Elliott Sound Products **Wind Farm Intro**

Introduction to Sound, Noise, Flicker and the Human Perception of Wind Farm Activity

Mr Bruce Rapley, Editor

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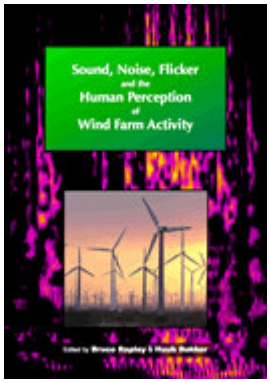
Main Index

This document is the full text of the Introduction to the book linked below. It is reproduced here verbatim, and this is for two reasons. First and foremost, this is material that the public needs to know. Amyone who lives in an area that gets a reasonable supply of wind on a consistent basis is likely to have a wind farm dumped on their doorstep (as it were), and will be made a great number of empty promises and meaningless platitudes to get you to agree to the project. Once it's installed, your involvement (and objections) are no longer required. A vast amount of pseudo-science and legal postulations will be used in an attempt to shut you up. This has already happened to a frightening number of people, many of whom have been forced to simply abandon their properties just to get a decent night's sleep. We don't need this happening to more people, and those who are educated are much harder to silence because they know the *real* story.

Let the learning begin ...



Man has sought to harness the awesome power of the wind since the beginning of recorded history. As early as 3,500 BC boats were using sails to harness the wind, allowing man to explore the world by water and as a consequence, expand trade. Architects have been using wind-driven ventilation in buildings from about the same period. In the 17th century BC, the Babylonian emperor Hammurabi was planning to use wind power to drive irrigation. As early as 300 BC saw the ancient Sinhalese utilising the monsoon winds to power furnaces. This allowed these early artisans to generate furnace temperatures of about 1200 degrees Celsius needed for smelting metals. History records the "Windwheel" of Heron of Alexandra around 200 BC, however the first practical wind mills were built in Sistan, Iran, around the 7th century. These were vertical axis windmills with long vertical drive shafts and rectangular blades. Made of 6 to 12 sails of reed matting or cloth covered material, these windmills were used for the arduous task of grinding corn and drawing up water. Horizontal axle windmills were not to appear until the beginning of the 1180s in Europe. Many Dutch horizontal-axle wind mills still exist in Holland to this day.

Man's fascination with machines, and this apparently free source of power from wind, saw the development of wind-powered automata in the middle of the 8th century. Such wind-powered statues existed over the domes of the four gates and palace complex of the round City of Baghdad. The Green Dome had a statue of a horseman carrying a lance that was believed to

point at the enemy, moving with the wind.

Widespread use of wind power, through windmills, came into prominence around 1185 AD. In medieval England, waterpower sites were often confined to nobility and clergy, so wind power was an important resource for the new middle class. In addition, windmills, unlike water mills, were not rendered inoperable by the freezing water in winter. By the 14th century, Dutch windmills were in use to drain areas of the Rhine delta. Denmark was just as innovative and by 1900 there were about 2500 windmills used for pumping water and grinding mills producing an estimated peak power of 30 Megawatts. Across the Atlantic, the American midwest had built around six million small windmills between 1850 and 1900, mainly on small farms that used them for irrigation.

The first windmill used to generate electricity was built in Scotland in 1887 by Professor James Blythe of Anderson's College, Glasgow (the precursor of Strathclyde University). This 33 foot high structure with cloth sails was installed in the garden of his holiday cottage at Marykirk in Kincardineshire where it was used to charge accumulators to power lights. Blythe offered excess power from his "contraption" to the people of Marykirk for powering lighting in the main street. This kind offer was turned down however as they thought electricity was "the work of the devil", perhaps showing us the first public resistance to wind-generated electricity!

In a strange turn of fate, Blythe later built a wind machine to supply emergency power to the local Lunatic Asylum, Infirmary and Dispensary of Montrose. The technology never really caught on however as it was not considered to be economically viable; an issue that may still haunt us. (Refer to Bryan Leyland's chapters in the section entitled: *Economic Assessment of Wind Farms.*)

In the 20th century, two distinct periods can be identified: 1900 to 1973, which saw widespread use of individual wind generators competing against fossil fuels plants and centrally generated electricity, and 1973 onwards when the first oil crisis shifted the focus to electricity generation without the use of fossil fuels.

