Wind Turbines and Health

A Rapid Review of the Evidence

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The purpose of this paper is to present findings from a rapid review of the evidence from current literature on the issue of wind turbines and potential impacts on human health. In particular the paper seeks to ascertain if the following statement can be supported by the evidence: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.* This statement is supported by the 2009 expert review commissioned by the American and Canadian Wind Energy Associations (Colby et al. 2009).

Context

In Australia, since the legislation of the *Renewable Energy (Electricity) Act* in 2000, wind power has been gaining prominence as a viable sustainable alternative to more traditional forms of energy production. Studies have found that there is increasing population demand for 'green' energy and that people are willing to pay a premium for renewable energy (Chatham-Kent Public Health Unit, 2008; Pedersen & Persson Waye, 2007). However as with any shift in technology, the emergence of wind farms is not without controversy.

There are two opposing viewpoints regarding wind turbines and their potential effect on human health. It is important to note that these views are frequently presented by groups or people with vested interests. For example, wind energy associations purport that there is no evidence linking wind turbines to human health concerns. Conversely, individuals or groups who oppose the development of wind farms contend that wind turbines can adversely impact the health of individuals living in proximity to wind farms.

Concerns regarding the adverse health impacts of wind turbines focus on the effects of infrasound, noise, electromagnetic interference, shadow flicker and blade glint produced by wind turbines. Does the evidence support these concerns?

Sound and Noise from Wind Turbines

Sound is composed of frequency expressed as hertz (Hz) and pressure expressed as decibels (dB). In terms of frequency sound can be categorised as audible and inaudible. Infrasound is commonly defined as sound which is inaudible to the human ear (below 16 Hz). Despite this commonly used definition, infrasound can be audible (EPHC, 2009). There is often confusion regarding the boundary between infrasound and low frequency noise (Leventhall, 2006). Human sensitivity to sound, especially to low frequency sound, is variable and people will exhibit variable levels of tolerance to different frequencies (Minnesota Department of Health, 2009).

Noise can be defined as any undesirable or unwanted sound. The perception of the noise is also influenced by the attitude of the hearer towards the sound source. This is sometimes called the nocebo effect, which is the opposite of the better known placebo effect. If people have been preconditioned to hold negative opinions about a noise source, they are more likely to be affected by it (AusWEA, 2004).

Wind turbines produce noise that can be classified into the following categories:

1. Mechanical noise which is produced from the motor or gearbox; if functioning correctly, mechanical noise from modern wind turbines should not be an issue.
2. Aerodynamic noise which is produced by wind passing over the blade of the wind turbine (Minnesota Department of Health, 2009).

As well as the general audible range of sound emissions, wind turbines also produce noise that includes a range of Special Audible Characteristics (SACs) such as amplitude modulation, impulsivity, low frequency noise and tonality (EPHC, 2009).

Table 1 compares the noise produced by a ten turbine wind farm compared to noise levels from some selected activities.

Activity	**Sound pressure level (dBA)**[1]
Jet aircraft at 250m	105
Noise in a busy office	60
Car travelling at 64kph at 100m	55
Wind farm (10 turbines) at 350m	**35-45**
Quiet bedroom	35
Background noise in rural area at night	20-40

Table 1: Noise levels compared to ten turbine wind farm (SDC, 2005).

Macintosh and Downie (2006) conclude that based on these figures "noise pollution generated by wind turbines is negligible".

One of the most common assertions regarding potential adverse noise impacts of wind turbines is concerned with low frequency noise and infrasound. It should be noted that infrasound is constantly present in the environment and is caused by various sources such as ambient air turbulence, ventilation units, ocean waves, distant explosions, volcanic eruptions, traffic, aircraft and other machinery (Rogers, Manwell & Wright, 2006). In relation to wind turbines, Leventhall (2006) concludes that there is insignificant infrasound generated by wind turbines and that there is normally little low frequency noise. A survey of all known published results of infrasound from wind turbines found that wind turbines of contemporary design, where rotor blades are in front of the tower, produce very low levels of infrasound (Jakobsen, 2005). Another recent report concludes that wind farm noise does not have significant low-frequency or infrasound components (Ministry of the Environment, 2007). As discussed in further detail below the principal human response to audible infrasound is annoyance (Rogers, 2006).

Effects of Noise from Wind Turbines on Human Health

The health and well-being effects of noise on people can be classified into three broad categories:

[1] The "A" represents a weighting of measured sound to mimic that discernable by the human ear, which does not perceive sound at low and high frequencies to be as loud as mid range frequencies (AusWEA, nd. a).

1. subjective effects including annoyance, nuisance and dissatisfaction;
2. interference with activities such as speech, sleep and learning; and
3. physiological effects such as anxiety, tinnitus or hearing loss (Rogers, Manwell & Wright, 2006).

