Adverse Health Effects in the Environs of Industrial Wind Turbines - Applying Bradford Hill Criteria of Causation (08/03/2015)

Consistency with the Bradford hill Criteria indicates that a high probability that serious harm to health will occur when a susceptible individual is beset by the noise that he or she suffers recurring sleep disturbance, anxiety and stress. A proportion of the individuals living in the vicinity of a large wind farm will experience serious harm to these adverse health effects (AHE).

1. **Strength of the Association**: **A small association does not mean that there is not a causal effect, though the larger the association, the more likely that it is causal.**

a. **Health Canada Research Protocol** 2012 states:

> There are studies which report that this sound level may be exceeded at some residences, suggesting the potential for WTN to disturb sleep among sensitive individuals (Pedersen and Waye, 2004; Pedersen et al., 2009; Krogh, 2011; Harry, 2007; Shepherd, 2011; Pierpont, 2009). http://www.hc-sc.gc.ca/ewh-semt/consult/_2012/wind_turbine-eoliennes/research_recherche-eng.php

b. **Nissenbaum M**, Hanning C and Aramini J. Effects of industrial wind turbines on sleep and health. Noise and Health 14:237-43; 2012. [See also 5. Biological Gradient v]

To compare sleep and general health outcomes between participants living close to industrial wind turbines and those living further away from them, participants living between 375 and 1400 m (n = 38) and 3.3 and 6.6 km (n = 41) from IWTs were enrolled in a stratified cross-sectional study involving two rural sites. Validated questionnaires were used to collect information on sleep quality (Pittsburgh Sleep Quality Index - PSQI), daytime sleepiness (Epworth Sleepiness Score - ESS), and general health (SF36v2), together with psychiatric disorders, attitude, and demographics. Descriptive and multivariate analyses were performed to investigate the effect of the main exposure variable of interest (distance to the nearest IWT) on various health outcome measures. Participants living within 1.4 km of an IWT had worse sleep, were sleepier during the day, and had worse SF36 Mental Component Scores compared to those living further than 1.4 km away. Significant dose-response relationships between PSQI, ESS, SF36 Mental Component Score, and log-distance to the nearest IWT were identified after controlling for gender, age, and household clustering. The adverse event reports of sleep disturbance and ill health by those living close to IWTs are supported. The adverse event reports of sleep disturbance and ill health by those living close to IWTs are supported.

c. **Shepherd D**, McBride D, Welch D, Dirks KN, and Hill EM. Evaluating the Impact of Wind Turbine Noise on Health-Related Quality of Life. *Noise and Health* 2011;13:333-9 http://waubrafoundation.org.au/resources/evaluating-impact-wind-turbine-noise-health-related-quality-life/]

The authors report a cross-sectional study comparing the health-related quality of life (HRQOL) of individuals residing in the proximity of a wind farm to those residing in a demographically matched area sufficiently displaced from wind turbines.

The study employed a non-equivalent comparison group post-test-only design. Self-administered questionnaires, which included the brief version of the World Health Organization quality of life scale, were delivered to residents in two adjacent areas in semirural New Zealand. Participants were also asked to identify annoying noises, indicate their degree of noise sensitivity, and rate amenity.

Statistically significant differences were noted in some HRQOL (Health-Related Quality of Life) domain scores, with residents living within 2 km of a turbine installation reporting lower overall quality of life, physical quality of life, and environmental quality of life. Those exposed to turbine noise also reported significantly lower sleep quality, and rated their environment as less restful. The authors also found that those residing in the immediate vicinity of a wind farm scored worse than a matched comparison group in terms of physical HRQOL and environmental QOL, and HRQOL in general. No differences were found in terms of psychological and social HRQOL, or in self-rated health. Study participants who cited wind turbine noise as more annoying also scored lower on sleep satisfaction ratings, suggesting that both annoyance and sleep disruption may mediate the relationship between noise and HRQOL.

The authors conclude that night-time wind turbine noise limits should be set conservatively to minimize harm, and, on the basis of our data, suggest that setback distances need to be greater than 2 km in hilly terrain.

d. **Reider S.** PSB Hearing July 29, 2014 : Wind Noise And Adverse Health Effects (statement to the Vermont legislature) http://psb.vermont.gov/sites/psb/files/docket/8167/Workshop3/Reider.pdf

Dr. Reider describes case studies of adverse effects with exposure to wind turbines, and personal experience as a physician and expert in the field.

e. **Krogh CME**, L Gillis, N Kouwen, and J Aramini. WindVOiCe, A Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring: Bull Sci Tech and Soc 31: 334-345; 2011.

f. **Arra I, Lynn H, Barker K**, et al. (2014-05-23 11:51:41 UTC) Systematic Review 2013: Association Between Wind Turbines and Human Distress. Cureus 6(5): e183.doi:10.7759/cureus.183 http://www.windconcernsontario.ca/wp-content/uploads/2014/06/Arra-LynnStudyMay2014.pdf

The objective of the study was to search the literature investigating the presence or absence of association between wind turbines induced noise and human distress.

The authors concluded that all studies rejected the Null Hypothesis (no association between wind turbine noise and human distress). In other words, evidence of association was found (Weak evidence: Level 4 and 5). No published peer-reviewed study showed lack of association. Three studies showed dose-response relationship.

2. **Consistency**: **Consistent findings observed by different persons in different places with different samples strengthens the likelihood of an effect.**

The most compelling information comes from consistency described on the hundreds of case reports and thousands of adverse event reports of those who are affected by industrial wind turbines. For clinical description of symptoms see Pierpont, N. Wind Turbine Syndrome, A report on a Natural Experiment. 2009, diagnostic criteria described by R McMurtry and CME Krogh (Diagnostic criteria for adverse health effects in the environs of wind turbines, J Roy Soc Med 2014: 5 (10)), and Dr. Reider's statement for the PSB hearing (http://psb.vermont.gov/sites/psb/files/docket/8167/Workshop3/Reider.pdf).

a. **Pedersen E, Högskolan i Halmstad**. Noise annoyance from wind turbines - a review. Report 5308 NATURVÅRDSVERKET SWEDISH ENVIRONMENTAL PROTECTION AGENCY. August 2003. http://www.naturvardsverket.se/Nerladdningssida/?fileType=pdf&downloadUrl=/Documents/publikationer/620-5308-6.pdf

The report reviewed the present knowledge (2003) on perception and annoyance of noise from wind turbines in residential areas as well as in recreational areas. It also summarized regulations in some European countries. In summary, field studies performed among people living in the vicinity of wind turbines showed that there was a correlation between sound pressure level and noise annoyance; annoyance was also influenced by visual factors such as the attitude to wind turbines' impact on the landscape. Noise annoyance was found at lower sound pressure levels than in studies of annoyance from traffic noise.

b. Pedersen E. Effects of wind turbine noise on humans. Third International Meeting on Wind Turbine Noise Aalborg Denmark 17 – 19 June 2009.

