Select Committee on Wind Turbines

Subject: Low Frequency Noise, Infrasound Visual Health Effects and Wind Turbines

This submission focuses on health issues associated with the establishment of Wind Farms in Australia and their effect on people living in close proximity to them. It is very clear from the documented experiences of people living in close proximity to these developments that Governments both State and Federal need to be better informed on these issues and provide uniform legislation to protect the rights of individuals.

The role and the capacity of the National Health and Medical Research Council in providing guidance to state and territory authorities are to me less than encouraging – refer comments below.

Overseas reports show "Regulatory authorities must accept that annoyance by low frequency noise presents a real problem which is not addressed by the commonly used assessment methods." [18]

My comments are as follows:

NHMRC Statement: Evidence on Wind Farms and Human Health
February 2015

This Statement appears to be an inconclusive document highlighting the limitations of current research in Australia on the effects of wind farms on human health. It simply states "Examining whether wind farm emissions may affect human health is complex, as both the character of the emissions and individual perceptions of them are highly variable. After careful consideration and deliberation of the body of evidence, NHMRC concludes that there is currently no consistent evidence that wind farms cause adverse health effects in humans." However it obviously attempts to provide a rider to that conclusion by stating "Given the poor quality of current direct evidence and the concern expressed by some members of the community, high quality research into possible health effects of wind farms, particularly within 500 metres (m), is warranted". It further states "There is consistent but poor quality direct evidence that wind farm noise is associated with annoyance. While the parallel evidence suggests that prolonged noise-related annoyance may result in stress, which may be a risk factor for cardiovascular disease, annoyance was not consistently

defined in the studies and a range of other factors are possible explanations for the association observed.

It would be interesting to know a full history of what people affected by health issues caused by wind turbines have suffered and the impact wind turbines have had on their daily lives including financial costs and losses imposed on them.

There have been reports of low frequency sound generated by wind turbines travelling considerably greater distances than 500 metres. In my opinion this indicates that the establishment of wind farms should be banned from "Rural/Residential" areas until high quality research into possible health effects of wind farms is completed and clearly shows there is little if any impact on the health of people residing in close proximity to them.

Overseas studies into the health issues associated with wind farms should not be ignored. Considerable research has been conducted by various authorities as noted below. Of particular concern is the reported finding of –

A NASA technical paper on wind turbine noise that states -

"People who are exposed to wind turbine noise inside buildings experience a much different acoustic environment than do those outside….They may actually be more disturbed by the noise inside their homes than they would be outside….One of the common ways that a person might sense the noise-induced excitation of a house is through structural vibrations. This mode of observation is particularly significant at low frequencies, below the threshold of normal hearing." [47]

And

"Jung and colleagues (2008), in a Korean study, concluded that low-frequency noise in the frequency range above 30 Hz can lead to psychological complaints and that infrasound in the frequency range of 5–8 Hz can cause complaints due to rattling doors and windows in homes." [45] Field studies and "…research has shown that the acoustic energy from wind turbines is capable of resonating houses, effectively turning them into three-dimensional loud speakers in which the affected residents are now expected to live. The phenomenon of natural resonance combines to produce a cocktail of annoying sounds which not only disturb the peace and tranquility once-enjoyed by the residents, but also

stimulate a number of disturbing physiological effects which manifest in the physical symptoms...” [46]

Interestingly “Sick Building Syndrome” was linked to low frequency sound caused by plant and machinery decades ago. It is certainly nothing new.

Overseas Reports

Wind Turbines

Visual Health Effects and Wind Turbines

“…wind-energy projects create negative impacts on human health and well-being, the impacts are experienced mainly by people living near wind turbines who are affected by noise and shadow flicker.”

National Research Council (NRC). Environmental Impacts of Wind-Energy Projects, 2007

World Health Organization acknowledges that in addition to noise pollution wind turbines also have visual burdens. [1]

The health impact of visual burdens cannot be underestimated. An epidemiology study conducted by World Health Organization determined a “bad view out of window” increased the risk for depression by 40%. The same study also demonstrated disturbance by noise and sleep disturbance by noise increased the risk of depression 40%, and 100% respectively. [2] In addition to visual burdens wind turbines create noise pollution [3] which is acknowledged to cause annoyance, stress and sleep disturbance. [4], [5], [6], [7], [8] In light of these statistics it is expected that people may suffer adverse health effects from visual and noise impacts of wind turbines.

