Summary of Submissions on Proposed Moonies Hill Energy Pty Ltd Flat Rocks Wind Farm

No.	Submitter	Summary of Submission	MHE Comment
1		Opposes the granting of planning approval on the following grounds:	
		• Technical Capacity Not satisfied the proponents can complete complex and specialist tasks required for project. No details available relating to type of wind technology and its operational demands.	Not relevant to DA process – see additional comments
		• Financial Capacity Not satisfied the proponents demonstrate financial capacity required for project. Requires full life cycle financial plan to support the proposal. Welcomes suggestion of community fund and recommends the Shire gain further commitments to implement and manage the fund.	Not relevant to DA process – see additional comments
		• Environmental, Landscape and General Amenity Impact Comments the application is light on detail regarding environmental studies and potential impacts as required under WA Planning Commission Guidelines for Wind Farm Development No. 67.	All reports available on Shire and MHE website
		The loss of amenity and landscape values needs to be considered. Provides comments from national real estate agent showing negative effect on value of adjoining lands to wind farms which needs to be reconciled between the proponents and adjacent landholders.	MHE has supplied research papers to Shire addressing this issue
		• Lack of Shire Policy on Renewable Energy/Sustainable Community Development Believes Shire should have policy in place before assessing this application. Lack of a policy creates ad hoc development and recommends a policy would enable the broader community to be involved to determine the shape and direction of the renewable energy industry within a sustainable community framework.	WAPC PB67 relevant legislation in WA
		• Information and Communication Not satisfied with proponent's communication with the community. Became aware of the project late and would have preferred comprehensive information as potential affected landholder. Comments that any aviation navigation lights have the potential to affect night amenity. Questions if proponents have contacted other landholders in local LCDC. Sees no correspondence from relevant government agencies regarding the project.	As not sure who this is can't comment on when they were notified. Navigation light see Airspace Study
		• Asset Management and Decommissioning Strategy Not satisfied with the proponent's details regarding decommissioning or any 'bond' to ensure the project is properly decommissioned and sites restored.	See Environmental report
		• Grid Connectivity and Evidence of Capacity Not satisfied the proponents can complete technical and financial tasks required for	See Environmental report

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		project. No details available demonstrating preliminary approval for connection to grid. Comments it seems to reflect prospecting for potential locations rather than complete project. • Risk Management Comments due to fire risk, the proponents should develop risk management plan to address issues before the application be considered.	See Environmental report
2		Supports construction of wind farm. Comments on renewable energy and tourism benefits as well as environmental and employment opportunities. Requests assurances that turbines do not shadow any housing as German experience has caused disturbance to residents.	See Shadow Flicker report – no homes will be affected
3		Have received the development application report and advise fully support project.	
4		Raise no objection subject to the following requirements: • Additional details are required from the proponents to enable MRWA to completely assess road impacts. • All utility services require special approval and would be at the cost of the developer if approved. • The developer must submit a traffic management plan to detail transport needs and its impact on network and the users. • Oversize/weight permits for transporting of loads are required.	MHE has committed to a traffic management plan in the Environmental Impact Report
5		This information is provide as preliminary advice and may require assessment under the Environmental Protection Act. Recommend Shire/proponents contact regional officer dealing with industrial proposals. Preliminary assessment identified several threatened or priority bird species may be impacted including Carnaby's Cockatoos, Forest red Tailed Black Cockatoos and Muir's Corellas. The issues relate to death/injury from turbines. Advice several research papers published that deal with issue and may be useful to refer to when developing the project. No flora or ecological communities were identified.	MHE referred the FRWF project to the EPA in Feb 2011 – Deemed NOT ASSESSED See Flora, Vegetation and Fauna Assessment Report
6		Object to the proposal as follows: • The value of land prices being affected. Will receive no benefit from the wind farm but their land could be devalued. • The health effects. Advice of personal circumstances that may be adversely affected by wind farm development and provide supporting comments. • The noise levels. The noise levels and their impacts should be established before the	MHE has supplied research papers to Shire addressing this issue MHE has supplied research papers to Shire addressing this issue See Noise impact report

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		wind farm is developed. • The effect on wildlife. • The interference to television and radio receptions. No interference is considered acceptable. • The secrecy which has surrounded the proposal. • The division within the neighbouring community. Request the Shires reject the proposal due to the concerns. If approved demand exclusion zone from farm boundaries of 2km for a 2MW turbine or 3.3km for a 3.3MW turbine. Advise they will comment further once more information and community input has been received.	See Flora, Vegetation and Fauna Assessment Report See EMI report WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards available for assessing wind farm developments globally
7		Advise, have no specific authority to require obstacle marking and lighting of tall towers such as wind farms located away from aerodromes. Advise owners of structures which could be hazardous have a duty of care to aviators and the proponents should complete the following consultation to assess potential hazards: • Identify any aerodrome within 30km of wind farm boundaries and consult with operator to determine any impact on Obstacle Limitation Surfaces as penetration of theses surface is likely to cause hazard to normal operations. • Consult with Airservices Australia to have them assess any potential impact on instrument approach procedures, navigational aids, communication or surveillance facilities. • Contact Aerial Agricultural Association of Australia to advise them of the proposal. Comment that maximum height of blades is 146m and aircraft are permitted to fly as low as 500 feet (152m) although some operations are permitted below this height. Believe the turbines are likely to be a hazard to aircraft traversing the area. Due to height of turbines, it is recommended that the proponent consider whether or not the wind farm should be obstacle lit or otherwise marked. If lighting is proposed will need to comply with CASA standards. If development proceeds, the location, extent and height of wind farm should be advised to Aeronautical Data Officer at Department of Defence.	Addressed in Airspace Report MHE has committed to do this – See Airspace Report
8		Concerned as follows: • Negative impact on land values in the region. • Noise impact to local residents and inhabitants. • The aesthetic visual nature of the infrastructure.	MHE has supplied research papers to Shire addressing this issue See Noise Impact Report See Landscape and Visual Assessment Report

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		• The establishment of infrastructures and dangers to our community. • Impact on roadways etc. • Potential impact on normal farming practices i.e. aerial spraying. • Making good commitments if decommissioned. • Potential impacts on telecommunications i.e. mobile coverage, radio, GPS, television etc. Advises any impact will dramatically impact farming businesses. • Would prefer minimums not maximums. • The potential for non-adherence to Occupational Health & Safety issues considering farm need to maximise profits and productivity from all land available. • Potential negative impacts on animal welfare. • Questions the viability after contacting sources in energy sector. Support renewable energies, but do not believe wind farm provides commercial and environmental benefits into the local community.	See Environmental Impact Report See Environmental Impact Report See Airspace Report See Environmental Impact Report See EMI report MHE must comply with all relevant regulations and laws during construction and operation of the FRWF See Flora, Vegetation and Fauna Assessment Report
9		Oppose the wind farm. Raise following concerns: • Health Have research that low frequency sound from wind turbines can cause problems to residents. Given that some turbines will be within 800m of houses, feel risk to health is too great. Cite anecdotal evidence from Victoria and NZ. Request research on effects of wind turbines on food production including production losses. • Land Values Comment that although a close neighbour; receive no benefit from the wind farm. Question what guarantee is available their land won't be devalued as their research says this is possible. Any reduction to the ability to conduct present operations would be inequitable. • Environmental Concerned for impacts on fauna especially in local reserves (Nogapitchup Swamp and Graham's Well) including Carnaby's cockatoo. • Visual Pollution Concerned with location and height of turbines. Will from an arc around their skyline impinging on their rural outlook and will create an industrial landscape. • Aircraft Issues Proposal only discusses commercial and defence aircraft. No mention of crop dusters and whether they can continue to use them.	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue See Flora, Vegetation and Fauna Assessment Report See Landscape and Visual Assessment Report See Airspace Report See Airspace Report

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		• Socioeconomics Their research identified that wind turbines are inefficient and recommend a biomass plant as a more suitable alternative. Support individual solutions to create self sufficient houses/businesses. • Electromagnetic Interference Application did not deal with electromagnetic interference to bush fire radios. Questions impacts and ability to still use radio/televisions despite assurances. Do not believe the project has community and landholder support and request the Shire deny approval.	See EMI report
10		Notes request from Council for comment on wind farm application. Notes application is for planning approval and that no environmental approvals have been sought. Comments that other wind farm operators apply for planning approval following their analysis and gaining other approvals and this result in a conditional approval art best. Comments this may put the Shire to unnecessary cost/effort in approving an application that does not get some other necessary approval. Detail present farm operations and assets. Are concerned about the recent and limited knowledge of the proposal and insufficient time to respond and will make further submissions when additional information becomes available. Request copy of Environmental Report is sent to them for consideration and comment and questions whether the proposal has been referred to the EPA. Do not support the application for the following reasons/comments: • Application should be refused. • Application is premature. • Council needs to consider the enormity and impact of the scale of this development, how it will impact upon the local community and who it will benefit and who it will adversely affect. • Council should await outcome of Federal Government enquiry prior to making any determination. • Kojonup's rural and visual amenity will be severely affected if application is approved. • The issues relating to noise, fire risk, radio interference and negative impact on surrounding rural property values need to be addressed and would like to view reports when completed. • Visual impact studies prepared by the proponents are needed for each individual affected	MHE referred the FRWF project to the EPA in Feb 2011 – Deemed NOT ASSESSED See senate report on inquiry June 2011 See Landscape and Visual Assessment Report All reports available on MHE and Shire websites. MHE has supplied research papers to Shire addressing this issue

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		property. • The proposed development site is not conducive in an area with small farming lots, other wind farms are situated on larger flat broad acre farms. • Not enough is known about adverse health effects associated with wind farms. • If development is approved, Council should impose a 3km exclusion buffer from any property boundaries to any proposed windmill. • Suggest that more time is required so that outstanding issues can be worked through with the proponents. • • Will likely present a report to Council in the future on the decreased property values associated with the development of the wind farm which is contrary to their fiduciary duties. • No consideration of micro-climate changes i.e. moisture and dew levels. • Concerned about development restrictions that may be imposed on their farm in the future and request Shire and proponents provide response. • No details on water supplies provided. • Concerned that company has no previous experience or capability statement for the proposal. • No details regarding community fund are given and how proponents will be bound to commitment. • Concerned not consulted or involved in site selection. • Advises 3km buffer is industry norm. • No details on grid connection or consultation with affected landowners provided. • Concerned about impacts on local aircraft movements. Reiterates the application should be refused for the reasons stated and will provide a copy of the submission to the proponents when they meet.	See Landscape and Visual Assessment Report Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available MHE has supplied research papers to Shire addressing this issue See Environmental Impact Report See additional comments See Environmental Impact Report WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available See Environmental Impact Report See Airspace report

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11		Concerned as with others about proposed wind farm. Has long association with the area and does not support the proposal. Comments project seems rushed with insufficient time available to consider the effects. Highlights confidentiality agreements. Shire should be aware of any future litigation that may arise.	MHE had CA with landowners during possible turbine hosting and land rental agreements – standard commercial practice Would need further info to comment on future litigation
12		Opposed to the proposal for the following reasons: • Productive land should be used for food production especially as there are food shortages worldwide. • Feels the proposal has been rushed and more community consultation is required. • Wind farms would be better suited where it is windy and where little/no arable land is used i.e. coastline.	After completion the FRWF will occupy around 1% of land and is compatible with broadacre farming MHE has measured the wind resource at FRWF for over 2 years and has established that it is an economic resource
13		Opposes the wind farm proposal.	
14		Concerned with reports land values will be decreased. Advise if they had known of wind farm may not have purchased the land. Concerned with electromagnetic interference as farm uses GPS and impacts of turbines on aerial and farm plane use. Has visited wind farm in SA and does not support its development in the area due to noise and visual intrusion. Questions the overall viability of wind farms and use of government funding. Advise in the Eastern States 2MW wind turbines are being pushed to 2km from houses and we need to learn from that experience. Questions how given the negative effects highlighted, can governments approve the wind farm which benefits a few and an offshore energy company. Believe the negatives outweigh the positives 10 fold and hope the Shires do not give the go ahead for the project.	MHE has supplied research papers to Shire addressing this issue See EMI & Airspace reports See Noise Impact and Landscape and Visual Assessment Report WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available MHE is a locally owned company Benefits of FRWF see Environmental Impact Report
15		Oppose the proposal for the following reasons: • Negatives outweigh positives. • Concerned about falling land values citing examples in Eastern States. • • Comment it is dangerous to fly aeroplanes near turbines citing USA study.	Benefits of FRWF see Environmental Impact Report MHE has supplied research papers to Shire addressing this issue See Airspace report

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		• Concerned about health effects citing Victoria's experience. • Concerned about impact on local fauna (have cockatoos) that nest and migrate through bush.	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See Flora, Vegetation and Fauna Assessment Report
16		Do not support the wind farm proposal. Concerned with reports on adverse health effects from wind farms and recommend the Shire seek independent advice before proceeding. Comment on Waubra examples. Concerned the project is being sped through and not allowing adequate consultation. Concerned some turbines will be less than 1km from homes whilst European studies recommend several kilometres. Do support wind farms generally and renewable energy. Reiterates need for the Shire to conduct independent investigations.	WA has different planning regulations to Vic – Windfarms have been operating in WA for 25 years MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health No turbine is closer than 1km from a residence
17		Supports the wind farm. Commends the forward thinking proponents and highlights the business/workforce benefits. Believes it will promote a positive forward drive for the town. Believes the negative group do not have credible arguments or scientific support. Comments it would be a shame to lose the project due to opposition. Reiterates support for the project.	
18		Have been prompted by the Flat Rocks Wind Farm to research wind farms. Include questions and concern from their research for consideration. Believe the evidence supports the application being refused and whilst not an easy decision, it is the correct decision for the community. Have consulted with friend who has done a great deal of research into effects of wind farms and included copies of various articles and web discussions on wind farms and their adverse health effects including from Victoria (Waubra and Dean report) and overseas. Concerned about impact on farm animals. Advise they have researched the National Health and Medical Research Council (NHMRC) and	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health