The review was based on data from two Swedish studies *[Pedersen 2004, Pedersen 2007]* and one Dutch study *[van den Berg 2008]* in which self-reported health and well-being were related to calculated A-weighted sound pressure levels outside the dwelling of each respondent. The main adverse effect was annoyance due to the sound; the prevalence of noise annoyance increased with increasing sound pressure levels. Disturbance of sleep was related to wind turbine noise; the proportion of residents reporting sleep disturbance due to noise increased significantly at sound levels close to those recommended as highest acceptable levels at new installations. Noise annoyance was correlated with several measurements of stress and lowered well-being.

The author concluded that consistencies in results from these studies make it possible to summarize the impact of wind turbine noise on people living in the vicinity of the turbines. And that the study design

does not allow causal conclusions, but the association indicates a probable interference with psycho-physiological restitution.

c. van den Berg F, Pedersen E, Bouma J, Bakker R. WINDFARMperception Visual and acoustic impact of wind turbine farms on residents. FP6-2005-Science-and-Society-20 Specific Support Action Project no. 044628; June 3, 2008. https://www.wind-watch.org/documents/visual-and-acoustic-impact-of-wind-turbine-farms-on-residents/; http://docs.wind-watch.org/wfp-final-1.pdf

Three out of four participants declared that swishing or lashing is a correct description of the sound from wind turbines. Perhaps the character of the sound was the cause of the relatively high degree of annoyance. Another possible cause is that the sound of modern wind turbines on average does not decrease at night, but rather becomes louder, whereas most other sources are less noisy at night. At the highest sound levels in this study (45 decibels or higher) there is also a higher prevalence of sleep disturbance. ILFN w2as not measured.

The study also found that the 14% of people receiving economic benefit were not annoyed by the IWT noise. On average those with an economic interest were better educated, younger and (therefore) healthier. One of the participants remarked: “If we are disturbed by the turbine we stop it, and we do the same for the neighbours”.

d. Health Canada (HC) clinical study: preliminary results (autumn 2014) demonstrated that a proportion of people have symptoms of “annoyance”, associated with annoyance that was statistically related to several self-reported health effects including, but not limited to, blood pressure, migraines, tinnitus, dizziness, scores on the PSQI, and perceived stress. HC also stated: “the findings support a potential link between long-term high annoyance and health.”

Nonetheless HC also did a cooperative press release with the wind industry in which they claimed there was no link to adverse health effects which is clearly at odds with the content of the report. At the outset HC denied that the study answers the question of causality and appears to maintain that position post-release which further underlines their ambivalence about AHE and IWT. Since HC identifies their results as preliminary no legitimate conclusions can be drawn from their study.

3. Specificity: **Causation is likely if a very specific population at a specific site and disease with no other likely explanation. The more specific an association between a factor and an effect is, the bigger the probability of a causal relationship.**

a. Phillips, Carl V. Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents. Bull Sci Tech Soc 31 (4) 2011. (see 2. Consistency A vii, above)

The author states that there is overwhelming evidence that wind turbines cause serious health problems in nearby residents, usually stress-disorder type diseases, at a nontrivial rate. The bulk of the evidence takes the form of thousands of adverse event reports. The sheer volume of reports elevates the evidence

beyond the few coincidental cases that can usually be found. The quantity further tells us that the effects go beyond a few rare individuals who are extremely susceptible.

Most reported health problems are similar across reports and are plausibly related to each other and the exposure. There is a core list of symptoms – sleep disorders, headaches, mood disorders, inability to concentrate, tinnitus, vestibular (balance) problems – appearing in most reports. The commonly reported problems all exist at the border of the psychological and physical, and can all be caused by either of two very plausible effects of wind turbine exposure: stress reactions or vestibular disturbance. The fact that many of the published adverse event reports include case crossover observations and experiments push the evidence beyond a hint of plausible doubt that the turbines cause the adverse effects.

The authors conclude that these case reports taken together offer the most compelling scientific evidence of serious harm. Just because the prevailing models have failed to explain observed adverse health effects does not mean they do not exist.

b. Arra I, Lynn H, Barker K, et al. (2014-05-23 11:51:41 UTC) Systematic Review 2013: Association Between Wind Turbines and Human Distress. Cureus 6(5): e183.doi:10.7759/cureus.183 http://www.windconcernsontario.ca/wp-content/uploads/2014/06/Arra-LynnStudyMay2014.pdf

This review found a consistency of complaints among populations evaluated in all published studies reviewed i.e. there were no studies demonstrating an absence of effects.

c. Hanning, Christopher D. and Evans, Alun Editorial: Wind turbine noise British Medical Journal, BM J2 012;344 doi: 10.1136/ bmj.e1527 (8 March 2012) www.bmj.com

The editorial addressed the consistency of reports of AHE internationally, including sleep disruption, and emphasized the importance of sleep as "…a prerequisite for human health, particularly child health,…".

d. Krogh, Carmen M.E.; Gillis, Lorrie; Kouwen, Nicholas; and Aramini, Jeffery WindVOiCe, a Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring Bulletin of Science Technology & Society 2011 31: 334, DOI: 10.1177/0270467611412551, http://bst.sagepub.com/content/31/4/334

A detailed tabulation of AHE in Ontario Canada demonstrated consistency of complaints among the incident reports of AHE.

4. **Temporality**: **The effect has to occur after the cause (and if there is an expected delay between the cause and expected effect, then the effect must occur after that delay).**

a. The Krogh et al study cited above (3d) demonstrated the onset of operations of IWT preceding the advent of AHE with a range of latent periods generally up to 6 months before onset of symptoms.

b) Pierpont, N. Wind Turbine Syndrome, A report on a Natural Experiment. 2009. (see also 1. Strength of Association)

Dr. Pierpont collected data documenting health status and medical problems for individuals prior to exposure to operating wind turbines, followed by a detailed clinical history of symptoms while exposed, followed by a detailed clinical history of symptoms when people reduced their exposure to operating wind turbines by leaving their homes. A clear pattern of symptoms relating to exposure to operating wind turbines was evident.

The predisposing risk factors identified by Dr. Pierpont include having a pre-existing problem with motion sickness, inner ear pathology, or a clinical history of migraines. The elderly and the very young appear also appear to be more vulnerable to developing symptoms early.

c. **Hansen K, Zajamsek B, Hansen C**. Noise Monitoring in the Vicinity of the Waterloo Wind Farm May 26, 2014. [Adelaide University, funded by the Australian Research Council] 2014

(http://waubrafoundation.org.au/resources/hansen-zajamsek-hansen-noise-monitoring-waterloo-wind-farm/; http://www.windaction.org/posts/41063-noise-monitoring-in-the-vicinity-of-the-waterloo-wind-farm#.VGzOZU10y1s)**.**

The report describes the results of full spectrum acoustic monitoring conducted at a number of homes located between 2 km out to nearly 10km from the Waterloo Wind Energy facility.

