where there was already a mismatch due to the tower), causing higher blade loading and more turbulence. This effect is readily audible when night falls: the blades start clapping or beating at the blade passing frequency. The effect is stronger when stability increases, and also when wind speed at hub height increases up to the point where friction turbulence overrides stability and the atmosphere becomes neutral.
2- As was shown earlier [8], in a stable atmosphere wind turbines can run almost synchronously because the relative absence of turbulence leads to less random motion

superimposed on the constant (average) wind speed at each turbine. Turbines in a wind park therefore experience a wind that is more constant over greater distances. As a result they tend to react the same, that is: their turbine speeds are more nearly equal. This is confirmed by long term measurements by Nanahara *et* al who analysed coherence of wind speeds at locations at increasing distances in two coastal areas [12]. At night hours wind speeds at different locations were found to change more coherently than they did at daytime [13]. The difference between night and day hours was not very strong, probably because just time of day is a helpful, but not sufficient indicator for stability, especially not near sea and over all day lengths in an entire year.
Because of the *near*-synchronicity of several turbines, sometimes two are in phase and the blade passing pulses coincide, and then go out of phase again. The same can happen for three and perhaps more turbines. Exact synchronicity would not give the same effect, because it is improbable that an observer would hear these pulses at the same time. Because of near-synchronicity however, an observer will hear coinciding pulses for part of the time. Synchronicity here refers to the sound pulses of the different turbines at the location of the observer: pulses synchronize when they arrive simultaneously. This does not imply that the rotors are in phase: in that case the pulses would not arrive simultaneously unless the turbines would be at a distance to the observer equal to the distance sound propagates in one pulse repetition time or a multiple.

Both effects, the wind speed gradient and the near-synchronicity, increase the level of the sound heard when the blades pass the tower. The extra blade loading itself is not audible because of the high hearing threshold at the very low blade passing frequency. But the effect of added induced turbulence increases the levels at frequencies that already were dominating the best audible part of the sound, that is, at 750 m distance, at 200 – 1600 Hz (= range with high correlation in figure 1). When the pulses at the Rhede wind park synchronize, the level of the 800 Hz 1/3 octave band (best correlated to audibility: see façade spectrum in figure 1) increases with 10 dB, whereas the total A-weighted level increases with 5 dB. In general the height of the pulse will depend on the change in angle of attack and the distances of the wind turbines relative to the observer: the beat due to several turbines will reach higher pulse levels when more turbines are at approximately equal distances and contribute equal immission levels. The clapping or beating is thus at well-audible frequencies and has a repetition rate equal to the blade passing frequency.

Window rattling
Although infrasound levels from large turbines at frequencies below 20 Hz are too low to be audible, they may cause structural elements of buildings to vibrate. The vibrations may produce higher frequency, audible sound.
Windows are usually the most sensitive elements as they move relatively easy because of the low mass per area. Perceptible vibrations of windows may occur at frequencies from 1 to 10 Hz when the incoming 1/3 octave band sound pressure level is at least appr. 52 dB [14]; at higher or lower frequencies a higher level is needed to produce perceptible vibrations. As can be seen in figures 1 – 3 sound pressure levels above 60 dB at frequencies below 10 Hz occur close to a turbine as well as at 750 m distance and further.

A window vibrating at the impinging frequency transmits this frequency to the indoor air. If this does not coincide with a room resonance, the sound will not be louder than outdoors. For rooms in dwellings with a greatest dimension of 10 m, resonance frequencies are higher than appr. 15 Hz and thus cannot coincide with relevant harmonics of f_B, the blade passing frequency.

However, a window pane itself may have a resonant frequency of, *e.g.,* 40 Hz and a frequency of 10 Hz then may sustain a window pane resonance, thus transforming inaudible infrasound to audible higher frequencies. Also, a loosely fitted window may move to and fro and being stopped by the window frame vibrates at higher frequencies radiated into the room.

