Elliott Sound Products **Wind Farms**

Introduction To Wind Farm Noise and Economics

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A-Weighting & LF Noise

This is the main issue behind much of the argument, so I will make this point right at the outset. Using A-Weighting to measure the annoyance value of very low frequency noise is not only pointless, it is stupid beyond belief. If a room (or a whole house) is vibrating such that one can feel (and sense) vibrations, it is of no consequence whatsoever that a sound level meter indicates that there is no noise.

Of course there is noise - it can be felt and sensed. Until such time as there is a proper standard for very low frequency (VLF) noise (especially anything below 30Hz) that clearly states that *any* vibration of walls, floors, other structures or body parts is utterly unacceptable. There is no situation where such vibration can or should be considered "acceptable", just because some sausage-grabber from the local council or other body says that their meter didn't show any problem.

The meter won't show any problem because the low frequency energy is almost completely removed by the A-Weighting filter ... the level is reduced by *40dB* at 30Hz compared to the 1kHz reference level. This is one of the most flawed standards ever developed, and allows people with no training whatsoever in psycho-acoustics (or common sense) to tell governments and others whether there is a problem. Pardon my language, but ...

This is bullshit - please make it stop ... now

To *everyone* involved in such tests - you must stop using A-Weighting for VLF noise. A-Weighting does not (and can not) give an accurate indication of the annoyance value of *any* very low frequency signal, regardless of what anyone might claim. It never did, and never will. Even the most basic laboratory test will show that what I have stated here is correct, and it's about time that those who set the standards actually take some advice from those who know that problems exist. This has been done and verified!

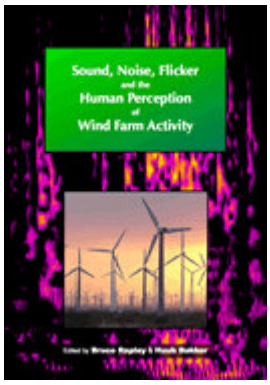
Any noise measured using A-weighting must be completely free of tonality or rhythm, and will ideally be a broad bandwidth random signal at no more than around 50dB SPL. For the vast majority of real-world measurements that do not fulfil these criteria, A-weighted noise level measurements give a completely unrealistic reading that does not reflect audibility or annoyance value of parts of the sound ... especially very low frequency signals (modulated or otherwise) and/

or any rhythmic sound. Even for sounds that do *fit the above criteria, A-Weighting may still give a result that is completely at odds with what you actually hear. This cannot be considered a useful test under any conditions.*

In particular, all logged sound level measurements should always include a non-weighted SPL as well as the A-Weighted level. Any recording of noise *must* be full range. It is easy (but usually pointless) to apply an A-Weighting filter later, but it is almost impossible to reverse the effects of the filter if A-Weighting was applied when the recording was made.

> Note that many of the points made here are repeated throughout the text. I make no excuses for this, because I consider these issues to be so important that it is essential to ensure they are not only publicised but emphasised until someone starts listening! Also, make sure that you read the Footnote - I know it looks like conspiracy theory, but this is reality.

Introduction



The primary reference for the material here is from a book published in New Zealand - "Introduction to Sound, Noise, Flicker and the Human Perception of Wind Farm Activity" [1]. The book should be essential reading for anyone contemplating a wind farm, or who risks having one thrust upon them by local operators and the combined might of the power generation industry and local government. The one primary issue is that the wind generator manufacturers, the operators and council appointed noise consultants will most commonly seriously under-estimate the noise level from these machines.

Please buy a copy - it will make everyone involved in this important work very happy because it helps to fund their research. Somewhat predictably, windfarm installers and operators (along with various government bodies and the like) are less than impressed, because the material contradicts their "official" position on the subject. Their response is somewhat childlike - stick fingers in your ears and sing "La-La, La-La-La, Laaa" until you shut up or go away (preferably both).

The cynical amongst you may call the deliberate manipulation of test results to be lying, but it is more the exploitation of existing loopholes in existing noise regulations to get the result you *want*, rather than the result the residents *need*. Hmmm. Perhaps "lying" is an accurate definition after all. The problem is that noise measurements are traditionally taken using what is called A-weighting, where extreme low and high frequencies are filtered out prior to the measurement result being displayed. Anyone who has been disturbed by a distant but noisy party will have noticed that the most prominent sound is the bass. Even after the normal attenuation caused by air has reduced high frequencies to the point where they cannot be heard (or are heard at a very low level), the incessant "THUMP, THUMP, THUMP" of the bass carries a long way.

A meter that is set for A-weighting will probably indicate that there is no problem, so the noise abatement or police officer sent to investigate will say "There's no problem here." - even though they can hear the annoying thumping bass quite clearly themselves! This is a classic case where "science" is believed even though it is obviously complete nonsense. If the noise is audible and the meter fails to detect it, the fault is with the meter and the regulations - *not the resident who is disturbed by the noise!*

This is precisely the problem with wind turbines. It is generally true that the gearbox, power transmission system (which may be hydraulic or mechanical) and alternator will not cause audible noise above the normal background noise level when measured at a sensible distance from the

machine. What is not currently considered - but is finally coming under increased scrutiny - is the sub-sonic noise (aka infrasound). This has been ignored for far too long, because it is "common wisdom" that we humans cannot hear sounds below ~20Hz. Wind farm operators use this serious error in the noise measurement regulations to their advantage - the vast majority of all noise that's likely to cause a problem is at (very) low frequencies, so is not measured in a way that corresponds to human perception.