The effects on the residents at Waterloo in mid-2013 were compared, when the wind turbines were operating, then not operating for a week, and then again operating, in a case series cross-over tabulation.

In an acoustic survey report, they confirmed there is a sleep damaging, low frequency noise problem from wind turbines at Waterloo Wind Development out to 8.7 km.

• The indoor limit for wind turbine hosts of 30 dB(A) recommended by the SA EPA (EPA, 2009) was exceeded in houses more than 2 km from turbines

• The LCeq -LAeq criteria was often exceeded and there was a large scatter in the data.

• The overall G-weighted level of 85 dB(G) was never exceeded however this does not preclude the possibility that infrasound was not detectable.

• The Danish low frequency noise guidelines were exceeded on a number of occasions. In general, the exceedences occurred for downwind conditions and hub height wind speeds greater than 8 m/s.

• The DEFRA criteria were exceeded on multiple occasions, usually corresponding to downwind conditions and hub height wind speeds greater than 8 m/s

Monitoring was at the same time as the South Australian EPA Acoustic survey; the data and conclusions indicate serious flaws in the SA EPA acoustic survey. [Three months after receiving the report, the EPA had not commented –March 2015]

d. Phillips CV. Epidemiologic Evidence for Health Effects from Wind Turbines July 19, 2011 (see 2. Consistency A vii, and 3. Specificity i, above)

The study documented the consistent patterns of adverse events that occur after exposure onset to industrial turbines. As an epidemiologist, he felt that the following were easily identified and analyzed: exposure and outcomes, incidence, cross-over results (observing whether someone's outcomes change as their exposure status to turbines changes). He stated that the observed effects of turbine exposure lend themselves perfectly to such studies because the exposure is transient and the effects, while not instantaneous in their manifestation or dissipation, are generally transient. Complete relief was reported upon relocating, where there was ability to sleep well when staying somewhere other than the subject's own home. People are so confident that the relationship is causal that they expend substantial resources – retrofitting their houses to reduce noise, selling their properties at a loss, or even abandoning their homes without being able to sell them – in order to try to reduce the health impacts.

e. Ambrose SE, Rand RW. Bruce McPherson infrasound and low frequency noise study. *Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed* December 14, 2011 (http://waubrafoundation.org.au/resources/bruce-mcpherson-infrasound-low-frequency-noise-study/) (For details see 8. Experimental Evidence)

This study was commissioned through a private philanthropic grant created to determine why there were so many strong complaints about the loss of well-being and hardships experienced by people living near large industrial wind turbines operating in Falmouth, Massachusetts.

The investigators were surprised that they experienced the same adverse health symptoms described by neighbors living at this house and near other large industrial wind turbine sites. The onset of adverse health effects was swift, within twenty minutes. It took about a week to recover from the adverse health effects experienced during the study, with lingering recurring nausea and vertigo for almost seven weeks for one of the investigators.

B. Animal data:

Possible fertility, developmental and reproduction adverse effects, as well as stress-like reactions possibly associated with wind turbines: temporal observations. While most evidence is anecdotal, incidences of high animal miscarriage rates, mass die-offs of farm animals, chickens laying soft-shelled eggs, and disappearance of wildlife near turbines should not be ignored.

An advantage of examining animal data, as it cannot be argued that effects result from the subject not wanting the view of turbines.

a. Biologist Dr. Lynne Knuth, in a letter to the Public Service Commission of Wisconsin, testified as follows: "The problems with animal reproduction reported in the wind farms in Wisconsin are lack of egg production, problems calving, spontaneous abortion (embryonic mortality), stillbirth, miscarriage and teratogenic effects

• In chickens: Crossed beaks, missing eyeballs, deformities of the skull (sunken eyes), joints of feet/legs bent at odd angles (Jim Vollmer, personal communication)

• In cattle: missing eyes and tails (updated Excerpts from the Final Report of the Township of Lincoln Wind Turbine Moratorium Committee).

"It is disturbing to me that in chickens and cows in separate wind farms (separated by 50 miles) similar teratogenic effects are being observed, namely missing eyeballs. Based on the correlation of effects seen experimentally and those seen in the wind farm in chickens, these defects may be due to low frequency vibration. "Animal health problems in the Srnkas' formerly award-winning herd include cancer deaths, ringworm, mange, lice, parasites, cows not calving properly, dehydration, mutations such as no eyeballs or tails, cows holding pregnancy only 1 to 2 weeks and then aborting, blood from nostrils, black and white hair coats turning brown, mastitis, kidney and liver failure. . . ."

b) Mink (Demnark) http://wcfn.org/2014/06/07/windfarms-1600-miscarriages/; http://wcfn.org/2014/06/23/another-horror-story-from-denmark/:

At a long-established mink farm, the onset of the following after wind farms began operation, the following was reported: 1600 stillbirths, deformed offspring, refusal of dams to mate, and mothers attacking the young. An increased incidence of aggressive behavior of mother minks towards their puppies was noted when the wind blew from the south west, the direction of the wind turbines.

c) Horse (Portugal): Alves-Pereira, Mariana; Castelo Branco, Nuno; et al. Portuguese Family and Horses Affected by Low-Frequency Wind Turbine Noise (School of Veterinary Medicine, Technical University, Lisbon, Portugal; study written up as MSc theses, titled "Acquired flexural deformity of the distal

interphalangic joint in foals.") https://www.wind-watch.org/documents/portuguese-family-and-horses-affected-by-low-frequency-wind-turbine-noise/

Healthy horses had been bred on the farm for 8 years. The study was performed after the observation that, with no change in diet, exercise, management, several foals and yearlings developed deformities after the installation of wind turbines adjacent to the paddocks.

- Subjects: 11 Lusitano horses (6 males and 5 females, age 0- 48 months old); 9 born at the stud farm, 2 acquired from a different breeder to rule out genetic issues.

- Measurements: Complete physical and orthopaedic examination (the determination of the angle between the dorsal hoof wall and the floor), radiographic examination, CT imaging, determination of the thickness of the cortical bone of the third metacarpian and histopathology of some tissues collected in biopsy and necropsy.