Conclusion

Infrasonic harmonics of the blad passing frequency from modern, tall wind turbines must be considered inaudible. Low frequency in-flow turbulence sound may be audible, but wind turbine sound is loudest at medium to high frequencies. This readily audible sound is caused by atmospheric and induced turbulence at the blade surface. The level of this medium/high frequency turbulent sound varies at the rate of the blade passing frequency, which causes the typical swishing sound of a modern wind turbine.
When the atmosphere becomes more stable, which is usual at night when there is a partial clear sky and a light to moderate wind (at ground level), there is an important change in wind profile affecting the performance of a modern, tall wind turbine. The airflow around the blade then changes tot less than optimal, resulting in added induced turbulence. This effect is strongest when the blades pass the tower, causing short lasting, higher sound levels at the rate of the blade passing frequency. In a wind park these pulses can synchronize, leading to still higher pulse levels for an observer outside the park. The resulting repetitive pulses change the character of the wind park sound and must be expected to cause added annoyance.

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FINDINGS AND RATIONALE
THE MONTVILLE WIND TURBINE GENERATOR ORDINANCE

Guiding principle: "A subset of society should not be forced to bear the cost of a benefit for the larger society". Via Kamperman and James, from George S. Hawkins, Esq., "One Page Takings Summary: U.S. Constitution and Local Land Use", Stony Brook-Millstone Watershed Association; "...nor shall private property be taken for public use, without just compensation." Fifth Amendment, US Constitution.

As part of its mandate to develop a WTG ordinance, the Montville Wind Turbine Sub-Committee reviewed upwards of 100 documents. These documents included professional papers, white papers, including peer reviewed scientific and medical studies of the effects of WTGs on nearby populations. The available evidence is abundant and credible. A partial listing of these reference materials can be found in Part III – Bibliography of this Appendix.

There is a perceived lack of concern at the state level for the well-being of residents in rural communities. The following is from Kamperman and James:

> When Wisconsin's Town of Union wind turbine committee made an open records request to find out the scientific basis for the sound levels and setbacks in the state's draft model ordinance, it found that no scientific or medical data was used at all. Review of the meeting minutes provided under the request showed that **the limits had been set by Task Force members representing the wind industry.** This may explain why state level committees or task forces have drafted ordinances with upper limits of 50 dBA or higher instead of the much lower limits applied to similar projects in other countries. There is, in fact, no independent scientific or medical support for claims that locating 400 foot tall wind turbines as close as 1000 feet (or less) to non-participating properties will not create noise disturbances or other risks. But, there is considerable independent research supporting that this will result in public health risks and other negative impacts on people and property.

Part I – Setbacks

1. Negative health impacts have been observed wherever large turbines have been placed too close to where people live. In numerous instances, these impacts are severe enough that residents have had to move out of their homes some of which they have occupied continuously for more than 30 years. These symptoms have been studied, analyzed, catalogued and documented by professional physicians and scientists, and are not limited to any one region of the world. They are classified under 3 separate clusters of symptoms; Wind Turbine Syndrome, Vibro-Accoustic Disease, and to a lesser extent in humans but widespread among livestock, Electromagnetic Hypersensitivity. The symptoms manifested include: sleeplessness and accompanying exhaustion and irritability, headaches, tinnitus, ear pressure, dizziness, blurred vision, vertigo, nausea, racing heartbeat, tachycardia, difficulties with concentration and memory.

2. We include, as Exhibit A of this Appendix, a letter by Phil Bloomstein, published in the July 16, 2009 issue of *The Republican Journal*. Phil Bloomstein a 34 year resident of Freedom, ME, documents how his and his family's life, was affected after the WTG went online late in 2008.

His story is typical of families living in quiet rural communities where WTGs have been built too close to homes and without due regard for the quietness of the rural setting.

3. Within the state of Maine, the families living 3500 feet or less of the industrial wind facility in Mars Hill have reported experiencing severe negative health effects, loss of quality of life, and loss of property values. All the families living within that distance, participating in a medical survey have expressed the desire to move away, were they able to salvage the investment they have made in their homes. At the time of this writing, there are no residences in Mars Hill between distances of 3500 feet and 1.25 miles from the industrial wind facility.