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		believe their views may be influenced by the Federal Government's commitment to having 20% of power generated by renewable resources by 2020. Consider some of the comparisons used by the NHMRC are irrelevant and relies on outdated research. Advise that their claim that 'There is currently no published scientific evidence to positively link turbines with adverse health effects' is contrary to the views of Dr Sarah Laurie (Waubra Foundation) who acknowledges that whilst there is no peer reviewed independent evidence, this does not mean there is no problem and calls for research to be done. Repeat request for application be refused.	See additional comments
19		Requests given emotion and controversy being evoked within the community, Council should not make hasty decision. Council should only make decision when satisfied there will be no negative impacts on: • Health and well being of nearby residents. • Ecological and visual environment. • Land values of properties. Urge Council to research issues around wind farms, including those in Victoria where 2km buffer from neighbours is in place.	See all reports MHE has supplied research papers to Shire addressing this issue
20		Are neutral on the wind farm proposal but do have concerns that should be addressed before the Shire makes a decision. They have received conflicting information and some issues have been difficult to determine. Concerns include: • As no final layout for turbines is available, they are unable to determine the impact on their house and farming operations. • Research indicate wind farms can have adverse health outcomes if living near a turbine and without knowing the precise distance to the nearest turbine and the reliability of available information makes it difficult to make an informed decision. • The marketability of their property adjacent to a wind farm. • Question if there are adverse outcomes from the wind farm, will the company be prepared to negotiate settlements satisfactory to all parties. • Seek clarification regarding no-fly zones around the wind farm as this may affect aerial spraying and recreational flying on and around their property. Request to be kept informed about the outcomes of the submissions received by Council to	See Environmental Impact Report MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue Common law exists for this purpose should it arise See Airspace report

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		assist them reach an informed decision.	
21		Object to the proposed wind farm for the following reasons: • It is being developed as a private venture and cannot be allowed to run powerlines through their property without compensation. • The powerlines will compromise the viability of our farming operation. • The powerlines through their property decreases the value of the land.	Should MHE need to run powerlines through private property it would enter into compensation negotiations Stage 1 Kojonup – will not run powerlines on any land external to the development zone
22		Concerned about proposed wind farm without sufficient research into effects on residents. Advises turbines will encroach on best farming land in WA and land would be better used to feed starving world into the future. Comments there needs to be a lot more investigation into where turbines are located before permission is granted.	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health After completion the FRWF will occupy around 1% of land and is compatible with broadacre farming
23		Opposes the wind farm for the following reasons: • Will create visual pollution and detract from the natural surroundings of the site and given the 146m height will be visible for some distance in all directions. • Concerned about health impacts and refers to various websites etc. including citing Dean report, International Symposium, Dr. Nissenbaum's research and Dr. Amanda Harry's research. • Lack of community consultation and questions proponents commitments to consultation in the past. • Concerned that if wind farm approved then 'flood gates' would open for further applications. Urges Council to look into adverse impacts and consider if Kojonup really needs a wind farm and reject the proposal.	See Landscape and Visual Assessment Report MHE has supplied research papers to Shire addressing this issue Benefits of FRWF see Environmental Impact Report
24		Objects to the wind farm for the following reasons: • The effect on the health of people who live close to the wind towers. Provides details (including Waubra Foundation report) to support comments. Suggests waiting until more information is available rather than risk consequences. • The downward effect on land prices. Advise there will be an effect on the price of land.	MHE has supplied research papers to Shire addressing this issue Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire

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		Advise they don't want to live near the windmills and others think the same which affects the desirability of the land and its price. • The danger of wind farms. Highlights the history of wind farms starting fire and provided details from 'The Times SA (4/11/2010)' to support claim Urges the Shire to consider the divisive nature of the proposal as few benefit whilst the many neighbours are seriously affected and receive no benefit.	addressing this issue See Environmental Impact report for Fire safety
25		Raises concerns regarding the wind farm as follows: • Comments the studies released in 2010 regarding health issues with Waubra wind farm in Victoria is enough for Shire to realize it should not be considered. • Are aware of health issues on humans, but questions what are the impacts on livestock. • Question of it is fair for farming families to live next to turbines. • Advise studies reveal value of properties can drop as much as 30% with turbines close by, which is unacceptable. • Comments that the Shire is meant to be progressive and encourage families to the district. These wind turbines will be a sure way of decreasing numbers at school ands stop newcomers considering Kojonup as an option.	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue Benefits of FRWF see Environmental Impact Report
26		Provide the following comments: • Existing primary production activities will not be affected by proposal and that will provide additional income through their involvement. • Support this form of green energy. • A wind farm is far more acceptable in the landscape than the Collie mines. • Reports conclude very little impact on local flora/fauna. • Are parents of 4 small children and have heard and found sources of unsubstantiated health concerns surrounding wind farms and their own research provided evidence of no risk of adverse health effects. • See an opportunity for local employment and see it providing prosperity for the region. Reiterate support for the proposal and urge Shire to grant approval for the wind farm.	
27		Would have been happy to support project if there were no ill effects. Following investigation appears to be a very high chance of financial and health effects from the wind farm. Cannot condone project that sacrifices some of our own for the benefit of others. Proposal should not proceed.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue

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			New Research by Prof Gary Wittert – shows NO LINK between WT & health
28		Objects strongly to the proposal. Comments there are many adverse health issues involved with wind turbines. Comments no need to increase health issues within the community. Advises time available for discussion and comment and discussion on the proposal was appalling. Comments that town welcome signs should be changed to warn of turbine affects.	Prof Gary Withert – recent study of 10, 000 people and PBS data near 4 Australian wind farms shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health Benefits of FRWF see Environmental Impact Report
29		Many reasons to be opposed to the development. Feel timeframe for submissions was very short given time of year. Advises appears to be widespread ignorance in the community of the proposal with some not knowing of the application. Oppose the development and have the following concerns: • Health issues including flicker and infra-sound. • Loss of visual amenity. • Decreases in surrounding property values. • Adverse impacts on present farming operations including aerial spraying, chemical drift. • • Electromagnetic interference to television, radio, GPS, microwave links 2-way radio. • Impact on bats and Carnaby's Black Cockatoo. • Haste to commit to wind energy will stifle development of more appropriate forms of renewable energy such as biomass, thermal, solar, wave technologies. • Buffer zone of at least 2km from wind turbines is acknowledged as minimum required to have lesser impact on neighbours (for smaller turbines than proposed by Flat Rocks Wind Farm). Reiterate opposition to proposal.	MHE has supplied research papers to Shire addressing this issue See Shadow Flicker report See Landscape and Visual Assessment Report MHE has supplied research papers to Shire addressing this issue After completion the FRWF will occupy around 1% of land and is compatible with broadacre farming; See Airspace report See EMI report See Flora, Vegetation and Fauna Assessment Report WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available

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30		Advise many people are uninformed about wind farms and the associated problems. Advise people are unaware of the ramifications of the proposed wind farm and believe all residents should be informed to understand the impacts on close neighbours and the general community. Advise wind farms are not tourist parks, they are industrial and commercial installations. Are concerned as follows: • Health Highlight health issues to those living close to wind farms from around world and particularly low frequency noise from Dr Michael Nissenbaum's research into health effects from industrial wind turbines. The research found people within 1.5km of the turbines were affected and the health improved as the distance to turbines increased. Their research also identifies some people up to 4.5km from the turbines were affected. Advise it would be unwise in rural areas were mental health issues suffer from a lack of resources to build any facility which could exacerbate these issues. Given the 20-year life span of the proposed wind farm they are worried about any prolonged exposure to low frequency noise. Identify blade flicker and high blood pressure reports from people living within 5km of wind farms in South Australia. • Noise Highlight noise concerns particularly low frequency noise. Advise some wind farm operators have complained they cannot comply with noise regulations. Advise it is not possible to predict noise levels and a source of common complaint. The impacts should also consider the feeling of the noise and vibrations from the low frequency impacts. • Visual Impact Advise chose house site for picturesque views and comment the proposed turbines will be as tall as the Sydney Harbour Bridge. Comment that 74 turbines would have significant visual impact combined with a red flashing light and question of this creates the best site for a wind farm. Comment the turbines will be taller than those at the Albany wind farm. Advise area is renown for its natural beauty and high productivity giving it high aesthetic and monetary value. Believe these would be compromised by the proposed wind farm and property values have been affected by the development of wind farms. Advise compensation has been awarded when property value has been compromised by the proximity of a wind farm.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See Shadow Flicker report MHE has supplied research papers to Shire addressing this issue See Noise Impact Report See Landscape and Visual Assessment Report MHE has supplied research papers to Shire addressing this issue

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		• Buffer Zones Advise that Europe and America require 2km buffers from dwellings. These recommendations were made for small turbines and larger buffer zones should be considered to larger turbines to lower risks. Consider it essential the buffer zone be 2km from property boundaries otherwise it precludes future dwellings being built and could render large tracts of land incapable of being built on. Advise legal proceedings could arise if a landowner near a wind farm wants to build or subdivide. Advise of law suits around the world for violation of permits and adverse impacts. Comment on effects of wind turbines on aerial spraying and farm plane use.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available
		• Electromagnetic Interference The proponents acknowledge wind farms do impact on GPS, radio and television systems. The proposal does not specify what might constitute unacceptable interference. Dispute claims by proponents about consultation with licensed radio operators as 2 operators have not been consulted, including 1 who would be affected. Will exacerbate problems with mobile phone signal coverage.	See EMI report
		• Fauna Dispute proponent's claims that fauna are not threatened by the wind farm proposal. Advise Carnaby's Black Cockatoo, Australasian Bittern (around Ngopitchup Swamp are all vulnerable from the development. Also comment about bats which will be affected by the wind farm.	MHE referred the FRWF project to the EPA in Feb 2011 – Deemed NOT ASSESSED See Flora, Vegetation and Fauna Assessment Report
		• Cost Comment on the expensive nature of wind power and question the stated capacity figures. Are concerned if the proposed on-site substation was to be located close to their property or dwellings. Dispute the reductions in world CO_2 emissions from the proposed wind farm. Recommend government funds be used for alternatives such as biomass or solar thermal power generation.	Not relevant to DA process
		• Funding Question funding for the proposed wind farm and what happens if the energy company is liquidated. Sees possible parallels with agroforestry plans and tax breaks driving industry development rather than longer term alternative sources such as biomass or solar thermal power which may be cheaper.	Not relevant to DA process
		• Construction Question claims of local employment opportunities that may arise from the development	Benefits of FRWF see Environmental Impact

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		of the wind farm. Question who will pay for road and bridge upgrades. Comment that road reserves will have to be cleared and electrical cable put underground, possibly also through road reserves. Concerned about consultation claims by proponents as some residents including Broomehill-Tambellup Councillors have only recently become aware of the project. Question who the proponents spoke to if some Councillors were unaware of the proposal. • Biofuel Believe the wind farm may threaten other alternative industries such as oil mallees and will benefit 6 farmers rather than 100's. Wind farms may take line capacity using public funds discriminating against other technologies such as biomass. Growing oil mallees could assist lower water tables and help fight salinity. • Decommissioning of Wind Farms Advise current proposal is for 20 years and question if the turbines will then be decommissioned. Comment on the high cost of decommissioning and questions if the proponents can guarantee removal rather than left to fall into disrepair. Question if solar or bioenergy becomes more developed will turbines be decommissioned earlier. • Accidents Advise of web report on wind farm accidents. • Solar Power Quote Nobel-prize winning Professor Jack Steinberger advise that wind power is not the future, thermal solar is. • Tourism Suggest claims that wind farms could become tourist attractions are not borne by overseas experience where wind farm as tourist attractions are closing due to lack of visitors. • Community Advise wind farm proposals are divisive to communities. Those who benefit are 'pro' and close neighbours are adversely affected outlined in this proposal are much opposed. Have spoken to 12 neighbours and all are opposed to the development. Advise of August 2008 meeting which did not include several people affected by the	Report Not sure how Broomehill-Tambellup Councillor only JUST aware as MHE submitted planning application to the BH/TA council for wind monitoring mast in 2008 See Environmental Impact Report MHE must comply with all relevant regulations and laws during construction and operation of the FRWF including occupational health and safety

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		proposal, although the proponents claim that landowners within a 10km radius were invited. This approach was similar to a meeting organised in September 2010. Advise of difficulty obtaining information and signing confidentiality agreements. Question the need for secrecy. Advise rural communities are small places and are distressed to see the negative effects wind farms can have on people. Advise wind farms may have place in energy production, preferably on large farms in single ownership where impacts would be far less than an area comprising several smaller farms with many neighbours impacted by the turbines.	
31		Advises proposed wind farm may have detrimental impacts on Carnaby's Black Cockatoos as it lies within their annual migration path and highlights data from the United Sates on bird deaths from turbines and powerlines. Enquires if the powerlines will be underground. Advises Forest Red-tailed Black Cockatoo and Australasian Bittern may also be vulnerable. Recommends power generation be closer to settlement centres with solar being more reliant than wind.	MHE referred the FRWF project to the EPA in Feb 2011 – Deemed NOT ASSESSED See Flora, Vegetation and Fauna Assessment Report
32		Does not support wind farm on the following grounds: • The loss of visual amenity. • The impact on neighbouring land values. • The strong evidence of significant health issues. • The impact on land based and aerial spraying operations. • The serious rifts that might emerge at a community level. Provides the following additional comments: • Electricity Production and Renewable Energy Sources The claims for wind farms are driven by profit motives for a few rather than economic and social benefits to the general community or greenhouse emissions it might remove. Includes detailed comments to support claims. • Request for Consideration in Planning for a Wind Farm Suggests the following actions to deal with present and future wind farm applications: 1 Consider declaring the shires a no go zone for wind turbines as exists in Victoria fro areas of high aesthetic value or to preserve valuable farm land.	See Landscape and Visual Assessment Report MHE has supplied research papers to Shire addressing this issue MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See Airspace report

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		2 If 1 is not adopted, a 2km exclusion zone is declared from property boundaries for 2MW turbines and larger for bigger turbines as exists in Victoria.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available
		3 That any adverse impacts including noise, GPS, television and communication signals interruptions there is sufficient resources and legislative powers available to enforce compliance.	See EMI report See Noise Impact Report
		4 That the Shire considers a biomass plant as an alternative and its positive benefits.	
		5 That consideration is given to remove hosting landholders waiving setback provisions to their dwellings as a protection mechanism for children/employees who live on that property.	
		• Land Values States the proposed wind farm will detrimentally affect property values and farm liquidity. The effect will be determined by its actual impact and level of intrusion and annoyance. Provides comments from national real estate agent showing negative effect on value of adjoining lands to wind farms and any loss of equity needs to be recovered from those who caused the loss. This is one of the reasons we rejected their proposal to site turbines on our properties. Provides copy of article from The Australian 27/11/2010 on the decisive nature of wind farm proposals within communities.	MHE has supplied research papers to Shire addressing this issue
		• Impacts on Agricultural Pursuits The impacts of turbines on neighbouring properties need to be considered. Advise the Senate Standing Committee on Community Affairs will report on their investigations into the impacts of rural wind farms in April 2011. Provides a copy of the Aerial Agricultural Association of Australia submission to the inquiry which highlights that wind farms are leading to reduced treatment areas with no compensation available. This supports their call for a 2km buffer to wind farm boundaries.	See Airspace report
		• Health Problems Considered the most serious of all areas and warrants a conservative approach given the reported health impacts. Provides a copy of Senate submission from South Australian Local Government and advises there are 28 residences within 2km of the boundaries of the hosting properties. Recommend they be located in areas of unproductive such as north of Perth on land preferably near the coast. Provides comments and news report (single copy with the CEO's Executive Assistant) from noise impacts from Waubra to	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health