All 11 developed the deformities after 6 months. Two of the affected foals were placed in a pasture away from the initial one and two others were admitted at the Faculty of Veterinary Medicine of Lisbon. In those animals, except for one that had to be euthanized for humane reasons, an improvement was observed on their condition, with partial recovery of the deformity. Histopathology showed dissociation of myofibrils of the smooth muscle in the small intestine and in the capillary walls, including those of the tendon vasculature. The flexural deformities occur due to uncoupling of the longitudinal development of the bone and its adjacent soft tissues, but also from shortening of the tendon-muscle unit in response to pain.

d) Farmers in Ontario have observed health problems with their livestock which began shortly after the wind turbines were installed. http://docs.wind-watch.org/ADVERSE-HEALTH-EFFECTS-OF-WIND-TURBINES.pdf

Ross Brindley (December 2008 *Better Farming Magazine*)

At a farm near the Kingsbridge wind turbine development near Goderich, the cattle exhibited aggressive and erratic behaviour, "including the kicking of newborn calves, prolapsed birthing, weight loss, decline in fertility, a high incidence of mastitis, calves being deformed at birth and a high incidence of stillbirths." The problems with the herd resulting in him going out of business.

d) Are wind turbines killing innocent goats? Reported by BBC and Discovery Magazine http://blogs.discovermagazine.com/discoblog/2009/05/21/are-wind-turbines-killing-innocent-goats/:

During 4 years after eight wind turbines were installed close to their grazing land, 400 goats in Taiwan died. The goats demonstrated reduced eating, weight loss and reduced sleeping. The Council of Agriculture suspects that noise may have caused the goats' demise through lack of sleep. The power company, Taipower has offered to pay part of the cost of building a new farmhouse elsewhere.

5. **Biological gradient: Greater exposure should generally lead to greater incidence of the effect. However, in some cases, the mere presence of the factor can trigger the effect. In other cases, an inverse proportion is observed: greater exposure leads to lower incidence.**

Dose response effect – Correlation with proximity: more reported adverse effects when closer to/ greater noise energy from the turbines.

a) Pederson and colleagues, The Netherlands:

i. Bakker RH, Pedersen E, van den Berg GP, Stewart RD, Lok W, Bouma J. Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. Science of the Total Environment 2012 May 15;425:42–51.(Netherlands) https://www.wind-watch.org/documents/impact-of-wind-turbine-sound-on-annoyance-self-reported-sleep-disturbance-and-psychological-distress/

Data were gathered by questionnaire that was sent by mail to a representative sample of residents of the Netherlands living in the vicinity of wind turbines.

A dose-response relationship was found between emission levels of wind turbine sound and self-reported noise annoyance. Sound exposure was also related to sleep disturbance and psychological distress among those who reported that they could hear the sound, however not directly but with noise annoyance acting as a mediator. Respondents living in areas with other background sounds were less affected than respondents in quiet areas.

The authors concluded that people living in the vicinity of wind turbines are at risk of being annoyed by the noise, an adverse effect in itself. Noise annoyance in turn could lead to sleep disturbance and psychological distress. No direct effects of wind turbine noise on sleep disturbance or psychological stress was demonstrated.

ii. Pedersen E, van den Berg F, Bakker R, Bouma J. Response to noise from modern wind farms in The Netherlands. J Acoust Soc Am. 126(2):634-43; 2009. (Netherlands) https://www.wind-watch.org/documents/response-to-noise-from-modern-wind-farms-in-the-netherlands/

The paper reports the results of a 2007 field study in The Netherlands with 725 respondents.

A dose-response relationship between calculated A-weighted sound pressure levels and reported perception and annoyance was found. Wind turbine noise was more annoying than transportation noise or industrial noise at comparable levels. Annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study further demonstrates that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, despite exposure to similar sound levels. Response to wind turbine noise was similar to that found in Sweden so the dose-response relationship should be generalizable.

iii. van den Berg F, Pedersen E, Bouma J, Bakker R. WINDFARM perception Visual and acoustic impact of wind turbine farms on residents. FP6-2005-Science-and-Society-20 Specific Support Action Project no. 044628; June 3, 2008. https://www.wind-watch.org/documents/visual-and-acoustic-impact-of-wind-turbine-farms-on-residents/; http://docs.wind-watch.org/wfp-final-1.pdf

This report gives the results of the EU financed study WINDFARM perception on how residents perceive a wind farm in their living environment, based on sound and sight.

The study includes a postal survey among Dutch residents (n = 725, response rate: 37%). Respondents were exposed to levels of wind turbine sound between 24 and 54 dBA, at distances from 17 m to 2.1 km. Wind turbine were 500 kW or more. The sound level at the residents' dwellings was calculated according to the international ISO standard for sound propagation, the almost identical Dutch legal model and a non-spectral calculation model.

Almost all respondents (92%) were satisfied with their living environment; 50% were (very) positive towards wind turbines in general, 20% were (very) positive towards their impact on the landscape scenery. Respondents with economic benefits (14%) were less negative to wind turbines in general and their influence on the landscape scenery.

The percentage of respondents noticing the sound of wind turbines increased with sound level: 25% at sound levels less than 30 dBA, over 80% at sound levels above 35 dBA.

The percentage of respondents that were annoyed by the sound also increased with sound level up to 25% at 40 to 45 dBA and then decreased. The decrease may have been due to the fact that respondents having economic benefit were generally nearest the turbines, and did not complain of annoyance.

There only health effect indicated was interruption of sleep. At high levels of wind turbine sound (more than 45 dBA) interruption of sleep was more likely than at low levels.

Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. Respondents (4% to 13%) were also annoyed by vibrations, the movement of rotor blades, or their shadows in- or outdoors.

b) Pederson and colleagues , Sweden

i. Pedersen E and Waye K, 2007. Wind turbine noise, annoyance and self-reported health and well being in different living environments –on line and Environ. Res. Lett. 3; 2008. (Sweden) https://www.wind-watch.org/documents/perception-of-wind-turbine-noise-two-abstracts/; http://docs.wind-watch.org/pedersen-windturbinenoiseannoyance-20070310.pdf

A cross-sectional study was carried out in seven areas in Sweden across dissimilar terrain and different degrees of urbanisation. A postal questionnaire regarding living conditions including response to wind turbine noise was completed by 754 subjects. Outdoor A-weighted sound pressure levels (SPLs) were

calculated for each respondent. Perception and annoyance due to wind turbine noise in relation to SPLs was analysed with regard to dissimilarities between the areas.