4. In Vinalhaven, the industrial wind plant Fox Island Wind, inaugurated on November 17, 2009 – initially welcomed with near unanimous support – began losing that support as families up to 1.5 miles from the project experienced disturbing noise levels and vibrations – all as described in previous studies and literature and in industrial wind plant installations in Mars Hill and Freedom. Prior to construction, residents had been assured that any noise generated would be no louder than a "quiet conversation". Further, a resident who raises ducks reported they went off their feed when the turbines started operating.

5. The Maine Medical Association on Sept. 12, 2009 and the Maine Osteopathic Association on Sept. 25, 2009 adopted nearly identical resolutions calling for modification of existing industrial wind turbine siting procedures and commited to work with regulatory bodies towards developing up-to-date evidence-based regulations that reflect and incorporate findings of scientific studies on their health effects on nearby populations.

6. For information regarding effects on humans at distances beyond the 3500 foot setback from wind turbines we look to the experience in other locations both at home and abroad, including Europe, whose experience with industrial wind turbines is counted in decades. Researchers at these various locations have made the setback recommendations below. This is by no means a comprehensive listing, but it is representative of the most repeated recommendations. The trend clearly shows a lengthening of the setback distances in order to protect health and well being.

    a. Dr. Robyn Phipps Ph.D., New Zealand – A 2007 survey of 614 respondent households in New Zealand with topography very similar to Maine's (long, parallel mountain valleys and rocky substrata), found that "wind farm noise has a significant effect on people that may well extend more than 5 kilometers (3.1 mi.) from the site of the turbines"
    b. Marjolaine Villey-Migraine, Ph.D., France – A 2004 paper concludes that no industrial wind turbines must be placed any closer than 5 kilometers (3.1 mi.) from where people live
    c. Scotland requires setbacks of at least 2 kilometers (1.24 miles) from cities, towns and villages
    d. In Feb 2007 United Kingdom's Dr. Amanda Parry conducted a survey resulting in setback recommendations of no less than 1.5 miles
    e. The Champaign, IL planning commission recommends a minimum 2.5 mile setback from municipal boundaries.

f. Dr. Nina Pierpoint, MD. Ph.D. recommends minimum setbacks of at least 2 kilometers (1.24 mi..) in flat terrain and 2.2 miles in mountainous terrain.
g. A nationwide petition in the USA is gathering signatures for minimum setbacks of 2 kilometers (1.24 mi..) with greater distances of 2 - 3 miles for rolling hills and quiet rural areas.
h. Robert Rand, Full Member INCE, Brunswick, Maine in his April 29 2009 email to the Natural Resources Council of Maine, recommends setbacks of 2 to 3 miles or more.
i. In the Report of the Governor's Task Force on Wind Power Development (Maine) dated Feb 14, 2008 recommended "... removing from consideration, 100 percent of the land within two miles of the Appalachian Trail..." even though there are no year-round residents on the trail.
j. Pharmacist Carmen Krogh of Ontario, Canada cites research calling for setbacks of 1.5 to 3.5 kilometers (.93 to 2.17 mi)
k. Angus King, former Governor of Maine, and partner of Independence Wind at his March 3, 2009 presentation at the Hutchinson Center, Belfast, ME said setbacks should be "about a mile".

7. We can also confirm that over time countries have lengthened their setback requirements after documenting the harmful effects of too-short industrial wind turbine and industrial wind turbine plant setbacks.

a. United Kingdom: original setbacks in 1991 were based on a multiple of rotor diameter resulting in setbacks of 120 to 170 meters. In 2006, those recommendations changed to no less than one mile.
b. Scotland: original setbacks were the same as the 1991 setbacks in the UK. In 2007, the Scottish Planning Policy SPP6 - PAN 45 recommended with the support of the Scottish Ministers a separation distance of 2 kilometers (1.24 mi..) "...between turbines and the edge of cities, towns and villages..."
c. France: although at first it placed no limits for setbacks other than sound limitations, in 2006 the Academy of Medicine recommended a setback of 1.5 kilometers(.93 mi) until epidemiological studies could be carried out to determine health effects.

