

5 SOUND AND HEALTH

Introduction

This Introduction is by B. Rapley as recorded in 'Sound, Noise, Flicker and the Human Perception of Wind Farm Activity' introducing the monograph by Dr D. Shepherd.

To understand the nature of the potential hazard, it is necessary to understand the nature of sound and the way it interacts with the human body. Dr. Daniel Shepherd takes on this task, providing a tutorial on the nature of the phenomenon and the method of interaction with human physiology. He makes the important point that, contrary to popular belief, we do not become used to noise (unwanted sound). To assume that someone can simply learn to accommodate a noise and ignore it is largely untrue. Dr Shepherd concludes that there is now convincing evidence in the literature that community noise causes annoyance, disrupts sleep, impairs children's school performance and negatively affects cardiovascular health. It also impedes rest, relaxation and recreational activity.

The latest research indicates that nuisance noise from wind farms is associated with psychological distress, stress, difficulties with falling asleep and sleep interruption. Furthermore, it is very hard to predict how annoyance from noise will compromise the health of susceptible individuals by considering the physical properties of the noise. This surely raises red flags for both those setting noise standards and those involved with policing consents. On these issues alone it is clear that there must be far more care in the siting of any future wind farms and a better understanding of how to mitigate the noise and compensate the affected individuals. The age-old question still exists: when do the needs of the many outweigh the needs of the few?

Brief excerpts from Dr Shepherd's monograph follow. For the complete monograph and references see 'Sound, Noise, Flicker and the Human Perception of Wind Farm Activity' the evidential text for the proposed Turitea wind farm (New Zealand) hearing.

What is noise

Sufficient evidence now exists to link community noise to health problems, with one literature review concluding the following:

"It can be seen that these international groups of experts considered that there was sufficient evidence for the effects of noise on health regarding annoyance, school performance, ischaemic heart disease, hypertension and various aspects of sleep disturbance."

7 WIND FARM NOISE AND HUMAN PERCEPTION

Investigations in New Zealand have proven that the sound(s) of wind turbines are audible at low amplitudes inside homes. Such sound has readily identifiable perceptual dissonance and has a direct relationship to annoyance and sleep disturbance. This Report presents the effects of wind farm noise on residents near the Waubra wind farm and two wind farms in New Zealand and identifies concerns with potential adverse health effects, including audible, low frequency and infrasound effects.

My observations and measurements indicate that a wind farm is a source of noise (sound and vibration). It is a highly complex source of noise and is, in my opinion, unique due to its complexity and human perception. The receivers of the noise (that is, people) are highly complex in response. People do not respond to "single number" sound levels or noise levels for that matter. In the event, the installation of turbines at Waubra and Te Rere Hau and Makara (New Zealand) has resulted in widespread complaint concerning sleep disturbance due to unreasonable noise. My observations within a Makara residence show that outdoor levels of modulated sound below $L_{eq} 30 \text{ dB(A)}$ are clearly audible within the home at night under calm weather conditions outside.

Based on my observations in the Manawatu, at Makara and in Waubra, it is my opinion that a background sound level of 40 dB(A) (or 38 dB(A) LAeq) due to wind farm noise is too high at residences. At the West Wind (Makara New Zealand) Hearing Dr van den Berg and I received agreement from the Experts' Caucus to present a separate statement to the agreed matters-

"We believe that the conditions here agreed upon will protect residents from severe annoyance and sleep disturbance, but not from annoyance and loss of amenity. We believe annoyance and loss of amenity will be protected when the wind turbine noise limit would be $30 \text{ dBA } L_{95}$ in conditions of low wind speed at the dwellings and modulation restricted to 3 dB ."

The LA_{95} background sound level of 30 dB(A) is broadly equivalent to 32 dB(A) LAeq .

I am of the opinion, based on my own research, that wind farm noise can and does create unreasonable noise within residences and consequential adverse effects in the sense of sleep disturbance, annoyance and potential adverse health effects to residents living within 2000 metres of large wind turbines set in a wind farm. These risks are quantifiable and the effect is significantly more than minor.

Based on my observations within the Manawatu and Makara I am of the opinion that wind farm sound can be heard and recorded within residences situated within 3500 metres of large turbines

set in a wind farm. The risk of adverse effect due to sleep disturbance and annoyance is quantifiable and the effect is significantly more than minor.