What has *not* been considered is that although these sounds are not audible in the traditional sense, they are still perceptible - we can feel the effects. It is mistakenly believed in some areas that this moves the argument from "sound" to "vibration", so different measurement techniques apply. There are regulations that restrict vibration from wind turbines, and most comply easily. Since infrasound can be said to fall into neither category, it's simply ignored. As pointed out in the book, vibration is typically not an issue at all - the problem is infrasound.

Some individuals are very susceptible to very low frequency sound (0 - 20Hz range), but others are completely oblivious to it. In the same way, some people get seasick very easily, and others don't. It has been suggested that people who are prone to motion sickness are more likely to be affected by infrasound, because the balance mechanism in the inner ear is more sensitive than average. Very heated arguments have occurred between those who are unaffected and those who are made (literally) physically ill as a result of subsonic sounds. Neither can understand (let alone experience) the feelings of the other, so one group becomes "the insensitive <expletives>", and the others are a "bunch of bloody whingeing <expletives>". Predictably, this achieves no resolution for either group.

It should be noted here that military establishments have experimented long and hard with infrasound, as a method of crowd control on a small scale, or as a system of causing mass disorientation (including "fall down incapacitation") of enemy forces. Their experiments have (apparently) occasionally worked, but there remains a major problem of being able to generate the required SPL (sound pressure level) to cause the desired effects. Propagating VLF (very low frequencies) requires a very large transducer. Horn loaded loudspeakers (driven by many kilowatts of power) have been tried, but have limited application because the loudspeaker is a large target and easily destroyed by a long-range missile. Providing sufficient power and a large enough transducer is also a challenge. I have not included any reference material on this topic, but there is a great deal on the Net (as is to be expected). Beware of conspiracy theorists and general-purpose-crackpots though, as there is a great deal of nonsense and misinformation on the topic. Quite possibly the majority of material you'll find is suspect at best, but infrasound is known to cause issues with humans and no doubt animals as well.

A wind farm provides the ideal VLF transducer! A number of *very* large turbines, each of which is known to create a low frequency atmospheric disturbance, will combine their LF output energy as constructive or destructive interference patterns. The direction of propagation and noise output is both random and hard to predict, because most turbines will have their blades at slightly different positions, will experience slightly different wind velocity, and are a different distance from the observer. These relationships can change dramatically in a relatively short time, simply from a shift in wind speed or direction.

These phenomena are covered extensively in a great deal of material available from reputable scientists, acoustic engineers and (perhaps most importantly) from affected residents who have had a wind turbine installation installed near their property. Even the specific terrain around the generator site can have a highly significant influence on the levels of infrasound experienced, and it is extremely difficult to use any form of computer modelling to predict the outcome.

Now, add to this an almost infinite number of possibilities for wind direction, speed, temperature and humidity, ground effects (which change the speed of the wind based on height above ground), temperature inversions in the air and wind turbine blade inertia. Prediction is obviously extraordinarily difficult at best, and verges on being impossible if *all* possibilities are to be calculated. There are also several different computer prediction systems, and (no surprise) they will commonly give very different results for the same number and type of turbines.

The affected homeowner has no chance against the combined "expertise" of the wind farm operators, tame audio consultants whose results will always favour their employer (the wind farm operator) and the local government bureaucracy. Naturally, people can employ their own consultants, but at considerable cost. How does the householder know if a consultant fully understands the implications of infrasound, how to measure it, and what the measurements mean? Once the problem goes to court, the chances of a judge actually understanding *anything* that's said are remote unless s/he has extensive experience in the field of acoustics. If affected, how would *you* rate your chances ... especially since the vast majority of those whose amenity of their home has been destroyed have had no luck in the court system. Courts are likely to rule that the needs of the many are more important then the amenity of the few, but it can be argued that this is a violation of human rights - whole papers have been written on this alone.

In one case in Australia, the court found "on balance, the broader public good must prevail" and approved a wind farm near the Southern Highlands heritage town of Taralga [2]. The Land and Environment Court judge(s) who made this decision should be taken outside and shot. He has effectively stated that the affected people don't count or matter, because the needs of the many come first. Their human rights have been trampled, and this particular lunatic judge didn't even think that compensation was appropriate ... and *these* are the people who get to make decisions that affect the likes of you and me? I don't like anyone's chances as long as cretins like this are allowed to sit in judgement of anything more complex than their own daily ablutions.

Indeed, many people worldwide have been forced to abandon their homes because they have suffered sleep deprivation, and/or simply cannot tolerate the noise. Nausea, dizziness, headaches and general malaise are surprisingly common. The effects of sleep deprivation are by far the worst though, and there is a great deal of very specific information on this topic in medical journals and other peer reviewed publications from university studies and medical institutions.