8. It has also been documented that the distance at which human health is negatively impacted by these industrial facilities is influenced by the terrain of the location, whether flat or mountainous, whether loamy or rocky substrata – in the case of Maine, the abundance of ledge which transmits noise and vibration easily and further. The number of turbines also adds to the variables, more turbines means louder noise, traveling further. Higher name plate production turbines result in louder noise.

9. It has also been documented that industrial wind turbine facilities have negative impacts on animals, both domestic livestock and wildlife, including land animals as well as birds, bats, raptors including numerous endangered species.

***Conclusion*:**

The best protection against the negative effects of WTGs on the health, peace of mind, well being

and real estate values is proper setbacks. The research literature repeatedly supports longer setbacks as does recorded long-term experience of nearby residents.

Part II – Sound Limitations

1. Improper and inadequate sound measurements have consistently favored the needs of the industry over the needs of the residential, quiet rural communities where they are sited. This has resulted in turbines placed too close to where people live, with real, negative impacts on people, their health, well-being, peace of mind, financial status. In far too many cases, these adverse effects have been severe, and borne not by the greater community, but by those individual families who, through no fault of their own, find themselves in an unliveable situation caused by improperly sited WTGs. The scientific, medical literature and the news outlets, including the Internet, document these at great length and detail, in print and in video, in the USA and abroad.

2. Unlike other urban or suburban sounds, or loud industrial noise, or traffic noise, those living near these WTGs report being unable to get used to the noise. Rather, reports describe that affected populations become increasingly sensitized to it. Employees in loud factories, or people exposed to traffic noises, or other noises can usually get away from them at home. Because WTGs generated noise occurs at home, 24 hours a day, 7 days a week, individuals cannot escape it. The only cure, is proper sound measurements, resulting in protective setback distances.

3. The noise generated by the WTGs is turbulent broadband noise often described as a jet engine perpetually revving for take-off as the blades move through the air, and a sonically unique and repetitive "wooshing" "thumping", "clapping", pulsing noise as the blades pass in front of the turbine mast. This noise is more pronounced at nighttime when the air at ground level is still, but the winds high up at the hub of the turbine are forceful enough to turn the turbine at capacity. Further, the pulsating noise generated by two or more turbines can combine to create louder and more complex noise that carries for longer distances.

4. The most susceptible populations to harmful effects of WTGs noise are young children, individuals with long-term medical conditions, and the elderly.

5. Further, even though many of these WTGs are placed in rural/wilderness areas, such as the Town of Montville, which are very quiet communities, government agencies charged with the protection of the citizenry, consistently espouse noise limitations more appropriate to urban residential or urban mixed areas whose background noise levels are much higher than urban/wilderness areas such as the Town of Montville. The disruption level of these misguided and permissive noise limitations are the cause of much of the sleeplessness and other real health issues suffered by residents near these WTGs.

6. The World Health Organization (WHO) in its reports "Guidelines for Community Noise" and "Report of the Third Meeting on Night Noise Guidelines" recommends that evening and nighttime sound levels should be less than 30 dBA to protect children's health. Below are some references made in its "Community Noise" (Berglund et al, 2000):

    a. "It should be noted that low frequency noise...can disturb rest and sleep even at low sound

levels

b. For noise with a large proportion of low frequency sounds a still lower guideline (than 30 dBA) is recommended
c. When prominent low-frequency components are present, noise measures based on A-weighing are inappropriate.
d. Since A-weighing underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighing.
e. It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health"
f. The WHO also states: "The evidence on low frequency noise is sufficiently strong to warrant immediate concern"
g. For sounds that contain a strong low frequency component, which are typical of the sound emitted by wind turbines, the WHO says that limits may need to be even lower than 30 dBA to avoid harmful health impacts. The WHO further recommends that the criteria be based on dBC frequency weighing.

7. The low-frequency vibrations, known as dBC, is not usually measured by wind developers, and yet, this is the component that more than the other is the cause of severe health impacts. A reading of the dBC noise level, in addition to the dBA readings, is far more predictive of loudness.

