

Independent review of the state of knowledge about the alleged health condition known as **Wind Turbine Syndrome (WTS)**

Health and Safety Briefing

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RenewableUK is the leading renewable energy trade association in the UK. Wind has been the world's fastest-growing renewable energy source for the last seven years, and this trend is expected to continue with falling costs of wind energy and the urgent international need to tackle CO2 emissions to prevent climate change.

In 2004, RenewableUK expanded its mission to champion wave and tidal energy, and to use the Association's experience to guide these technologies along the same path to commercialisation.

Our primary purpose is to promote the use of wind, wave and tidal power in and around the UK. We act as a central point of information for our membership and as a lobbying group to promote wind energy and marine renewables to government, industry, the media and the public. We research and find solutions to current issues and generally act as the forum for the UK wind, wave and tidal industry, and have an annual turnover in excess of four million pounds.

Status of this document

Health and Safety briefings are intended as a basic overview of a particular technical, legal or policy issue relevant to the core membership base of RenewableUK. Briefings provide general Health and Safety information on the topic concerned, and where appropriate offer basic guidance about how the issues can be addressed. Health and Safety briefings will not normally be subject to regular review or updating, and so the accuracy of the briefing can only assumed to be relevant and up-to-date at the time of publication. Attention is also drawn to the disclaimer below.

Disclaimer

The contents of this briefing are intended for information and general guidance only, do not constitute advice, are not exhaustive and do not indicate any specific course of action. Detailed professional advice should be obtained before taking or refraining from action in relation to any of the contents of this guide, or the relevance or applicability of the information herein.

RenewableUK

RenewableUK (formerly known as BWEA) is the UK's leading trade association representing the renewable energy sector.

RenewableUK has made a commitment to ensuring that Health and Safety, including public safety, is given top priority in the wind, wave and tidal industry. We recognise our responsibility to take a lead on Health and Safety matters as they directly relate to the risks particular to our sector. This briefing is in response to the profile and media attention given to the alleged condition known as Wind Turbine Syndrome (WTS) that developed towards the end of 2009.

RenewableUK's initial assessment of the alleged health condition was that it had no scientific basis and could not be supported by the available evidence. RenewableUK had received no independent reports on the condition or the alleged symptoms being cited. However, as a responsible trade body, we needed to be confident that we presented a fair, accurate and independent assessment of the issues involved. RenewableUK therefore instructed three independent experts to review the evidence available on WTS and present their conclusions.

This briefing sets out:

- a background presenting the context of the alleged condition;
- the scope of the reviews conducted;
- the executive summaries of the reviews; and
- a RenewableUK commentary on the issues involved.

Wind Turbine Syndrome – Background

RenewableUK has monitored the developing state of knowledge on a range of health and environment issues in recent years, which could be relevant to renewable energy generation and in particular wind turbine generators (WTGs).

“WTGs generate infrasound that directly causes a range of physical sensations”

Concerns that noise radiating from wind turbines could contain sufficiently high levels of low frequency energy that may pose a threat to human health have been subject to significant scientific and public debate for several years. However, the consistent and scientifically robust conclusion has always been that there is no independent evidence to demonstrate any significant health effects from noise at the levels of that generated by wind turbines.

Towards the end of 2009 a few high-profile media articles were published in response to the pre-publication of a book titled *Wind Turbine Syndrome*¹. This publication provided the industry with an opportunity to update its state of knowledge of the science concerned. The central premise of the book is that WTGs generate infrasound that directly causes a range of physical sensations (e.g. tinnitus, headaches etc.) and effects (e.g. sleeplessness, anxiety etc.).

The independent reviews conducted sought to determine if there is any robustness or efficacy in the science and aetiology² proposed.

Reviews

RenewableUK instructed three independent experts to carry out reviews of the issues, and this specifically included an assessment of the:

- suitability, efficacy and robustness of the research conducted by Dr Pierpont, with particular emphasis on the strength or otherwise of any cited causal links, and with reference to recognised statistical, analytical and epidemiological techniques applied;
- underlying scientific and acoustic principles being cited for infrasound/low frequency noise generated by wind turbines; and
- medical/audiological evidence that infrasound/low frequency noise from wind turbines is the probable cause of the alleged new health condition known as Wind Turbine Syndrome.

Summaries of the reviews conducted are overleaf³.

Executive Summaries

Expert Opinion 1: Evaluation of Scientific and Epidemiological Methodology

Author: Richard J.Q. McNally, BSc, MSc, DIC, PhD

Scope of the review:

Dr McNally was instructed to provide:

- a summary of the basic methods carried out by Dr Pierpont;
- an assessment of the competence and independence of the author;
- commentary on the adequacy and reliability of the methods;
- an assessment on the validity, veracity and relevance of the cited case histories;
- commentary on the reliability of conclusions drawn by Dr Pierpont;
- an evaluation of the general quality and efficacy of the research performed; and
- analysis of the critical evidential and epidemiological gaps in the methodology performed.

“Dr Pierpont’s use of epidemiological and statistical methods is seriously flawed.”