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		support claims. • Alternative Renewable Energy Sources Supports the development of biomass energy plant as an alternative to wind farms and provides supporting information on tree energy crops. • Moonies Hill Planning Submission 1 Wind Farm Benefits 4 – Disputes claims by proponents on saving CO_2 emissions. 2 Consultation 8 – Dispute claims by proponents that all landholders within 10km radius were consulted and there are references to the concerns raised at the meeting. 3 Fauna 9.4 – There is no mention of Carnaby's Black Cockatoo found in the area or Ngopitchup Swamp. 4 Electromagnetic Interference 9.6 – Do not accept any level of interference. Dispute claims by proponents about consultation with licensed operators as they have not been consulted, nor have Bush Fire Brigades. 5 Shadow Flicker 9.8 – Are concerned if flicker intrusion of 30hrs per year is acceptable and commitment to value neighbours well being is required. 6 Conclusion 10 – Dispute proponent's claims of community and landowner support. • Conclusion Provide information on power generation prices in WA and Eastern States. Comments that coupled with evidence of health impact and decreased property values and visual pollution, the Shire should oppose the application. Submission includes additional information on DVD including ABC Stateline report on Waubra wind farm.	Need more info to comment See Flora, Vegetation and Fauna Assessment Report See EMI report See Shadow Flicker report
33		Has seen the landscape changing and believes the wind farm is another progression and fully supports the project. Expects any change in the community to provide both positive and negative reactions. Comments on misinformation being used by some people opposed to the project and requests all information is verified and creditable. Encourages the community to embrace the wind farm proposal and lists the following benefits from the project: 1. Socioeconomic Benefits The wind farm will provide direct and indirect employment opportunities for Kojonup and the region including 200 construction jobs and expect local residents to secure employment. Advise local electrician has contacted them re employment already. Following commissioning 10-15 permanent jobs will be created.	

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		The wind farm will increase the viability of individual farmers as the turbines will generate extra income. Advises the land area occupied by the wind farm equates to 1% so normal broadacre agriculture can proceed with minimal impact. Believes the wind farm will broaden economic base of the district including some tourism. Advise the proponents have discussed the opportunity to combine a visitor area/viewing platform and local museum with local collector. Expects the project to inject $30m into local community business through accommodation services, catering, building and constriction supplies, finance and trade and labour related services. 2. Environmental Benefits Highlights environmental benefits of project. The environmental report by Mattiske Consulting concludes there are no impediments to the development of the wind farm. Reiterates comments on misinformation being used by some people opposed to the project and believes the information is not from scientific peer reviewed sources. 3. Impacts of the Proposed Development Human Health Is aware of concerns raised when wind farm developments are proposed. Quote National Health and Medical Research Council report that there is no published scientific evidence to positively link wind turbines with adverse health effects. Advise to ensure residents are not affected; the proponents have completed studies on noise, flicker/glint, electromagnetic interference to comply with WA Planning Commission Guidelines for Wind Farm Development. This is supported by Clean Energy Council paper (November 2010) which concluded there is no evidence of direct or indirect health effects provided all planning guidelines are adhered to. Property Values Acknowledges the increased debate about wind farm developments and property values. Quotes Henderson and Horning (2006) report in NSW which looked at property values and concluded the underlying agricultural productivity of the land is not affected. Advise this is supported by UK and NSW Valuer General (2009) research. Provides summary of the NSW paper. Effects on Birds and Livestock Advises their reports conclude the wind farm does not pose a threat to rare or endangered birds. Advise there is no impact on livestock from the turbines.	

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		Reiterates support for the proposal due to benefits outweighing unsubstantiated claims of harm.	
34		Outlines History of association and industry. Don't support the wind farm as they monopolise opportunities for their industry to develop. Believe the wind farm will have significant detrimental impacts on the rural area including health, fall in land value and reduced agricultural production. Provide details and supporting reports promoting development of oil mallee industry. Provide details and supporting reports to show adverse health claims being experienced elsewhere in the world (referred to by other submitters such as Dean and Waubra reports). Provide details regarding loss of land values (including similar comments from McIntyre and Aerial Agricultural Association of Australia referred to by other submitters). • Approval for the wind farm be refused. • The Shire seek advice from Verve and IMO re capacities of wind farms. • That the Shires inform the State Government of ratepayer concerns relating to process of approving any wind farms. • The Shire commission a regional energy plan. • The Shire request more information on the nature of the leases and decommissioning of the site. Provide a number of reports/papers supporting their claims including Oil Mallee - A Natural Solution, Energy Tree Crops, and Oil Mallee Industry Development Plan for WA.	
35		Oppose the wind farm. Raise concerns as follows: • Health Have provided copy of letter by Dr Sarah Laurie to Victorian Premier requesting further research is conducted into health problems to residents from wind turbines. • Land Values Have provided comments from national real estate agent showing negative effect on value of adjoining lands to wind farms. • Electromagnetic Interference Question assurance to fix television interference. Application did not deal with electromagnetic interference to GPS, microwave, radio receptions. Use GPS systems and cannot afford to have it affected by wind farm.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue See EMI report

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		• Aerial Spraying Concerned those aerial spraying areas will not be available due to turbines. Concerned about right of entry and weeds and footrot spreading.	See Airspace report
36		Has supported the project since 2007 based on positive economic benefits for Kojonup and Great Southern and positive environmental benefits for WA. Comments on level of public discussion and advises the proponents have been thorough and complied with guidelines and completed necessary studies. These are specific to the project rather than based on anecdotal evidence or projects that may be governed differently. Highlights some of the community concerns are provides the following responses: • Exclusion Zones – the exclusion zones used by the proponents are 1km from sensitive residences as required by planning guidelines. The community assumption it is 800m is false. Comments the WA planning guidelines are the strictest in the world. • Health Concerns – there is no evidence that wind turbines affect health. Evidence may deal with turbines less than 1km and often less than 500m from sensitive residences. Advises health concerns are dealt with in National Health and Medical Research Council paper 'Wind Turbines and Health July 2010'. • Property Prices – There is no evidence that wind farms affect property process. Seasonal conditions and commodity process are considered more likely to influence prices. This has been researched in NSW Valuer Generals paper 'Wind Farms and Property Prices (Duponts August 2009). Highlights the positive economic benefits from the project including employment, development of community fund and funds injected into the local community to create opportunities that do not exist locally. Advises will continue to support the project and trusts Councillors will seek facts about the development of this proposal.	
37		Request the Shire not approve the wind farm until there has been consultation between the proponents and landholders affected by the required power line as it will affect their farm and value of the land.	Cannot comment until submitter is identified
38		Have sought information on the impacts of wind farms and now oppose the proposal for the following reasons: • Health Issues Have visited Albany wind farm and do not want to live close to a wind turbine. Highlight reported health problems some up to 4.5km from turbines.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue

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		• Impact on Land Values Comment there is no benefit for people living near a wind farm and the turbines will negatively impact on neighbouring property land values. Would not purchase land adjoining a wind farm and expect most people would have a similar opinion. • Visual Pollution Concerned with location and height of turbines. Will create an eyesore on the rural landscape and a number will be visible from their house. • Land and Aerial Spraying Operations Comment that impacts on spraying can not be determined until after the turbines have been erected and this is too late. Any impediment to continue existing farming operations should be avoided. Provide copy of article from Illinois Aerial Aviation Association regarding aerial spraying operations for consideration. • Renewable Energy/Community Benefits Their research identified that wind turbines are inefficient and recommend a biomass plant as a more suitable alternative. Provide copy of comments from Oil Mallee Association on the proposed wind farm. • Liability Concerned that if the wind farm was built, legal action may be required to have later impacts addressed. Advise there are 20 houses less than 4.5km from the proposed turbines. Comment that experience in Victoria shows they will be affected and the site is not appropriate. Urge Council to strongly reject the proposal.	New Research by Prof Gary Wittert – shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue See Landscape and Visual Assessment Report See Airspace report See Environmental Impact Report Common law exists for this purpose should it arise
39		Concerned about the development of the wind farm and believe it is not in the best interests of the community. Raise following concerns: • Health risks from noise and flicker. Advise 28 houses are within 2km of the turbines and health issues affect those within 4.6km. • Still need base load power stations when wind fails. • May further wind farm developments exacerbating resident concerns. • Research shows wind farms are inefficient and are using alternatives. • There has been no consultation, despite Moonies Hill's claims they have good community support. • Question proponents address.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health

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		• Comment that govt funding should not be available for these types of private projects that only benefit project shareholders and not the wider community. • Turbines will prevent aerial spraying operations. • The wind farm will disrupt radio communication. • The wind farm will create visual pollution from many kilometres around including Kojonup townsite. • The potential for negative impact on birds in the locality particularly threatened species. Comment that Kojonup is a cohesive community and the proposal has been divisive where a few investors will benefit and the general community will pay the cost.	See Airspace report See EMI report See Landscape and Visual Assessment Report See Flora, Vegetation and Fauna Assessment Report
40		Advise are dealing with similar application concurrently and provide no other comment at this stage. Advise that proponents will be required to meet costs of any necessary road upgrading and maintenance requests.	
41		Advises benefits will be great from a personal and community point of view. Suggests Kojonup faces many challenges to remain vibrant and the wind farm development would assist address these challenges. Comments as follows: 1. The local population has been in decline and the older generation are not being replaced by younger generations. Believes the wind farm development will expose the town to many people during constriction and offer 10-15 permanent positions after commissioning to help reverse this situation. 2. There has been a decline in local rainfall and scientists predict this trend will continue. Reduced rainfall may affect productivity and the district fortunes. Believes the wind farm will broaden economic base of the district and be used to leverage other industries. 3. The wind farm will increase the viability of individual farmers as the turbines will generate extra income. Acknowledges present development only benefits small number of farmers and nothing stops future other developments. 4. Advises as a proponent has undertaken significant research on effects of wind turbines on health and environment. Believes that the views will be altered and health effects can be dealt with by applying state planning guidelines. Comments some arguments about health impacts are weak. Would not support a development that put family or community at risk. 5. Reiterates support for the project due to overall benefits. Comments on disappointment about misinformation being used by some people opposed to	

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		the project. Would prefer people checked information. Comments on possibilities of innovation and change or unwillingness to change and miss an opportunity.	
42		Objects to the wind farm as it conflicts with their policies. Provided copy of previous correspondence to Federal Minister for Infrastructure and Transport regarding wind farms. Advise their formal policy is to automatically oppose wind farms unless the developer can demonstrate that: 1. Consulted honestly and in detail with local aerial operators. 2. Sought and received independent expert opinion on safety/economic impacts of the development. 3. Clearly and fairly identified there will be no sort/long term impacts on aerial application. 4. If there is an impact, provided legally binding agreement for compensation over a fair period of years for loss of income to aerial operators affected. Advise they do not provide specific comment on particular proposals due to the site specific nature and variety of proposals. Reiterate recommendation that wind farm developers undertake tasks 1 and 2 above. Believe that all wind farm infrastructure be clearly marked to assist pilots and all infrastructure be removed when no longer in use. Outline the organisations history, purpose etc. Provide copies of their policies relating to wind farms and powerlines.	See Airspace Report
LATE SUBMISSIONS			
43		Provided copy of advise to proponents on assessment of proposed wind farm as follows: • At a maximum height of 526m (1726ft) AHD, some of the proposed wind turbines will affect the Katanning Aerodrome 25 Minimum Sector Altitude (MSA) procedure. No other sector or circling altitude, nor any approach/departure procedure at Katanning is affected. Please note: The maximum allowable height for any wind turbine associated with this wind farm is 522.7m (1751ft) before the 25 MSA procedure is affected. • This wind farm will not impact the technical performance of Precision/non-precision Navigation aids, HF/VHF Communications, A-SMGCS, Radar or Satellite/Links. • If applicable to Katanning, no assessment was conducted in relation to Naverus designed Navigation Performance procedures or any other procedures designed by external providers.	See Airspace report

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		• These comments are provided for information and advice to the Shires of Broomehill – Tambellup and Kojonup to fulfil their consultation requirements.	
44		Provided copies of articles from The Border Watch newspaper in Mt Gambier SA regarding an approved wind farm and landholder/community opposition to it.	
45		Provided response to questions from the Shire as follows: • Advice there is no specific timeframe to review Planning Bulletin 67 'Guidelines for Wind farm Development'. Advise the Environment Protection and Heritage Council 'National Wind Farm Development Guidelines – Draft 2010' will be released mid-2011. This may require updating of the policy and planning bulletins to reflect the new guidelines and other State initiatives towards renewable energy. • Advise the Shire should follow the guidance in Planning Bulleting 67 in response to wind farm applications. • Other guidelines that the Department uses to assess wind farm proposals are: - Visual Landscape Assessment in Western Australia: A Manual for Evaluation, Assessment, Siting and Design, Part 3 Utility Towers, Wind Farms (pp. 128-136); - Best Practice Guidelines for Implementation of Wind Energy Projects in Australia (Auswind 2006); - Environment Protection and Heritage Council 'National Wind Farm Development Guidelines – Draft 2010'; and - Any specific local planning scheme provisions (if applicable). • Advise the Department's response to the Senate Inquiry is directly aligned to this response, in regards to environmentally and socially responsible wind farm development. Advise the Department's response was specifically related to buffer requirements. • The Department's advice regarding suggested buffer distance (as contained in Planning Bulletin 67) notes the setback distance is only suggested as a guide: *'As a guide, the distance between the nearest turbine and a noise-sensitive building not associated with the wind farm, is likely to be 1km. The ultimate distance between sensitive sues and the wind turbine, may be determined on the basis of acoustic studies'* pg 4, Section 6.2 Noise. • Advise the Environment Protection and Heritage Council 'National Wind Farm Development Guidelines - Draft' (July, 2010) do not state a specific buffer distance as each jurisdiction has differing statutory requirements. In the case of noise-sensitive areas/residences, the draft Guidelines recommend noise impact assessment be completed, as does Planning Bulletin 67. The buffer distance would then be determined	WAPC PB67 - the relevant legislation in WA. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available See Landscape and Visual Assessment Report See Noise Impact Report