8. Although the siting of WTGs in the United States consistently favors the needs of the wind developers over the needs for quietude of families living near the WTGs, history shows that they are capable of meeting far stricter sound limitations which have evolved over the 20 plus years of experience in other continents with these industrial facilities. Below is a listing of the sound limitations in place overseas, as compared to those used in the United States:

- Australia: higher of 35 dBA or L90 + 5 dBA
- Denmark: 40 dBA
- France: L90 + 3 dBA (night) and L90 + 5 dBA (day)
- Germany: 40 dBA
- Holland: 40 dBA
- United Kingdom: 40 dBA (day) and 43 dBA or L90+5 dBA (night)

In the USA:

- Illinois: Octave frequency band limits of about 50 dBA (day) and about 46 dBA (night)
- Wisconsin: 50 dBA
- Michigan: 55 dBA

9. Further, the International Standards Organization (ISO), an independent organization in ISO 1996-1971 recommends a maximum noise limit of 25 dBA for night time in rural communities. (See table below).

ISO 1996-1971
Recommendations for Community Noise Limits (dBA)

	Daytime Limit	Evening Limit 7 pm - 11 pm	Night Limit 11 pm - 7 am
Rural	35 dB	30 dB	25 dB
Suburban	40 dB	35 dB	30 dB
Urban residential	45 dB	40 dB	35 dB
Urban mixed	50 dB	45 dB	40 dB

10. From the State of Maine's Technical Assistance Bulletin #4 – Noise. May 2000:

> Prolonged noise exposure is a serious threat to human health; it can result in high stress levels and, at high sound levels, impaired hearing. Common environmental noise sources can cause or contribute to stress-related illnesses such as cardiac and circulatory diseases. Noise can also negatively impact concentration, communication, and sleep creating annoying and sometimes even hazardous conditions. These factors are important in setting noise standards for the community. [.....] It is also important to protect neighborhoods so that residents can communicate and enjoy their property. Residential areas should also be protected from noise so that residents are able to obtain uninterrupted sleep. Interrupted sleep can result in serious health impacts and also affect personal safety at home and at work. Another consideration for municipal officials is property values. Neighborhoods subject to noise disturbance will generally have lower values.
>
> Nighttime noise is more annoying than daytime noise and may cause more noticeable health impacts through the disruption of sleep. — Pages 2 and 3

11. Finally, the same document (Page2) identifies the Sound Pressure Level (dBA) for a "quiet house interior or rural nighttime" as 20 dBA even lower than the ISO's 25 dBA.

Conclusion:

The Town of Montville is a rural environment, and as such, sound limitations should reflect the quiet nature of its surroundings. Many of its residents have come to Montville from noisier urban environments attracted by its rural character, peaceful, quiet surroundings and community values. Given the abundant documentation readily available from independent professionals and researchers, it is unconscionable that any governing entity, at the local, state or higher level, charged with protecting the health, safety and well being of its citizens, would inflict avoidable hardship on them through either ignorance, carelessness, indolence or undue influences by powerful interested parties with conflicts of interest and their lobbyists.

EXHIBIT A – Letter from Phil Bloomstein

As it appeared on page A9 of the July 16, 2009 issue of the **Republican Journal**.

Living Next To a Wind Turbine

We have the distinct "privilege" of living 1,000 feet from tower T3 of the Beaver Ridge Wind Project. Freedom residents on both sides of Beaver Ridge live almost as close but none as close as my family and me. We have tower T3 literally staring us right in the face winter and summer. In the summer the tower and blades almost disappear when you are by the house, but the tower and blades still hang above the house as you walk in our lower gardens. And, you can view the wind turbine from many other spots on our land.

As disturbing as the visual presence of a nearly 400-foot wind turbine is, and its occasional hours of turbine-blade flicker, all that pales in comparison to the noise the turbines often produce. I would dare say we live in one of the noisiest neighborhoods in Waldo County.

Let's get one thing straight. I'm not claiming my life has been ruined. I'm not looking for sympathy. I'm sure many of you have suffered personal tragedies much worse than having a wind turbine built next to you.