Executive summary:

The overall objective of the report was to independently review the state of knowledge about the alleged health condition known as Wind Turbine Syndrome (WTS). The specific aim was to critically evaluate the scientific and epidemiological methodology. In addition to carrying out the instruction above, Dr McNally critically evaluated each part of the report and specifically critically assessed the epidemiological and statistical methods.

Dr McNally’s summary is presented below:

- Dr Pierpont’s report is based on a highly selected small case series.
- She has defined the alleged WTS by a set of vague clinical symptoms (this

approach is not an accepted technique for researching the causes of diseases – a precise a priori case definition is required).

- The method of comparison is invalid; she has no clear prior hypotheses.
- She has interviewed members of 10 highly selected families.
- She has used a structured questionnaire for her interviews, but the questionnaire is not included in the report.
- She has compared symptoms in cases before and after exposure to wind turbine noise. Dr Pierpont has looked for associations between symptoms of the alleged WTS and exposure to wind turbine noise.
- Dr Pierpont has repeatedly used simple chi-squared statistics to evaluate putative associations. These statistical techniques are not robust enough in this field – there is the problem of multiple testing resulting in incorrect p-values, and also the possibility of some associations being due to confounding.
- She has only reported selected results of the chi-squared analyses.
- Dr Pierpont has concluded that there is an association between certain symptoms and exposure to wind turbine noise.
- I do not find that Dr Pierpont has either the necessary independence or the relevant competence with regard to scientific approach or epidemiological analysis.
- Dr Pierpont's use of epidemiological and statistical methods is seriously flawed.
- Dr Pierpont's conclusions are completely unreliable.
- A high-quality epidemiological study should always include a range of experts including epidemiologists and biostatisticians. Dr Pierpont has attempted to conduct a study, by herself, and without including appropriate experts.

In conclusion, Dr McNally states that the positive findings are based on a flawed design and flawed analysis, and he would not recommend publication.

Expert Opinion 2: Infrasound and Low Frequency Sound from Wind Turbines and Wind Turbine Syndrome – an Assessment

Author: G. Leventhall, MSc, PhD, FInstP, HonFIOA

Scope of the review:

Dr Leventhall was instructed to provide:

- a simple description of the terms and terminology (infrasound/low frequency noise) and their application to wind turbines;
- a summary of the peer-reviewed evidence of infrasound/low frequency noise and wind turbines;
- discussion on the audibility and physiological response to infrasound/low frequency noise;
- a summary of the basic noise and acoustic principles cited by Dr Pierpont;
- an assessment of the validity of the scientific and acoustic evidence being presented by Dr Pierpont; and
- conclusions on the available state of knowledge about any significant acoustic effects from wind turbines.

“Dr Pierpont makes the common mistake of taking a one-dimensional view of sound, considering only frequencies and ignoring the importance of levels.”

Executive summary:

- The Wind Turbine Syndrome being cited is based on the assumption that infrasound from wind turbines upsets the balance systems in the body and deceives the body into thinking that it is moving, resulting in various distressing effects, which are collected together as the syndrome.
- A review of published measurements of infrasound from wind turbines shows the levels to be low and inaudible. However, Pierpont assumes that infrasound at 1–2Hz and at 4–8Hz is the cause of the effects she noted, incorrectly basing this on previous work on whole body vibration, which is not relevant to excitation by sound. She also bases her theories on work for the Apollo Space Program, when potential astronauts were exposed to very high levels of infrasound in the

120–140dB range, which is also not relevant to the inaudible infrasound from wind turbines.

- Pierpont makes the common mistake of taking a one-dimensional view of sound, considering only frequencies and ignoring the importance of levels. A weakness of her work is the absence of decibel levels or threshold levels for the effects that she claims. This is a serious failing, as urban dwellers are exposed to similar levels of infrasound to that from wind turbines.
- The results of her case studies are valid for the individuals in the small group of people included. However, all the symptoms that she describes have been known previously as stress effects, which arise in a few sensitive persons when exposed to an adverse element in their environment. They are not a pathological effect of wind turbine noise.
- Complaints of wind turbine noise result mainly from audible aerodynamic modulation, typically in the 500Hz to 1,000Hz range. The effects of wind turbine noise are similar to the effects of other noises.

Expert Opinion 3: Effects of Low Frequency Noise from Wind Turbines on Humans

Author: Mark E. Lutman, PhD, BSc, MSc

Scope of the review:

Dr Lutman was instructed to provide a review of:

- the patho-physiology being cited by Dr Pierpont, with specific reference to the physiological pathways and symptoms being cited;
- the clinical and audiological validity of the symptoms being cited, and the availability of evidence to support a link to low frequency noise;
- commentary on the robustness of the clinical methodology applied and the veracity of the conclusions being drawn; and
- conclusions as to the existence of any substantiated evidence to indicate the existence of the alleged condition known as WTS.