One of the biggest hurdles to sensible measurement is the continued and unshakeable belief that A-weighted noise measurements are appropriate. Quite simply, the use of A-weighting is completely *inappropriate* for a great many noise measurements, and is worse than useless where low frequency disturbances are creating a nuisance noise level. Returning to the distant noisy party referred to above, if a noise reading is taken using the normal procedure (A-weighting), the nuisance noise from the bass will barely register (if it registers at all), so even though the noise is obviously audible, the meter says "there is no noise". This is quite obviously nonsense, but common sense being surprisingly uncommon, no-one in "authority" seems to have noticed that they have mandated a test process that does not (and cannot) provide a true indication of the nuisance value of a noise. Even if the officer holding the instrument can hear the noise, if the meter says "there is no noise" that's likely to be the end of the story.

Noise is defined in many different ways, but one of the better explanations suggests that noise is any sound that conveys no (wanted) intelligence, and that impinges on ones amenity in a way that disturbs or annoys the listener. As noted above, just because a filtered signal that displays a value on a meter doesn't show any significant "noise", this does not mean that it's not perceptible or that it doesn't exist. This is the traditional approach taken by the wind farm operators, local government

offices and the law courts. In order, we have vested interests (the wind farm operators), likelihood of litigation (local government) and an almost complete lack of the specialised knowledge needed to make an informed decision (law courts).

The vested interests in particular have far more power and can throw much larger amounts of money at any complaint than the average householder (or even group of householders) can ever hope to match. This means that the affected residents have little chance of redress unless the problem is so obvious that it can't be obfuscated by a concerted campaign of disinformation from those who stand to lose if an action succeeds. There are countless stories (many in peer reviewed academic papers) of just this problem. People have literally abandoned their homes because the noise is so bad that they cannot remain without illness, yet no-one responsible for the noise will even accept that there is a problem.

Contrary to popular belief (and claims made by turbine operators et al), most people do *not* get used to noise. Some noise is more (or less) tolerable than other noises, and naturally occurring noises (wind through trees or grass, surf on the beach, etc.) are treated differently by our ear-brain processing system than many other noises. Noises with a rhythmical or pulsing character seem to bring out primitive reactions, leading to increased stress levels and blood pressure, amongst many other adverse effects. Needless to say, these issues are dealt with by Bruce Rapley and the others who contributed to the book, and there are also countless papers available from libraries (both public and university) or the Net.

None of this is helped in any way by the fact that noise abatement bodies worldwide are completely unable to reach any kind of agreement as to the proper measurement techniques for large wind turbines. Because these are usually part of a massive installation, it is imperative that not only measurement techniques, but predictive modelling methods are adopted in a global standard. As long as there is a perceived need for renewable energy from wind, wind farms will increase in number and size. The number of disaffected residents will grow, and the public opinion of wind farms in general will suffer.

Any (rural) real-estate agent will likely tell you that a) you will never get a decent price for a property that's near a wind farm, or b) if you want a really cheap property, go to where the wind farms are located. This already tells you about the public perception of wind farms in general - even if the property is unaffected, buyers will be very wary. Needless to say, wind farm proponents will claim that there is no negative impact at all, while others (such as property owners) will say just the opposite. The overall perception of wind farms seems to be that most people like them - *provided they are somewhere else*.

There seems to be little or no redress if residents experience any of the many and varied issues with wind farms, and this is an appalling state of affairs. It is equally appalling that many people (and this includes local government officials, turbine operators and other vested interests) appear to have absolutely no idea of the actual problems, and brand anyone who complains as deluded or just complaining for the sake of complaining. One of the most pointless and misleading videos of a wind turbine is available on-line (popular video site). A wind turbine is shown, then a busy intersection, and the purpose is supposedly to demonstrate the noise difference.

Why is this video pointless? Because distances are not provided, microphone sensitivity was not disclosed (for all we know the mic was disconnected for the wind turbine), microphone equalisation data were not included, and there was absolutely no information that allowed us to be even a little bit certain that the whole video clip wasn't just an exercise in deliberate disinformation. To me, this *is* deliberate disinformation, precisely because all of the required information is missing - including the name and credentials of the lunatic who posted the video in the first place. Based

on my knowledge of recording microphones, even if infrasound was generated by the turbine in question the video recorder microphone would not pick it up, and no PC speaker system could reproduce it. Such "demonstrations" are proof of exactly nothing, and must be treated for what they are - disinformation and horse-feathers.

Most of the literature, specifications and white papers publicly released by turbine operators and/or manufacturers must likewise be dismissed. These are vested interests, and they cannot be expected to provide information that will be used against them. Unless all such corporations are legally obliged to provide information that may be detrimental to their profitability, it's not going to happen. Many of the small wind turbine makers have used the excuse that the test equipment and procedures are "too expensive", and/ or "too difficult" [3]. Some of the small turbines can't be considered anything short of an unmitigated disaster based on the information in the referenced article. However, these generally only affect those in reasonably close proximity, and are unlikely to cause audible subsonic noise 3km away. There are reports of turbines that can be heard over 5km away, so the commonly applied buffer zones are quite obviously inadequate.