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		on a case-by-case basis, as an outcome of the noise impact assessment. • The Department supports the above advice in relation to buffer distances for noise-sensitive areas.	
46		Has provided copy of papers provided with talk given by Roger Bilney to Kojonup Rotary Club (28/4/2011) regarding wind farm developments and their impacts and additional information from various sources (Senate Committee Hansard – Pyrenees Senior Town Planner evidence, Pacific Hydro Pty Ltd evidence and Dean report (p.153)). Questions whether very large turbines in relatively populated areas is the best way of providing power? Questions whether the setback form turbine to homes is sufficient (advises WA does not have regulation setback at this stage)? Questions whether the setback should be from the boundaries of neighbours rather than from the existing homes (to allow neighbours to use their land as they wish)? Considers that until further research into health issues and setback distances has been completed, the best decision might be to put the project on hold.	Population in the development area is 0.2 people/km^2 or 1 person/km^2 WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health
47		Has provided copy of Flat Rocks Wind Farm Fact Sheet with information on the wind farm project, the reasons for building it in the Flat Rocks area, the benefits derived for the Great Southern Region from the project (financial, employment, tourism, community fund established etc.) and an opportunity to provide comment to the proponents till 3/6/2011.	
48		Provided response to questions from the Shire as follows: • NHMRC have commenced process of updating the Rapid Review document. Have commenced looking for new evidence and will hold workshop in June with experts and community members and government to identify key issues surrounding wind turbines and possible health effects. Advise not possible to say when work will be completed. • Advise purpose of Rapid Review was to present findings from evidence search from	See additional comments relating to health impacts of electricity generation

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		current literature on potential impacts of wind turbines on human health. Planning issues are beyond scope of the Rapid Review. The NHMRC Council acknowledges public concern about impacts of wind turbines and advises a precautionary approach is required (and that individuals seek medical opinion should they have concerns). • Suggest the Shire consider the Environment Protection and Heritage Council 'National Wind Farm Development Guidelines - Draft' (July, 2010). • Advise NHMRC have contributed a submission to Senate Inquiry on the Social and Economic Impact of Rural Wind Farms (Submission 850). • Advise NHMRC is not able to give advice on planning implications. Reiterates considering EP & HC Draft Guidelines and suggests contacting Department of Environment and Conservation and Department of Planning for specific information to WA.	
49		Are ratepayers and community residents concerned with decision process on wind farm proposal. Believe the recent visit to the Merredin wind farm showed only the initial construction benefits. State that the wind farm is not operational and is in a remote location so does not represent a true comparison to the Flat Rocks proposal which is in a populated area. Suggest the Shire consider visiting Ballarat/Waubra wind farm which would be more relevant. Advise the damage to lives and farm operations has been enormous. Advise health is most important thing in our life. Concerned that people originally in favour of turbines no longer able to live in their homes. Advise increasing health effects are starting to be recognised. Advise the quoted response to health issues is there is no scientific proof. This was tobacco companies' response to their health impacts in the past. Question why Federal Government would be having a Senate Inquiry if there were no concerns? Recommend that the outcomes be considered to guide decision making before allowing a permit. Question the rush? Concerned with land values and ability to carry on business without effect. State the objectives for the Rural zone from TPS3. Advise they have heard of a report saying that land values are not affected. Advise this is absolute rubbish. Question if offered 2 pieces of land, 1 with industrial wind farm turbines nearby and the other without any structures , that were otherwise identical, which would you chose? Advise land competition is lessened and land is worth less than it was. Suggest it seems direct	Population in the development area is 0.2 people/km^2 or 1 person/km^2 NOT densely populated Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health Prof Gary Withert – recent study of 10, 000 people and PBS data near 4 Australian wind farms shows NO LINK between WT & health MHE has supplied research papers to Shire addressing this issue

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		transfer of wealth from landholders on and around wind farm to proponents. Are concerned with divisive nature of the project in the community. Concerned with Moonies Hill Energy claims of widespread community support. As direct neighbour, only correspondence received has been from the Shire. Advise until the correspondence received from the Shire, had not been officially informed, despite Moonies Hill Energy claims of widespread community support. Advise most people spoken to after being advised of the proposal were completely unaware of the proposal. Advise consultation process by Moonies Hill Energy has been completely lacking. Concerned the consultation required them to find out where the turbines are to be site, which seems to change. Consequently, believe all direct neighbours are opposed to the project. Advise Shire website did not contain March and April 2011 Council Meeting minutes. As residents, appreciate efforts of Councillors and ask that seel all views before making a decision on proposal that has potential to change lives and community unity.	MHE doesn't believe the community is divided but rather that a small but vocal group has continuously threaten MHE and spread erroneous information about the project and the wind industry in general Unable to comment on project awareness until submitter identified Layouts have changed over the past months, mainly in response to impact studies.
50		Provided copy of submission to Moonies Hill Energy advising oppose the proposal for the following reasons: • Turbines are too close and concerned with wind turbine sickness (lack of sleep, high blood pressure etc.) • Visual impacts – too many, too high, too close (@1km). Question why not site wind farm in an area where neighbouring dwellings are much further away? Advise have researched for and against these 'industrial plants' in agriculture/farm areas. • Too much secrecy/lack of communication with neighbours and possible long term ill feeling between farmers.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See Landscape and Visual Assessment Report See Environmental Impact report for brief summary of consultation process
51		Thanks the Shire for the opportunity to comment and question the proposed wind farm. Concerns: 1. As there are no definitive studies regarding health aspects of living near wind turbines, it would seem to put the Shire in great risk of future claims should they arise from residents close to the turbines 2. Some farming operations will be affected, such as aerial spraying, which may lead to	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health Common law exists for future claims See Airspace report

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		claims for loss of income. The setback distance for turbines from property boundaries can be an intrusion on property rights, restricting location numbers where an owner may build residences in the future. Questions is there any guarantee that the proponents would be responsible in such a scenario? 3. Questions can the Shire be sure it won't be drawn into any foreseen or unforseen legal issues? 4. Currently there are matters with Moonies Hill proposal that are either vague or being altered over the period available for discussion/decision. Request the Shire delay any agreement with Moonies Hill Energy until more certain information is obtained.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available Unable to comment unless the "uncertain information" is identified
52		State the Scheme objectives and objective (c) for the Rural zone from TPS3 and the following points need to be taken into account in the context of the Scheme text: 1. Low Frequency noise – known as infrasound – Health and Safety Advise recent press articles and research shows low frequency sound associated with wind turbines are a major concern to neighbours of wind farms and some have been driven from their homes. Clearly the Shire needs to take notice and be fully aware of all the potential health risks and ensure that any development safeguards the health and safety of the inhabitants. 2. Detraction of Rural Visual Amenity State one of the key functions and objectives of Council is to preserve the rural amenity, which is key quality of living/owning property in the area the subject of the proposed wind farm and the existing property values reflect the lifestyle and enjoyment afforded by the rural aspect and amenity in its current form. Council approval of the wind farm on the planned scale and height, being an industrialisation of the landscape would clearly adversely affect the rural character and amenity including visual amenity. The introduction to the landscape of such enormous man made structures will severely detract from the existing rural character and level of visual amenity for at least 20 years and possibly forever. Outlying low rainfall areas do not have this amenity factor to the same degree as reflected in the different property values for land in the eastern Wheatbelt where such developments are far better suited from an impact on amenity perspective. 3. Site Suitability – proposed development site fragmented and non-contiguous Advise they have had no consultation as to site selection and specific locations, understands no	MHE has supplied research papers to Shire addressing this issue See Landscape and Visual Assessment Report Wind farms need to be sited in proximity to transmission infrastructure

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		specific turbine sites have been given, as an adjoining landowner this is not satisfactory on the sound issue alone. The map that accompanied the application clearly shows 4 groupings or clusters of turbine sites which have been selected which is not suitable as they have a large number of rural properties interspersed throughout, including some of which they own are surrounded on 2 or more sides and some others on all sides, many who are believed to have expressed opposition to the application. Has not been able to find any such example in WA where wind farm is sited in such a manner that is fragmented and non-contiguous and the current application can be likened to an urban area with industrial areas interspersed throughout. Understands this application relates to 6800 hectares and by contrast the Collgar wind farm at Merredin is quite properly sited on some 18,000 hectares. 4. Applicable level of Shire Rates for a $400 million industrial development Queries what category of land is envisaged the development area would be classified and the level of rating proposed. Queries whether it is seriously proposed that a $400 million development employing a number of people and contractors who will be utilising Shire assets will be liable for rates at a rural scale when the generation of electricity for sale is clearly an industrial use. Requests commonsense prevails and Council rejects the application.	
53		Refers to earlier request from Shire for comment and views on the proposed Moonies Hill wind farm. Advises has been seeking information from proponents of the development. Have had no response in a month and anticipates further queries will arise if and when answers are received. Requests advice on status of application and what consultant's reports have been received and likely timeframe for Council to make a decision and whether any opponents will be given the opportunity to make detailed submissions especially in light of Senate Inquiry findings, medical information, and recent legal cases on town planning schemes on loss of amenity and zoning issues. Enquires whether it was applicant or Council that determined what reports would accompany the application as it many key issues have not been addressed. Has a number of serious concerns which have been raised with proponent but remain unanswered. As a lot has happened since the Shire advised of the proposal some 6 months ago, wishes to	Not sure who this is but MHE responded to all submissions in mid August 2011 MHE would like to hear these concerns so they can be dealt with if there haven't already.

Summary of Submissions on Proposed Moonies Hill Energy Pty Ltd Flat Rocks Wind Farm

No.	Submitter	Summary of Submission	MHE Comment
		make further detailed submissions to the comments made previously when questions have been answered by the proponents. Enquires if Shire has obtained any independent expert reports on diminution of land values and adverse health issues that have recently come to light. Enquires as to whether the Shire is aware exactly where each turbine is to be sited and how many are in each Shire. Draws Council to the fact that the development if approved may have serious consequences in relation to adjoining landowners obligations under Occupational Health and Safety Acts and Regulations to provide a safe working environment especially where accommodation is supplied as part of remuneration packages; the potential voiding of existing insurance policies; adverse aerial fire fighting setbacks; foreseeable adverse health issues; foreseeable loss of rural amenity and ensuing diminution in land values. Looks forward to response and submit the proponents should pursue a development in an area with a lower population density unlike where it is proposed where their average lot size is 160 acres and which is clearly in breach of existing town planning schemes of the two affected Shires.	See Environmental Impact Report Population in the development area is 0.2 people/km^2 or 1 person/km^2
54		Believes that wind power may be in the important in the future. Does not believe that landowners should be subjected to them within 2km of their homes. Would be greatly opposed to having wind turbine within 800m of my home and until research is done properly, does not believe any has the right to subject home owners to them without knowing full the health implications or implications to the property value. If property values decrease, then the Shire would have to adjust rates accordingly, very similar to if farmers are constricted in their farming practices because of GM/non-GM issue. Would not like to pay rates at higher rate if value is down. No-one knows the full implications of farmers trying to sell and if turbines will affect hoe quickly they sell. Would like the Shire to move a recommendation that wind turbines be situated at least 2km from a dwelling, regardless of who owns the dwelling. Also the Shire needs to consider the whole of the community, not just a small minority.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available MHE has supplied research papers to Shire addressing this issue This issue was discussed y David Parks at the WA senate inquiry into Social and Economic impacts of wind farms in rural Australia
55		Have concerns with the way that the wind farm industry uses the NHMRC to allay community and policy maker fears of health issues and wind turbines. Advised of Senate Inquiry submission from CEO of NHMRC advising that precautionary approach is required. Advised of the 7 recommendations produced by the Senate Committee and quotes recommendations 3 and 4 and advises that following correspondence from the NHMRC	Precautionary approach is applied to new technologies with unknown effects; Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades.

Summary of Submissions on Proposed Moonies Hill Energy Pty Ltd Flat Rocks Wind Farm

No.	Submitter	Summary of Submission	MHE Comment
		confirming that a precautionary approach should be taken. Highlights this approach in relation to a case before the SA Environment Court. Requests the Shire seek independent legal advice on the matter. Believes the standards set out in PB67 are far from the precautionary approach being 7 years out of date. Advises the community deserve nothing less than best practice and the Senate Inquiry advises that such a code of best practice has not been settled on. Concludes that if the prerequisites for the precautionary principle are satisfied, believes that the Shire has no option but to refuse the application until the scientific uncertainty surround this issue is removed. Included 'Explicit Cautionary Notice' from Waubra Foundation, Details on Directors of Waubra Foundation, Emails from Bilney to NHMRC and responses, Copy of SAERDC 23 [2011} Partridge & Ors v District Council of Grant & Anor.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available This document was posted to all shareholders, directors and participating landowners. MHE is investigating the origin of these letters.
56		Advises no objection to details and submission being included in report to Council. Advises not against wind farms in general as they support generating electricity for renewable resources but have concerns about wind farm developments as far as: 1 Placement of turbines close to boundaries of neighbouring properties as well as residences. 2 The potential impacts on the health of some people living in close proximity to turbines. Included 'Explicit Cautionary Notice' sent from Waubra Foundation which may assist Council in making a decision on Moonies Hill Energy and advises copies provided to Councillors directly.	WAPC PB67 - the relevant legislation in WA does not use mandatory setbacks. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See additional comments
57		Advise whilst not landowners within the Kojonup Shire still maintain links etc with the community. Advise that MHE have withdrawn their planning application for Broomehill/Tambellup Shire due to the planning scheme. Advise MHE have confirmed they will be applying for scheme amendment and will continue to seek approval in both shires. The main issue with wind farms in Australia is they are being sited in inappropriate and socially unsustainable locations. Believe until independent research is conducted into setbacks for health and land value reasons, wind farms pose a danger to communities and their members. It is important that decision makers are aware of the problems with wind farms in other parts of Australia and do want this happening to us. We urge the Council to be adequately informed on all issues on wind farms before making a decision.	MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health

Summary of Submissions on Proposed Moonies Hill Energy Pty Ltd Flat Rocks Wind Farm

No.	Submitter	Summary of Submission	MHE Comment
		Advise Victorian Government has introduced new laws with regards to wind farms and now turbines cannot be placed within 2km from a dwelling without written consistent. Currently in WA the distance is 800m. Adviser the MHE proposal is placing turbines within 1km of people's homes and this will be detrimental to our residents and communities. WA needs to ask why the Victorian government has taken such a strong stance on future siting of turbines and protect the rural population as they are. Advise they are for a cleaner and greener society and are not against wind farming, this project has the potential to ruin our lives and livelihoods. Any decisions made need to be taken with extreme caution.	WA PB 67 states no set backs but indicates a 1km buffer to be checked with acoustic modelling. The WAPC PB67 manages development impacts through some of the most stringent noise standards of any global wind turbine planning rules available
58		Does not envy the very hard decision to make on the MHE proposal to build an industrial wind farm at Flat Rocks. Advises not opposed to generating electricity from renewable resources such as sun, wind and wave but has grave concerns about positioning of wind turbines close to human habitation and neighbour's boundaries, because of health concerns as well as inhibiting what a landowner can do on his/her property. Included copy of newspaper article from Warrnambool Standard regarding decision by Moyne Council (Victoria) on wind farm. Advises also has other information ion health issues and from NHMRC which can be supplied if required.	Wind turbines are not NEW technology. Tens of thousands of people around the world live near wind farms without suffering ill effects. Many have done so for several decades. MHE has supplied research papers to Shire addressing this issue New Research by Prof Gary Wittert – shows NO LINK between WT & health See additional comments

78 Pensioner Road Kojonup
Western Australia 6395
T:+0419 864 493
F:+61 8 9831 1608
E:info@MHEnergy.com.au

24 October 2011
Mr Stephn Gash
CEO of Shire of Kojonup
PO Box 163
KOJONUP WA 6395

Dear Stephen

RE: DEC comments on Noise Assessment

Following our meeting on 19th October 2011, it was requested that MHE provide some comment on the report prepared by DEC in relation to the Flat Rocks Wind Farm Project. In particular clarification was sought on the jurisdiction of turbines and residences presented in Table 3 of the report prepared by Mr John Macpherson, Principal Environmental Noise Officer.