Several commentators argue that noise from wind turbines only produces effects in the first two categories (Rogers, 2006; Pedersen & Persson Waye, 2007).

Various studies of wind turbine effects on health have concentrated on the self-reported perception of annoyance. There are difficulties with measuring and quantifying subjective effects of noise such as annoyance. According to the World Health Organization (WHO) (1999) annoyance is an adverse health effect, though this is not universally accepted. Kalveram proposes that annoyance is not a direct health effect but an indication that a person's capacity to cope is under threat. The person has to resolve the threat or their coping capacity is undermined, leading to stress related health effects (Kalveram 2000). Some people are very annoyed at quite low levels of noise, whilst other are not annoyed by high levels.

It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health (Chapman 2010). The measurement of health effects attributable to wind turbines is therefore very complex.

One study of wind turbine noise and annoyance found that no adverse health effects other than annoyance could be directly correlated with noise from wind turbines. The authors concluded that reported sleep difficulties, as well as feelings of uneasiness, associated with noise annoyance could be an effect of the exposure to noise, although it could just as well be that respondents with sleeping difficulties more easily appraised the noise as annoying (Pedersen & Persson Waye, 2007).

Many factors can influence the way noise from wind turbines is perceived. The aforementioned study also found that being able to see wind turbines from one's residence increased not just the odds of perceiving the sound, but also the odds of being annoyed, suggesting a multimodal effect of the audible and visual exposure from the same source leading to an enhancement of the negative appraisal of the noise by the visual stimuli (Pedersen & Persson Waye, 2007). Another study of residents living in the vicinity of wind farms in the Netherlands found that annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study also concluded that people who benefit economically from wind turbines were less likely to report noise annoyance, despite exposure to similar sound levels as those people who were not economically benefiting (Pedersen et al, 2009).

In addition to audible noise, concerns have been raised about infrasound from wind farms and health effects. It has been noted that the effects of low frequency infrasound (less than 20Hz) on humans are not well understood (NRC, 2007). However, as discussed above, several authors have suggested that low level frequency noise or infrasound emitted by wind turbines is minimal and of no consequence (Leventhall, 2006; Jakobsen, 2005). Further, numerous reports have concluded that there is no evidence of health effects arising from infrasound or low frequency noise

generated by wind turbines (DTI, 2006; CanWEA, 2009; Chatham-Kent Public Health Unit, 2008; WHO, 2004; EPHC, 2009; HGC Engineering, 2007). In summary:

- 'There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects' (Berglund & Lindvall 1995).

- Infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour (DTI, 2006).

- Findings clearly show that there is no peer-reviewed scientific evidence indicating that wind turbines have an adverse impact on human health (CanWEA, 2009).

- Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effects in humans. Subaudible, low frequency sounds and infrasound from wind turbines do not present a risk to human health (Colby, et al 2009).

- The Chatham-Kent Public Health Unit (Ontario, Canada) reviewed the current literature regarding the known health impacts of wind turbines in order to make an evidence-based decision. Their report concluded that current evidence failed to demonstrate a health concern associated with wind turbines. 'In summary, as long as the Ministry of Environment Guidelines for location criteria of wind farms are followed … there will be negligible adverse health impacts on Chatham-Kent citizens. Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence' (Chatham-Kent Public Health Unit, 2008).

- Wind energy is associated with fewer health effects than other forms of traditional energy generation and in fact will have positive health benefits (WHO, 2004).

- 'There are, at present, very few published and scientifically-validated cases of an SACs of wind farm noise emission being problematic … the extent of reliable published material does not, at this stage, warrant inclusion of SACs … into the noise impact assessment planning stage (EPHC, 2009).

- While a great deal of discussion about infrasound in connection with wind turbine generators exists in the media there is no verifiable evidence for infrasound and production by modern turbines (HGC Engineering, 2007).

The opposing view is that noise from wind turbines produces a cluster of symptoms which has been termed Wind Turbine Syndrome (WTS). The main proponent of WTS is a US based paediatrician, Dr Pierpont, who has released a book 'Wind Turbine Syndrome: A report on a Natural Experiment, presents case studies explaining WTS symptoms in relation to infrasound and low frequency noise. Dr Pierpont's assertions are yet to be published in a peer-reviewed journal, and have been heavily criticised by

acoustic specialists. Based on current evidence, it can be concluded that wind turbines do not pose a threat to health if planning guidelines are followed.

Shadow Flicker and Blade Glint

Shadow flicker occurs when the sun is located behind a wind turbine casting a shadow that appears to flick on and off as the wind turbine blades rotate (Chatham-Kent Public health Unit, 2008). It is possible to use modelling software to model shadow flicker before the finalisation of a wind farm layout and siting.