The mere fact that there *are* buffer zones between the closest turbine and dwelling shows that problems are known to exist, and the buffer is a means of minimising likely complaints. From this, we *know* that everyone involved knows that wind turbines are not the silent, graceful machines that they are claimed to be. It's time for the wind power proponents to pull their heads out of the sand and accept that there are real issues that must be solved. The smear campaigns against those who have suffered due to the installation of wind turbines has to stop too. The vast majority are not deranged and nor are they trying to profit at the expense of others (it seems that privilege is reserved for wind farm operators). These are ordinary people trying to live their lives free of daily interruptions to sleep or recreation, but they are thwarted by business, government and the legal system so they have no redress against the march of "progress".

In the interests of science, I conducted a basic test - I freely admit the test was rudimentary, but it is easily repeated by anyone who cares to do so. I have no doubt that the results will be similar, although will probably be more accurate (I have a basic workshop, not an acoustics laboratory). The test was conducted in my workshop, with the radio playing through my normal system. This includes a subwoofer that can reproduce 30Hz quite easily. Using a sound level meter and a parametric equaliser, I was able to boost the very low bass quite easily. Bass was boosted below about 70Hz, and all other frequencies were unaffected. Average SPL (sound pressure level) was around 60dBA and 70dBC for these tests. This is roughly the level of normal speech at ~1 metre.

When the sound level meter was set to A-weighting (dBA), it registered no discernible increase in sound level when the low frequency range was boosted, *even though the deep bass was clearly audibly increased*! Setting the meter to C-weighting (close to flat response), a consistent 6dB increase of SPL was easily measured. Both the meter (when set to C-weighting) and my ears easily detected the low frequency boost, yet the meter indicated no change when set for A-weighting. Bear in mind that most music has little recorded bass below 40Hz and insists on changing as we listen, so a wideband pink noise source was also tested.

The noise level was adjusted until the meter indicated 60dBA, and when the low bass was increased by about 8dB (the range of my equaliser at these frequencies) no increase was shown on the meter. The increased bass was clearly audible, and I verified this by inviting my wife into the workshop to listen to the test. Initially, she thought the deep rumble came from outside (not sure what she though may have made the noise), but several tests later it was easy to tell whether the equaliser was in or out of circuit. The difference between the normal (flat) condition and deep bass boost was consistently audible. The meter sat stoically showing a level of about 60dBA

regardless of whether boost was applied or not. The deep rumble would be *extremely* annoying if it were present for any length of time.

Without changing any settings (or the meter placement), I switched to C-weighting. The meter then showed the average level as 68dB, and this increased to about 76dB when boost was applied. So the meter now registered that there was about 8dB more low bass energy, and it was clearly audible as before. Acoustic theory tells us that we can't hear these frequencies well, courts and governments believe the theory, everyone insists on using A-weighting (dBA), and they are quite clearly wrong in any case that involves deep bass. I have complained bitterly about the stupidity of measuring all noises (regardless of SPL) in dBA, and this simple test has proved that my complaints are (and always were) justified.

It is remarkable that such a basic test can demonstrate quite clearly that A-weighting is a fundamentally useless way to quantify low frequency annoyance levels, and I urge anyone who is involved in any kind of acoustic testing to run this same test. It is even more remarkable that no-one involved in acoustics seems to have run tests and published their findings, because this is fundamental to our understanding of the perception of low frequency noise.

Huub Bakker (Massey University, NZ) has reproduced my test with a tad more science, and found ... exactly the same results. Has no-one ever done this? It would seem not, or if they have they've stayed quiet because they would hate the general population to know that the "official" tests are as much use as a rollbar on a rowboat.

The world Health Organisation (WHO) is aware of the problem, but no-one is listening ... 'Since A-weighting underestimates the sound pressure level of noise with low-frequency components, a better assessment of health effects would be to use C-weighting.' [WHO Guidelines for Community Noise 1999, S.3.9, 'The effects of combined noise sources'.] [4].

No wind farm annoyance tests can be conducted using a measurement technique that is so obviously flawed. As the frequency is reduced further (where it becomes a sensation rather than an audible sound), a sound level meter measuring dBA may as well be replaced by a small stone wrapped in a handkerchief - both are equally pointless as a measure of the *actual* nuisance value of the noise. Any measurement taken with A-weighting will not register very low frequency noise components - *even if the noise is clearly audible while the measurement is taken*. This is an untenable position, as should be obvious to anyone involved in noise testing.

A noise measurement taken with A-weighting is only applicable where the noise has a reasonably continuous spectrum - having a wide frequency range, and without significant tonality or modulation. Such measurements are only valid where the noise level is either close to the limits of audibility, or close to the normal background noise level, which in itself should be free of tonality or modulation. Using dBA as a measure of the potential annoyance value of wind farms is clearly ludicrous, and must be discontinued forthwith.