Firstly MHE would like to point out that the report confirms the conclusions presented the Flat Rocks Wind Farm Noise Impact Report prepared by Herring Storer Accoustics, that the 74 turbine layout presented for consideration by the Shires or Kojonup and Broomehill/Tambellup complies with all relevant state noise legislation, ie Guidelines presented in WAPC Planning Bulletin No 67 and the EPA Noise Regulations 1997.

In his report John Macpherson made reference to the consideration of moving turbines located within the vicinity of the residential locations shown in Table 3. MHE would like to point out that this would only be necessary if the final turbine choice and noise modeling and impact curves showed that the aforementioned noise regulations were not complied with. MHE is well aware of its commitment to meet all noise regulations relevant the development of a wind farm in Western Australia.

Of the residences listed in Table 3, only the proposed residence NSH34 is influenced by wind turbine generators (WTG) located in the Shire of Kojonup. All other residences listed in Table 3 are located near WTG located in the Shire of Broomehill/Tambellup and fall outside the jurisdiction of your Council. Several of the residences listed above are however located in the Shire of Kojonup. For your reference these residences are identified as;

- NSH03, NSH12, NSH13, NSH14 (? Occupied?), and NSH34 as mentioned above.

As stated above, MHE is aware of the “marginal” compliance for these residences and will monitor very carefully this section of the development during all pre construction investigations and planning to ensure compliance with all relevant state legislation.

Table 3: Comparison of predicted noise levels with alternative background noise criteria for some receiving locations

Receiving / background location	Predicted / Criteria	Predicted noise level / *Noise criteria*, dB(A)				Exceedance, dB
		6m/s	7m/s	8m/s	9m/s	
NSH03	Predicted	27	31	36	36	
Loc 6	*Criteria*	*35*	*35*	*37*	*38*	*Complies*
NSH04	Predicted	28	32	36	36	
Loc 6	*Criteria*	*35*	*35*	*37*	*38*	*Complies*
NSH12	Predicted	27	31	37	36	
Loc 6	*Criteria*	*35*	*35*	*37*	*38*	*Complies*
NSH13	Predicted	26	30	36	36	
Loc 2	*Criteria*	*35*	*36*	*37*	*39*	*Complies*
NSH14	Predicted	27	31	37	37	
Loc 9	*Criteria*	*37*	*39*	*41*	*43*	*Complies*
NSH15	Predicted	28	32	37	37	
Loc 6	*Criteria*	*35*	*35*	*37*	*38*	*Complies*
NSH34	Predicted	28	32	37	37	
Loc 6	*Criteria*	*35*	*35*	*37*	*38*	*Complies*

MHE would also like to highlight the section of this report which commented on low frequency noise and infrasound in light of recent conversations regarding “precautionary approach”. In the report it is concluded that; “In light of this analysis, low frequency noise and infrasound are considered highly unlikely to represent a problem for residences in the vicinity of the Flat Rocks Wind Farm.”

The risk of noise emissions to future residences mentioned in this report has been assessed by MHE during the project feasibility stage. MHE will be monitoring this situation closely and will endeavor to minimise this risk during the preconstruction phase and final layout design of the project. It is the responsibility of MHE to negotiate with adjacent landowners should this situation arise.

If you require any further assistance or comment in regards to this report or any other matters relating to the proposed development please contact me directly.

Kind regards

Dr Sarah Rankin- Director
Moonies Hill Energy

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Wind farms versus coal health impacts

Dear Sir,

As an organisation with considerable expertise on both the health impacts of fossil fuel and renewable energy sources Doctors for the Environment Australia (DEA) would like to respond to the recent reports of sleep disturbance and health problems in relation to the Hepburn Community Wind farm in Victoria. We believe the information below may help those rural Australians living near wind farms to understand how safe this new technology is.

DEA is a voluntary National organisation of medical doctors who advocate a rapid transition away from fossil fuels to renewable energy forms for the health benefit of current and future communities. The organisation is supported by many medical and scientific experts http://dea.org.au/about/file/committees.

We recently conducted a review of the scientific literature (see our Senate Submission at http://www.aph.gov.au/senate/committee/clac_ctte/impact_rural_wind_farms/info.htm) and failed to identify any physical illness caused by wind farms.

There may, however, be social and psychological effects seen in a small number of individuals who have increased sensitivity to audible noise. The symptoms they display are due to the annoyance experienced when this noise is heard and may include sleep disturbance and associated fatigue. These symptoms tend not to be found in those individuals who view wind farms in a positive way http://dea.org.au/images/general/Health_Effects_of_Wind_Turbines_July_2011.pdf.

When considering the health effects of energy sources it is important to appreciate the alternatives to renewables energy sources like wind and solar power.

Coal, for example, produces a chemical cocktail of pollutants which effect our health by contributing to climate change, causing heart, lung and neurological diseases and consume vast tracts of valuable farming land and precious drinking water. These health impacts have been clearly documented and cost us billions of dollars per year.

Climate change itself causes severe weather events like bush fires, droughts, floods and heat waves as well as threatening the very foundations of good health- clean water, biodiversity and productive farmlands. Thus we need to move away from energy sources like coal and gas which produce greenhouse gases and contribute to climate change.

It is important to find ways to support those in our communities who are unsure about new technologies and to provide clear information about what is and what isn't considered a health risk.

DR DIMITY WILLIAMS
MBBS(Hons) FRACGP
Secretary Victorian Committee
Doctors for the Environment Australia

ENVIRONMENTAL HEALTH

REVIEW Open Access

Health effects and wind turbines: A review of the literature

Loren D Knopper[1*] and Christopher A Ollson[2]

Abstract

Background: Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential complaints from, or potential effects to, people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet.

Methods: The purpose of this paper is to review the peer-reviewed scientific literature, government agency reports, and the most prominent information found in the popular literature. Combinations of key words were entered into the Thomson Reuters Web of Knowledge[SM] and the internet search engine Google. The review was conducted in the spirit of the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions.

Results: Conclusions of the peer reviewed literature differ in some ways from those in the popular literature. In peer reviewed studies, wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise. To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population. In the popular literature, self-reported health outcomes are related to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured.

Conclusions: What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. The difference between both types is the reason for annoyance. While it is acknowledged that noise from wind turbines can be annoying to some and associated with some reported health effects (e.g., sleep disturbance), especially when found at sound pressure levels greater than 40 db(A), given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from wind turbines themselves. In other words, it appears that it is the change in the environment that is associated with reported health effects and not a turbine-specific variable like audible noise or infrasound. Regardless of its cause, a certain level of annoyance in a population can be expected (as with any number of projects that change the local environment) and the acceptable level is a policy decision to be made by elected officials and their government representatives where the benefits of wind power are weighted against their cons. Assessing the effects of wind turbines on human health is an emerging field and conducting further research into the effects of wind turbines (and environmental changes) on human health, emotional and physical, is warranted.

Keywords: Wind turbines, health, annoyance, infrasound, sound pressure level, noise

* Correspondence: lknopper@intrinsik.com
[1]Intrinsik Environmental Sciences Inc., 1790 Courtwood Crescent, Ottawa ON, K2C 2B5, Canada
Full list of author information is available at the end of the article

Background

Wind power has been identified as a clean renewable energy source that does not contribute to global warming and is without known emissions or harmful wastes [1]. Studies on public attitudes in Europe and Canada show strong support for the implementation of wind power [2]. Indeed, wind power has become an integrated part of provincial energy strategies across Canada; in Ontario, the Ontario Power Authority has placed a great deal of emphasis on procuring what they term "renewable and cleaner sources of electricity", such as wind [3].

Although wind power has been harnessed as a source of electricity for several decades around the world, its widespread use as a significant source of energy in Ontario is relatively recent. As with the introduction of any new technology, concerns have been raised that wind power projects could lead to impacts on human health. These concerns are related to two primary issues: wind turbine design and infrastructure (i.e., electromagnetic frequencies from transmission lines, shadow flicker from rotor blades, ice throw from rotor blades and structural failure) and wind turbine noise (i.e., levels of audible noise [including low frequency noise] and infrasound). If left unchecked and unmanaged, it is possible that individually or cumulatively, these issues could lead to potential health impacts. In terms of noise, high sound pressure levels (loudness) of audible noise and infrasound have been associated with learning, sleep and cognitive disruptions as well as stress and anxiety [4-8].

As a result, minimum setback distances have been established world-wide to reduce or avoid potential effects for people living in proximity to wind turbines. Under the Ontario Renewable Energy Approval (REA) Regulation (O. Reg. 359/09, as amended by O. Reg. 521/10), a minimum setback distance of 550 m must exist between the centre of the base of the wind turbine and the nearest noise receptor (e.g., a building or campground). This minimum setback distance was developed through noise modeling under worst-case conditions to give a conservative estimate of the required distance to attain a sound level of 40 dB(A) [9], the noise level that corresponds to the WHO (Europe) night-noise guideline, a health-based limit value "necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise" [8]. Globally, rural residential noise limits are generally set at 35 to 55 dB(A) [10].

This paper focuses on the research involving land-based wind turbine projects. There are several international off-shore marine projects that are in operation. There was considerable interest in Ontario in developing off-shore wind projects on the Great Lakes. However, in February, 2011 the Province announced that it would not proceed with proposed offshore wind projects until further scientific research is conducted http://www.news.ontario.ca/ene/en/2011/02/ontario-rules-out-offshore-wind-projects.html. This does not appear to have been related, however, to health concerns.

Regardless, debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. People interested in this debate tend to turn to two sources of information in order to make decisions: scientific peer-reviewed studies published in scientific journals, and the popular literature and internet. For the general public, the latter sources are the most readily available and numerous websites have been constructed by individuals or groups to support or oppose the development of wind farms. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group. The majority of information posted on these websites cannot be traced back to a scientific peer-reviewed source and is typically anecdotal in nature. This serves to spread misconceptions about the potential impacts of wind energy on human health making it difficult for the general public (and scientists) to ascertain which claims can be substantiated by scientific evidence.

Accordingly, the purpose of this paper is to provide results of a review of the peer-reviewed scientific literature and the most prominent information found in the popular literature. We have selected this journal as the source of publication because it is a scientifically credible journal with peer-reviewed articles that are easily accessible by the general population who are interested in the subject of wind turbines and health effects. Results of this review are used to draw conclusions about wind turbines and health effects using a weight-of-evidence approach.

Methods

Peer-Reviewed Literature

Publication of scientific findings is the basis of scientific discourse, communication and debate. The peer review process is considered a fundamental tenet of quality control in scientific publishing. Once a research paper has been submitted to a journal for publication it is reviewed by external independent experts in the field. The experts review the validity, reliability and importance of the results and recommend that the manuscript be accepted, revised or rejected. This process, though not perfect, ensures that the methods employed and the findings of the research receive a high level of scrutiny, such that an independent researcher could repeat the experiment or calculation of results, prior to their publication. This process seeks to ensure that the published research is of a high standard of quality, accurate, can

be reproduced and demonstrates academic/professional integrity.

In order to assess peer-reviewed studies designed to test hypotheses about the association between potential health effects in humans and wind turbines, a review of the primary scientific literature was conducted. While our review did not strictly follow the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions [11], the standard for conducting information reviews in healthcare and pharmaceutical industries, it was conducted in the spirit of the Cochrane systematic review in that it was designed based on the principle that "science is cumulative", and by considering all available evidence, decisions could be made that reflect the best science available. It also involves critical review and critique of the published literature and at times weighting some manuscripts over others in the same scientific field.

To facilitate this review, combinations of key words (i.e., annoyance, noise, environmental change, sleep disturbance, epilepsy, stress, health effect(s), wind farm(s), infrasound, wind turbines(s), low frequency noise, wind turbine syndrome, neighborhood change) were selected and entered into the Thomson Reuters (formerly ISI) Web of Knowledge^{SM}. The Web of Knowledge^{SM} is a database that covers over 10,000 high-impact journals in the sciences, social sciences, and arts and humanities, as well as international proceedings coverage for over 120,000 conferences. The Web of Knowledge^{SM} comprises seven citation databases, two of which are relevant to the search: the Science Citation Index Expanded (SCI-Expanded) and the Social Sciences Citation Index (SSCI). The SCI-Expanded includes over 6,650 major journals across 150 scientific disciplines and includes all cited references captured from indexed articles. Coverage of the literature spans the year 1900 to the present. On average, 19,000 new records per week are added to the SCI-Expanded. SSCI is a multidisciplinary index of the social sciences literature. SSCI includes over 1,950 journals across 50 social sciences disciplines from the year 1956 to the present. It averages 2,900 new records per week. Use of this literature search platform means the most up-to-date multidisciplinary studies published and peer-reviewed could be obtained.

Although hundreds of articles were found during the search, very few were related to the association between potential health effects and wind turbines. For example, numerous articles have been published about infrasound, but very few have been published about infrasound and wind turbines. Indeed, only fifteen articles, published between 2003 and 2011, were found relevant [12-26]. What can be seen from these articles is that the relationship between wind turbines and human responses to them is extremely complex and influenced by numerous variables, the majority of which are nonphysical. What is clear is that some people living near wind turbines experience annoyance due to wind turbines, and visual impact tends to be a stronger predictor of noise annoyance than wind turbine noise itself. Swishing, whistling, resounding and pulsating/throbbing are sound characteristics most highly correlated with annoyance by wind turbine noise for those people who noticed the noise outside their dwellings. Some people are also disturbed in their sleep by wind turbines. In general, five key points have come out of these peer-reviewed studies with regards to health and wind turbines.