Results showed that odds of perceiving wind turbine noise increased with increasing SPL (odds ratio [OR] 1.3; 95% confidence interval [CI] 1.25 to 1.40). The odds of being annoyed by wind turbine noise also increased with increasing SPLs (OR 1.1; 95% CI 1.01 to 1.25). Perception and annoyance were associated with terrain and urbanisation: (1) a rural area increased the risk of perception and annoyance in comparison with a suburban area; and (2) in a rural setting, complex ground (hilly or rocky terrain) increased the risk compared with flat ground. Annoyance was associated with both objective and subjective factors of wind turbine visibility, and was further associated with lowered sleep quality and negative emotions.

ii. Pedersen E. and Persson Waye K. Perception and annoyance due to wind turbine noise—a dose-response relationship. J Acoust Soc Am 2004, 116, 3460–3470. https://www.wind-watch.org/documents/perception-of-wind-turbine-noise-two-abstracts/; http://docs.wind-watch.org/Pedersen-dose-response-2004.pdf

The aims of this study were to evaluate the prevalence of annoyance due to wind turbine noise and to study dose-response relationships. Interrelationships between noise annoyance and sound characteristics, as well as the influence of subjective variables such as attitude and noise sensitivity, were also assessed. A cross-sectional study was performed in Sweden in 2000. Responses were obtained through questionnaires (n = 351; response rate 68.4%), and doses were calculated as A-weighted sound pressure levels for each respondent. A statistically significant dose-response relationship was found, showing higher proportion of people reporting perception and annoyance than expected from the present dose-response relationships for transportation noise. The unexpected high proportion of annoyance could be due to visual interference, influencing noise annoyance, as well as the presence of intrusive sound characteristics. The respondents' attitude to the visual impact of wind turbines on the landscape scenery was found to influence noise annoyance.

iii) Nissenbaum MA, Aramini JJ, Hanning CD. Effects of industrial wind turbine noise on sleep and health. Noise Health14:237-43; 2012. http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2012;volume=14;issue=60;spage=237;epage=243;aulast=Nissenbaum

To compare sleep and general health outcomes between participants living close to industrial wind turbines and those living further away from them, participants living between 375 and 1400 m (n = 38) and 3.3 and 6.6 km (n = 41) from IWTs were enrolled in a stratified cross-sectional study involving two rural sites. Validated questionnaires were used to collect information on sleep quality (Pittsburgh Sleep Quality Index - PSQI), daytime sleepiness (Epworth Sleepiness Score - ESS), and general health (SF36v2), together with psychiatric disorders, attitude, and demographics. Descriptive and multivariate analyses were performed to investigate the effect of the main exposure variable of interest (distance to the nearest IWT) on various health outcome measures. Participants living within 1.4 km of an IWT had worse

sleep, were sleepier during the day, and had worse SF36 Mental Component Scores compared to those living further than 1.4 km away. Significant dose-response relationships between PSQI, ESS, SF36 Mental Component Score, and log-distance to the nearest IWT were identified after controlling for gender, age, and household clustering. The adverse event reports of sleep disturbance and ill health by those living close to IWTs are supported. The adverse event reports of sleep disturbance and ill health by those living close to IWTs are supported. [See also: Strength of Association]

iv. Takashi Yano, Sonoko Kuwano, Takayuki Kageyama, Shinichi Sueoka and Hideki Tachibana Dose-response relationships for wind turbine noise in Japan. Internoise 2013. http://docs.wind-watch.org/internoise-2013-0598.pdf [part of the 3 year study described in 6. Plausability, iv]

In order to obtain a base for wind turbine noise policy, a socio-acoustic survey was carried out throughout Japan from Hokkaido to Okinawa over three years (2010-2012).

In total 747 responses were obtained with face-to-face interview method. The wind turbine noise was measured at several points in each site for successive five days. The average sound pressure level at the regular operation during nighttime, LAeq.n, was taken as noise exposure. A representative exposure-annoyance relationship was drawn based on all data.

The trend was consistent to those from Swedish and Dutch surveys. When LAeq.n was more than 40 dB, the adjusted odds ratio for % extremely annoyed was significantly higher. Severe annoyance was more strongly associated with LAeq.n than mild annoyance. People at sites with sea wave sound were less annoyed by wind turbine noise than those at sites without.

v. Mroczek B, Kurpas D, Karakiewicz B. Influence of distances between places of residence and wind farms on the quality of life in nearby areas. Ann Agricultural Environmental Med 2012 19(4) 692-96.

The aim was to assess how the quality of life is affected by the close proximity of wind farms. The study group consisted of 1,277 Polish adults (703 women and 574 men), living in places located near wind farms. Approximately 33.2% of participants lived more than 1,500 m from wind farms; 17% lived below 700 m. The research tool consisted of the Norwegian version of the SF-36 General Health Questionnaire, the Visual Analogue Scale (VAS) for health assessment, and original questions. The results demonstrated that close proximity of wind farms did not result in the worsening of the quality of life, using these methods.

This is the only study to demonstrate no effects on quality of life of exposed people. Those closer to IWT reported a higher quality of life than those further away. As the authors commented:

> This may indicate the influence of other contributors, which were not taken into consideration during the analysis, namely, economic factors. While repeating this research, respondents should be asked about the possibility of employment in the wind energetics industry and the opportunity of proceeds from renting their land for wind farm construction.

6. Plausibility: **A plausible mechanism between cause and effect is helpful (but Hill noted that knowledge of the mechanism is limited by current knowledge).**

Mechanism: Infrasound and low frequency noise (ILFN)

The dividing line between low frequency noise and infrasound varies among individuals but 20 Hertz is generally accepted. In this convention LFN is accepted as 20-200 Hertz and infrasound as 0-20 Hertz. The practice of using dBA for measuring noise from IWT is problematic and should be reconsidered as weighting measurements with dBA eliminates much of the ILFN signal. Thus despite the well-documented effects of infrasound on animals and humans, the vast majority of studies of sound from wind turbines ignore the effects of infrasound. Data are in part limited due to the practice of omitting the infrasound and LFN from noise measurements. This occurs despite evidence from thirty years ago (N D Kelley) relating to the direct causation of symptoms including sleep disturbance from impulsive wind turbine and gas turbine lower frequency sound and vibration energy (http://waubrafoundation.org.au/resources/kelley-et-al-methodology-for-assessment-wind-turbine-noise-generation-1982/).

There is evidence that people and animals exposed to infrasound display adverse events similar to those experienced by those near industrial turbines. (see also: 8. Experimental Evidence) Unlike infrasound, low-frequency turbine noise is audible; that produced by industrial scale wind turbines falls within the threshold of human hearing and can disturb sleep and lead to other possible adverse health effects. (Hansen, 2013 http://www.windaction.org/posts/37289-low-frequency-turbine-noise-is-audible-a-critique#.VGzXnk10y1s)

The precise noise and vibration frequencies which are causing these symptoms in people, especially the episodes of night time waking in a panicked state and the body vibrations are not fully determined but Steven Cooper's work provides the first definitive evidence of infrasound as at least part of the problem in is 6 subjects. The concern is that we do not know what the SAFE exposure cumulative dose is for adults AND particularly young children. The concern is compounded by the failure of government authorities to monitor exposed people. This failure is at odds with WHO recommendations. http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf see Discussion

There is a pressing need for risk assessment of the deployment of IWT into rural community settings. As the WHO document recommends;

> The process of risk assessment of environmental noise requires knowing:
>
> • the nature of the health effects of noise;
>
> • the levels of exposure at which health effects begin to occur and how the extent of
>
> the effect changes with increasing noise levels; and

• the number of people exposed to these hazardous levels of noise. p. 1

These recommendations were based upon the findings of the burden disease of noise in Western Europe. It is clear that this information is absent in regards to IWT exposure.

Estimated burden in western Europe

Conservative estimates applied to the calculation using exposure data from noise maps give a total of 903 000 DALYs lost from noise-induced sleep disturbance for the EU population living in towns of > 50 000 inhabitants. p. xvi

Annoyance

WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Therefore, a high level of annoyance caused by environmental noise should be considered as one of the environmental health burdens. p. xvi

and

It is estimated that DALYs lost from environmental noise in the western European countries are 61 000 years for ischaemic heart disease, 45 000 years for cognitive impairment of children, 903 000 years for sleep disturbance, 22 000 years for tinnitus and 654 000 years for annoyance. If all of these are considered together, the range of burden would be 1.0–1.6 million DALYs p.xvii [DALY = disability adjusted life years, which combines the concepts of (*a*) potential years of life lost due to premature death and (*b*) equivalent years of "healthy" life lost by virtue of being in a state of poor health or disability.]

a. **Møller H, Pedersen CS**. Low-frequency noise from large wind turbines. J Acoust Soc Am. 129(6):3727-44; 2011. https://www.wind-watch.org/documents/low-frequency-noise-from-large-wind-turbines-2/

The noise emission from 48 wind turbines with nominal electric power up to 3.6 MW was analyzed and discussed. The relative amount of low-frequency noise is higher for large turbines (2.3–3.6 MW) than for small turbines (≤ 2 MW) (statistically significant). Due to the air absorption, the higher low-frequency content becomes even more pronounced, when sound pressure levels in relevant neighbour distances are considered. Even when A-weighted levels are considered, a substantial part of the noise is at low frequencies, and for several of the investigated large turbines, the one-third-octave band with the highest level is at or below 250 Hz. It was concluded that, beyond any doubt that the low-frequency part of the spectrum plays an important role in the noise.

b. **Salt AN, Hullar TE**. Responses of the ear to low frequency sounds, infrasound and wind turbines. Hear Res. 268(1-2):12-21; 2010. https://www.wind-watch.org/documents/responses-of-the-ear-to-low-frequency-sounds-infrasound-and-wind-turbines/; http://docs.wind-watch.org/Salt-Hullar-ear-wind-turbines-nihms214369.pdf

In this review, the authors consider possible ways that low frequency sounds, at levels that may or may not be heard, could influence the function of the ear.

The analyses showed that hearing perception, mediated by the inner hair cells of the cochlea, is remarkably insensitive to infrasound. Other sensory cells or structures in the inner ear, such as the outer hair cells, are more sensitive to infrasound than the inner hair cells and can be stimulated by low frequency sounds at levels below those that are heard. There are some states (e.g. Meniere's disease) in which the ear becomes hypersensitive to infrasound. In most cases, the inner ear's responses to infrasound can be considered normal, but they could be associated with unfamiliar sensations or subtle changes in physiology. This raises the possibility that exposure to the infrasound component of wind turbine noise could influence the physiology of the ear.

c. **Chen Yuan Huang Qibai and Hammin Shi**, An Investigation on the Physiological and Psychological Effects of Infrasound on Persons. Journal of Low Frequency Noise, Vibration and Active Control. School of Mechanical Science & Engineering, Huazhong University of Science and Technology, Wuhan, 430074, P.R. of China Received 30th March 2004

In an experimental situation, infrasound below the audible perception dose is BELOW the audible perception threshold resulted in both physiological changes (blood pressure elevation and increase in heart rate) and symptoms such as nausea, tiredness and fretfulness at levels which were below the current perception threshold used to assert that levels below that threshold were "safe" and did not cause those physiological effects. This is confirmatory experimental evidence from almost 10 years ago that these perception thresholds were not appropriate and needed to be much lower.

d. **Walker B, Hessler G, Hessler D, Rand R and Schomer P**. Joint report: Cooperative Measurement survey and analysis of low frequency and infrasound at the Shirley wind Farm. 2012 [Schomer, P appendix D; Rand, R appendix C] https://www.windwatch.org/documents/cooperative-measurement-survey-and-analysis-of-lowfrequency-and-infrasound-at-the-shirley-wind-farm/ Schomer, Paul, et al. 2013. A proposed theory to explain some adverse physiological effects of the infrasonic emissions at some wind farm sites. http://waubrafoundation.org.au/resources/schomer-et-al-wind-turbine-noise-conference-denver-august-2013/

In a recent acoustic survey at the Shirley wind project, Wisconsin, evidence of the role of infrasound between 0 – 10 Hz in the generation of symptoms such as nausea and headaches was shown. On the basis of the data collected, four firms of acousticians, including those working for wind developers and those working for sick residents as well as a very senior member of the acoustics profession in America who has worked for both wind developers and residents (Dr Paul Schomer), signed a common report.

The report stated the following: “The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry. It should be addressed beyond the present practice of showing that wind turbine levels are magnitudes below the threshold of hearing at low frequencies”.

e) **Kelley ND, McKenna HE, Hemphill RR, Etter CL, Garrelts RL, Linn NC** (under the auspices of the **US Department of Energy and NASA**. Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact and Control. (http://waubrafoundation.org.au/resources/kelley-et-al-1985-acoustic-noise-associated-with-mod-1-wind-turbine/)

The authors established direct causation of symptoms from wind turbine generated impulsive infrasound and low frequency noise from a single downwind bladed wind turbine.

Protective maximum levels of low frequency sound were recommended:

> The joint radiation levels (expressed in terms of acoustic intensity and measured external to a structure) in the 8, 16, 31.5 and 63 Hz standard (ISO) octaves should not exceed band intensity threshold limits of 60, 50, 40 and 40 dB (re 1 pWm –2) more than 20% of the time. [see also Reider, Sandy, Wind noise and adverse health effects. *Public Service Board Hearing, July 29, 2014* http://psb.vermont.gov/sites/psb/files/docket/8167/Workshop3/Reider.pdf]

f. Health Canada 2014 *preliminary results*: http://www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-eoliennes/summary-resume-eng.php.

Noise (dBA) and low frequency noise (dBC, likely from 16 dB) were reported. Results from infrasound (0-20 Hz) are not yet available. Self-reported stress, health conditions and quality of life were not found to be associated with exposure to WTN levels. Yet, "annoyance" was related to the noise and distance from turbines. Annoyance was also related to self-reported health effects and objective stress indicators. Logically then, noise was related to self-reported health effects and objective stress in this population. While the HC study is “preliminary” the foregoing statements point to the fundamental divide that exists around annoyance as something unrelated to health effect in the view of proponents. A direct interview with the Principle Investigator of the HC study is revealing;

"Recently Dr. David Michaud, the principal investigator for the study, discussed the research design and assured my office of the integrity of the process. Dr. Michaud acknowledged that there is credible scientific support for an association between wind turbine noise and community annoyance. He explained the study will help to build the evidence base to determine the link (he later said this should have been worded “assess the association”) between noise created by wind turbines including infrasound and low frequency and variables like sleep .

When asked “Is it the position of Health Canada that there is credible scientific support for an association between wind turbine noise and community annoyance?” Michaud answered yes.

http://www.falconers.ca/documents/EvidenceofDavidMichaud.pdf ASAP Reporting Services Inc.

7. Coherence: **Coherence between epidemiological and laboratory findings increases the likelihood of an effect. However, Hill noted that "... lack of such [laboratory] evidence cannot nullify the epidemiological effect on associations".**

a. Salt AN, and Hullar TE. Responses of the ear to low frequency sounds, infrasound and wind turbines. Hear Res 2010:268(1-2): 12–21. http://docs.wind-watch.org/Salt-Hullar-ear-wind-turbines-nihms214369.pdf (see also 6. **Plausability**, b and c above)

Although low frequency hearing sensitivity depends on many factors including the mechanical properties of the middle ear, low frequency hearing sensitivity has been shown to be correlated with cochlear length for many species with non- specialized cochleas, including humans and guinea pigs (West, 1985; Echteler et al., 1994). The thresholds of guinea pig hearing have been measured with stimulus frequencies as low as 50 Hz; average sensitivity from 4 studies at 125 Hz was 37.9 dB SPL, which is 17.6 dB less sensitive than the human at the same frequency and is consistent with the shorter cochlea of guinea pigs.

It is therefore reasonable to assume that if low frequency responses are present in the guinea pig at a specific level, then they will be present in the human at a similar or lower stimulus level.

b. **Mikołajczak J, Borowski S, Marć-Pieńkowska J, Odrowąż-Sypniewska G, Bernacki Z, Siódmiak J, Szterk P.** Preliminary studies on the reaction of growing geese (*Anser anser f. domestica*) to the proximity of wind turbines. Pol J of Veterin Sci 2013:16(4); 679–686. http://www.windturbinesyndrome.com/wp-content/uploads/2014/02/Miko%E2%89%88%C3%87ajczak-et-al-2013-Preliminary-studies_reaction_growing_geese-IWT_lfn_Polish-J-Vet-science-V16_No4-2013.pdf

The aim of the study was to determine the effect of noise, generated by wind turbines, on the stress parameters (cortisol) and the weight gain of geese kept in surrounding areas.

- Subjects: 40 domestic geese (*Anser anser f. domestica*), 20 per group; 5- week- old.

- Measurements: During the 12 weeks of the study: Group I remained within 50 m from turbine; Group II within 500 m from turbine. Noise measurements were taken. Weight gain and the concentration of cortisol in blood were assessed.

Significant differences between groups were found in both weight gain and blood cortisol levels. Geese from Group I gained less weight (10%) and had a higher concentration of cortisol in blood, compared to individuals from Group II. Lower activity and some disturbing changes in behavior of animals from group I were noted. Group II had elevated blood cortisol compared to control values, indicating that they were still at an unsafe distance from the turbines. Results of the study suggest a negative effect of the immediate vicinity of a wind turbine on the stress parameters of geese and their productivity. In addition, stress parameters (cortisol concentration) increased with the residence time in the vicinity of the wind turbine.

c. **Gregorio CA, Maull EA, Carson BL, and Haneke KE. U.S. National Institute of Environmental Health Sciences**, Infrasound – Brief Review of Toxicological Literature 2001 (http://www.nvda.net/files/Infrasound_508.pdf; https://www.wind-watch.org/documents/infrasound-brief-review-of-toxicological-literature/):

Although it is a review article this summarizes highly relevant studies identified in the open literature relating to the biological and other effects of infrasound exposure in humans and laboratory animals. Over 100 relevant studies were identified that differed widely in their experimental design and selection of endpoints for evaluation. Experimental studies have been reported where humans or various species of animals (rats, mice, guinea pigs, chinchillas) had been exposed to infrasound in the laboratory. Most of the studies identified involved exposures at 90 dB and higher and ranged from minutes to several months; there were no long-term studies. Few studies employed modern pathology/toxicology protocols. Endpoints generally included behavioral, sensory or simple physiological measures.

Most studies reported some effects attributed to infrasound exposure. Some of the animal studies show evidence of a physiological stress response. Generally the doses of infrasound are higher than those extremely limited data sets of full spectrum acoustic measurements inside and outside homes at existing wind developments, but the exposure durations are very short in comparison to those living near turbines. The report makes it clear that there are significant knowledge gaps with respect to chronic exposure to infrasound and low frequency sound at lower “doses”. Although the authors did not comment on IWT they did note that many of the human subjects exposed to infrasound reported the same adverse health effects — fatigue, sleeplessness, nausea, heart disorders — that afflict those living near wind turbines.

8. Experimental Evidence: **"Occasionally it is possible to appeal to experimental evidence". (It is often unethical to perform.)**

There is increasing evidence that the adverse events reports by those living within 10 km of industrial wind turbines is a result of the infrasound produced by turbines. In experiments where people have been exposed to infrasound, similar symptoms are reported to those living near turbines.

A. Clinical studies/experiments:

a. **National Physical Laboratory**, UK 2003
(www.sarahangliss.com/extras/Infrasonic/infrasonicResults.doc)

In a U.K. experiment involving the country's largest applied physics organization, back-to-back music concerts were staged in London's Purcell Hall. The concerts were similar in all respects except that two different musical pieces in each concert were laced with infrasound. The result: while hearing the infrasound-laced pieces, audience members reported significantly elevated sensations of nausea, dizziness, increased heart rates, and tingling in the neck and shoulders, among other sensations.

b. Ambrose SE, Rand RW. Bruce McPherson infrasound and low frequency noise study. *Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed* December 14, 2011
(**http://waubrafoundation.org.au/resources/bruce-mcpherson-infrasound-low-frequency-noise-study/)**

This study was commissioned through a private philanthropic grant created to determine why there were so many strong complaints about the loss of well-being and hardships experienced by people living near large industrial wind turbines operating in Falmouth, Massachusetts. The purpose of this study was to investigate and confirm or deny the presence of infrasonic and low frequency noise emissions (ILFN) from the "WIND 1", a municipally-owned Vestas V82 industrial wind turbine. As a result of many complaints and strong appeals, WIND 1 operations were curtailed when hub height wind speed exceeded 10 m/s. Therefore, this study focused on noise emissions from the "NOTUS" wind turbine, an identical make and model.