Flicker And Glint

This is an area where there hasn't been a lot of publicity, but the problems are very real indeed. Again, wind farm operators and councils (or other local government bodies) will underestimate or dispute that flicker and glint affect anyone, but they obviously don't have to put up with it on their properties. Flicker is caused by the turbine blades momentarily blocking the sun (or possibly moon), causing the light to dim quite noticeably was each blade passes between the observer and the sun. No-one will tolerate sitting under a fluorescent lamp that flickers, but somehow people

are expected to accept that turbine generated flicker is harmless and can be ignored easily.

This text has been included as an example. The ability to use flashing (or blinking) text is considered by many to be the worst HTML command ever created.

Few people would argue that the above line of text isn't intensely irritating, and for that I apologise. Even as you read past it, it catches your eye and distracts you from being able to read the adjacent text easily. Imagine sitting in your house, with the morning (or evening) sunlight modulated so that you experienced a constant flicker whenever the sunlight was interrupted by the turbine blades. Most people would have little option but to close the blinds and switch on the light to be able to read, prepare food, or many of the things we normally do indoors (and no, I'm not going there). Outdoor activities will be affected too, and there is some concern that flicker could cause seizures in people with photo-sensitive epilepsy.

Glint is caused by light reflecting off part of the blade(s) as they rotate, and while the direct effects are likely to last only a short time, glint will be just as irritating as flicker. Some turbine manufacturers have apparently used non-reflective paint to reduce glint, but I have no data on the effectiveness or otherwise of such treatments. Regardless, anti-reflective coatings will do nothing to alleviate flicker. There is no reason to suspect that sunlight can't be interrupted by more than one turbine, although the path will be fairly narrow and probably wouldn't last long each day.

To most people who don't have to put up with any of these effects, they might sound rather trivial. For those affected, they generally don't consider it to be at all trivial - quite the reverse. These are real problems, experienced by real people, who just happen to have had wind turbines thrust upon them. There are many stories where people have said that the wind farm operators had guaranteed that residents would not be subjected to any noise that would cause disturbance, would not experience flicker or glint and that their amenity would be unaffected. Only after the turbines are installed and operational do the residents discover that the "guarantee" was based solely on the standards set by the turbine operators, and that essentially the residents were lied to from the outset.

Economic Viability

Much is made of the "free energy" available from wind farms, but of all conventional means of power generation, wind farms are one of the *most* expensive [5]. There are several reasons for this, with the primary cost being that of the turbines themselves. These are enormous structures, and are subjected to enormous forces in operation. The cost of manufacture, shipping and installation is generally kept rather quiet, because it's obviously better if the general public is unaware of the total expenditure to set up a wind farm in the first place, and then to maintain it. A modern wind turbine blade assembly may be anything from 40 to 90 metres diameter (130-300 feet), and typically stand 2-3 times the blade length high (40 to 135 metres). Increased height makes better use of the higher velocity of wind at greater distance from the ground, but there is a limit where stability and cost make it uneconomical to attempt anything higher.

A massive concrete base is needed to make sure that the turbine won't topple over in a high wind, and the structure of modern high power machines is necessarily massive to support the weight of the generator, gearbox, turbine blades and the mechanism that's used to point the turbine into the wind for maximum power generation. There are also braking mechanisms, and a means of varying the blade pitch to make best use of available wind, or protect the machine against wind that's too strong. All of this has to operate unattended, and survive storms, lightning strikes and all the other exciting things that Mother Nature can throw at them.

Of course, some don't survive, and there are some spectacular videos on the Net showing wind turbines collapsing or on fire. Although these very dramatic events are fairly rare, we can be sure that more mundane failures will be happening worldwide on a daily basis. The same would be true of conventional power generation systems as well, but the maintenance costs for wind turbines seem to be a closely guarded secret. Perhaps they cost more to maintain than their owners and operators would like to admit, and they are reluctant to let the end users know the real costs involved. I don't know, but in the interests of transparency it would be nice to have a few real figures that could be used. This also applies to conventional generating systems of course.

At this stage, I haven't even mentioned one of the least desirable aspects of wind power - the requirement for backup generation capabilities that can take over from the wind farm whenever there is insufficient wind to supply the power demand. If a 10MW wind farm is operational, that is the *maximum* it can provide. The long-term average will be much less, depending on wind conditions. Ideally, it would be nice if the wind would do everyone the kindness of blowing at a nice steady 4-8m/s (15-30km/h) 24/7, but this doesn't happen in practice. Wind turbine manufacturers know that wind is notoriously variable, so must make machines that can handle a reasonable range of wind velocity.

It seems that an average power output from a typical wind farm will be somewhere between 10-50% of the design maximum, and this will be subject to day-to-day and seasonal variations. Because the output can go from nothing to maximum and back again in a relatively short time, reserve capacity must be available to ensure the grid is not stressed should the wind farm(s) cease to provide electricity due to the lack of wind. Most traditional generating systems are not very responsive to short term demands, and the most flexible reserve generating capacity comes from OCGT (open cycle gas turbine) plants. These can respond faster than any coal fired or CCGT (combined cycle gas turbine) generating plant, but are relatively inefficient.

