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AUSTRALIA'S PEAK BODY FOR THE WIND ENERGY INDUSTRY

Wind farms and noise

The issue: Wind turbines are rotating machinery, and thus necessarily make some noise. The sound usually heard is the whooshing of the rotor blades as they pass the tower. It is quite typical to be able to stand beneath an operational wind turbine and carry on a normal conversation without shouting, and steady design improvements since the 1980s mean that they elicit very few noise complaints. A modern turbine at 350 metres is about as audible as the background noise of a quiet bedroom.

"Thanks to improvements in technology .... noise is no longer the issue it was."
House of Lords Select Committee on the European Communities,
12th Report, Session 1998-99, Electricity from Renewables HL Paper 78

Summary
Are wind turbines noisy? Thanks to steady design improvements, a modern wind turbine just 350 metres away is less noisy than a quiet conversation[6] (about 35 dB[A]).

Wind turbines are made up of rotating machinery, so there is some noise. Indeed "noisy" was an apt description for early wind turbines developed in the 1980s. At that time, turbines were designed for maximum generation and emissions savings, and reduction of noise was not a priority. By comparison, today's turbines make less noise for up to 50 times more electrical power.

As wind farms have become more plentiful they have attracted greater regulatory scrutiny, and quiet operation is now an important design criterion for success. It is quite possible to carry out a normal conversation at the base of a turbine running at maximum power, without raising one's voice.

For an "industrial" noise, wind also has some unique characteristics. The sound turbines produce is predominantly aerodynamic, and is generally perceived as more "natural" than most sources of industrial noise. In addition, the noise tends to be at a lower level when wind speed is low, and rises as the wind speed increases. As wind speed increases, so does wind-generated background noise from trees and bushes at neighbouring houses, which tends to mask the sound of the turbine.

Members of the public invariably comment on wind turbines' quietness when visiting a wind farm. More than 22,000 wind turbines have been installed around the world, often in close proximity to homes. Many countries have less rigorous noise regulation than Australia, yet there have been very few noise complaints.

Breakdown of issues & research

Background
Like virtually every other type of rotating machinery, wind turbines do make some noise. Indeed "noisy" was a reasonable description of early wind turbines in the 80s which were designed with maximum generation and emission savings in mind, rather than the reduction of adverse environmental impacts from the wind turbines themselves. However, as wind turbines have become a more widespread form of electricity generation, wind farms have been built closer to people. Thus the issue of noise has attracted more attention both from the regulatory authorities who assess and control the environmental impacts of wind farm developments, and from wind turbine manufacturers themselves. As a result, a modern wind turbine is a much quieter piece of machinery than its predecessors and the level of noise permitted to reach neighbouring houses is carefully regulated.

In view of the large number of wind turbines installed around the world (in excess of 22,000), and the close proximity of many to homes, particularly in countries with less rigorous regulation of permitted levels of noise than Australia, there have been very few noise complaints.

[6] Technical Manual: Design for Lifestyle and for the Future, Australian Greenhouse Office website: http://www.greenhouse.gov.au/yourhome/technical/fs53.htm

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Comparison of wind & other noise

The level of noise permitted from wind farms at neighbours' houses is similar to the level of noise that would be audible from traffic on a road[7] five kilometres away. Indeed the noise from a wind farm 100 m away would be inaudible in most residential areas of Australia, drowned out by road noise and the other background noise of large numbers of people living in a relatively small space. It is quite possible to carry out a normal conversation at the base of a turbine running at maximum power, without raising one's voice. People invariably comment on the quietness of wind turbines when visiting a wind farm for the first time.

Comparative table

The table below[8] contains various noise sources with levels for comparison with wind turbines. Measurements of environmental noise are usually made in dB(A), which includes a correction for the sensitivity of the human ear.

Source/Activity	Indicative noise level dB (A)
Threshold of hearing	0
Rural night-time background	20-40
Quiet bedroom	35
Wind farm at 350m	35-45
Busy road at 5km	35-45[2]
Car at 65 km/h at 100m	55
Busy general office	60
Conversation	60
Truck at 50km/h at 100m	65
City traffic	90
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Sources of noise from wind turbines

The two main sources of wind turbine noise are mechanical noise from components such as gearboxes and generators, and aerodynamic noise from the blades. Standing next to the turbine, it is usually possible to hear a swishing sound as the blades rotate; the whirr of the gearbox and generator may also be audible. However, as distance from the turbine increases, these effects are reduced.