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level

In the studies designed to evaluate the interrelationships amongst annoyance and wind turbine noise, as well as the influence of subjective variables such as attitude and noise sensitivity, Pedersen and Persson Waye [13-15] showed that people tend to notice sound from wind turbines almost linearly with increasing sound pressure level. Briefly, Pedersen and Persson Waye conducted cross-sectional studies (in 2004: n = 351; in 2007: n = 754) and gave people questionnaires regarding housing and satisfaction with the living environment, including questions about degree of annoyance experienced outdoors and indoors and sensitivity to environmental factors, wind turbines (noise, shadows, and disturbances), respondents' level of perception and annoyance, and verbal descriptors of sound and perceptual characteristics. The third section had questions about chronic health (e.g., diabetes, tinnitus, cardiovascular diseases), general wellbeing (e.g., headache, undue tiredness feeling tensed/stressed, irritable) and normal sleep habits (e.g., quality of sleep, whether or not sleep was disturbed by any noise source). The last section comprised questions on employment and working hours. Of import, the purpose of the study was masked in the questionnaires, which was done to reduce the potential for survey bias.

Of the 754 respondents involved in the Pedersen and Persson Waye study [14], 307 (39%) noticed sound from wind turbines outside their dwelling (range of sound pressure level: < 32.5, 32.5-35.0, 35.0-37.5, 37.5-40.0, and > 40.0 dB(A)) and the proportion of respondents who noticed sound increased almost linearly with increasing noise. In the 37.5-40.0 dB(A) range, 76% of the 71 respondents reported that they noticed sound from the wind turbines; 90% of respondents (n = 18) in the > 40.0 dB(A) category noticed sound from the wind turbines. The odds of noticing sound increased by 30% for each increase in dB(A) category. When data from both studies [13,14] were combined (n = 1095) results were the same: the proportion of respondents who noticed sound from wind turbines showed increased almost linearly with increasing

sound pressure level from roughly 5-15% of people noticing noise at 29 dB(A) to 45-90% noticing noise at 41 dB (A)[15].

In 2011 Pedersen [25] reported on the results of three cross-sectional studies conducted in two areas of Sweden (a flat rural landscape (n = 351) and suburban sites with hilly terrain (n = 754) and one location in the Netherlands (flat landscape but with different degrees of road traffic intensity (n = 725)) designed assess the relationship between wind turbine noise and possible adverse health effects. Questionnaires were mailed to people in the three areas to obtain information about annoyance and health effects in response to wind turbines noise. Pedersen included questions about several potential environmental stressors and did not allow participants to know that the focus of the study was on wind turbine noise, again in an attempt to reduce self-reporting survey bias. For each respondent, sound pressure levels (dB(A)) were calculated for nearby wind turbines. The questionnaires were designed to obtain information about people's response to noise (i.e., annoyance), diseases or symptoms of impaired health (i.e., chronic disease, diabetes, high blood pressure, cardiovascular disease, tinnitus, impaired hearing), stress symptoms (i.e., headache, undue tiredness, feeling tense or stressed, feeling irritable), and disturbed sleep (i.e., interruption of the sleep by any noise source). Results showed that the frequency of those annoyed with wind turbines was related to an increase in sound pressure level as shown by odds ratios (OR) with 95% confidence intervals (CI) greater than 1.0. Sleep interruption was associated with sound level in two of the three studies (the areas with flat terrain), but unlike the finding that people tend to notice sound from wind turbines almost linearly with increasing sound pressure level, sleep disturbance did not increase gradually with noise levels, but spiked at 40 dBA and 45 dBA.

2. A proportion of people that notice sound from wind turbines find it annoying

Results of the Pedersen and Persson Waye studies [13-15] also suggested that the proportion of participants who were fairly annoyed or very annoyed remained quite level through the 29-37 dB(A) range (no more than roughly 5%) but increased at noise levels above 37 dB(A), with peaks at 38 db(A) and 41 dB(A), where up to 30% of people were very annoyed. Respondents in the cross-sectional studies (and other studies [12]) noted that swishing, whistling, resounding and pulsating/throbbing were the sound characteristics that were most highly correlated with annoyance by wind turbine noise among respondents who noticed the noise outside their dwellings. This was also found by Leventhall [16]. Seven percent of respondents (n = 25) from the Pedersen and Persson Waye study [13] were annoyed by noise from wind turbines indoors, and this was related to noise category; 23% (n = 80) were disturbed in their sleep by noise. Of the 128 respondents living at sound exposure above 35.0 dB(A), 16% (n = 20) stated that they were disturbed in their sleep by wind turbine noise. The authors comment that some people may find wind turbine noise more annoying than that of other types of noise (e.g., airplane and traffic) experienced at similar decibel levels.

Similar results were shown by Pedersen and Persson Waye [14]: a total of 31 of the 754 respondents said they were annoyed by wind turbine noise. In the < 32.5 to the 37.5 dB(A) category 3% to 4% of people said they were annoyed by wind turbine noise; in the 37.5-40.0 dB(A) category, 6% of the 71 respondents were annoyed; and in the > 40.0 category, 15% of 20 of respondents said they were annoyed by wind turbine noise. In addition, 36% of those 31 respondents who were annoyed by wind turbine noise reported that their sleep was disturbed by a noise source. Nine percent of those 733 respondents not annoyed said their sleep was disturbed by a noise source. Results of Pedersen [25] showed similar results: the frequency of those annoyed was related to an increase in sound pressure level. Moreover, self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself (OR and 95% CI > 1.0). Sleep interruption, however, was associated with sound level and annoyance (OR and 95%CI > 1.0). Pedersen notes that this finding is not necessarily evidence of a causal relationship between wind turbine noise and stress but may be explained by cognitive stress theory whereby "an individual appraises an environmental stressor, such as noise, as beneficial or not, and behaves accordingly". In other words, it appears that it is the change in the environment that is associated with the self-reported health effects, not the presence of wind turbines themselves.

Keith et al. [17] proposed that in a quiet rural setting, the predicted sound level from wind turbines should not exceed 45 dB(A) at a sensitive receptor location (e.g., residences, hospitals, schools), a value below the World Health Organization guideline for sleep and speech disturbance, moderate annoyance and hearing impairment. The authors [17] suggest this level of noise could be expected to result in a 6.5% increase in the percentage of highly annoyed people. Since publication of the Keith et al. study, the WHO Europe Region has released new Night Noise Guidelines for Europe [8] and state that: "The new limit is an annual average night exposure not exceeding 40 decibels (dB), corresponding to the sound from a quiet street in a residential area". The value of 40 dB is considered the lowest observed adverse effect level (LOAEL) for night noise based on the finding that an average night noise level over a year of 30-40 dB can result in a number of effects on sleep such as body movements, awakening, self-reported sleep disturbance and arousals [8]. The WHO

states that even in the worst cases these effects seem modest [8].

3. Annoyance is not only related to wind turbine noise but also to subjective factors like attitude to visual impact, attitude to wind turbines and sensitivity to noise

Pedersen and Persson Waye [13] revealed that attitude to visual impact, attitude to wind turbines in general, and sensitivity to noise were also related to the way people perceived noise from turbines. For example, 13% of the variance in annoyance from wind farms could be explained by noise and the odds that respondents would be annoyed by noise from wind turbines increased 1.87 times from one sound category to the next. When noise and attitude to visual impact was statistically assessed, 46% of the variance in annoyance from wind farms could be explained and the odds that respondents would be annoyed from wind turbines increased 5.05 times from one sound category to the next. Statistical analyses showed that while attitude to wind turbines in general and sensitivity to noise were also related to annoyance, they did not have a greater influence on annoyance than visual effect. Building on their 2004 paper, Pedersen and Persson Waye [14] conducted a cross-sectional study in seven areas in Sweden across dissimilar terrains and with different degrees of urbanization. Three areas were classified as suburban; four as rural. Noise annoyance related to wind turbines was also statistically related to whether or not people live in suburban or rural areas and landscape (flat vs. hilly/complex). Visual impact has come out as a stronger predictor of noise annoyance than wind turbine noise itself. People who economically benefit from wind turbines had significantly decreased levels of annoyance compared to individuals that received no economic benefit, despite exposure to similar sound levels [18].

One suggestion of the difference between rural and suburban areas is level of background sound and interestingly, perception and annoyance was associated with type of landscape, "indicating that the wind turbine noise interfered with personal expectations in a less urbanised area... pointing towards a personal factor related to the living environment" [14]. The authors also concluded that visual exposure enhances the negative associations with turbines when coupled with audible exposure. They also point out that this study showed that aesthetics play a role in annoyance: "respondents who think of wind turbines as ugly are more likely to appraise them as not belonging to the landscape and therefore feel annoyed" [14].

In 2007 Pedersen et al. [19] conducted a grounded theory study to gain a deeper understanding of how people living near wind turbines perceive and are affected by them. Findings indicated that the relationship between exposure and response is complex and possibly influenced by variables not yet identified, some of which are nonphysical. The notion that wind turbines are "intruders" is a finding not reported elsewhere. A conclusion of this paper is that when the impacts of wind turbines are assessed, values about the living environment are important to consider as values are firmly rooted within a personality and difficult to change.

In 2008, Pedersen and Larsman [20] conducted a study to assess visibility of wind turbines, visual attitude and vertical visual angle (VVA) in different landscapes. This study follows up on the findings of previous work showing a relationship between noise annoyance in people living near wind turbines and the impact of visual factors as well as an individual's attitude toward noise [13-15,25]. Overall, Pedersen and Larsman concluded that respondents in a landscape where wind turbines could be perceived as contrasting with their surroundings (i.e., flat areas) had a greater probability of noise annoyance than those in hilly areas (where turbines were not as obvious), regardless of sound pressure level, if they thought wind turbines were ugly, unnatural devices that would have a negative impact on the scenery. The enhanced negative response could be linked to aesthetical response, rather than to multi-modal effects of simultaneous auditory and visual stimulation. Moreover, VVA was associated with noise annoyance, especially for respondent who could see at least one wind turbine from their dwelling, if they were living in flat terrain and rural areas. Pedersen and Larsman suggest that these results underscore the importance of visual attitude towards the noise source when exploring response to environmental noise. In 2010 Pedersen et al. [21] hypothesized that if high levels of background sound can reduce annoyance by masking the noise from a wind farm, then turbines could cause less noise annoyance when placed next to motorways instead of quiet agricultural areas. In general, the hypothesis was not supported by the available data [15], further providing support for the notion of visual cue being a strong driver of annoyance.

4. Turbines are designed not to pose a risk of photo-induced epilepsy

Harding et al. [22] and Smedley et al. [23] investigated the relationship between photo-induced seizures (i.e., photosensitive epilepsy) and wind turbine blade flicker (also known as shadow flicker). This is an infrequent event, typically modelled to occur less than 30 hours a year from wind turbine projects we have reviewed and would be most common at dusk and dawn, when the sun is at the horizon. Both studies suggested that flicker from turbines that interrupt or reflect sunlight at frequencies greater than 3 Hz pose a potential risk of inducing photosensitive seizures in 1.7 people per 100,000 of the photosensitive population. For turbines with three blades, this translates

to a maximum speed of rotation of 60 rpm. The normal practice for large wind farms is for frequencies well below this threshold.

Although shadow flicker from wind turbines is unlikely lead to a risk of photo-induced epilepsy there has been little if any study conducted on how it could heighten the annoyance factor of those living in proximity to turbines. It may however be included in the notion of visual cues. In Ontario it has been common practice to attempt to ensure no more than 30 hours of shadow flicker per annum at any one residence.

5. The human ear responds to infrasound

Infrasound is produced by physiological processes like respiration, heartbeat and coughing, as well as man-made sources like air conditioning systems, vehicles, some industrial processes and wind turbines. Salt and Hullar [24] provide data to suggest that the assumption that infrasound presented at an amplitude below what is audible has no influence on the ear is erroneous and summarize the results of previous studies that show a physiological response of the human ear to low frequency noise (LFN) and infrasound. At very low frequencies the outer hair cells (OHC) of the cochlea may be stimulated by sounds in the inaudible range. Salt and Hullar hypothesize that "if infrasound is affecting cells and structures at levels that cannot be heard this leads to the possibility that wind turbine noise could be influencing function or causing unfamiliar sensations". These authors do not test this hypothesis in their paper but suggest the need for further research.

To assess the possibility that the operation of wind turbines may create unacceptable levels of low frequency noise and infrasound, O'Neal et al. [26] conducted a study (commissioned by a wind energy developer, NextEra Energy Resources, LLC) to measure wind turbine noise outside and within nearby residences of turbines. At the Horse Hollow Wind Farm in Taylor and Nolan Counties, Texas, broadband (A-weighted) and one-third octave band data (3.15 hertz to 20,000 hertz bands) were simultaneously collected from General Electric (GE) 1.5sle (1.5 MW) and Siemens SWT-2.3-93 (2.3 MW) wind turbines. Data were collected outdoors and indoors over the course of one week under a variety of operational conditions (it should be noted that wind speeds were low during the measurements; between 3.2 and 4.1 m/s) at two distances from the nearest wind turbines: 305 meters and 457 meters. O'Neal et al. found that the measured low frequency sound and infrasound at both distances (from both turbine types at maximum noise conditions) were less than the standards and criteria published by the cited agencies (e.g., UK DEFRA (Department for Environment, Food, and Rural Affairs); ANSI (American National Standards Institute); Japan Ministry of Environment). The authors concluded that results of their study suggest that there should be no adverse public health effects from infrasound or low frequency noise at distances greater than 305 meters from the two wind turbine types measured.

Popular Literature

Scientific studies peer reviewed and published in scientific journals are one way of disseminating information about wind turbines and health effects. The general public does not always have access to scientific journals and often get their information, and form opinions, from sources that are less accountable (e.g., the popular literature and internet). Some of the same key words used to obtain references from the primary literature were entered into the common internet search engine Google: "health effects wind farms" returned 300,000 hits; "health effects wind turbines" returned 120,000 hits; "annoyance wind turbines" returned 185,000 hits and "sleep disturbance wind turbines" returned 19,500 hits. What is apparent is that numerous websites have been constructed by individuals or groups to support or oppose the development of wind turbine projects, or media sites reporting on the debate. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group hosting the website. The majority of information posted on these websites cannot be traced back to a scientific, peer-reviewed source and is typically anecdotal in nature. In some cases, the information contained on and propagated by internet websites and the media is not supported, or is even refuted, by scientific research. This serves to spread misconceptions about the potential impacts of wind energy on human health, which either fuels or diminishes opposition to wind turbine project development.