Despite the inefficiency, there are few other choices. While hydro-electric systems can respond quite quickly, they must have the necessary water supply directly available, close to the turbines. Few countries or localities have the water reserves and/or infrastructure to allow this, and downstream flows need to be maintained at a reasonably steady pace to prevent flooding or other surges that may interfere with marine life, boating and recreational use of the waterways. You can't suddenly release thousands of litres of water through a turbine without disturbing everything downstream. While there are ways to mitigate the possible issues, only a relatively small number of localities are suitable for hydro-electric power stations.

In contrast, an OCGT plant can be located almost anywhere convenient, and can be up to full power in around 10 minutes from startup. They are also relatively small for the power output (in the order of 25 x 75m for a single complete 150MW unit), but need a generous supply of fuel [6]. It seems to be standard procedure that any wind farm has a backup OCGT (or other fast-start generating plant) to fill in the gaps when wind is either missing altogether or is not strong enough to supply the power needs of the community or main grid.

The use of wind definitely reduces the amount of fossil fuel used, but government press releases invariably state the wind farm maximum power with no qualification and no mention of backup power requirements. The public can't be expected to know the details of how power is generated, the demands placed on the distribution grid or the nature of wind power in general. This makes it much easier for governments and wind farm operators to make it appear that they are doing far more "for the environment" than is really the case.

Based on what I've read in the Atkinson-Rapley book and have found on-line, it's hard not to feel that wind turbines are largely a waste of time, space and money. Unfortunately, from a

government perspective they make a very bold statement, and this is far more important than actually *doing something useful*. I do realise that this is a very cynical outlook, but it's very hard to come to any other conclusion when all the factors are considered.

The energy production of a wind farm is highly variable, and cannot be relied upon to provide power when it's needed. The maximum possible efficiency for the extraction of power from the wind is 59% (Betz' law), but no currently available turbines can achieve this. Should the wind be at any velocity other than the design optimum, the efficiency falls further, so wind that's faster or slower than optimum will result in lower than expected efficiency. With no efficient and economical storage system available for large-scale wind farms, they are really little more than an interesting diversion from the real problems of energy generation. That they cause so many problems for nearby residents is the final nail in what should be their (grossly oversized) coffin.

The Future of Power Generation

The continued use of fossil fuel has to be reduced and eventually (sooner rather than later) stopped altogether. This includes coal, natural gas, coal seam methane and other non renewable resources. There is no denying that the levels of CO^2 have increased dramatically over the last 50 years, and this will continue for some time to come. Whether this is the cause of global warming or climate change is immaterial - what we are doing at present is unsustainable no matter how one looks at it, and real alternatives need to be put into place. Wind is one method, but has many problems - not the least of which is the amount of land needed and the requirement for backup generating capacity. Noise, flicker and general loss of amenity of surrounding properties are issues that need to be addressed, but wind farms *can't* be located in the middle of nowhere.

It is necessary for any power generation system to be close enough to the grid to facilitate electrical connections, and they must be near transport corridors so they can be built and maintained. In the case of wind farms, it's helpful if they are built where there is a reasonable chance that some wind will be available. Other generating plants need a good supply of water for cooling and require rail or pipeline facilities for their fuel supply. Hydro-electric plants need a plentiful supply of water to function, and a carefully designed out-flow system to prevent over or under supply of water downstream.

Nuclear power is not only one of the cheapest ways to generate electricity, but it has effectively no carbon dioxide emissions. CO^2 Emissions occur only for the manufacture of concrete and other material produced during construction. However, nuclear reactors have had rather bad press for some time, no-one wants one in their neighbourhood, and of course there is the not insignificant problem of waste disposal. Unfortunately, there is very little private or government funding anywhere in the world for a potentially vastly more efficient and safer form of reactor, using Thorium as the fuel.

Of the various thorium fuelled reactors, one promising technique is known as the LFTR (pronounced "lifter") - Liquid Fluoride Thorium Reactor [7]. Such reactors are readily scaled to meet the power needs of small or large communities, and are intrinsically safe - they cannot experience a meltdown. The waste products are low grade, unsuited for any form of nuclear weapon, and degrade in a comparatively short time (around 300 years, as opposed to > 10,000 years for conventional nuclear waste).

It is very much the opinion of the author that this is the way forward. Part of the funding currently being applied to so-called "clean coal" (now there's an oxymoron if ever I heard one), wind power, and other flawed concepts should be (immediately) applied to proper research into Thorium

reactor technology. Success in this would secure most of our energy needs for a very, very long time. Thorium is relatively abundant, and many countries have significant reserves of an element that has otherwise somewhat limited usefulness. Tiny amounts are used as the electron emitter material for the cathodes of thermionic valves (aka vacuum tubes) including magnetrons (as used in microwave ovens), and it's used in a number of alloys, ceramics and gas mantles. It's use as a nuclear fuel would not affect any current usage.

Governments need to act decisively, and electricity consumers need to be aware of the stupidity of the present reliance on fossil fuels and unreliable alternative power sources. Any generating plant that cannot be relied upon to provide base-load power (that which is needed on a continuous basis) is rather pointless in the greater scheme of things, especially since we don't have any storage facilities that have usable efficiency or don't rely on expensive materials and processes. If the storage issue could be solved, many of the problems would go away, but in the case of wind generation, the problems for residents close to the wind farms will get worse because wind farms will spring up like mushrooms.