What I am asking for is the truth and some justice.

I want to present you with a credible picture of the turbine's effects on the quality of our family's home life. I also want you to understand that the town of Freedom's planning and permitting of the Beaver Ridge Wind Project was extremely flawed. It was marked by deceptions, poor planning, and small-town politics at its worst. In my opinion, the project has proven that many good folks in the town of Freedom were outwitted by CES now Beaver Ridge Wind. Many community members were so pro green they were susceptible to the developer's deceptive practices and failed to be responsible to us and our neighbors.

My challenge is to convince you that I am telling the truth. And that others, including my neighbors, the folks in Mars Hill and as far away as the Midwest, are also telling the truth about the disturbing noise created by these machines. Living next to a wind turbine is, to say the least, a very unpleasant experience. Good-meaning people write me and say; "We just don't get it". They tell me they have visited the Beaver Ridge turbines several times in different wind conditions, and it just doesn't seem that bad.

I also visited wind turbines. I visited them with the knowledge that one was going to be built very close to my house. I came away thinking living next to one was going to be somewhat annoying but that it probably was going to be OK. I was encouraged by the promises of Beaver Ridge Wind (then called CES). The very same promises that were never kept.

What my neighbors and I have experienced has been much more negative than we had ever imagined.

What is it really like living next to the turbines? There are "good days," but there are way too many bad ones. Although the noise is almost always there, it is not constant in its intensity or type of sound. In minutes it can turn from an almost tolerable drone to a pulsating nightmare so oppressive that any outdoor activity is challenging. The noise also penetrates into the house. On many nights, as soon as you turn off the TV or stereo you immediately hear them. At least four to eight times a month they are very loud. The night noise can be especially disturbing. Some nights there is a loud pulsating noise that lasts right into the

morning, on those days we get discouraged. We think that this can't be good for our health and we might as well give up and sell out.

The wind industry, often in concert with well-meaning government officials and environmental activists, uses all its power to diminish complaints and convince the general public that "wind farms" are quiet and that most folks don't mind living next to them.

When CES (now called Beaver Ridge Wind) came to Freedom, they assured us the turbines would be quiet. During the permitting process, they presented a study showing the noise level at our home would hardly ever be above 45 dBa. When all was said and done, the noise levels exceeded the promised levels (often twice as loud). When I asked Beaver Ridge Wind what they were going to do about the noise, they looked me right in the eyes and said they never really exactly promised us that.

The developer's clever promises and use of wind industry propaganda made it easy for the townspeople to support the project even though the setbacks in Freedom were among the weakest in the country. The setbacks were even below manufacturer's suggested distances at property lines. It is my intent to show how the townspeople were misled. But for now, understand the developers presented a wind study they commissioned saying the sound levels at my house would rarely exceed 45 decibels. The truth is, sound levels are regularly over the promised level, and on many windy nights, can be twice as loud.

Victims of poorly planned wind turbine developments from Mars Hill, Maine to the Midwest are not believed. Fine citizens with the highest of motives dismiss these folks as whiners or less than credible. I have heard people say, you'll get used to it. You don't. There are many contributing factors to this. A few are that the noise changes with wind speed, the types of noise produced, wind direction and atmospheric pressure. The developers should have considered the fact that our home is on a side of a hill downwind from the prevailing wind. Documents can be found and downloaded on the Beaver Ridge Wind web site that explain, "in some hilly terrain where residents are located in sheltered dips or hollows downwind from the turbines, turbine sounds may carry further and be more audible."

Why was this not considered in our case?

There is the classic wind-energy comparison of a turbine's noise level to your refrigerator. First of all, at my house, the turbines are much louder and more annoying than my refrigerator. But let's assume the turbines do sound like my refrigerator. I ask you to imagine your fridge is always running and that also, you have one on your deck, in your garden, by the compost, next to the garage, three or four in your backyard, several well placed down your driveway, one at each door, one next to the grandkids's wing set, and don't forget the ones hanging outside your bedroom window.