Blade glint occurs when the surface of wind turbine blades reflect the sun's light and has the potential to annoy people (EPHC, 2009).

Effects of Shadow Flicker and Blade Glint on Human Health

Shadow flicker from wind turbines that interrupts sunlight at flash frequencies greater than 3Hz has the potential to provoke photosensitive seizures (Harding, Harding & Wilkins, 2008). As such it is recommended that to circumvent potential health effects of shadow flicker wind turbines should only be installed if flicker frequency remains below 2.5 Hz under all conditions (Harding, Harding & Wilkins, 2008).

According to the EPHC (2009) there is negligible risk of seizures being caused by modern wind turbines for the following reasons:

- less than 0.5% of the population are subject to epilepsy at any one time, and of these, approximately 5% are susceptible to strobing light;
- Most commonly (96% of the time), those that are susceptible to strobe lighting are affected by frequencies in excess of 8 Hz and the remainder are affected by frequencies in excess of 2.5 Hz. Conventional horizontal axis wind turbines cause shadow flicker at frequencies of around 1 Hz or less;
- alignment of three or more conventional horizontal axis wind turbines could cause shadow flicker frequencies in excess of 2.5 Hz; however, this would require a particularly unlikely turbine configuration.

In summary, the evidence on shadow flicker does not support a health concern (Chatham-Kent Public Health Unit, 2008) as the chance of conventional horizontal axis wind turbines causing an epileptic seizure for an individual experiencing shadow flicker is less than 1 in 10 million (EPHC, 2009). As with noise, the main impact associated with shadow flicker from wind turbines is annoyance.

In regards to blade glint, manufacturers of all major wind turbine blades coat their blades with a low reflectivity treatment which prevents reflective glint from the surface of the blade. According to the Environment Protection and Heritage Council (EPHC) the risk of blade glint from modern wind turbines is considered to be very low (EPHC, 2009).

Electromagnetic Radiation and Interference

Electromagnetic radiation (EMR) is a wavelike pattern of electric and magnetic energy moving together. Types of EMR include X-rays, ultraviolet, visible light, infrared and radio waves (AusWEA, nd. b).

Electromagnetic interference (EMI) from wind turbines may affect electromagnetic or radiocommunication signals including broadcast radio and television, mobile phones and radar (EPHC, 2009).

As high and exposed sites are best from a wind resource perspective, it is not unusual for any of a range of telecommunications installations, radio and television masts, mobile phone base stations or emergency service radio masts to be located nearby. Care must be taken to ensure that wind turbines do not passively interfere with these facilities by directly obstructing, reflecting or refracting their radio frequency EMR signals.

Effects of Electromagnetic Radiation and Interference from Wind Turbines on Human Health

Electromagnetic Fields (EMF) emanate from any wire carrying electricity and Australians are routinely exposed to these fields in their everyday lives. The electromagnetic fields produced by the generation and export of electricity from a wind farm do not pose a threat to public health (Windrush Energy 2004). The closeness of the electrical cables between wind turbine generators to each other, and shielding with metal armour effectively eliminate any EMF (AusWEA, nd. b).

Measures to Mitigate Potential Impacts of Wind Turbines

As with the introduction of any new technology, some communities are against wind farms being located in their area. Some factors which may increase community concern include coerced or unequal exposure, industrial, exotic and/or memorable nature of the turbine, dreaded, unknown or catastrophic consequences, substantial media attention, potential for collective action and a process which is unresponsive to the community. Voluntary exposure, for example choosing to house the turbine on community land, reduces concern (Adapted by Professor Chapman from Covello et al. methodology 1986).

One review of wind turbines and noise recommends that best practice guidelines such as those identifying potential receptors of turbine noise, following established setbacks and dispelling rumours regarding infrasound which have not been supported by research, are followed in order to mitigate any potential noise issues associated with wind turbines (Howe, 2007).

Sustainable Energy Authority Victoria (2003) also recommend that complying with standards relating to turbine design and manufacturing, site evaluation and final siting of wind turbines will minimise any potential impacts on the surrounding area.

The recently released Draft National Wind Farm Development Guidelines (EPHC, 2009) include detailed methodologies at different stages of the planning and development process to assess such issues as noise and shadow flicker to mitigate any potential impact. Such processes include a range of measures such as high-level risk assessment, data collection, impact assessment, detailed technical studies and public consultation.

Therefore if planning guidelines are followed and communities are consulted with in a meaningful way, resistance to wind farms is likely to be reduced and annoyance and related health effects avoided.

Conclusion

The health effects of many forms of renewable energy generation, such as wind farms, have not been assessed to the same extent as those from traditional sources. However, renewable energy generation is associated with few adverse health effects compared with the well documented health burdens of polluting forms of electricity generation (Markandya & Wilkinson, 2007).

This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.*

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