Based on anecdotal evidence I have heard from affected people visual amenity also affects the perception of sound from sources of noise. This effect should be considered as part of a risk assessment. Perception of noise is enhanced when the turbines have visual dominance. By day, blade glint and flicker increase perception. At night, the red warning lights cause blade glint and strobing effects. Light bounce from low cloud creates visual dominance.

As previously stated the most significant issue for the practical management of wind farm noise is that the New Zealand standard lacks a methodology to separate single-value LA95 sound levels created by the wind turbines from ambient LA95 sound levels existing at a specific time and place due to wind movement, vegetation movements, bird song and so on. The "different" background levels cannot be separated using the standard's approach unless the turbines are switched off.

Unreasonable or disturbing noise will occur when the sound from a wind farm disturbs sleep and thereby causes anxiety, annoyance and stress. That unreasonable or disturbing noise can occur is well documented in peer-reviewed and impartial research. My research over 5 years and in Victoria and New Zealand indicates the existence of noise induced sleep disturbance and adverse health effects due to wind farm noise.

The expression sub-audible character is given in this Report to differentiate between low frequency sound (which has a solid foundation in hearing response) and infrasound, which has a less solid foundation in hearing response. Infrasound, however, has characteristics that may lead to adverse health effects. There is an extensive world-wide debate between acousticians, health professionals and the community (primarily affected persons) concerning potential adverse health effects due to the influence of wind farms. This is still the subject of debate, as outlined in this Report. However, there is sufficient peer-reviewed research and solid acoustical foundation for analysis to be made.

The above issues are debated in more detail in the evidential text "*Sound, Noise, Flicker and the Human Perception of Wind Farm Activity*" that was prepared for the Board of Inquiry Turitea Wind Farm Proposal Hearing, New Zealand, March 2010. The authors are a team of researchers that provide independent unbiased advice to the community and wind farm developers concerning the potential for adverse effects and mitigation of wind farm activity on people.

Chapter 1: Audible Sound and Noise

Wind farms and wind turbines are a unique source of sound and noise. The noise generation from a wind farm is like no other noise source or set of noise sources. The sounds are often of low amplitude (volume or loudness) and are constantly shifting in character ("waves on beach", "rumble-thump", "plane never landing", etc). People who are not exposed to the sounds of a wind farm find it very difficult to understand the problems of people who do live near to wind farms. Some people who live near wind farms are disturbed by the sounds of the farms, others are not. In some cases adverse health effects are reported, in other cases such effects do not appear evident. Thus wind farm noise is not like, for example, traffic noise or the continuous hum from plant and machinery. Wind turbines such as those proposed are large noise sources relative to dwellings, Figure 1:

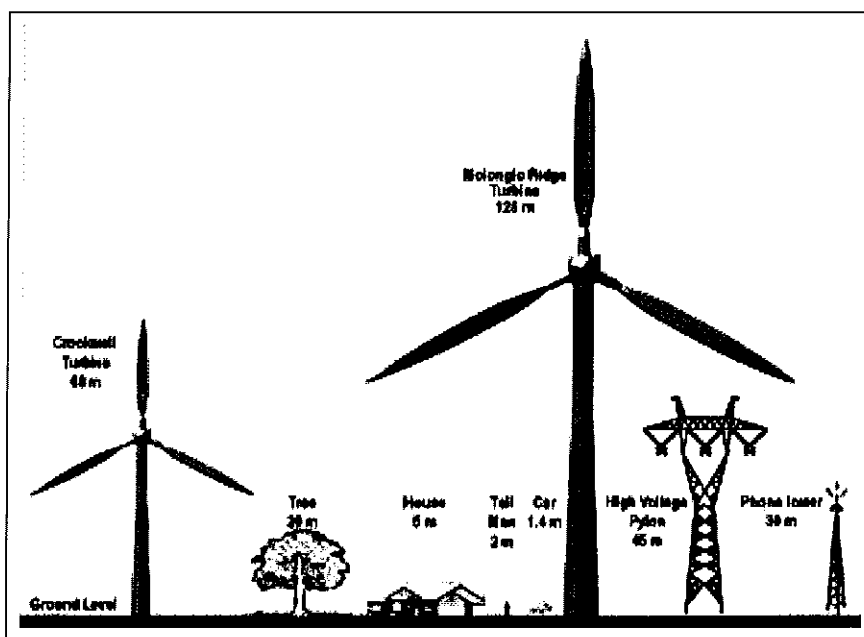


Figure 1: Relative heights of turbines to dwellings

(Source: Molonglo Landscape Guardians, by permission)