We are presently being lied to, and the creation of emissions trading schemes will simply add to the cost of new and existing power generation facilities. The effect on CO^2 emissions will almost certainly be too small to be useful, but a whole new industry of buying and selling "carbon credits" will see the cost of energy to the consumer rise out of all proportion. This is already happening in Australia, with power cost expected to rise by up to 600% over the next few years in some areas.

The present schemes are not sustainable, and I can well imagine future students studying the history of this period, and wondering how widespread lunacy at this level ever happened. Perhaps they will assume that someone had introduced LSD or something similar into the water supplies of all major seats of government. I'm forced to wonder if that's not the case now - many of the decisions and plans made can only be described as insane. Perfectly viable alternative options are available, but we (as a global group) seem intent on mining and burning every last molecule of fossil fuel, but being seen to be doing "something" by installing token renewable energy systems that cannot possibly supply our needs without the assistance of the fossil fuel burning monstrosities that are still being built all over the world.

Makes you wonder, doesn't it?

Footnote

Throughout the text of every publication or website you come across dealing with wind turbines, there are references to the continued use of A-Weighting, despite the fact (and it *is* a fact) that many people in the field know full well that it doesn't work. No-one will actually tell you this though - they will assure you with hand on heart that they are doing the right thing. Utter nonsense - they *know* they are deliberately using the standards to fudge the figures, but they can never admit it to the press or the population.

While I quite obviously cannot provide specific details as it may jeopardise a career or two, I know of at least one case where a very qualified person was told that if a single word was spoken about research done, the present test methods and their total unsuitability to the task, the university job currently held would be no more. Why? *Because the Uni in question received funding from a wind farm operator*.

There is ample evidence that "QANGOs" (quasi-autonomous non-government organisations), governments (through "donations") and other bodies (including universities and other research

groups) often rely on external funding, and it is to be expected that they cannot be openly critical of those who provide the funds. This is an appalling situation, and means that a great deal of information released to the press and public is either tainted, misleading, or just plain and simply wrong. The threat of losing funding means that any data that fails to support the goals and/or claims of the organisation providing the money *will be suppressed*.

This is not a conspiracy theory - it is very real. It is obvious to anyone who is involved directly (or even peripherally in many cases). Simple logic tells us that if a wind farm operator engages a university or other facility to perform research, they will be very displeased if the researchers come out and tell the public that the whole concept is flawed, many of the claims are outright lies, and that wind turbines are not really silent benefactors at all.

In addition, wind by its very nature is variable - often extremely so. Wind turbines cannot be used to provide base-load power, and the operators (and most material intended for the public) tel us nothing about what happens when there is lots of wind but little demand, or huge demand but no wind. We can discover some of the info from the Net, but it's either from conspiracy theorists or sites like this one. The people who really know the details won't tell you.

Have a look at the websites for any of the major wind farm operators. Glowing reports of their successes (imagined or otherwise), nothing about backup power, very little to give us any real factual data that we can use to determine the true economic viability of the farms, and zero info about adverse reactions from nearby residents. Don't expect any wind farm operator or turbine manufacturer to even mention noise below 30Hz - as described above, it doesn't exist because an A-Weighted measurement doesn't register anything.

Of course, the general public can see that their government is "serious" about climate change, because they are told about (and shown) the large wind farms that are solving the energy problems. Being so visible, we are convinced that this is working. In Australia, we are told that the Sydney desalination plant " ... uses reverse osmosis filtration membranes to remove salt from seawater and is powered using 100 percent renewable energy. The renewable energy is supplied to the national power grid from the Capital Wind Farm at Bungendore, NSW."

Complete bollocks!

- Was a separate electrical feed provided from Bungendore to Kurnell? **No!**
- Is there any way whatsoever to "tag" power so its origin can be determined? **No!**
- Can a reverse osmosis plant be allowed to receive (possibly wildly) varying power input during operation? **No!**
- Does the plant shut down if there's no wind in Bungendore? **No!**

None of this nonsense will stop until the people get so fed up with being treated like idiots that they lynch a few politicians (a generally laudable idea) and start exposing those who are consistently feeding us misinformation and political "spin" for what they are - liars! Just in case you think I might be exaggerating, I've been informed that the New Zealand standard (NZS 6808-2010) denies that there is *any* problem with low frequency noise whatsoever, and also fails to mention even *once* that A-Weighting is completely inappropriate for measuring infrasound!

The Fletcher-Munson curves have been taken as nectar from the Gods for so long that it seems no-one is willing to challenge them. I don't have a problem with the curves per sé - for steady state tones (the critical and ignored factor!) I'm sure they still hold up very well. I doubt that anyone at the time when the curves were studied and devised ever envisaged that cretins would be using the exact same curves to "prove" that people cannot hear or sense VLF signals that are not steady

tones, but are amplitude modulated, may contain significant harmonics, and/or are pulsating or rhythmic.