Executive summary:

- The review considered whether low frequency noise from wind turbines might cause adverse physiological effects on people living in proximity, within a mile or so. The review examines the contention put forward by Dr Pierpont that there is a specific and newly identified physiological syndrome (Wind Turbine Syndrome) that is directly related to low frequency wind turbine noise and mediated via the vestibular system.
- The relevant properties of sound and its impacts on the human auditory system are outlined and contrasted with the functioning of the human vestibular system, which is responsible for perceiving posture and motion. It is demonstrated how the auditory system is specialised for sound and the vestibular system is specialised for motion, showing that the vestibular system is extremely unresponsive to low frequency sound, undermining any connection between low frequency sound and the symptoms of Dr Pierpont's respondents.

“Responses to low frequency vibration only occur when the vibration is applied directly to the head, causing shaking.”

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- The mechanisms of noise generation from wind turbines are outlined, showing that they do not create material low frequency noise. Instead, they create broadband noise that is modulated at low frequencies, leading to the characteristic “swishing” sound. The argument that wind turbine noise causes physiological symptoms in humans through low frequency noise therefore fails.
 - The evidence for response of the human vestibular system to acoustic stimulation is reviewed and it is shown that such responses only occur for high intensities of sound, much greater than created by wind turbines. Responses to low frequency vibration only occur when the vibration is applied directly to the head, causing shaking. These findings further indicate that noise from wind turbines cannot contribute to the symptoms reported by Dr Pierpont’s respondents, by the mechanism that she proposes.

The most-likely explanation for the reported symptoms, which are probably exceedingly rare, is a psychological reaction to the intrusion of wind farms, with consequent somatic (felt in the body) effects mediated by stress and anxiety.

RenewableUK Commentary

RenewableUK is committed to understanding all relevant technical and scientific evidence about potential health risks connected to the industry.

Experience has demonstrated that the reputation of and confidence in an industry can only be earned through open and honest debate on the issues concerned, based on the most reliable and up-to-date information available. As a responsible industry it is appropriate to consider societal concerns (actual or perceived) about a given technology, such as wind turbines. However, judgements and conclusions about what risks are acceptable must be evidence led.

The independent reviews on the alleged condition known as Wind Turbine Syndrome, summarised above, represent a robust and reliable state of knowledge on the issues involved. The experts conclude that:

- the scientific and epidemiological methodology and conclusions drawn are fundamentally flawed;
- the scientific and audiological assumptions presented by Pierpont relating infrasound to WTS are wrong; and
- noise from wind turbines cannot contribute to the symptoms reported by Pierpont's respondents by the mechanisms proposed.

These conclusions are further reinforced by two recently published independent reports.

The publication *Wind Turbine Sound and Health Effects – An Expert Panel Review 2009*⁴ involves an extensive review, analysis and discussion of the large body of peer-reviewed literature on sound and health effects in general, and on sound produced by wind turbines. The principle conclusions drawn by this expert panel are:

- There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.
- The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.
- The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's

“There is no reason to believe that the sounds from wind turbines could plausibly have direct adverse health consequences.”

experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences.

The Health Protection Agency (HPA) publication *Health Effects of Exposure to Ultrasound and Infrasound – Report of the Independent Advisory Group in Non-Ionising Radiation 2010*⁵ is another key source of information.

This comprehensive report presents a robust and expert state of knowledge on the health effects of ultrasound and infrasound. The most significant conclusion it presents relevant to the wind sector is that “...there is no consistent evidence of any physiological or behavioural effect of acute exposure to infrasound in humans”.

All wind turbines will generate both mechanical and aerodynamic noise and vibration. Mechanical noise is not typically a significant source of noise for modern wind turbines. Aerodynamic noise will arise at all frequencies, from the infrasound range over low frequency sound to the normal audible range, and is the dominant source. Whilst wind turbines are a source of noise and vibration, any residual risks can be effectively mitigated by technical or organisational means.

Advice to industry:

RenewableUK recommends that a proactive approach be taken by the industry in addressing what is a complex and emotive subject. Whilst there is no scientific evidence that wind turbines have any physiological health effects, it is important to understand that certain individuals and interested parties may, despite this evidence, perceive that health effects remain. Although it is difficult to counter these views, the industry can still take a number of actions that can assist in alleviating some or all of these concerns. Examples RenewableUK would encourage the industry to consider include:

- Consultation
- Early dialogue and communication with the public and key stakeholders on any proposed development;
- Recognising and understanding that lay perceptions of health risks are valid and should be taken into account.
- Planning
- Ensuring environmental impact assessments include a robust evaluation of the noise and vibration risks of the project;
- Taking specific account of any sensitive receptors (e.g. local residents) that may have concerns particular to the project.
- Design
- Ensuring the design of the turbine, and where appropriate the wind farm, takes account of the relevant project and environmental issues concerned;
- Ensuring that suitable mitigation measures are considered following completion of risk assessment to address any residual risks where they exist.
- Monitoring
- Ensuring a regular programme of environmental noise measurements are performed;
- Ensuring, post consent, that there is regular community engagement, and there are mechanisms in place to address any general or specific concerns relating to noise and related issues.

In the vast majority of cases the above summary merely reflects what is existing good practice operated by developers and operators throughout the UK.

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