Get the idea? I think you might find even your fridge noise a little annoying.

Then there are the possible negative health effects. Remember, the tower is almost 400-feet tall at the tip of the blades and we are 1,060 feet from the middle of the base. So at times, the tips of the blades are about 930 feet away. After a night of pulsating turbine noise that continues right into the morning, (no matter what studies prove) I feel as if this can't be good for my family. I can only imagine what it would be like if one were predisposed to headaches, depression or a sleep disorder.
Perhaps you are thinking, well someone has to suffer for the good of humanity, it might as well be the Bloomsteins. Maybe you are right, but does that give the developers and the wind-energy industry the right

to lie about the impact? Beaver Ridge Wind and other projects in Maine are not municipal projects, these wind turbines are for profit. I might be less angry if they had said, OK your life is going to change and not in a good way. There will be a negative impact, you will be sacrificing the quiet rural life you once had for the good of the environment.

But no, they don't do that. They lie and tell your town you'll barely hear them and it will be like being in a quiet room or a library. They could be honest and tell you that it will be noisy at your home. Beaver Ridge Wind could have mentioned the fact that other people have chosen to sell out rather than live close to a wind turbine. Instead they show videos and PowerPoint slideshows with misleading and deceptive statements.

For us the damage is done. The turbines are up, and most likely, they are not coming down for a long time.

So the question for my family and me is: What do we do? We have lived and worked on our property for the past 34 years. Do we leave the house we built, the gardens we've planted, the place my children and their children love? Or, do we stay and learn to deal with the noise, worry about unknown health hazards, keep windows closed at night in the summer, sleep with earplugs on loud nights — whatever it takes to stay sane?

We know our home will never be the same. If we do leave, what about the value of our house? The industry will tell you house values go up or stay the same, but there are many studies which show quite the opposite.

No matter what we do our family now must fight for our rights. No one comes up to us and offers a solution. Oh, Beaver Ridge Wind might tell you they are working with us and in fact they are: but not until we approached them with our concerns. Beaver Ridge Wind never did a sound study after the turbines went into operation. Their basic approach is to say nothing, do nothing and only respond when the Bloomsteins or other neighbors complain, but not until then.

It has become evident to us that trying to be reasonable, open-minded and pro green has been rewarded by deceptive practices, small-town politics at its worst and a radically negative change to our lifestyle.

We struggle to figure out what to do. We want the truth to be known. We want to be believed. We seek justice in the form of adequate compensation. We also hope in some small way we can prevent others from suffering a similar fate.

Please don't be so zealous in your support of alternative energy that you allow an industry, even a green one, to avoid any reasonable regulations. They need to be held accountable. No company out for profit should be given a free pass.

My family and other families in similar situations should not be forced to seek compensation in the courts or make deals under conditions of confidentiality.

Maine needs to grow up when it comes to wind development. There is no need to repeat the mistakes that were made in Freedom and Mars Hill.

Phil Bloomstein – Freedom, Maine

Part III – Bibliography

This is only a partial listing of the nearly 200 separate documents and references consulted during the Sub-Committee's research. Additional listings are available upon request.

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Personal Video Testimonies/Documentaries

1. From Mars Hill, ME., residents speak about how the wind turbines have affected their lives.
   Part One: http://www.youtube.com/watch?v=Lp31TWPC5tc
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2. From the Meyesdale, PA windplant, nearby residents speak about their lives. Affected residents live as far as 1 plus miles as the crow flies to the windplant.
   Part One: http://www.youtube.com/watch?v=SNxvkrgoPLo
   Part Two: http://www.youtube.com/watch?v=_utFV2ukOtU&feature=related
   Part Three: http://www.youtube.com/watch?v=AOd5tSZF3A4&feature=related

3. Dairy Farmer Scott Smrynka in Lincoln township, Wisconsin tells how the nearby windfarm has affected his milk production and the health of his herds:
   http://www.youtube.com/watch?v=JP5zT7a8U0Y

4. In Cohocton, NY, Hal Graham, town Justice, describes how leasing his land to a wind developer has impacted his life:
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