Rotating wind turbine blades interrupt the sunlight producing unavoidable flicker bright enough to pass through closed eyelids, and moving shadows cast by the blades on windows can affect illumination inside buildings. [9] This effect is commonly known as shadow flicker.

Wind turbine shadow flicker has the potential to induce photosensitive epilepsy seizures however the risk is low with large modern models and if proper planning is adhered to. [10], [11] Planning should ensure the flash frequency does not exceed three per second, and the shadows cast by one turbine on another should not have a cumulative flash rate exceeding three per second. [12]

Wind turbine shadow flicker induced adverse human health effects include annoyance and/or stress. [13], [14], [15], [16], [17]

Wind turbine noise including low frequency noise may also contribute to the overall annoyance.

“Wind turbine noise is easily perceived and annoying even at low A-weighted SPLs….Wind turbines are furthermore prominent objects whose rotational movement attracts the eye. Multimodal sensory effects or negative aesthetic response could enhance the risk of annoyance. Adverse reactions could possibly lead to stress-related symptoms due to prolonged physiological arousal and hindrance to psychophysiological restoration.” [18]

No generalized dose-response curves have yet been modeled for wind turbine shadow flicker primarily due to the lack of results of published field studies.

Further investigation into the effects of wind turbine stressors including shadow flicker is required to assist in the development authoritative guidelines designed mitigate potential adverse health effects. [19]

Shadow flicker is also a safety concern. For example it can cause vehicle driver distraction. [20]

Most jurisdictions do not have explicit regulations to protect people from the

adverse health effects of shadow flicker. [21]

To mitigate risk to human health wind turbines should be sited to ensure people will not be adversely affected. For example in the northern hemisphere people located East-NE or WNW from the turbine must be protected from shadow flicker. [22]

Recommended shadow flicker setbacks for current wind turbine designs are 10 rotational diameters which would typically translate to approximately 1000 m. [23]

Greater setback distances may be required when wind turbines are sited on elevated ridges as the shadows can be cast over distances of several kilometres.

It is acknowledged that "…shadow flicker can be an issue both indoors and outdoors when the sun is low in the sky. Therefore, shadow flicker may be an issue in locations other than the home." [24] Shadow flicker modelling must consider human exposure to shadow flicker outside a building.

Protection from wind turbine shadow flicker exposure must be engineered into the design of the wind turbine facility during the planning stage. [25], [26]

To ensure protection from adverse human health effects a shadow flicker study must be conducted during the planning stage of a wind turbine facility. The shadow flicker study should:

- Calculate shadow flicker based on the actual location of the wind turbines.
- Calculate shadow flicker exposure on the entire neighbouring properties and not just the "receptor (house)".
- Calculate shadow flicker for both sun and moon induced flicker using conservative assumptions to ensure maximum protection against adverse

human health effects and safety risks.

- Protect against photosensitive epilepsy by ensuring the flash frequency does not exceed three per second, and the shadows cast by one turbine on another do not have a cumulative flash rate exceeding three per second.

Conclusions

Based on the best available science the following conclusions can be drawn.

- Wind turbines produce noise and visual burdens.
- Scientific research confirms visuals impacts can adversely affect human health.
- Wind turbine shadow flicker has the potential to induce photosensitive epilepsy seizures however the risk is low with large modern models and if proper planning is adhered to.
- Wind turbine shadow flicker induced adverse human health effects include annoyance and/or stress.
- No generalized dose-response curves have yet been modeled for wind turbine shadow flicker primarily due to the lack of results of published field studies.
- Protection from wind turbine shadow flicker exposure must be engineered into the design of the wind turbine facility during the planning stage.

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Low Frequency Noise, Infrasound and Wind Turbines

"Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general" - World Health Organization

Wind turbines generate a broad spectrum of noise including low frequency noise and infrasound which may be audible or inaudible. [2], [3], [4], [5]

It is widely affirmed that exposure to audible low frequency noise can cause adverse health effects in humans. [6], [7], [8], [9]

Low frequency noise can cause "…immense suffering to those who are unfortunate to be sensitive to low frequency noise and who plead for recognition of their circumstances." [10]

"Wind turbines are generally located in areas devoid of trees and other large vegetation. Instead, ground cover usually consists of grass, sagebrush, plants, and low shrubs, which are minor impediments to noise propagation except at very high frequencies. At frequencies below about 1000 Hz, the ground attenuation is essentially zero." [11]

The farther away from the wind turbine the greater is the low frequency content due to a relatively larger atmospheric absorption of high frequencies. Considering the A-weighted sound level outdoors in relevant distances to neighbours, the lower frequencies constitute a substantial part of the noise. [12]

There is no doubt that as wind turbines get larger and more densely sited the lower frequency part of the noise spectrum is of importance to the neighbours' perception of noise from large wind turbines. Noise from wind turbines is under certain atmospheric conditions more annoying and - especially the low frequency part - spread much farther than generally accepted. Wind turbines may cause low frequency noise induced annoyance both inside and outside a building. [13]

Peer reviewed articles and other references acknowledge annoyance to be an adverse health effect.[14],[15], [16], [17]

"Regulatory authorities must accept that annoyance by low frequency noise presents a real problem which is not addressed by the commonly used

assessment methods." [18]

Literature reviews and peer reviewed scientific articles confirm the symptoms associated with low frequency noise exposure include annoyance, stress, sleep disturbance, headaches, difficulty concentrating, irritability, fatigue, dizziness or vertigo, tinnitus, heart ailments anxiety, stitch and beating palpitation. [19], [20], [21]

International research and media reports document people exposed over time, to too-close wind turbines, are experiencing adverse health effects. "These symptoms include sleep disturbance, headaches, difficulty concentrating, irritability and fatigue, but also include a number of otologic symptoms including dizziness or vertigo, tinnitus and the sensation of aural pain or pressure." [22]

The American Wind Energy Association and Canadian Wind Energy Association sponsored literature review entitled "Wind Turbine Sound and Health Effects" acknowledges wind turbine noise may cause annoyance, stress and sleep disturbance and as a result people may experience adverse physiological and psychological symptoms. The literature review specifically acknowledges that wind turbines may cause low frequency noise induced annoyance. [23]

More specifically Geoff Leventhall, a coauthor of the wind energy association sponsored "Wind Turbine Sound and Health Effects" states

"The symptoms of… Wind Turbine Syndrome...sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic attack episodes associated with sensations of internal pulsation or quivering when awake or asleep…I am happy to accept these symptoms, as they have been known to me for many years as the symptoms of extreme psychological stress from environmental noise, particularly low frequency noise." [24]

World Health Organization advises that "Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general…The evidence on low-frequency noise is sufficiently strong to warrant immediate concern." and consequently "Noise with low-frequency

components require lower guideline values." [25]

The effects of low frequency noise induced annoyance and stress may be serious and it is acknowledged that "The claim that their "lives have been ruined" by the noise is not an exaggeration…" [26]

It is acknowledged that "…LFN (low frequency noise) does not need to be considered "loud" for it to cause such forms of annoyance and irritation." [27]

"The effects of infrasound or low frequency noise are of particular concern because of its pervasiveness due to numerous sources, efficient propagation, and reduced efficiency of many structures (dwellings, walls, and hearing protection) in attenuating low frequency noise compared with other noise." [28]

"Unlike higher frequency noise issues, LFN is very difficult to suppress. Closing doors and windows in an attempt to diminish the effects sometimes makes it worse because of the propagation characteristics and the low-pass filtering effect of structures. Individuals often become irrational and anxious as attempts to control LFN fail, serving only to increase the individual's awareness of the noise, accelerating the above symptoms" [29]

"Those exposed may adopt protective strategies, such as sleeping in their garage if the noise is less disturbing there. Or they may sleep elsewhere, returning to their own homes only during the day." [30]

Some individuals have resorted to sleeping in a tent [31], been billeted by the wind energy proponent, [32], [33] or have abandoned their homes [34], [35] to escape the wind turbine noise that has invaded their home.