Audible noise from modern wind turbines is primarily due to infrasound, turbulent flow and trailing edge sound. Sound character relates to blade characteristics and blade/tower interaction and can be grouped into 4 main bands. The sound can be characterised as being impulsive and broadband, audible and inaudible (infrasonic):

- Infrasound below 20 Hz
- Low frequencies 20 Hz to 250 Hz
- Mid Frequency 250 to 2000 Hz (broadly, although the higher level could be 4000 Hz)
- High frequency 2000 Hz to 20,000 Hz

The Effects on People near the Waubra Wind Farm, Victoria

The Waubra wind farm commenced operation in March 2009 in the Ballarat section and May 2009 in the northern Waubra section. Within a short time nearby residents were becoming concerned about noise. By August 2009 adverse health effects were being reported. In September-October I interviewed 5 different families near the northern section of the wind farm, all of whom report some adverse reaction since the commissioning of a nearby wind farm earlier in the year. The families are all within approximately 1000 – 2000 metres of turbines and had at least two sets of turbines near to them. Under these circumstances the residences are affected by wind farm activity over a range of wind directions. The interviews were preliminary in nature and standard psych and noise sensitivity tests were not conducted, nor were detailed health notes recorded.

Family A reports headaches (scalp and around the head pressure), memory problems and nausea when the turbines are operating. Symptoms include an inability to get to sleep and sleep disturbance, anxiety and stress, pressure at top and around head, memory problems, sore eyes and blurred vision, chest pressure. When the turbines are stopped the symptoms do not occur. A difference in severity is recorded with different wind directions. A personal comment made states:

"I am having problems living and working indoors and outdoors on our property ... problems include headaches, nausea, pain in and around the eyes, sleep disturbance, pain in back of head; we feel this is coming from generation of wind from wind farm as it is OK when turbines are stopped."

Family B reports tinnitus, dizziness and headaches since the turbines have started operating. Sleep disturbance at night with the sound of the turbines interrupting sleep pattern. Vibration in chest at times. Tiredness and trouble concentrating during the day. Does not have problems sleeping when not at Waubra overnight.

Family C reports the noise coming from the turbines at night disturbs sleep. During the day there is noise which causes bad headaches, sore eyes causing impaired vision earache and irritability.

Family D reports suffering from sleep disturbance, headaches, nausea and tachychardia (rapid heart rate) since the turbines started operating.

Family E reports that when the turbines are operating symptoms include feeling unwell, dull pains in the head (acute to almost migraine), nausea and feeling of motion sickness. At night when the turbines are in motion sleep disturbance from noise and vibration (unable to get any meaningful deep sleep), sleep deprivation leading to coping problems. The problems are reported as:

"Some days when the wind is in the north-east my eyes feel swollen and are being pushed out of the sockets. I have a buzzing in my ears. On these days I feel it very difficult to summon memory and difficult to concentrate."

and

"The sound of the turbines when functioning is on most days so intrusive that it affects my concentration and thought processes when performing complex tasks. I suffer from sleep interruption as a direct result of the noise which then affects my ability to function at 100% the following day. One is aware of a throbbing in the head and palpitations that are in synchrony with the beat of the turbines and to a degree the flashing of the red lights. Because of this impact on my everyday life it causes me great stress and in turn great irritability."

Two families identified blade glint / flicker and the red warning lights on the top of each tower as an additional source of annoyance.

Statutory declarations (June 2010) concerning noise issues have been declared by residents affected by the Waubra wind farm. Noise from the turbines is being experienced by residents within approximately 1000 metres of the nearest turbines and at distances of approximately 3000 to 4000 metres distant from the nearest turbines. The locales where the residents experience noise are shown in Plate W1. The noise and health effects experienced by residents are presented in Table W1.

The Waubra north and Ballarat locales are rural in nature with relatively low hills and rolling countryside. The northern section of the wind farm is illustrated in Plate W2 following. The locale is affected by south-west winds at turbine level but can be relatively calm at residences. The prevailing winds at Ballarat airport are shown in Figure W1, following. The measured wind directions are given to illustrate the importance of accurate wind data in predicting or assessing complaints.

Table W1: Waubra wind farm affects, perception and complaint analysis

Locale	Distance	Noise affect
1	1500-2500	Sleep disturbance, headaches, affects eyes and back of head, tinnitus. Worst affect is while working the farm. Heart pressure changes
2	1000	Sleep disturbance, headaches, high blood pressure
3	1000-1300	Sore eyes and headaches when the turbines are operating
4	1250-3000	Sleep disturbance. Affects people working on the farm. Headaches, earaches, blood pressure changes and poor eye sight.
5	1300-2200	Insomnia, headaches, sore eyes, dizziness, tinnitus and heart palpitations. Deteriorating health due to lack of sleep and stress levels. Unable to sleep through the night. Affects while working outside on the farm.
6	2000-2300	Headaches and pressure in ears when working on the farm.
7	550-1400	Sleep disturbance, windows vibrate. Affects while working on the farm. Headaches, lack of sleep, major problem with flicker. Excessive noise under a strong southwest wind
8	1000-3500	Headaches when working farm within 1500 metres of turbines. Dizziness when 2 turbines inline and in sync, effect went when approx 300m out of alignment. Sleep awakenings and disturbed by pulsating swish. Heart palpitations, vibrating sensation in chest and body. Headaches while at home. Stress and depression.
9	3500-4300	Frequently suffer from headaches, tinnitus, irritability, sleepless nights, lack of concentration, heart palpitations. Turbines exhibit a loud droning noise and pulsating whoosh.
10	3400-3800	Headaches, ringing in ears when turbines are operating. Pressure in ears, heart palpitations and anxiety attacks. Awaken at night, sleep disturbance.
11	3000-4600	Elevated blood pressure, heart palpitations, ear pressure and earache, disrupted sleep, increasing frequent headaches, head pressure, vibration in body, mood swings, problems with concentration and memory. Awaken at night, sleep disturbance.
12	1000-1200	Headaches, sickness, frequent sleep disturbance, very stressed. Affects personal life. Lights on turbines cause extreme distress. Ear pressure and loss of balance while working on the farm. Enormous pressure and stress on home and work.

Notes: 'Distance' is the distance in metres between the locale and the nearest turbines. The distances vary where turbines are in different directions surrounding the locale. Each locale contains one or more affected families. A common observation is that the adverse health effects noted did not exist before the wind farm commenced operation or diminish / disappear when not in the district affected by turbines.

The Effects on People near the "West Wind" wind farm, New Zealand

The Westwind wind farm commenced operation in May 2009. From my observations at Makara New Zealand at a residence situated approximately 1200 - 1300 metres from 5 turbines and within 3500 metres of 14 turbines there is known probability that the wind farm will exhibit adverse "special audible characteristics" on a regular basis resulting in sleep disturbance, annoyance and stress.

The observations and measurements being recorded at Makara involve the residents taking notes of the noise heard when they are awakened. At the same time a fully automated monitoring system records exterior audio as well as exterior and interior sound level data in summary levels and third-octave band levels. This allows the generation of tracking data and sonograms for compliance and unreasonable noise assessment. The complaint data is retained by the City Council. Statistical data is retained by the wind farm operator and summarized for the Council. Audio data for real-time analysis of special audible characteristics is not recorded by either Council or the wind farm operator. Audio data is recorded, however, by at one affected resident.

In the period April 2009 to 31 March 2010 a total of 906 complaints have been made to the Wellington City Council New Zealand concerning noise from the wind farm at Makara. These complaints have been made by residents living near to and affected by the wind farm. The turbines are Siemens 2.3MW machines situated approximately 1200 metres to 2200 metres from residences.

In personal interviews at Makara some residents have identified nausea as a problem. In the most severely affected case known the residents have bought another property and moved away from their farm.

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. This effect is evident even inside a dwelling and the characteristics are modified due to the construction of the building and room dimensions.

An analysis of the complaint history has been made. The character of 650 complaints has been sorted by type, figure WW1. Rumble, with 252 mentions, is the most common characteristic. Hum and thump are the next most common annoying sounds. In comparing complaints of noise outside to inside, of 650 complaints, only 23 specifically mention the noise as being outside. This, from my measurements, would be outdoor background levels of much less than 40 dB(A), around 28 to 30 dB(A) L95. Of the indoor complaints, 4.5% specifically mention sleep disturbance.