Works by Dr. Michael Nissenbaum conducted at Mars Hill and Vinalhaven Maine [27] and Dr. Nina Pierpont in New York [28] seem to be the primary popular literature studies referenced on websites. These works suggest a causal link between human health effects and wind turbines. Works by Dr. Robert McMurtry and Carmen Krogh, and Lorrie Gillis, Carmen Krogh and Dr. Nicholas Kouwen [29] have also been used to suggest a relationship between health and turbines. These works have been presented as reports or as slide presentations on websites and authors of these studies have presented their findings in various forua such as invited lectures, affidavits, public meetings and open houses. Briefly, Nissenbaum evaluated 22 exposed adults (defined as living within 3500 ft of an arrangement of 28 1.5 MW wind turbines) and 27 unexposed adults (living about 3 miles away from the nearest turbine). Participants were interviewed and asked a number of questions about their perceived health, levels of

stress and reliance on prescription medications in relation to the turbines [27].

In 2009, a book entitled Wind Turbine Syndrome: A Report on a Natural Experiment by Dr. Nina Pierpont, was self-published and describes "Wind Turbine Syndrome", the clinical name Dr. Pierpont coined for the collection of symptoms reported to her by people residing near wind turbines [28]. The book describes a case series study she conducted involving interviews of 10 families experiencing adverse health effects and who reside near wind turbines. Similar to the process followed by Nissenbaum, people living in proximity wind turbines were interviewed about their health. For all of these works, self-reported symptoms generally included sleep disturbance, headache, tinnitus (ringing in the ears), ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), irritability, problems with concentration and memory and panic episodes. These symptoms have been purported to be associated with proximity to wind turbines, and specifically, to the infrasound emitted by the turbines. It should be noted that of the 351 people assessed by Pedersen and Persson Waye [13], 26% (91) reported chronic health issues (e.g., diabetes, tinnitus, cardiovascular diseases), but these issues were not statistically associated with noise levels. Results of Pedersen [25] showed similar results: self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself. Sleep interruption, however, was associated with sound level and annoyance.

In 2007, Alves-Pereira and Castelo Branco http://www.wind-watch.org/documents/industrial-wind-turbines-infrasound-and-vibro-acoustic-disease-vad/ issued a press-release suggesting that their research demonstrated that living in proximity to wind turbines has led to the development of vibro-acoustic disease (VAD) in nearby home-dwellers. It appears that this research has only been presented at a conference, has not been published in a peer-reviewed journal nor has it undergone thorough scientific review. Moreover, Alves-Pereira and Castelo Branco appear to be the primary researchers that have promulgated VAD as a hypothesis for adverse health effects and wind turbines. Indeed, Dr. Pierpont has noted that VAD is not the same "wind turbine syndrome" [28].

To date, these studies have not been subjected to rigorous scientific peer review, and given the venue for their distribution and limited availability of data, it is extremely difficult to assess whether or not the information provided is reliable or valid. What is apparent, however, is that these studies are not necessarily scientifically defensible: they do not contain noise measurements, only measured distances from study participants to the closest turbines; they do not have adequate statistical representation of potential health effects; only limited rationale is provided for the selection of study participants (in some cases people living in proximity to turbines have been excluded from the study); they suffer from a small number of participants and appear to lack of objectivity as authors are also known advocates who oppose wind turbine developments. Unlike the questionnaires used by Pedersen et al. [13-15,25], the purpose of the studies are not hidden from participants. In fact, the selection process is highly biased towards finding a population who believes they have been affected by turbines. This is not an attempt to discount the self-reported health issues of residents living near wind turbines. Rather, it points out that the self-reported health issues have not been definitively linked to wind turbines.

What the peer reviewed literature and popular literature have in common is the conclusion that wind turbines can be a source of annoyance for some people. Of note are the different reasons and possible causes for annoyance. In the peer reviewed studies, annoyance tends to peak in the > 35 dB(A) range but tends to be more strongly related to subjective factors like visual impact, attitude to wind turbines in general (benign vs. intruders) and sensitivity to noise rather than noise itself from turbines. In the popular literature, health outcomes tend to be more strongly related to distance from turbines and the claim that infrasound is the causative factor. Though sound pressure level in most of the peer reviewed studies was scaled to dB(A) (but refer to O'Neal et al. [26] for actual measurements of low frequency noise and infrasound), infrasound is a component of the sound measurements and was inherently accounted for in the studies.

Annoyance

Studies on the health effects of wind turbines, both published and peer-reviewed and presented in the popular literature, tend to conclude that wind turbines can cause annoyance for some people. A number of governmental health agencies agree that while noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, wind turbines can be a source of annoyance for some people [1,30-34].

It has been hypothesized that the self reported health effects (e.g., sleep disturbance, headache, tinnitus (ringing in the ears), ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), irritability, problems with concentration and memory, and panic episodes) are related to infrasound emitted from wind turbines [28]. Studies where biological effects were observed due to infrasound exposure were conducted at sound pressure levels (e.g., 145 dB and 165 dB [5,16]; 130 dB [7]) much greater than what is produced by wind turbines (e.g., see O'Neal et al. [26]). Infrasound is not unique to wind turbines but is ubiquitous in the environment due to natural and man-made sources, meaning that people living near wind turbines were exposed to

infrasound prior to turbine operation. For example, Berglund and Hassmen [35] reported that infrasound (a component of low frequency sound) is emitted from road vehicles, aircraft, industrial machinery, artillery and mining explosions, air movement machinery including wind turbines, compressors, and air-conditioning units, and Leventhall [5] reported that infrasound comes from natural sources like meteors, volcanic eruptions and ocean waves. Indeed, many mammals communicate using infrasound [36]. Given the low sound pressure levels of infrasound emitted from wind turbines and the ubiquitous nature of these sounds, the hypothesis that infrasound is a causative agent in health effects does not appear to be supported.

Peer reviewed and scientifically defensible studies suggest that annoyance and health effects are more strongly related to subjective factors like visual impact and attitude to wind turbines rather than to noise itself (both audible and inaudible [i.e., infrasound]). Indeed, many of the self reported health effects are associated with numerous issues, many of which can be attributed to anxiety and annoyance (e.g., Pedersen 2011 [25]). Shargorodsky et al. [37] published that roughly 50 million adults in the United States reported having tinnitus, which is statistically correlated (based on 14,178 participants) to age, racial/ethnic group, hypertension, history of smoking, loud leisure-time, firearm, and occupational noise, hearing impairment and generalized anxiety disorder (based on 2265 participants) identified using a World Health Organization Composite Diagnostic Interview). In fact, the odds of tinnitus being related to anxiety disorder were greatest for any of the variables tested. Folmer and Griest [38], based on a study of 174 patients undergoing treatment for tinnitus at the Oregon Health Sciences University Tinnitus Clinic between 1994 and 1997, reported that insomnia is associated with greater severity of tinnitus. Insomnia is also associated with anxiety and annoyance. Bowling et al. [39] described statistically that people's perceptions of neighbourhood environment can influence health. Perceptions of problems in the area (e.g., noise, crime, air quality, rubbish/litter, traffic, graffiti) were predictive of poorer health score. In their 2003 publication Henningsen and Priebe [40] discussed the characteristics of "New Environmental Illness", illnesses where patients strongly believe their symptoms are caused by environmental factors, even though symptoms are not consistent with empirical evidence and medically unexplained. A key component to such illnesses is the patient's attitude toward the source of the environmental factor. What is more, health effects from annoyance have been shown to be mitigated though behavioural and cognitive behavioural interventions [30,41], lending support to Pedersen's [25] conclusion that health effects can be explained by cognitive stress theory. In other words, it appears that it is the change in the environment that is associated with health effects, not a turbine-specific variable like infrasound.

Conclusions

Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential effects for people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet.

We found that conclusions of the peer reviewed literature differ in some ways from the conclusions of the studies published in the popular literature. What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. In the peer reviewed studies, wind turbine annoyance and some reported health effects (e.g., sleep disturbance) have been statistically associated with wind turbine noise especially when found at sound pressure levels greater than 40 db(A), but found to be more strongly related to subjective factors like visual impact, attitude to wind turbines in general and sensitivity to noise. To date, no peer reviewed scientific journal articles demonstrate a causal link between people living in proximity to modern wind turbines, the noise (audible, low frequency noise, or infrasound) they emit and resulting physiological health effects. In the popular literature, self-reported health outcomes and annoyance are related to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured. Infrasound is not unique to wind turbines and the self reported health effects of people living in proximity to wind turbines are not unique to wind turbines. Given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from infrasound. This hypothesis is supported by the peer-reviewed literature pertaining to environmental stressors and health.

The authors have spent countless hours at community public consultation events hosted by proponents announcing new projects and during updates to their environmental assessment process. Historically, citizens' concerns about wind turbine projects appeared to involve potential impact on property values and issues surrounding avian and bat mortality. Increasingly in North America the issue surrounding fears of potential harm to residents' health have come to the forefront of these

meetings. It is clear that the announcement of a new project can led to a heightened sense of anxiety and annoyance in some members of the public, even prior to construction and operation of a wind turbine project. The authors have been involved in all manner of risk communication, consultation and risk assessment projects in the energy sector in Canada and it has been our experience that this heightened sense of annoyance, agitation or fear is not unique to the wind turbine sector. Whether the proposed project is a wind turbine, gas-fired station, coal plant, nuclear power plant, or energy-from-waste incinerator we have seen a level of concern in a sub-set of the population that goes well beyond anything that would be considered the traditional sense of not-in-my-back-yard (NIMBY). These people genuinely are fearful about the potential health effects that the project may cause, regardless of the outcomes of quantitative assessments that demonstrate that there is a *de minimus* of potential risk in living next to a particular facility. The literature and our own experience highlight the need for informative discussions between wind power developers and community members in order to attempt to reduce the level of apprehension. We encourage continued dialogue between concerned citizens and developers once projects become operational.

Canadian public health agencies subscribe to the World Health Organization definition of health. *"Health is a state of complete physical, mental and social well-being and not merely the absence of infirmity or disease"*, a quote often used by both sides of the wind turbine debate. We believe that the primary role of the environmental health/risk assessment practitioner is to ensure that physiological manifestation of infirmity or disease is not predicted to occur from exposure to an environmental contaminant. In terms of wind power, ethics dictate an honest reporting of the issues surrounding annoyance and the fact that it appears that a limited number of people have self-reported health effects that may be attributed to the indirect effects of visual and attitudinal cue. We believe that any physiological based effect can be mitigated through the use of appropriate setback distances. However, it is not clear that for this hypersensitive annoyed population that any set back distance could mitigate the indirect effects. Therefore, it is up to our elected officials and ministerial staff when establishing an energy source hierarchy to weigh all of the information before them to determine the trade-offs between "mental and social well-being" of these individuals against the larger demand for energy and its source.

A number of governmental health agencies agree that while noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, wind turbines can be a source of annoyance for some people. Ultimately it is up to governments to decide the level of acceptable annoyance in a population that justifies the use of wind power as an alternative energy source.

Assessing the effects of wind turbines on human health is an emerging field, as demonstrated by the limited number of peer-reviewed articles published since 2003. Conducting further research into the effects of wind turbines (and environmental change) on human health, emotional and physical, as well as the effect of public consultation with community groups in reducing pre-construction anxiety, is warranted. Such an undertaking should be initiated prior to public announcement of a project, and could involve baseline community health and attitude surveys, baseline noise and infrasound monitoring, observation and questionnaires administered to public during the siting and assessment process, noise modeling and then post-construction follow-up on all of the aforementioned aspects. Regardless it would be imperative to ensure robust study design and a clear statement of purpose prior to study initiation.

We believe that research of this nature should be undertaken by multi-disciplinary teams involving, for example, acoustical engineers, health scientists, epidemiologists, social scientists and public health physicians. Ideally developers, government agencies, consulting professionals and non-government organizations would form collaborations in attempt to address these issues.

List of Abbreviations

ANSI: American National Standards Institute; CI: Confidence intervals; dB(A): A-weighted decibels; DEFRA: Department for Environment, Food, and Rural Affairs; LFN: low frequency noise; LOAEL: lowest observed adverse effect level; MW: mega watt; O.Reg.: Ontario Regulation; OR: odds ratio; OHC: outer hair cells; REA: Renewable Energy Approval; SCI: Science Citation Index; SSCI: Social Sciences Citation Index; VAD: vibro-acoustic disease; VVA: vertical visual angle; WHO: World Health Organization

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None

Author details

[1]Intrinsik Environmental Sciences Inc., 1790 Courtwood Crescent, Ottawa ON, K2C 2B5, Canada. [2]Intrinsik Environmental Sciences Inc., 6605 Hurontario Street, Suite 500, Mississauga, ON, L5T 0A3, Canada.

Authors' contributions

LDK and CAO both researched and wrote the manuscript. Both authors read and approved the final version.

Competing interests

In terms of competing interests (financial and non-financial), the authors work for a consulting firm and have worked with wind power companies. The authors are actively working in the field of wind turbines and human health. Dr. Ollson has acted as an expert witness for wind power companies during a number of legal hearings. Although we make this disclosure, we wish to reiterate that as independent scientific professionals our views and research are not influenced by these contractual obligations. The authors are environmental health scientists, trained and schooled, in the evaluation of potential risks and health effects of people and the ecosystem through their exposure to environmental issues such as wind turbines.

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Infrasound and low frequency noise from wind turbines: exposure and health effects

Karl Bolin[1], **Gösta Bluhm**[2], **Gabriella Eriksson**[3] and **Mats E Nilsson**[2,4]

[1] Marcus Wallenberg Laboratory, Department of Aeronautical and Vehicle Engineering, Kungliga Tekniska Högskolan, Sweden
[2] Institute of Environmental Medicine, Karolinska Institutet, Sweden
[3] Swedish National Road and Transport Research Institute and Linköping University, Sweden
[4] Gösta Ekman Laboratory, Department of Psychology, Stockholm University, Sweden

E-mail: kbolin@kth.se

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Abstract
Wind turbines emit low frequency noise (LFN) and large turbines generally generate more LFN than small turbines. The dominant source of LFN is the interaction between incoming turbulence and the blades. Measurements suggest that indoor levels of LFN in dwellings typically are within recommended guideline values, provided that the outdoor level does not exceed corresponding guidelines for facade exposure. Three cross-sectional questionnaire studies show that annoyance from wind turbine noise is related to the immission level, but several explanations other than low frequency noise are probable. A statistically significant association between noise levels and self-reported sleep disturbance was found in two of the three studies. It has been suggested that LFN from wind turbines causes other, and more serious, health problems, but empirical support for these claims is lacking.