In Denmark, wind power was an important factor in the decentralisation of electrification in the first quarter of the century. At this time wind-powered electric generators were developed with an output of 5 to 25 kilowatts. The largest machines were on 79 foot (24 m) masts with four-bladed, 75 foot (23 m) diameter rotors. In 1956 Johannes Juul installed a 24 m diameter wind turbine at Gedser which ran until 1967. Denmark continued with incremental improvements until the present day when they are considered one of the world leaders of wind turbine design and construction. It is perhaps worth noting that while Denmark leads the world with the highest penetration of wind turbines for electricity generation - some 20% of their internal energy demand is claimed to be met by wind power - they have both the highest cost of electricity of 27 countries in the European Union and the worst carbon dioxide emissions in Europe.

In America in 1927, two brothers, Joe and Marcel Jacobs, operated a factory in Minneapolis to produce wind turbine generators for farms. Over 30 years the factory produced some 30,000 small wind turbines that ran for many years. They were even exported to such remote places as Africa and Antarctica. By the 1930s wind turbines were widely used to generate electricity on farms throughout the United States where distribution systems had not yet been installed. Power was stored in batteries for uses as varied as lighting through to electrifying bridges to prevent corrosion. Such small generators had limited power and were generally of a few hundred Watts to a few hundred kilowatts. The cheap price of high tensile steel favoured the construction of open-lattice towers on which to mount the blade assemblies and generators. In the 1930s the most widespread wind turbine was the Wincharger, a two-blade, horizontal axis, 200 Watt machine. These machines continued to be manufactured into the 1980s, proving the effectiveness of the design. It was fitted with hub breaks so that the turbine speed could be regulated in the

case of severe winds. The widespread rural electrification project in the United States killed the market for these turbines.

In Australia, the Dunlite Corporation built hundreds of small wind turbine generators for use in isolated postal stations and farms. Manufacture of these units stopped in 1970.

The oil crisis of the 1970s started the search for new and innovative ways to create electricity; the viability of wind turbines for power generation was revisited. With the rising cost of fossil fuels and the perceived need to reduce the production of greenhouse gas emissions, wind has again been seen as a possible source of renewable energy. As a result, the last 20 years has seen a resurgence in research and development to design and construct efficient turbines to harness the wind for electricity generation. Indeed the world has been quick to embrace these new advances and, as a result, a plethora of wind farms have sprung up throughout the developed countries.

While scientists and engineers are expert at developing new technologies (machines), history records that the effects of such developments precedes any real understanding of the impact they will make on human society. Accordingly, there is frequent reticence to embrace new developments (technology) until a better understanding of the potential human impacts is obtained. A brief reference to the reaction of people in 1764 with the invention of the spinning jenny by James Hargreaves is but one example. The fear at this time was that the invention would put many people out of work. A more recent example would be the introduction of radio frequency communication devices: cell phones. While few could deny the enormous benefits of such technology, there is an increasing body of scientific evidence on the potential health effects associated with this area of the electromagnetic spectrum. The new field of Bioelectromagnetics is testament to those concerns and is currently regarded as one of the fastest growing disciplines in science.

The widespread proliferation of wind farms is being met with increasing resistance from communities as the negative effects of existing installations become apparent and filter through the public media. This Review is an attempt to put together a series of scientific papers that provide the reader with an understanding of the wider issues how wind farms affect their human neighbours.

While not exhaustive, every attempt has been made to assemble a series of Papers which address the major issues affecting society. No apology is made for the strong focus on sound and noise, as this constitutes the major concern raised by communities. While another significant objection is the aesthetics of these large industrial structures in the existing countryside, this aspect is far harder to address in terms of tangible, scientific affects on the physiology and well-being of residents. Beauty, as they say, is in the eye of the beholder. What is graceful and beautiful to one person may be anathema to another, being perceived as intrusive and hideous. This is not the case for sound and noise, which lends itself to more objective assessment.

Two Papers of this review are devoted to explaining aspects of community perception of wind farms. The main thrust however concentrates on the scientific impact of wind turbine technology on the biology and well-being of neighbouring communities. It is noted that a number of scientific papers and several books have recently become prominent, not the least of which is Dr. Pierpont's book, *Wind Turbine Syndrome*.

Another significant component of the debate is the economic impact on the price of electricity in comparison to alternative, existing forms of generation. While there is no doubt that wind energy is free - in the sense that one does not need to dig it up and refine it before being able to use it. There is however, significant cost in harnessing this natural resource. Companies involved in the

production of wind farms are quick to point to the advantages of using this natural, free form of energy, however there is now significant evidence to suggest that this is not quite as free as has been promoted.