As a side issue (but closely related), it is known that our brains can easily synthesise bass frequencies when provided with only the harmonics of the original. This has been exploited in a commercial application called *MAXXBASS*, but we have used harmonic reconstruction ever since sound recording and subsequent reproduction became possible. Many people will have noticed that they can pick out the bass guitar or double-bass even though the speaker system is quite obviously incapable of reproducing anything below perhaps 150Hz or so. The small transistor radios of yesteryear are a good example, as are the original horn "speakers" used with wax cylinders and early 78 RPM discs.

I've tried MAXXBASS just to have a listen, but IMO the sound was dreadful - there was plenty of ersatz bass though! There is no reason to imagine that the same processes cannot be duplicated by rotating turbines - especially when they are in large numbers and changing speed asynchronously.

The interference patterns that will be set up in a typical windfarm are almost infinitely complex - it is not inconceivable that some effects will only appear a few times a year, while others will be far more frequent. Interference patterns are always equally capable of reinforcement or cancellation of pressure waves, and the distance between nodes and antinodes may only be a few metres ... and constantly shifting. This is an enormously complex issue - one that will *never* be determined by a couple of noise abatement officers with an A-Weighted sound level meter!

Yet another consideration that gets scant attention is that a windfarm is a very large overall sound generator. Most papers consider that the sound intensity falls by 6dB each time the distance is doubled, but if the sound source is large compared to wavelength it becomes a line array. As every sound company on the planet will tell you, a line array causes the sound intensity to fall by only 3dB each time the distance is doubled. In most cases the real figure will be somewhere between the two, but terrain can make a spectacular difference (good or bad) in some cases.

While it might seem from the above that I totally disapprove of wind power, this isn't really true at all. I'm not against the overall principle at all - provided no-one is adversely affected in any way and the power generated can be put to good use. Unfortunately, it seems that the implementation and long-term planning have been seriously lacking to date. Any form of power generation that cannot supply base-load or transient (on-demand) loads, but is subject to the whim of weather patterns may be comparatively pointless until such time as a suitable energy storage system is developed. Stored hydrogen is one possible solution - it's not especially efficient overall, but nor are any of the other storage options.

I'm all for clean energy - it's absolutely essential to assure our way of life and not ruin what's left of our planet. I am very much against being lied to and shown great big shiny new wind turbines and being told these will solve the problems and we will all live happily ever after. They won't solve much, because demand and supply will often coincide at irregular intervals at best. It's (admittedly remotely) possible that some turbines will even struggle to provide as much energy as was used to produce, ship and install them. If people are lied to, cheated, or otherwise adversely affected, then there is obviously a problem.

It looks very much like there is indeed a series of problems, but there is none so blind as he who *will* not see.

References

It would be impossible to list every site I looked at during the research for this article, but those that actually had useful information are included below.

1. Introduction to Sound, Noise, Flicker and the Human Perception of Wind Farm Activity, Atkinson & Rapley Consulting Ltd
2. George in a spin over noisy wind power, SMH, 21 Sep 2009
3. Noise from Small Wind Turbines: An Unaddressed Issue, by Paul Gipe
4. Noise Radiation From Wind Turbines Installed Near Homes: Effects on Health
5. Cost of Generating Electricity (UK Study)
6. What is an OCGT?
7. The Liquid Fluoride Thorium Reactor: What Fusion Wanted To Be (Google Tech Talks)

Additional Reading

The following may also be found interesting. What used to be the first link here was included because it was a perfect example of the spin-doctor's work, cheerfully twisting the truth to (try to) convince people that wind farms are not only good for us and can't possibly do us any harm, but also have no downsides worthy of a mention. I call this "utter bollocks". The document used to be on the South Australian State Government website, but has since vanished without trace. The document was produced by "AusWEA".

AusWEA (Australian Wind Energy Association) is/was Australia's (self proclaimed) "Peak Body For The Wind Energy Industry". The South Australian parliament site *used* to have the document that did nothing other than prove that "AusWEA" produces lots of spin but few useful facts. A perfect example of disinformation from the industry. The link broke, and nothing on the original government site even looks like the nonsense I saw before.

Fortunately, by the magic of the Net, I was able to obtain the exact copy of the document, which is available here. This is quite possibly the most blatant piece of misinformation I've seen for some time. I included it here so you may guffaw at the nonsense therein, and do not suggest that a single word be accepted as fact. Needless to say, entire sentences are even less believable than individual words  .

A search will naturally find copious examples of nonsense of much the same kind from a variety of sources. Strangely, AusWEA doesn't even appear to have it's own website, although it seems that it once did. I attribute this to the high likelihood that it has fallen on its nose because it was nothing more than a crap factory, turning out nice looking brochures that were completely one-sided and pointless.

1. Primer for Addressing Wind Turbine Noise - Revised Oct. 2006, by Daniel J. Alberts, Lawrence Technological University
2. Wind turbines and health - Discussions covering the effects of wind turbines on the health of those who live nearby.
3. Energy From Thorium - Devoted to the discussion of thorium as a future energy resource, and the machine to extract that energy - the liquid-fluoride thorium reactor.

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