new zealand wind energy association

www.windenergy.org.nz

Sound and wind turbines

Modern wind turbines are quiet when they operate. Even so, New Zealand's wind farms must comply with strict noise-related resource consent conditions. These conditions ensure that while wind turbines may be audible at times, the level of sound heard at a nearby house will not be out of place with other sounds in the environment.

HOW DO WIND TURBINES CREATE SOUND?

The main source of sound from wind turbines is usually aerodynamic noise, which is created when the wind passes over the rotating blades. This broadband sound is often heard as a swishing or whooshing sound.

Turbines can also produce some mechanical noise from the operation of the generator and gear box. Improvements in turbine design have greatly reduced the mechanical sound emitted from modern wind turbines.

Sounds from wind turbines can be accurately measured using acoustic equipment.

HOW LOUD IS A WIND FARM?

Sound from wind turbines will vary considerably within and around wind farms. However, even when standing directly underneath an operating turbine it is possible to have a conversation without raising your voice.

Wind turbines will create more sound as the wind speed increases, until the wind turbine nears its maximum electricity output at around a wind speed of 10-12 metres per second (35-45 kilometres per hour). The background sound will also increase with the wind speed, as the wind blows through trees and past buildings, power lines and other objects. In high winds, it will often be hard to distinguish between these background sounds and the sound from the operating wind turbines.

A number of factors affect how sound from wind turbines is perceived by a listener, including:

- The distance between the listener and the wind turbines: sound decreases as the distance from its source increases.

FIGURE 1: RELATIONSHIP BETWEEN WIND TURBINE SOUND AND WIND SPEED

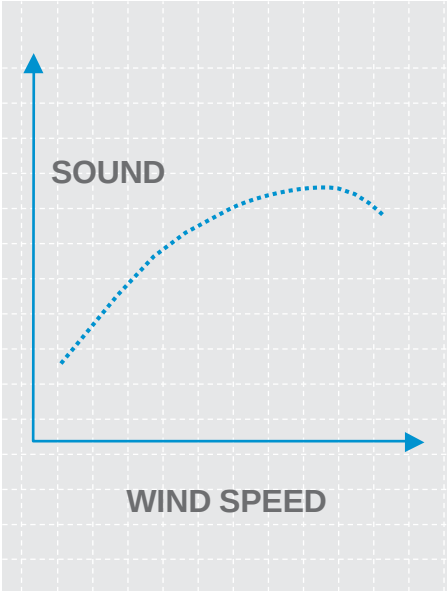
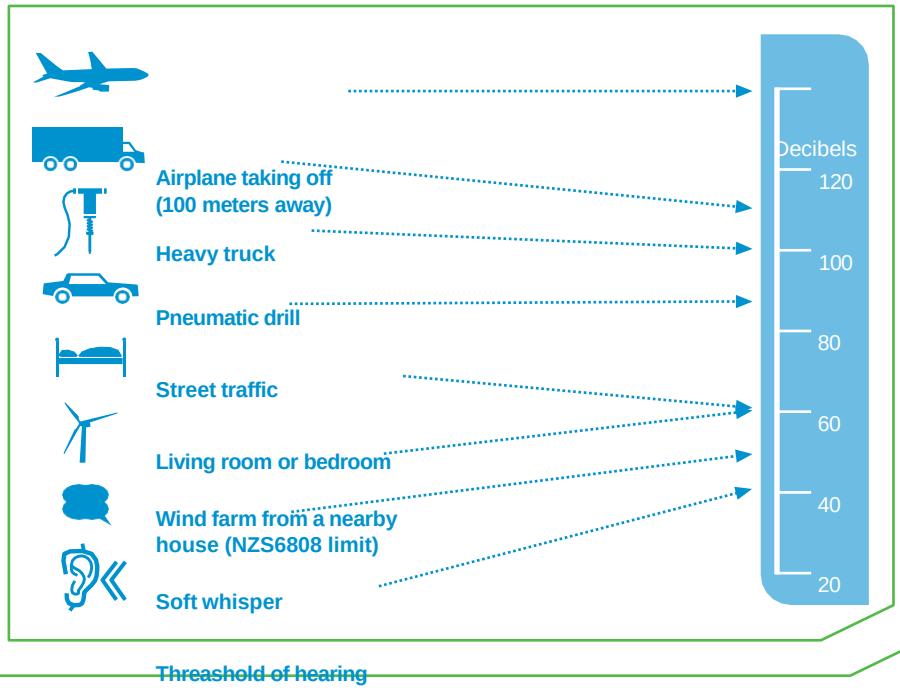


FIGURE 2: HOW LOUD IS A WIND TURBINE?