Consulting Engineer, Bryan Leyland, has spent a significant amount of time analysing the actual economic reality of electricity generation from wind. His research has highlighted the expensive method of construction and the cost to maintain a working wind farm. The additional cost of extra transmission lines and the relatively low yield of output energy, due to the intermittent nature of the wind, has brought into serious question the economic viability of wind farms. A fact not understood by many is that for every megawatt of wind-generated electricity, the same amount of spare capacity from other generating sources (hydro, coal, gas turbine, nuclear) must be available in reserve. When the wind drops and output from the turbine farm slumps, this reserve must supply the missing electricity in seconds to spare the distribution grid from possible brownouts or power cuts. In this sense, some energy is being wasted as more traditional sources idle, not generating much power, but ever ready to fill the gap left by the unreliable wind. For these reasons, wind is certainly not a free source of power. One consultant stated recently that, in their opinion, we are probably 50 years away from developing viable forms of energy storage that will make the widespread use of wind farms an economically viable option for electricity generation.

Many economic and industry indicators suggest that the use of wind to generate electricity is here to stay, at least in the short term. While scientists continue to search for more environmentally friendly ways to generate power - electro-solar is still looking for high output, high efficiency systems - wind turbines have their place. If wind farms are here to stay we must understand their affect on people. The first section of this Review focuses on the possible negative health effects.

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?

Before we can answer this question, the substantial differences in human perception between individuals needs to be understood. Dr. Bob Thorne is an expert in such matters and carefully outlines the topic. The process of personal hearing is of great importance and Dr Thorne states that the complexity of our hearing processes illustrates the reasons why any two individuals can interpret sound differently. Not only may one person hear a sound while another does not, but that person may be greatly affected. If an inappropriate method of noise assessment - such as a simplistic, standardised measure like background noise level - is used to describe the potential effects of the noise, predictions can be divorced from reality. If wind farms continue to proliferate,

regulators and industry must work together to more carefully assess the potential hazards associated with a particular site and the possible affects on nearby residents.

A mistake often made is to assume that sound, when emanating from a source, radiates outwards in a somewhat homogeneous fashion. This is not the case. Dr. Huub Bakker and Mr Bruce Rapley have undertaken a sizeable study of the physical nature of radiating sound and compared this to microphone array studies of the noise from multiple turbines at Makara, near Wellington, New Zealand. They define the term *heightened noise zone* (HNZ) to describe locations where the noise is louder than expected. This results from the way sound waves interfere with each other, akin to waves created by dropping two pebbles into a pond. As the ripples radiate out they will interact to create a beautifully symmetrical pattern of ripples. In places the ripples will meet crest-to-crest or trough-to-trough creating larger ripples. Where the ripples meet crest-to-trough the ripples become much smaller. These calm areas of water can be seen radiating out as rays from a point midway between where the two pebbles were dropped.

Taking this idea further, Bakker and Rapley reasoned that the same would be true for sound emanating from multiple wind turbines. Theory predicts it. Experiments carried out with an array of eight microphones proves it. Locations only one or two metres apart can have significantly different sound levels, so measuring sound levels using only one microphone or one location can be misleading.

They then looked at how noise from turbines is modulated, including a possible reason for the 'rumble/thump' described by residents. Their use of sonograms to identify and analyse modulation is as beautiful as it is revealing (as the cover of this Review can attest).

The idea of a Heightened Noise Zone stemmed from Bakker and Rapley's work with Dr. David Bennett and Dr. Thorne. Residents near a wind farm at Aokautere, near Palmerston North, New Zealand, had problems with low frequency noise that could be heard "through the pillow" suggesting that the 'noise' was partly vibrational. The noise was only heard - and felt - with the wind blowing from the wind farm and only one of a small number of properties was affected at any one time. Measurements using a seismometer showed otherwise unexplained bursts of vibration when the noise was heard.

The authors suggest two possible reasons for this phenomenon; that seismic waves were being produced by the wind farm in the upwind and downwind directions (Rayleigh waves) or that sound waves were resonating inside the building and shaking it. For either of these possibilities the house appeared to be in a Heightened Noise Zone. (It is noteworthy that a dwelling in the area of Cook Road, near Palmerston North, is said to be uninhabitable because of seismic or vibrational noise from the surrounding wind farm.)

Sound is not the only potential problem with wind farms. Light can create problems of blade flicker (the blade occluding the sun), shadow flicker (shadows falling on the ground or buildings some distance away), and glint (reflection off the blades). The frequencies created by rotating turbine blades are close to those that can trigger photosensitive epileptics but this is only one form of hazard. Various forms of flicker can still be annoying to sensitive individuals, even those who do not suffer from epilepsy. Again, the annoyance factor is dependent to a large degree on the individual. Dr. David McBride examines all these potential hazards, which should be considered by those involved in siting wind farms. Placement cannot be determined by simply mitigating the worst physiological effects, rather it is necessary to also include quality of life measures when assessing the impact on a community.