A spectral analysis of sounds emitted at a Michigan site revealed that unweighted peak levels at frequencies under 5 Hz exceeded 90 dB SPL (Wade Bray, pers. comm., 2009). [36]

"There is no doubt that some humans exposed to infrasound experience abnormal ear, CNS, and resonance induced symptoms that are real and stressful." [37]

There is no scientific consensus that infrasonic noise below the threshold of

hearing will have no effect on health. There is scientific uncertainty regarding the understanding of human response to infrasound.

“There is no consensus whether sensitivity below 20 Hz is by a similar or different mechanism than sensitivity and hearing above 20 Hz…” [38]

In a 2009 Environmental Review Report [39] for an Ontario, Canada wind turbine project the consultant acknowledged that regarding wind turbine low frequency noise (LFN) and adverse health effects:

“It is acknowledged that LFN may be one area of scientific uncertainty in the wind industry as a whole.”

and regarding wind turbine infrasound:

“…it is recognized that this may be an area of scientific uncertainty.”

The National Research Council states “Low-frequency vibration and its effects on humans are not well understood. Sensitivity to such vibration resulting from wind-turbine noise is highly variable among humans…. studies on human sensitivity to very low frequencies are recommended.” [40]

The conclusions of a 2010 peer reviewed scientific article states

“1) Hearing perception, mediated by the inner hair cells of the cochlea, is remarkably insensitive to infrasound.

2) 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. The concept that an infrasonic sound that cannot be heard can have no influence on inner ear physiology is incorrect.

3) Under some clinical conditions, such as Meniere’s disease, superior canal dehiscence, or even asymptomatic cases of endolymphatic hydrops, individuals may be hypersensitive to infrasound.

4) A-weighting wind turbine sounds underestimates the likely influence of the sound on the ear. A greater effort should be made to document the infrasound component of wind turbine sounds under different conditions.

5) Based on our understanding of how low frequency sound is processed in the ear, and on reports indicating that wind turbine noise causes greater annoyance than other sounds of similar level and affects the quality of life in sensitive individuals, there is an urgent need for more research directly addressing the physiologic consequences of long-term, low level infrasound exposures on humans." [41]

It is incorrect to assume that inaudible low frequency noise cannot cause adverse health effects as "…non-aural physiological and psychological effects may be caused by levels of low frequency noise below the individual hearing threshold." [42]

"Low-frequency noise may also produce vibrations and rattles as secondary effects." [43]

"Although infrasound levels from large turbines at frequencies below 20 Hz are too low to be audible, they may cause structural elements of buildings to vibrate." [44]

"Jung and colleagues (2008), in a Korean study, concluded that low-frequency noise in the frequency range above 30 Hz can lead to psychological complaints and that infrasound in the frequency range of 5–8 Hz can cause complaints due to rattling doors and windows in homes." [45]

Field studies and "…research has shown that the acoustic energy from wind turbines is capable of resonating houses, effectively turning them into three-dimensional loud speakers in which the affected residents are now expected to live. The phenomenon of natural resonance combines to produce a cocktail of annoying sounds which not only disturb the peace and tranquility once-enjoyed by the residents, but also stimulate a number of disturbing physiological effects which manifest in the physical symptoms..." [46]

A NASA technical paper on wind turbine noise states

"People who are exposed to wind turbine noise inside buildings experience a much different acoustic environment than do those outside….They may actually be more disturbed by the noise inside their homes than they would be outside….One of the common ways that a person might sense the noise-induced excitation of a house is through structural vibrations. This mode of

observation is particularly significant at low frequencies, below the threshold of normal hearing." [47]

Living conditions are acknowledged to be a key determinate of health. [48]

A World Health Organization epidemiology study confirms disturbed living conditions caused by noise increases the risk of ill health. [49]

Peer reviewed scientific research confirms "Pollution and degradation of the indoor environment cause illness, increased mortality, loss of productivity, and have major economic and social implications.…The health effects of indoor noise include an increase in the rates of diseases and disturbances… these illnesses, and the related reduction in human productivity, can result in substantial economic losses." [50]

Modern upwind industrial wind turbines produce a characteristic audible modulation of aerodynamic noise. [51] This is commonly referred to as amplitude modulation and is acknowledged to contribute to higher levels of wind turbine induced annoyance and/or sleep disturbance in the exposed population. [52], [53], [54]

Wind turbine low frequency noise and infrasound is also modulated.

"Low frequency sound and infrasound are normal characteristics of a wind farm as they are the normal characteristics of wind, as such. The difference is that "normal" wind is laminar or smooth in effect whereas wind farm sound is non-laminar and presents a pulsing nature." [55]

"A limitation of much work on assessment of low frequency noise has been

that long term averaged measurements were used and, consequently, information on fluctuations was lost. Many complaints of low frequency noise refer to its throbbing or pulsing nature." [56]

Research related to low frequency noise "…confirms the importance of fluctuations as a contributor to annoyance and the limitation of those assessment methods, which do not include fluctuations in the assessment." [57]

Adverse health effects associated with low frequency noise and infrasound can be avoided with authoritative regulations that ensure protection is engineered into the design of wind turbine projects.

Low Frequency Noise is an issue that must be resolved quickly and accurately to improve the sound environment and quality of life for the residents. For this reason, it remains the duty of authorities to implement regulations that will account for low frequency noise.[58]

It is widely affirmed that A-weighting underestimates the sound pressure level of noise with low-frequency components. [59], [60], [61] , [62], [63] "A-weighted level is very inadequate…" [64] when assessing low frequency noise and infrasound.

C-weighting and Z-weighting are more appropriate to assess noise with low frequency components.

Globally the adoption of low frequency noise and infrasound regulations is hampered by wind energy industry resistance. For example in Canada the Ontario Ministry of the Environment determined that wind turbine developers be required "…to monitor and address any perceptible infrasound (vibration) or

low frequency noise. [65] However CanWEA lobbies against having to address the impacts of wind turbine low frequency noise and infrasound "…CanWEA submits that the proposed requirement for infrasound or low frequency noise monitoring as a condition of the REA be removed." [66]

Conclusions

Based on the best available science the following conclusions can be drawn.

· Wind turbine noise is likely to be audible to receptors in the form of continuous low-level or intermittent swooshing, as well as low frequencies at approximately 50 Hertz.

· Exposure to audible low frequency noise can cause adverse health effects in humans.

· Humans must be protected from the adverse health effects of low frequency noise exposure.

· Wind turbine low frequency noise may induce annoyance, stress and sleep disturbance which may have other health consequences.

· International research and media reports document people exposed to wind turbines reporting adverse health effects. Reported symptoms include annoyance, stress, sleep disturbance, headaches, difficulty concentrating, irritability, fatigue, dizziness or vertigo, tinnitus and the sensation of aural pain or pressure.

· Wind turbines emit infrasound which may be audible or inaudible. There is scientific uncertainty regarding infrasound; however, it is plausible wind turbine infrasound could adversely affect human health.

· It is acknowledged infrasound can induce annoyance, stress and sleep disturbance by disturbing people inside their homes through structural vibrations.

· Based on current understanding of how low frequency sound is processed in

the ear, and on reports indicating that wind turbine noise causes greater annoyance than other sounds of similar level and affects the quality of life in sensitive individuals, there is an urgent need for more research directly addressing the physiologic consequences of long-term, low level infrasound exposures on humans.

· Adverse health effects associated with low frequency noise and infrasound can be avoided with authoritative regulations that ensure protection is engineered into the design of wind turbine projects.

· Members of the wind energy industry oppose addressing wind turbine low frequency noise and infrasound. For example the Canadian Wind Energy Association has lobbied against the introduction of protective guidance designed to address wind turbine low frequency noise and infrasound.

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Recommendations:

Prior to approval of Wind farm developments there should be mandatory cost benefits analyses of proposals to ensure Government funds are not used to keep Wind Farms viable at the expense of tax payers' funds and that there are net benefits to the economies of the areas in which the Wind Farms a proposed to be established.

To protect the rights of people living in close proximity to proposed Wind farms there is a need for uniform legislation in regard to planning, consultation and approval of wind farm developments.

Wind Industry data on health issues associated with developments must be thoroughly assessed by independent experts.

Legislation must be enacted to ensure the adequacy of monitoring and compliance with conditions of approval for Wind Farm developments

Peter Bowden