Sound is measured in decibels. Because the range of sound levels audible to the human ear is vast, from a pin dropping to a plane taking off, the decibel system uses a logarithmic scale to keep the numbers manageable.

On the decibel scale, a sound with a level of 50 decibels has ten times the energy of a sound with a level of 40 decibels. However, an increase in 10 decibels is only perceived as being approximately twice as loud, and a three decibel change in sound is about the smallest difference that can be heard.



- The shape of the land and ground cover: a turbine might be perceived as slightly louder if it can be heard from a sheltered location, alternatively hills and ridgelines between a wind turbine and a house may block the turbine's sound from the house.
- Speed and direction of the wind: sound levels can be different between upwind and downwind locations.
- Ambient sound levels: where existing background sounds - such as traffic, dogs, lawnmowers, children playing and farm machinery - and wind turbine sound levels are the same, the wind turbine's sound may be hard to distinguish from the background sound.
- Acoustic characteristics of the sound itself: if the sound has an audible tone (like a musical note) or modulations that the listener finds annoying.

Councils and the Environment Court consider all of these factors, along with noise limits identified in local planning documents, when they set noise limits as part of a wind farm's resource consent conditions. They will also consider other sources of sound that exist in and around the wind farm. As a result, noise limits for wind farms will usually be consistent with sounds from other rural activity.

SHOULD THERE BE A MINIMUM DISTANCE BETWEEN WIND TURBINES AND HOMES?

The distance from a home to the nearest turbine is not sufficient to determine the sound heard from a wind farm at a house. The factors discussed above, as well as the number, size and type of turbines in a wind farm, affect how sound from a wind farm is perceived from any given location.

A more reliable approach for protecting homes and residents near wind farms is to use a standard methodology for predicting the noise effects of a wind farm and then set appropriate noise limits based on these effects.

New Zealand Standard 6808:2010 Acoustics – Wind Farm Noise (NZS 6808) provides a robust methodology based on accepted good practice for the measurement and assessment of sound from wind turbines. It also identifies acceptable noise limits for protecting amenity at homes.

Developers use this Standard to identify the actual noise effects of a wind farm and then determine if any measures are needed to protect nearby properties.

WIND FARM NOISE LIMITS

NZS 6808:2010 recommends that the level of sound from a wind farm, when heard from outside a home, should not exceed the background sound level by more than 5 decibels (dB), or a level of 40 dB,whichever is the greater. In special circumstances for particularly quiet locations, the Standard recommends a lower, more stringent limit during the evening and night time of 35 dB or 5 dB more than the background sound level, whichever is the greater.

People living near a wind farm may hear the wind farm at times, but the limits recommended in the Standard are intended to provide protection against sleep disturbance and maintain a reasonable amenity at locations surrounding a wind farm. Recommendations in the Standard are based on the World Health Organisation's guideline noise limit of 30 dB inside bedrooms to prevent sleep disturbance. This equates to the noise limit in the Standard of 40 dB outside, as sound attenuates – or become quieter – as it travels through walls and windows.

ASSESSING SOUND FROM A PROPOSED WIND FARM

As part of an application for resource consent, a wind farm developer will engage a qualified expert to produce a report on the potential noise effects of the proposed wind farm.

The report will usually detail the guidance and regulations that need to be considered in setting noise-related consent conditions. This will include NZS 6808, other noise-related Standards (such as those related to construction noise and non-wind turbine operating noise), and rules in council plans.

The report will also provide predictions of the sound from the wind turbines that will be heard at neighbouring properties. The predictions will be based on the proposed wind farm layout (including all of the proposed turbines), the manufacturer's data for a wind turbine's sound output, and wind speed levels at the wind farm site.

These predictions will be used to determine whether the wind farm complies with relevant guidance and to suggest appropriate consent conditions.

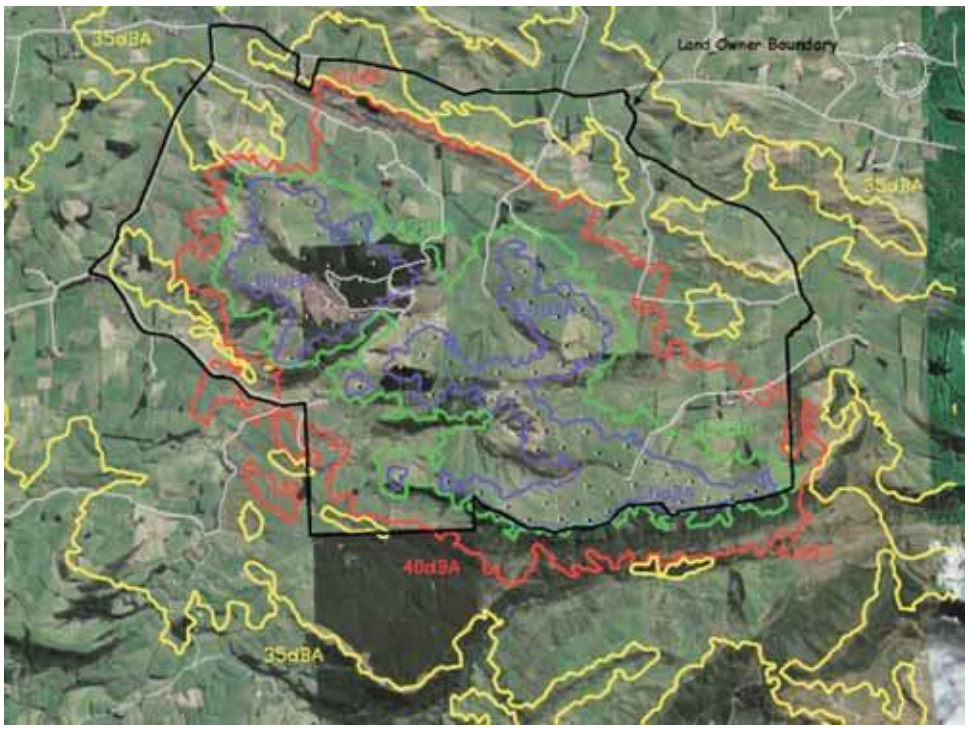


FIGURE 3: PREDICTED SOUND LEVELS FROM A WIND FARM

Wind farm developers usually include a visual depiction of a proposed wind farm and the predicted sound levels surrounding it ("sound contours") in their resource consent application. The image below shows the predicted sound levels from TrustPower's proposed Kaiwera Downs wind farm.

(Reproduced with the permission of TrustPower.)

As part of commissioning a wind farm, developers will monitor its sound to ensure the wind farm is operating within its noise-related consent conditions. This monitoring will be conducted over a period of time to enable measurements to be taken in a range of wind speeds and directions. If an unexpected issue arises during commissioning, developers are able to implement engineering or operational fixes to ensure noise conditions are met on an ongoing basis.

WHAT ABOUT LOW FREQUENCY SOUND AND INFRASOUND?

Low frequency sound can be produced by a variety of sources including machinery, refrigerators, vehicles, thunder, surf and even the wind itself.

Sound from modern wind turbines contains energy spread across the audible frequency range – which is often referred to as broadband sound. Like most sounds in the environment, sound from turbines has energy in the low-frequency and infrasound range. However, the levels of this sound are so low that they usually lie below the threshold of perception. The audible whooshing or swishing sound created as the wind passes over the rotating blades is often described as infrasound or low frequency sound, but it is in fact broadband sound.

Concern about low frequency noise from wind farms stems from early wind turbine designs, where the blades were down wind of (or behind) the turbine tower. This design caused a strong low frequency pulse, which also had significant levels of energy in the infrasound range, when the blades passed behind the tower.

Most modern wind turbines are designed with the blades upwind of the tower, and have an increased distance between blades and the tower to minimise any residual possibility that the blades may interact with disturbed air-flow upwind of the tower. These design developments have dramatically reduced the intensity of low frequency sound created by wind turbines.

A 2006 study into noise complaints at three UK wind farms concluded that low frequency noise from the turbines was measurable on a few occasions.[1] However, the levels of sound were significantly below the recognised threshold of perception. The study also noted that at all the measurement sites the low frequency sound from the traffic on local roads was greater than that from the wind farms. This study made an important finding that the common cause of complaint regarding sound from wind farms was not associated with low frequency noise, but the occasional audible modulation of aerodynamic noise, especially at night.

WHAT ABOUT ALLEGED HEALTH EFFECTS?

In 2009 an international panel of experts released a report based on a review of a large body of scientific literature on sound and health effects, and specifically with regard to sound produced by wind turbines.[2] After extensive review, analysis and discussion, the panel concluded:

- There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.
- The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.
- The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences.

The Panel also reaches the conclusion that: 'The evidence indicates that 'wind turbine syndrome' is based on misinterpretation of physiologic data and that the features of the so-called syndrome are merely a subset of annoyance reactions. The evidence for vibroacoustic disease (tissue inflammation and fibrosis associated with sound exposure) is extremely dubious at levels of sound associated with wind turbines.'

FIND OUT FOR YOURSELF

If you are concerned about sound from a proposed wind farm, your best options are to talk to the developer or visit an operating wind farm. Most developers hold open days, where you will be able to find out about their plans and the expected effects on the local community. The following wind farms have viewing platforms and interpretive displays:

- Brooklyn wind turbine, off Ashton Fitchett Drive, Brooklyn, Wellington
- Te Apiti, Saddle Road, near Palmerston North, Manawatu
- White Hill, Mossburn-Wreys Bush Road, near Mossburn, Southland
- Hau Nui, Range Road off White Rock Road, south of Martinborough, Wairarapa.

LOW FREQUENCY SOUND AND INFRASOUND EXPLAINED

The frequency, or 'pitch', of a sound is measured in cycles per second or 'hertz' (Hz). Most sound in the environment, including that from wind turbines, contains energy at many different frequencies combined together to give it its overall character, this is often referred to as broadband sound.

A healthy young adult's hearing range is usually 20Hz to 20,000Hz. The ear becomes decreasingly sensitive to sounds above and below these frequencies, and especially to very low frequencies, which have to be very loud to be perceived.

'Low frequency sound' is the term used to describe sound energy in the region below about 200Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range.

Infrasound describes sound energy below 20Hz. Almost all sound in the environment has components in this region as infrasound is naturally occurring. Infrasound is produced continually by wind's interaction with natural topography, and by common human activities such as running, driving with a window open and swimming. Sound which has most of its energy in the 'infrasound' range is only audible if it is at a very high level, far above normal environmental levels.

1. The Measurement of Low Frequency Noise at Three UK wind farms. View online at: http://www.berr.gov.uk/energy/sources/renewables/explained/wind/onshore-offshore/page31267.html

2. Wind Turbine Sound and Health Effects: An Expert Panel Review. View online at http://www.canwea.ca/pdf/talkwind/Wind_Turbine_Sound_and_Health_Effects.pdf

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Find out more about wind energy and wind farms in New Zealand at www.windenergy.org.nz.

NZ Wind Energy Association

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The New Zealand Wind Energy Association (NZWEA) is an industry association that works towards the development of wind as a reliable, sustainable, clean and commercially viable energy source. We aim to fairly represent wind energy to the public, government and the energy sector. Our members include 80 companies involved in New Zealand's wind energy sector, including electricity generators, wind farm developers, lines companies, turbine manufacturers, consulting firms, researchers and law firms.

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