Quiet operation has become an important design criterion for successful wind turbine manufacture. Great attention is given to ensuring that both mechanical and aerodynamic noise is as low as possible. Mechanical components are acoustically isolated from the tower and blades using anti-vibration mounts, and the nacelle is insulated to minimise airborne noise radiation. Noise from blades has also been reduced by careful design and manufacture. Compared to early wind turbines, a modern turbine makes less noise for up to 50 times more electrical power.

Impact on neighbouring populations

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[7] Calculated using the road traffic noise calculator at the National Physics Laboratory UK website (http://www.npl.co.uk/npl/acoustics/techguides/crtn/ defining a busy road as one with 10 vehicles (1 of which is a heavy vehicle), passing along it every minute at a speed of 80kmh. The level of noise audible from the road varies with a number of factors such as ground cover and height differences between the road and the listener but could be expected to be between 35-45 dB(A).

[8] Information other than road noise level taken from The Scottish Office, Environment Department, Planning Advice Note, PAN 45, Annex A: Wind Power, A.27. Renewable Energy Technologies, August 1994.

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In order to be economically viable, wind farms must be built in relatively close proximity to electrical infrastructure so that they can supply the electricity they produce to the end user. In practice this means that are usually built in areas where people live. The design of most wind farm projects must take this into consideration.

The level of noise emissions from any industrial source – including wind turbines – permitted at neighbouring residences is very strictly regulated in most countries, including Australia. The actual level permitted usually depends on the existing noise environment before the noise source is created. The noise level is usually assessed outside, rather than inside houses. This ensures that the amenity of outdoor recreation areas such as gardens is protected (noise levels inside the house from any external source can be expected to be much lower, even with all the windows open).

The sorts of places where wind turbines are usually placed tend to be in rural environments where the ambient noise is very low; indeed peace and quiet are often an important part of the amenity of the area. Noise limits are therefore usually set at a fairly low level such as 35 or 40 dB(A).

Wind's noise characteristics
As an industrial noise source wind turbines do have some unusual characteristics. The noise they produce is predominantly aerodynamic, which is generally perceived as more "natural" than most sources of industrial noise. In addition, it tends to be at a lower level when wind speed is low, and rises as the wind speed increases. Of course, below the "cut-in speed" for the turbines, no noise at all is generated. Fortunately, as wind speed increases, so does wind generated background noise from trees and bushes at neighbouring houses, leading to masking of the noise from the turbines.

Background noise & audibility
Most limits on wind turbines therefore allow the wind turbines to exceed the limit of 35 or 40 dB(A) as long as they don't exceed the level of background noise at the neighbours by more than a specified amount, often 5 dB(A). Extensive monitoring of the pre-existing noise environment over the range of wind conditions likely to be experienced at the site is carried out at neighbouring properties to determine what the level of wind-related background noise actually is.

In practice, this means that the noise limits applied to a wind farm do not mean that the turbines will necessarily be inaudible to all of its neighbours, at all times, under all conditions. They do, however, protect the amenity of neighbours and ensure that the development can reasonably be expected not to disturb them. If limits were to be applied with inaudibility as an objective it would be very difficult to build an economically viable wind farm (or indeed many other types of development) anywhere, as it would be difficult to find locations which combined the required resource, general environmental acceptability and electrical infrastructure at a viable distance for connection, with no nearby neighbours.

Perceptions of noise
Human perception of any noise source is influenced by many factors, including the acoustic characteristics of the noise, (whether it has audible tones or other characteristics that may annoy the hearer) and how much louder the noise is than the existing noise environment. Importantly, the perception of a noise is also often influenced by the hearer's attitude towards the noise source. One person may find the morning chorus delightful, whilst another may find the same sound aggravating. It is certainly true that a hearer who for some reason has a negative attitude towards a noise source is much more likely to view the noise itself negatively, however low its level.

Annoyance factor study
A mid-90s European study[9] on the annoyance factor of wind turbine noise at sixteen sites in three countries (Denmark, the Netherlands and Germany) involved interviews with nearby residents. The main finding was that "... the number of people actually indicating annoyance by wind turbine noise was fairly small. It appeared that the degree of annoyance was not related to an objective level of sound."

[9] Wolsink, M., Sprengers, M., Keuper, A., Pedersen, T. Holm, Westra, C. A.: *Annoyance from wind turbine noise on sixteen sites in three countries,* 1994.

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American Wind Energy Association
http://www.awea.org/faq/noisefaq.html

Danish Wind Energy Association
http://www.windpower.dk/faqs.htm#anchor39013