Greater involvement of the community is called for when siting wind farms. It is easy to overlook

the problems of small individual communities when considering the larger issue of wind farm placement. Issues of appropriate sites are dependent to a large degree on geography and, of course, wind history, Nearness to the grid and the ability to access the proposed site also place strong physical constraints on site placement. In this complex series of constraints, it must be easy overlook the importance on the sometimes small number of people who may live close by. Does this mean that the health and well-being, not to mention enjoyment and amenity, of a relatively small number of individuals can be ignored simply so that matters of a physical and engineering nature may take precedence? History now records the growing number of disaffected communities who, after the construction of a wind farm in their locale, are now deeply angered by the intrusion into their neighbourhood. Often such communities cite insufficient consultation during the process and a lack of information about the true nature of the intrusion. Only when the project gets underway or is nearing completion, do the true consequences become apparent.

Frequently such affected communities complain about nuisance noise which is far greater than they were led to believe at the outset of the project. They now find that for some, sleep is now seriously disturbed and the enjoyment of their home is disrupted. Some are essentially forced out of their homes in a search for the peace and tranquillity they once enjoyed. Is this good enough?

Why is there such a disparity between the expectation of the developers and the residents and the final reality? Part of the problem is that the physics of sound and the human perception of noise are still not well understood by many involved in the power industry. Human factors should take precedence over physical regulations and readings but are harder to quantify. The variation between individuals is never well accounted for by a statistical mean. While developers may believe that the noise from the turbines will be masked by natural sounds like a stream, the wind in the trees or animals, residents almost universally find these statements to be left wanting. Differences such as these will cause resentment against the developers. This can split communities into the affected and the unaffected, the latter group who, due to no fault of their own, cannot understand the views of those who complain. But for those adversely affected by the wind farm placement, there is no doubt about the intrusion into their lives.

Several chapters in this Review tackle the difficult topic of the difference between theory and practice, assumption and reality. Professor Dickinson raises our awareness of the need for a better understanding of sound, noise and its regulation as it relates to human habitation. If wind farms are to proliferate at their current rate then the impact on communities needs to be addressed urgently. His words echo those of Dr. Thorne and Dr. Shepherd in calling into question physical regulations and standards which bear little meaningful resemblance to the human condition. Dr. Shepherd suggests a way forward without recourse to standards where communities may be actively involved in setting such conditions for industrial activities. While the New Zealand Standard 6808 is still in a state of flux, now is a good time to have that debate.

To understand this issue it is necessary to move away from a model which looks at physiological damage in terms of power or simple energy. A pebble has little energy but may start an avalanche. Effect is not simply a matter of power. It depends on the nature of the stimulus and its effect, not simply on how big the stimulus is. Science has a long road ahead before a deep understanding of the effects of low power stimuli on the human body is achieved. Until such time, this author predicts that many more people will be adversely affected, both physiologically and psychologically, by the poor placement of wind farms. It is the strong suggestion of the author that more research into these very important areas be undertaken with all due speed and that wind turbine placement be more carefully investigated and managed, with a stronger focus on the possible negative effects on the neighbouring communities.

Finally, this present work puts forward a suggested protocol for how the process of monitoring

wind turbine sites for the purpose of consent may be managed. The concept of an independent monitoring agent is suggested and a process for more community based management could be instituted. The power companies and wind turbine proponents need to take more consideration of the effects of such industrial activities on the health and mental well-being of individuals and communities. Perhaps the age old question about the needs of the many outweighing the needs of the few should be reassessed.

While the arrival of a new clean, green alternative for generating electricity is promised by wind technology, the realisation of that may be somewhat different. There are numerous obstacles to overcome technically and the effects of such industrial installations on neighbouring communities need to be given more attention. This book is a significant step in putting more serious and relevant information into the public arena so that sensible and productive debate may be had. It is not at all exhaustive, but it is a start.

Additional Material

- AusWEA - Australia's Peak Body For The Wind Energy Industry (mostly bullshit)
- Wind Turbine Noise & Human Rights
- Noise from Small Wind Turbines - An Unaddressed Issue, Paul Gipe
- Primer for Addressing Wind Turbine Noise - Revised Oct. 2006 by Daniel J. Alberts
- Wind turbines and health

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