Keywords: wind turbine noise, infrasound, low frequency noise

1. Introduction

Wind power is a renewable source of energy that has seen a dramatic increase in installed capacity the last decade. The growth has not only been in the number of wind turbines but also in their size, from average capacities of 100 kW in the 1990s to 2 MW turbines at present date. Presently, hub heights are around 100 m with rotor blades around 50 m and 10 MW prototypes taller than 200 m have been developed.

The growing turbine sizes have raised fears that the sound characteristics will shift to lower frequencies (Møller and Pedersen 2011). This should be taken seriously, because sounds with prominent infrasound (1–20 Hz) and low frequency (20–200 Hz) components may affect human health and well-being to a larger extent than sounds without such components. For example, loudness and annoyance of infrasound and low frequency noise (LFN) increases more rapidly with increasing sound pressure level than sounds of higher frequencies (e.g., Møller and Pedersen 2004, Leventhall 2004). Thus, once the sound pressure passes the absolute threshold of detection (given in figure 1), only a small further increase is needed to make the sound loud and annoying. Prolonged exposure to audible low frequency sounds may cause fatigue, headache, impaired concentration, sleep disturbance and physiological stress, as indicated by increased levels of saliva cortisol (e.g., Berglund *et al* 1996, Bengtsson *et al* 2004, Pedersen and Persson Waye 2004). Similar effects may occur after exposure to infrasound, provided that the levels are high enough to exceed the absolute threshold of detection (e.g., Landström 1995).

This article reviews the present knowledge of infrasound and LFN exposure from wind turbines and related disturbances or ill-health of residents living near wind turbines. In this article, LFN is defined as sounds with frequencies between 20 and 200 Hz and infrasound is defined as sound with frequencies between 1 and 20 Hz. The literature review was

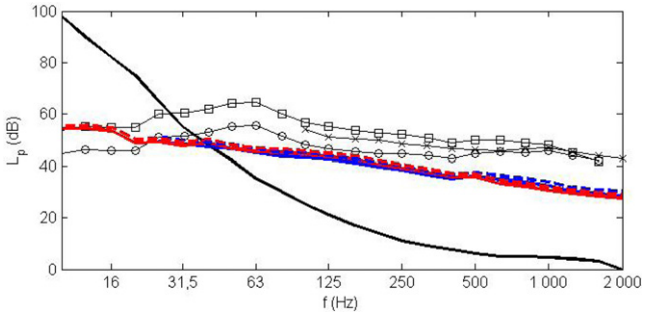

Figure 1. 1/3 octave sound power level spectra from old turbines <2 MW (-/– – –) and new ⩾2 MW (-/– – –), recalculated from Madsen and Pedersen (2010) to an average level of 40 dB (L_{Aeq}) at 500 m distance (solid) and 1000 m distance (dashed). For comparison, ISO717-1 (ISO 717-1 1996a) spectra for road traffic noise (-x-), measured road traffic noise 10 m distance (-o-) (light traffic) and recalculated at 500 m (-□-) are shown at 55 dB (L_{Aeq}), as well as the absolute detection threshold (-) (Watanabe and Møller 1990).

conducted over a six month period ending in April 2011. Literature was searched in the databases PubMed, PsycInfo and Science Citation Index. In addition, proceedings of the conferences Inter-Noise and Wind Turbine Noise were searched. Grey literature was searched through reference lists of published articles and using internet search engines (Google, Google Scholar). Finally, personal contacts were taken with researchers and noise consultants working with wind turbine noise.

2. Sound production and exposure

2.1. Generation mechanisms

Sounds generated by wind turbines are usually divided into mechanical sounds radiating from the machinery in the hub and aerodynamical sounds generated by the blades interacting with the air. Mechanical noise emitted from the rotating machinery is often of periodic and tonal character. These sounds are of less importance in modern wind turbines because of improved sound insulation of the hub (van den Berg 2005, Oerlemans *et al* 2007). Aerodynamic sources at the blades are therefore the dominating sound source from modern wind turbines. Laminar flow around the blade generates very little sound while turbulent flow will inherently produce sound (Wagner *et al* 1996). Three different generation mechanisms have been suggested by van den Berg (2005), here discussed in order of increasing frequency ranges. The first source is the periodic blade–tower interaction, which generates noise that contributes to the spectra at blade passing frequency and its harmonics from around 1 to about 30 Hz. Sounds from this source are typically far below the average absolute threshold of detection (cf figure 1). The second source originates from the in-flow turbulence which is the main sound source in frequencies from around 10 Hz up to a few hundreds of hertz (van den Berg 2005). A model for this source by Madsen (2008) has been experimentally verified and shows satisfying results from 10 to 50 Hz. The third source is the trailing edge noise, which has its peak frequency between 500 and 1000 Hz, that is, above the region of LFN.

2.2. Outdoor noise exposure

Several countries have guidelines for wind turbine noise at the facade of dwellings. As an example, the Swedish value is an A-weighted sound level of 40 dB (L_{Aeq}) and the Danish guideline value is 44 dB (L_{Aeq}), both at wind direction from the turbine towards the immission point at wind speeds of 8 m s^{-1} on 10 m height. In comparison, guideline values for road traffic noise, the main source of noise annoyance in many countries (e.g., EEA 2009), are higher. A compilation of guideline values in 14 European countries showed that the average value was 58 dB L_{DEN} outdoor at the facade of dwellings (EEA 2010), which corresponds to about 55 dB $L_{Aeq,24h}$.

A comprehensive Danish study of 33 old and 14 new turbines found an average increase of low frequency noise per installed power of around 1 dB for new turbines compared to older turbines (Madsen and Pedersen 2010). However, the variations between different turbines are large and an individual small old turbine may thus emit more LFN per installed power than a new turbine. This conclusion is disputed by Møller and Pedersen (2011), who show a significant shift towards lower frequencies for newer turbines.

Spectra of sound pressure levels from wind turbines, road traffic noise and the absolute detection thresholds are shown in figure 1. Sound propagation to representative distances from noise sources was calculated according to ISO9613 (ISO 1996b). To compare representative exposure levels, each source was normalized to levels corresponding to typical planning guideline values, 40 dB L_{Aeq} for wind turbine noise and 55 dB $L_{Aeq,24h}$ for road traffic noise. Compared to road traffic noise, the permitted noise from wind turbines is lower for all frequencies above 20 Hz, which indicates that LFN from wind turbines does not generate more LFN than road traffic noise at levels often found in urban residential areas (cf EEA 2009).

Two articles (Jung and Cheung 2008 and Sugimoto *et al* 2008) have been cited as arguments that wind turbines generate high levels of infrasound and LFN (Salt and Hullar 2010). However, the measurements reported in those articles were made in close proximity to wind turbines and are uncharacteristic of exposure in residential buildings. Jung and Cheung (2008) measured at 10 and 98 m from a 1.5 MW turbine with levels exceeding 80 dB in the frequency range 1–10 Hz. Sugimoto *et al* (2008) report levels of up to 80 dB in the frequency range 1–20 Hz inside a small shed 20 m from the wind turbine.

2.3. Indoor noise exposure

Lower frequencies are commonly less attenuated by buildings than higher frequencies. In combination with standing wave patterns in rooms this could potentially create high levels of infrasound and LFN indoors. However, conclusions from several studies indicate that indoor LFN from wind turbines typically complies with national guidelines (Lindkvist and Almgren 2010, Madsen and Pedersen 2010, O'Neal *et al* 2011, Department of Trade and Industry 2006). O'Neal *et al* (2011) compared indoor and outdoor LFN and infrasound at two wind farms (30 turbines × 1.5 MW and 15 turbines × 2.3 MW). They

concluded that the measured levels at both sites complied with several different national guidelines for LFN and infrasound at 305 m distance or more from the wind turbines. This does not, of course, exclude that a sizeable LFN component may occur in rare cases. As a rule of thumb, it has been proposed that further investigations should be conducted if the measured difference between C-weighted and A-weighted sound pressure level of the outdoor exposure is greater than 15 dB (Lindkvist and Almgren 2010; see e.g., Lundquist *et al* 2000 for dBC–dBA as an indicator of low frequency noise).

3. Noise annoyance

Noise annoyance is measured in questionnaire studies, in which the respondents are asked to give an overall assessment of the degree of annoyance evoked by a specific noise source during an extended period of time, for example the last 12 months (e.g., ISO 2003a, 2003b). Annoyance in relation to noise levels from wind turbines has so far been investigated in three cross-sectional studies (Pedersen and Persson Waye 2004, 2007, Pedersen *et al* 2009). These studies predicted equivalent sound levels from wind turbines and thus cannot give guidance to the specific effects related to LFN. The studies are nevertheless summarized below, to illustrate the extent of annoyance that wind turbine noise may evoke at exposure levels found in residential settings, and to discuss possible explanations for these effects.

The three studies were not independent of each other as they were conducted by the same researchers and used similar questionnaires. The response rate was around 60% in the Swedish studies and 37% in the Dutch study. The low response rate in the Dutch study is worrying. However, a non-response analysis gave support for the representativity of the sample.

All three studies used the same question to measure noise annoyance 'for each one of the following inconvenience if you noticed or were disturbed by them, when you are outdoors at your house', followed by a list of potential disturbances including noise from wind turbines. Noise annoyance was reported on a five-category scale, from 'do not notice' to 'very annoyed'. Two cut-offs were used, the two highest categories for defining 'annoyed' and the highest category for defining 'very annoyed' residents.

It should be noted that the three studies also measured annoyance to wind turbine noise as experienced indoors (Janssen *et al* 2009). The proportion annoyed indoors was lower than proportion annoyed outdoors (by approximately a factor of two). Compared to industrial noise from stationary sources, the proportion annoyed indoors was found to be higher for wind turbine noise at exposure levels above 40 dB L_{Aeq}.

Figure 2 shows the results from the three studies, the two Swedish studies combined (white bars) and the Dutch study (grey bars). These analyses did not include responses from persons who profited economically from wind turbines, as those persons reported significantly lower annoyance due to noise than those without economic benefit (Pedersen *et al* 2009). The studies show a clear association between levels of wind turbine noise and percentage annoyed residents.

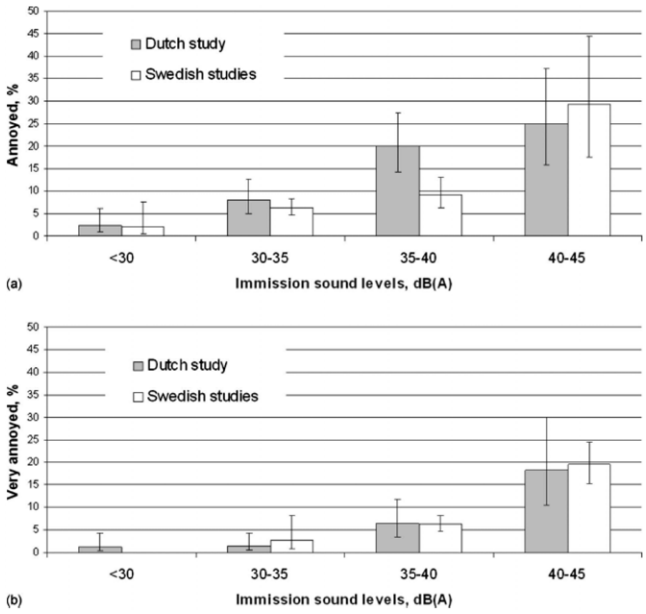

Figure 2. Proportion of respondents annoyed (a) and very highly annoyed (b) by wind turbine noise for different immission sound levels. Reprinted with permission from Pedersen E *et al* 2009 *J. Acoust. Soc. Am.* **126** 634–43. Copyright 2009, Acoustical Society of America.

Among the residents with exposures in the range of 35–40 dB, the percentage annoyed by noise was about 10% in the Swedish studies and approximately 20% in the Dutch study. The percentage very annoyed by noise was around 6% in all three studies at 35–40 dB exposure. These percentages are similar to the percentages of annoyed residents due to road traffic noise, at a typical planning guideline value of 55 dB $L_{\mathrm{Aeq,24h}}$. The most comprehensive meta-analyses of such annoyance studies (Miedema and Oudshoorn 2001) predicted that at this exposure about 14% of residents would be annoyed and 5% very annoyed (calculated using the same cut-offs for defining annoyed and very annoyed as in figure 2; observe that Miedema and Oudshoorn used slightly different cut-offs for their definition of 'annoyed' and 'highly annoyed').

Overall, these comparisons suggest that guidelines for wind turbine noise in the interval 35–40 dB would correspond to the proportion of annoyed persons comparable to the proportion annoyed by road traffic noise at a typical guideline value. However, it is also clear that wind turbine noise is more annoying than road traffic noise at the same equivalent noise level. At 40 dB wind turbine noise generates a substantial proportion of annoyed residents (see figure 2) whereas the proportion annoyed by 40 dB transportation noise is negligible (Miedema and Oudshoorn 2001). There is no indication that this is linked to infrasound or LFN from wind turbines. However, there are several other plausible explanations:

(1) Wind turbines are often built in environments with low ambient noise. Studies of road traffic noise have often focused on noise annoyance among residents of large cities, where background levels are 10–15 dB higher than in rural environments.

(2) Common verbal descriptors of wind turbine noise include 'swishing', 'whistling' and 'pulsating' (e.g., Pedersen and Persson Waye 2004, Pedersen *et al* 2007). This suggests that the pulsating (amplitude modulated) trailing edge noise, with a peak frequency between 500 and 1000 Hz, is the main cause of annoyance (van den Berg 2005, Leventhall 2006). Pulsating sounds are perceived as more annoying than continuous sound with the same frequency content and average noise level (Zwicker and Fastl 1990, Kantarelis and Walker 1988), as has also been demonstrated for wind turbine noise (Seunghun *et al* 2011).

(3) The visual intrusion of wind turbines in the environment may affect the assessment of noise annoyance. This is supported by the fact that the proportion annoyed by noise among residents who can see the wind turbines is significantly higher than among residents who do not see turbines, at the same average noise exposure (Pedersen *et al* 2009).

4. Sleep disturbance

Sleep disturbance is a serious effect of noise, because good sleep is essential for physical and mental health (WHO 2009). WHO's guideline value is that the level at the facade outside the bedroom should not exceed 40 dB L_{Aeq} during the night to ensure undisturbed sleep (WHO 2009).

The cross-sectional questionnaire studies described above also measured self-reported sleep disturbance. A compilation of the studies (Pedersen 2011) found a statistically significant association between the noise level and self-reported sleep disturbance in two of the three studies. Again, these studies only reported average A-weighted sound levels ($L_{\mathrm{Aeq,24h}}$) and therefore do not allow evaluation of effects specifically related to LFN. