

Submission to the to the Australian Senate's

Select Committee on Wind Turbines

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WIND TURBINES AND HEALTH

PREAMBLE

According to the World Health Organisation's recent report, 'Night Noise Guidelines for Europe,'¹ environmental noise is emerging as one of the major public health concerns of the twenty-first century. It observes that, "Many people have to adapt their lives to cope with the noise at night," and the young and the old are particularly vulnerable. This is because hearing in young people is more acute and, in older people, a loss of hearing of higher sound frequencies renders them more susceptible to the effects of low frequency noise. It is a particularly troublesome feature of the noise generated by wind turbines due to its impulsive, intrusive and incessant nature. A recent systematic review considered² 154 published studies, eventually including 18 on the basis that they examined the association of wind turbines and human distress and were published in peer-review journals in English from 2003-2013. All found between wind turbines and human distress with levels of evidence of four and five (Bradford Hill Criteria). In addition, two of these studies showed a dose response relationship between distance from wind turbines and distress. Thus there is a consistent relationship between the proximity of turbines and human distress.

The major adverse health effects caused by wind turbines seem to be due to sleep disturbance and deprivation with the main culprits identified to account for this being loud noise in the auditory range, and low frequency noise, particularly infrasound. This is inaudible in the conventional sense, and is propagated over large distances and penetrates the fabric of dwellings, where it may be amplified. It is a particular problem at night, in the quiet rural settings

most favoured for wind farms, because infrasound persists long after the higher frequencies have been dissipated.

Sleep is a physiological necessity and the sleep-deprived are vulnerable to a variety of health problems.^{2,3} particularly Cardiovascular Disease in which nocturnal noise is an important factor.⁴ Sleep deprivation in children is associated with increased bodyweight,⁵ which is known to ‘track’ into later life, and predisposes to adult disease. That is why “Encouraging more sleep” is a sensible target in the current Safefood/HSE/NI Public Health Agency campaign to prevent obesity in children.⁶ Sleep deprivation also interferes with learning causes memory impairment because memory is laid down and reinforced during both Slow Wave and Rapid Eye Movement phases of sleep, and in mice it has been shown that sleep has a key role in promoting learning-dependent synapse formation and maintenance on selected dendritic branches, which contribute to memory storage.⁷

There is an ever-mounting volume of research to show that sleep is essential for the brain and the physiological well-being of the entire body. For example, during sleep, neurotoxins are removed from the brain.⁸ Recently an association between sleep deprivation and loss of brain volume has been demonstrated.⁹ This study was based on serial MRI scans carried out in 147 community-dwelling adults.

Sleep deprivation is associated with an increased likelihood of developing a range of chronic diseases including Type II Diabetes, cancer (eg breast with shift work¹⁰), Coronary Heart Disease^{11, 12} and Heart Failure.¹³ Although the quality of the data are mixed, those on Heart Failure reported recently from the HUNT Study¹³ are quite robust as they are based on 54,279 Norwegians free of disease at baseline (men and women aged 20-89 years). A total of 1412 cases of Heart Failure developed over a mean follow-up of 11.3 years. A dose-dependent relationship was observed between the risk of disease and the number of

reported insomnia symptoms: i) Difficulty in initiating sleep; ii) Difficulty in maintaining sleep; and, iii) Lack of restorative sleep. The Hazard Ratios were '0' for none of these; '0.96' for one; '1.35' for two; and, '4.53' for three; this achieved significance at the 2% level. This means that such a result could occur once by chance if the study were to be repeated 50 times, Significance is conventionally accepted at the 5% level.

Another important, recent study is MORGEN which followed nearly 18,000 Dutch men and women, free of Cardiovascular Disease at baseline, over 10-14 years.¹² In this period there were 607 events: fatal CVD, non-fatal Myocardial Infarction and Stroke. Adequate sleep, defined as at least seven hours, was a protective factor which augmented the benefits conferred by the absence of four traditional cardiovascular risk factors. For example, the benefit of adequate sleep equalled the protective contribution of not smoking cigarettes. Given that cigarette smoking is such a potent risk factor for Cardiovascular Disease, this result is striking. The findings built on earlier ones from the MORGEN study.¹¹ It seems that adequate sleep is important in protecting against a range of Cardiovascular Diseases which result when arteries of different sizes are compromised: large (coronary, cerebral) arteries in heart attacks and stroke, small arteries (arterioles) in heart failure. The mechanisms are obscure, but it is known for example that exposing mice to stress activates hematopoietic stem cells, ie affects the immune system and accelerates atherosclerosis.¹⁴

All of these studies share the weakness that they are 'observational' as opposed to 'experimental' and, as such, their results do not constitute 'proof.' We now have the evidence of an experimental study carried out in human volunteers which shows that the expression of a large range of genes is affected by sleep deprivation of fairly short duration.¹⁵ This might be the key to understanding why the health effects of sleep deprivation are so diverse. It

could also shed light on the ‘Wind Turbine Syndrome (WFS),’ a cluster of symptoms which include sleep disturbance, fatigue, headaches, dizziness, nausea, changes in mood and inability to concentrate.¹⁶ In this condition infrasound is a likely causal agent. Another report from HUNT has examined insomnia in almost 25,000 persons and has demonstrated it to a robust risk factor for incident physical and mental disease, including several features of WFS.¹⁷

This group has now shown in another small intervention study that mistimed sleep desynchronized from the central circadian clock has a much larger effect on the circadian regulation of the human transcriptome (i.e., a reduction in the number of circadian transcripts from 6.4% to 1% and changes in the overall time course of expression of 34% of transcripts).¹⁸ This may elucidate the reasons for the large excess of cardiovascular events associated with shift work found in a meta-analysis of over 2 million subjects in 34 studies.¹⁹ The results demonstrate that any interference in normal sleeping patterns is inimical to cardiovascular health.

The old admonition that ‘What you can’t hear won’t harm you,’ sadly isn’t true. It is now known that organ of Corti in the cochlea (inner ear) contains two types of sensory cells: one row of inner hair cells which are responsible for hearing; and, three rows of outer hair cells which are more responsive to low frequency sound.²⁰ The infrasound produced by wind turbines is transduced by the outer hair cells and transmitted to the brain by Type II afferent fibres. The purpose is unclear as it results in sleep disturbance. Perhaps it served some vital function in our evolutionary past which has persisted to our detriment today? In fact, many animals use infrasound for communication and navigation. This could well have a genetic basis as it is only a minority, albeit a sizable one, which is affected. This may well be the group which is also liable to travel sickness. Schomer et al have now advanced the theory that as wind turbines

increase in size they increasingly emit infrasound with a frequency below 1Hz (CPS).²¹ Below this frequency the otoliths in the inner ear respond in an exaggerated way in a susceptible minority who will suffer symptoms of the Wind Farm Syndrome. Previously it was thought that the brain was only under the control of electrical and biochemical stimuli but there is new evidence that it is sensitive, in addition, to mechanical stimuli.²²

The problem of infrasound and low frequency noise was well-recognised in a report by Casella Stanger,²³ commissioned by DEFRA in 2001, and since ignored: “For people inside buildings with windows closed, this effect is exacerbated by the sound insulation properties of the building envelope. Again mid and high frequencies are attenuated to a much greater extent than low frequencies.” It continued: “As the A-weighting network attenuates low frequencies by a large amount, any measurements made of the noise should be with the instrumentation set to linear.” It drew heavily upon the DOE’s Batho Report of 1990.²⁴ In fact, these problems had already been elucidated and the measurement issues addressed in a trio of papers by Kelley (et al) in the 1980s.²⁵⁻²⁷

This research again has been ignored or forgotten so the problem continues to be seriously underestimated. When measured using a tool which can detect it, levels of infrasound and low frequency noise are disturbingly high, with ‘sound pressure levels’ greater than previously thought possible.²⁸ It has also been demonstrated that infrasonic noise interferes with the micro-mechanics of the human inner ear.²⁹

There were other important studies which were carried out in the 1980s which appear to have been forgotten. Danielsson and Landstrom carried out a study in 20 healthy male volunteers who were bombarded with Infrasound for varying periods. Just 30 minutes bombardment with 125 dB at 16 Hz resulted in

a mean 8 mm increase in diastolic blood pressure. On the other hand systolic BP was not affected whereas the Pulse Pressure decreased.³⁰

Scientists at the University of Toronto Institute for Aerospace and the University of Waterloo found a variability in response in volunteers exposed to Infrasound. The adverse responses of some individuals closely resembled motion sickness. They postulated that individual differences in the reaction to Infrasound might be explained by variability of inner-ear structure or central adaptive mechanisms.³¹

There are a number of other adverse effects associated with sleep deprivation. Tired individuals are more likely to have road traffic accidents and injure themselves while operating machinery. In addition, wind turbines can, and do, cause accidents by collapsing, blade snap, ice throw, and even going on fire. They induce stress and psychological disorder from blade flicker, which also has implications for certain types of epilepsy and autism. Even the current planning process, with its virtual absence of consultation, is stress inducing, as is the confrontation between land owners, who wish to profit from erecting turbines, and their neighbours who dread the effects. Finally, wind turbines considerably reduce the value of dwellings nearby and this has a negative long term effect on their owners' and their families' health.³² On top of this, increasing numbers of families will be driven into fuel poverty by spiralling electricity costs which are subsidising wind energy.

'Wind Turbine Noise' was reviewed in an editorial in the British Medical Journal in 2012.³³ The authors concluded that "A large body of evidence now exists to suggest that wind turbines disturb sleep and impair health at distances and noise levels that are permitted in most jurisdictions..." This remains the case today. The Public Health Agency has dismissed this editorial as falling

short of a 'systematic review,' which is fair enough, given the constraints of the format, yet ignores at least two recent systematic review.^{2, 33}

Interestingly, the Frey and Hadden review records³² the fact that in 1978 the British Government was found guilty in a case taken to Europe by the Irish Government of applying five techniques, including 'Subjection to Noise' and 'Deprivation of Sleep.' These were used in Ulster by the British Army to 'encourage' admissions and to elicit information from prisoners and detainees. They amounted to humiliating and degrading treatment, ie torture. This verdict was subsequently overturned and reduced to Inhuman and Degrading Treatment. It is ironic that the Irish is currently backing the pursuit of this case by 'The Hooded Men' when it is sanctioning the imposition of Noise and Sleep Deprivation on its rural citizens through its current setback guidelines

The Public Health Agencies in the UK are now relying on a document published in April 2013 which is also not peer-reviewed.³⁴ It was written by a group of acousticians at the University of Salford, which begs the question as to why such a group was selected to give advice on health issues. Since acousticians derive a significant proportion of their income from the wind industry, their scientific objectivity might be open to question. Similarly, if a profession, which worked closely with the tobacco industry, was asked to report on health, questions would be asked.

The wind industry has at times acted in a way that is reminiscent of the tobacco industry in the past. Recently a Vestas Powerpoint presentation from 2004 has surfaced³⁵ demonstrating that Vestas knew a decade ago that safer buffers were required to protect neighbours from wind turbine noise. They knew their pre-construction noise models were inaccurate and that "...we know that noise from wind turbines sometimes annoys people even if the noise is below noise limits." Some of this is due to the methods they use to measure noise. Presenting mean amplitude data means that 50% of the peak noise is disguised.

In 2011 the CEO of Vestas wrote to the Danish Minister of Environment admitting that it was not technically possible to produce wind turbines which produced less noise. Similarly, we are repeatedly told that modern turbines are quieter and produce less Infrasound and low frequency noise which in reality is the reverse of the case.³⁶

The Salford Report concludes³⁵ that there is "...some evidence for sleep disturbance which has found fairly wide, though not universal, acceptance." The increasing weight of evidence of sleep deprivation's association with several chronic diseases is totally ignored. The authors of the report are at pains to deny any 'direct' health effects. In terms of prevention any differentiation between 'direct' and 'indirect' is irrelevant: the introduction of iodine supplementation in milking cattle to improve their "reproductive performance" during the 1960s indirectly led to a reduction in endemic goitre in humans. This was thanks to the unforeseen spillover of iodine into milk and dairy products.³⁷

In 2008 the distinguished American acoustic engineers, George Kamperman, and Richard James posed the question,³⁸ "What are the technical options for reducing wind turbine noise emission at residences?" They observed that there were only two options: i) Increase the distance between source and receiver; or, ii) reduce the source sound power emission. They added³⁸ that neither solution is compatible with the objective of the wind farm developer to maximise the wind power electrical generation within the land available.

Although the associations between noise pollution and ill health can be argued against, and there are gaps in our knowledge, there is sufficient evidence to cause grave misgivings about its safety. Further research, supported by adequate funding, remains necessary. Good and caring Government should entail acting with greater caution when its policies could jeopardise the health and human rights of its people. It is essential that the '*Primum non nocere*,' or 'Precautionary' principle should be applied. Another recent review on the

‘Cardiovascular effects of environmental noise exposure’ quotes the Nobel Prize winning microbiologist, Robert Koch. As early as 1910, Koch predicted,³⁹ “One day man will have to fight noise as fiercely as cholera and plague.”

There is another aspect of the deployment of turbines in Ireland and which also impinges on human health. The siting of turbines on upland blanket bogs, and on lowland raised bog has the effect of increasing carbon dioxide emissions. There is mounting evidence that peatlands provide one of the best repositories of carbon dioxide on the planet. In Ireland alone it is estimated that the remaining near-intact peatlands store the equivalent of 200.000 tonnes a year.⁴⁰ Unfortunately this process is reversed when the peatlands are degraded, as they have been on a grand scale. As a consequence they make a net contribution to greenhouse gas emissions which is running at the equivalent of 9.6 million tonnes of carbon dioxide released into the atmosphere every year. An article in the current ‘Natural World’⁴¹ stresses the importance of peatlands as carbon dioxide sinks. It describes the vast lengths being gone to in Yorkshire to restore the damage done to the peatlands by a massive drainage programme undertaken between 1950 and 1980 to press more of the land into agricultural service. The article observes that “...the draining and burning of South East Asian peat forests [sic] contributes eight per cent of the world's carbon emissions as damaged bogs release their once-safely stored carbon to the atmosphere.” It goes on to quote the Head of the UN Environment Programme, who pronounced peatland restoration, "a low-hanging fruit, and the most cost-effective of options for mitigating climate change." In fact "...peatland restoration,...is a critical part of the world campaign to stop catastrophic climate change.

A recent scientific paper reviewing the economics of such a policy has found⁴² that the carbon dioxide release involved in manufacturing and erecting turbines on blanket bogs is never recovered. The authors conclude: “Given the

clear advantages in terms of carbon payback time of locating windfarms on mineral soils, and the marginal future savings of carbon by locating windfarms on peats, construction of windfarms on un-degraded peatlands is best avoided as far as practicable.” In short, erecting windfarms on blanket bog is likely to exacerbate Global Warming, and, in consequence, everyone’s health will suffer thanks to climate destabilization.

Worryingly, it is now predicted that the proliferation of wind farms will itself have an important contribution to make to climate change. Employing wind turbines to meet 10% or more of global energy demand could cause surface warming exceeding 10 1C over land installations. A three-dimensional climate model used by Wang and Prinn ⁴²forecasts that impacts resulting in significant warming or cooling can occur even in places remote from wind farms. Alterations of the global distributions of rainfall and clouds can also occur.

In conclusion, there are serious adverse health effects associated with noise pollution generated by wind turbines. It is essential that separation distances between human habitation and wind turbines are increased. There is an international consensus emerging for a separation distance of 2 km, indeed some countries are opting for 3 km.

TERMS OF REFERENCE

I should like to address myself to some specific points in your Terms of Reference. I have had experience as a physician and in General Practice, but I have spent the bulk of my professional life as a Cardiovascular Epidemiologist.

I became interested in the health problems surrounding wind turbines because of the ever growing research linking inadequate sleep to cardiovascular disease. Here are the specific observations I would like to make in relation to:

(d) the implementation of planning processes in relation to wind farms, including the level of information available to prospective wind farm hosts.

I have no firsthand knowledge of the situation in Australia, although I have gained the strong impression that there has been a very vociferous debate, not to say a confrontation between a Wind Industry, and its supporters, which has been pretty aggressive in furthering its aims, and a beleaguered number of citizens who have had wind farms imposed too closely upon them; to the extent that their health and human rights have been infringed. It seems that this scenario has largely been ignored by a somewhat aloof and conservative Medical Profession. The Medical Profession has always been characteristically slow to embrace a new disease, in this case the effects of Infrasonic bombardment, particularly when there is no known treatment for it. In Europe the Aarhus Convention stands for openness and transparency and a full public consultation in all cases involving Environmental Planning. This has been enshrined in a European Treaty but the sort of consultation required has been sadly lacking in Ireland. Here it has consisted of an agent of the Wind Company contacting an interested local man, who then goes about wining and dining nearby landowners and farmers. Usually the first the local inhabitants hear that a wind farm is to be erected almost on top of them is when the Planning Application appears in the local paper. It is a cruel thing to expose quiet rural communities to unbridled market forces. Old friendships are destroyed as communities are torn between those who stand to profit and those who stand to lose from the wind farm's construction. Once the objection letters are posted on the web by the County

Council, the intimidation starts in earnest: threats, dubious intimidating legal letters, bullets in the post, water supplies interfered with, and so on. As promoting wind energy is Government policy, there is a suspicion that the police aren't interested in getting involved. In fact, because of the nature of the contracts which the land owners/farmers have signed, they may be liable for any accidents that might occur and for eventually decommissioning derelict turbines. In essence everyone will end up a loser except the developer.

(e) the adequacy of monitoring and compliance governance of wind farms.

In Ireland there has been no cost-benefit analysis carried out whatsoever before the widespread introduction of wind power. This is bad enough but there has also been no independent prospective evaluation carried out as to its effectiveness. From a public health perspective I find it particularly disturbing that there have been no attempts to properly monitor any health effects. Even more disturbingly we hear public health experts trotting out blandishments that there are 'no health effects' which are oddly reminiscent of the Wind Industry's promotional literature. When the Irish Deputy Chief Medical Officer, Colette Bonner, was quoted as saying that there could be some substance in 'The Wind Farm Syndrome', she was roundly attacked in the press for her pronouncements by the Irish Wind Energy Association. Thankfully Dr Bonner stood by her opinions. It seems that the wind industry makes a habit of attacking women when given the opportunity. Could it be that the Industry perceives women as being potentially more vulnerable?

(f) the application and integrity of national wind farm guidelines.

The critical issue is the amount of setback but this will depend on the size of the turbines. In Ireland the current setback in the South is 500 m, irrespective of the size of the turbine. This is currently under review but it is extremely unlikely to increase by very much. In the North the current setback is ten times rotor diameter. The announcement that France will double setback to 1 km is encouraging as is the statement by the Australian NHMRC in its Report that:

"The parallel evidence assessed suggests that there are unlikely to be any significant effects on physical or mental health at distances greater than 1,500 m from wind farms."

This is to be applauded in view of Steven Cooper's findings at Cape Bridgewater. However I believe this recommendation still does not go nearly far enough.

References

- ¹ World Health Organisation. Night noise guidelines for Europe. Copenhagen. 2009.
- ² 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
- ³ Basner M, Babisch W, Davis A et al. Auditory and non-auditory effects of noise and health. *Lancet* 2013, dx.doi.org/10.1016
- ⁴ Hume KI, Brink M, Basner M. Effects of environmental noise on sleep. *Noise & Health* 2013:IP 193.171.77.1
- ⁵ Carter PJ, Taylor BJ, Williams SM, Taylor RW. Longitudinal analysis of sleep in relation to BMI and body fat in children: the FLAME study. *BMJ* 2011;342:d2712
- ⁶ Safefood. Your child's weight: A guide to preventing childhood obesity. Order code: HPM00851, October 2013.
- ⁷ Yang G, Lai CSW, Cichon J, Ma L, Li W, Gan W-B. Sleep promotes branch-specific formation of dendritic spines after learning. *Science* 2014;344:1173-8.
- ⁸ Xie L, Kang H, Xu Q et al. Sleep drives metabolite clearance from the adult brain. *Science* 2013;342;373-7.
- ⁹ Sexton ES, Storsve AB, Walhovd KB, Johansen-berg H, Fjell AM. Poor sleep quality is associated with increased cortical atrophy in community-dwelling adults. *Neurology* 2014;83:967-73.
- ¹⁰ Chung SA, Wolf TK, Shapiro CM. Sleep and health consequences of shift work in women. *J Women's Health* 2009;18:965-77.
- ¹¹ Hoevenaer-Blom MP, Annemieke MW, Spijkerman AMW, Kromhout D, van den Berg JF, Verschuren WMM. Sleep Duration and Sleep Quality in Relation to 12-Year Cardiovascular Disease Incidence: The MORGEN Study. *SLEEP* 2011;34:1487-92.
- ¹² Hoevenaer-Blom MP, Annemieke MW, Spijkerman AMW, Kromhout D, Verschuren WMM. Sufficient sleep duration contributes to lower cardiovascular disease risk in addition to four traditional lifestyle factors: the

MORGEN study. Eur J Prevent Cardiol 2013; doi:
10.1177/2047487313493057.

¹³ Laugsand LE, Strand LB, Platou C, Vatten LJ, Janszky I. Insomnia and the risk of incident heart failure: a population study. Eur Heart J 2013 doi:10.1093/eurheartj/ehs019.

¹⁴ Heidt T, Sager HB, Courties G, et al. Chronic variable stress activates hematopoietic stem cells. Nature Medicine. Published Online published online 22 June 2014; doi:10.1038/nm.35822

¹⁵ Möller-Levet CS, Archer SN, Bucca G, et al. Effects of insufficient sleep on circadian rhythmicity and expression amplitude of the human blood transcriptome. PNAS 2013; doi/10.1073/pnas.1217154110.

¹⁶ Pierpont N. Wind Turbine Syndrome: A Report on a Natural Experiment. K Selected Publications, Santa Fe, New Mexico 2009.

¹⁷ Sivertsen B, Lallukka T, Salo et al. Insomnia as a risk factor for ill health: results from the large population-based prospective HUNT Study in Norway. J Sleep Res 2014;23:123-32.

¹⁸ Archer NA, Laing EE, Möller-Levet CS et al. Mistimed sleep disrupts circadian regulation of the human transcriptome. PNAS 2014; www.pnas.org/cgi/doi/10.1073/pnas.1316335111

¹⁹ Vyas MV, Garg AX, Iansavichus AV et al. Shift work and vascular events: systematic review and meta-analysis. BMJ 2012;345:e4800 doi.

²⁰ Salt AN, Lichtenhan JT. Responses of the inner ear to infrasound. IVth International Meeting on Wind Turbine Noise, Rome, Italy April 2011.

²¹ Schomer PD, Edreich J, Boyle J, Pamidighantam P. A proposed theory to explain some adverse physiological effects of the infrasonic emissions at some wind farm sites. 5th International Conference on Wind Turbine Noise Denver 28-30 August 2013.

²² Ananthaswamy A. Like clockwork. New Scientist, 31st August 2013 Pp 32-5.

²³ Casella Stanger. Report on Low Frequency Noise Technical Research Support for DEFRA Noise Programme (on behalf of DEFRA, Department of the Environment, Northern Ireland, Scottish Executive, National Assembly for Wales). 2001.

- ²⁴ Noise Review Working Party Report (Batho WJS, Chair). HMSO, London 1990.
- ²⁵ Kelley ND, Hemphill RR, McKenna HE. A methodology for assessment of wind turbine noise generation. *Trans ASME* 1982;104:112-20.
- ²⁶ Kelley ND, McKenna HE, Hemphill RR, Etter CI, Garrelts RI, Linn NC. Acoustic noise associated with the MOD .. 1 wind turbine: its source, impact, and control. Solar Energy Research Institute, A Division of Midwest Research Institute, 1617 Cole Boulevard, Golden, Colorado USA. February 1985
- ²⁷ Kelley ND. A proposed metric for assessing the potential of community annoyance from wind turbine low-frequency noise emissions. Presented at the Windpower '87 Conference and Exposition San Francisco, California, October 5-8, 1987. Solar Energy Research Institute. A Division of Midwest Research Institute 1617 Cole Boulevard Golden, Colorado USA, November 1987
- ²⁸ Bray W, James R. Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception. *Proceedings of Noise-Con; 2011, July 25-7;Portland, Oregon.*
- ²⁹ Kugler K, Wiegrebe L, Grothe B, et al, Low-frequency sound affects active micromechanics in the human inner ear. *R Soc open sci.* 1: 140166, 10 July 2014.
- ³⁰ Danielsson A, Landstrom U. Blood Pressure changes in man during infrasonic exposure. *Acta Med Scand* 1985;217:531-5.
- ³¹ Nussbaum DS, Reinis S. Some individual differences in human response to infrasound. University of Toronto Institute for Aerospace Report No. 282 (CN ISSN 0082-5225), January 1985.
- ³² Frey BJ, Hadden PJ. Wind turbines and proximity to homes: the impact of wind turbine noise on health (a review of the literature & discussion of the issues). January 2012. http://www.windturbinesyndrome.com/wp-content/uploads/2012/03/Frey_Hadden_WT_noise_health_01Jan2012.pdf
- ³³ Hanning CD, Evans A. Wind Turbine Noise. *BMJ* 2012: 344 e 1527
- ³⁴ von Hünerbein S, Moorhouse A, Fiumicelli D, Baguley D. Report on health impacts of wind turbines (Prepared for Scottish Government by Acoustics Research Centre, University of Salford), 10th April 2013.

- ³⁵ <http://aefweb.info/data/AUSWEA-2004conference.pdf>
- ³⁶ Møller H, Pedersen CS. Low-frequency noise from large wind turbines. *J Acoust Soc Am* 2011;129:3727-44.
- ³⁷ Phillips DJW. Iodine, milk, and the elimination of epidemic goitre in Britain: the story of an accidental public health triumph. *JECH* 1997;51:391-3.
- ³⁸ Kamperman GW, James R. The “How To” guide to siting wind turbines to prevent health risks from sound (P 8): <http://www.windturbinesyndrome.com/wp-content/uploads/2008/10/kamperman-james-8-26-08-report-43-pp.pdf>
- ³⁹ Münzel T, Gori T, Babisch W, Basner M. Cardiovascular effects of environmental noise exposure. *Eur Heart J* 2014;35:829-36.
- ⁴⁰ Daly G, Gonzalez G. Picture of Ireland: Where are our peatlands. *The Irish Times News Review*, 30th March 2013, P 6.
- ⁴¹ Anon. *Natural World: News from Wildlife Trusts across the UK*. Winter 2013, Pp 6-9.
- ⁴² Smith, J, Nayak DR, Smith P et al., Wind farms on undegraded peatlands are unlikely to reduce future carbon emissions. *Energy Policy* 2013: <http://dx.doi.org/10.1016/j.enpol.2013.10.066i>
- ⁴² Wang C, Prinn RG. Potential climatic impacts and reliability of very largescale wind farms. *Atmos Chem Phys* 2010;10:2053–61.