Acoustics: This study was conducted at a representative neighbour's home in Falmouth. It confirmed that there are dynamically modulated low frequency acoustic amplitudes and tones produced by the nearby wind turbine. Dynamic amplitude modulations occurred at 1.4 second intervals that were consistent with the blades rotating past the wind turbine tower (the blade pass rate). Dynamic amplitude modulations below 10 Hz were stronger indoors than outdoors. This effect is very important as others such as Kelley have observed that sympathetic resonance within houses can increase the strength of the IWT signal inside homes.

Health effects: The investigators experienced the same adverse health symptoms described by neighbors living at this house and near other large industrial wind turbine sites. The onset of adverse health effects was swift, within twenty minutes, and persisted for some time after leaving the study area. The dBA and

dBC levels and modulations did not correlate to the health effects experienced. However, the strength and modulation of the un-weighted and dBG-weighted levels increased indoors consistent with worsened health effects experienced indoors. The dBG-weighted level appeared to be controlled by in-flow turbulence and exceeded physiological thresholds for response to low-frequency and infrasonic acoustic energy as theorized by Salt.

Sleep was disturbed during the study when the wind turbine operated with hub height wind speeds above 10 m/s. It took about a week to recover from the adverse health effects experienced during the study, with lingering recurring nausea and vertigo for almost seven weeks for one of the investigators.

-- The authors noted that dysfunctions in the vestibular system can cause disequilibrium, nausea, vertigo, anxiety, and panic attacks, which have been reported near a number of industrial wind turbine facilities. This study underscores the need for more effective and precautionary setback distances for industrial wind turbines. It is especially important to include a margin of safety sufficient to prevent inaudible low-frequency wind turbine noise from being detected by the human vestibular system.

c. Cooper S. Australia: Pacific Hydro Wind Turbine Noise Acoustic Survey as reviewed by Paul D. Schomer and George Hessler

The conclusion of the commentary reads;

> Cooper's test shows cause and effect for at least one non-visual, no-audible pathway to affect people. If one only wanted to test for the ability to sense the turning on of wind turbines, and not replicate the cause and effect portion of Cooper's study, this reduced test could be accomplished in one to two months with a cooperative windfarm where there are residents who are self-selected as being very or extremely sensitive to wind turbine acoustic emissions and who also assert that they have this sensing ability. This study, a subset of the full Cooper tests, would only prove, again, that non-visual, non-auditory pathways exist by which wind turbine emissions may affect the body and "signal" the brain.

The full version is attached as Appendix ix. There is a singular importance to this study as the claim of no direct cause of adverse health effects by industrial wind turbines can no longer be sustained. While the study is of 6 individuals it establishes that for them given the input of IWT noise signal adverse health effects ensue. The results have been reviewed and verified by independent acousticians Schomer and Hessler as well as others.

From the perspective of a medical practitioner the conclusions of Cooper are compelling as are the validations noted above. In my opinion the circle of medical diagnosis would be completed if independent health care professionals such as family physicians confirm that the 6 individuals in the study satisfied the diagnostic criteria of McMurtry and Krogh.
http://shr.sagepub.com/content/5/10/2054270414554048.full

d. Pawlaczyk-Luszczynska M, Dudarewicz A, Szymczak W and Sliwinska-Kowalska M. Evaluation of annoyance from low frequency noise under laboratory conditions. Noise and Health 2010; 12(48): pp 166. (http://www.ncbi.nlm.nih.gov/pubmed/20603573)

The aim of the study was to investigate the annoyance of low frequency noise (LFN) at levels normally prevailing at workplaces in control rooms and office-like areas. Two different laboratory experiments were carried out.

The first experiment included 55 young volunteers; the second comprised 70 older volunteers, categorized in terms of sensitivity to noise. The subjects listened to noise samples with different spectra, including LFNs at sound pressure level (SPL) of 45-67 dBA, and evaluated annoyance using a 100-score graphical rating scale. The subjective ratings of annoyance were compared to different noise metrics.

Because the authors were particularly interested in the effects of LFN in occupational settings (e.g., those affected by ventilation systems, heating/air conditioning units), they note that several studies "suggest that LFN at levels normally occurring in control rooms and office-like areas (40-50 dBA) can be perceived as annoying and adversely affecting the human mental performance, particularly when more demanding tasks have to be executed.

e. Takahashi Y; Kanada K; Yonekawa Y; and Harada N. A Study on the Relationship between Subjective Unpleasantness and Body Surface Vibrations Induced by High Level Low-Frequency Pure Tones. Ind Health 2005; 43:580-587. (http://www.ncbi.nlm.nih.gov/pubmed/16100936)

Human body surface vibrations induced by high-level low-frequency pure tones were measured at the chest and the abdomen. At the same time, the subject rated the unpleasantness that he had just perceived during the exposure to low-frequency noise stimulus.

Examining the relationship between the measured vibration and the rating score of the unpleasantness revealed that the unpleasantness correlated closely with the vibration acceleration level (VAL) of the vibration measured. Taking previous results into account, this finding suggests that noise-induced vibrations primarily induce vibratory sensations and through the vibratory sensation or together with some other factors, secondarily contribute to the unpleasantness. The present results suggest that in evaluating high-level low-frequency noise, the effect of vibration should be taken into account. The vibration acceleration level (VAL) is not related to the loudness; the A-weighted sound pressure level is not related to the vibration.

This indicates that noise content at lower frequencies should be given more importance in evaluating high-level low frequency noise. To evaluate the effects of LFN, "the effect of vibration should be taken into account.

9. Analogous evidence: **The effect of similar factors may be considered.**

Other stimuli that are not perceived by the senses are pathogenic eg. ionizing radiation, carbon monoxide. For proponents to claim that noise must be audible in order to be considered as significant is not a defensible conclusion by analogy or by virtue of the compelling literature on infrasound.

Summary

1. The 9 criteria of Bradford Hill have been reviewed.

2. The weight of evidence clearly indicates that there are adverse health effects from living in the environs of IWT.

3. There is considerable evidence that exposure to infrasound and low frequency sound results in effects similar to those reported by people living near wind energy installations.

4. Evidence from both observed effects of IWT on various species of animals and from experimental studies on animals that adverse health effects including teratogenesis correlates with exposure to IWT noise energy and to infrasound.

5. From this analysis it can be concluded that it is probable that IWT noise energy, including ILFN, results in adverse health effects in some humans and animal species.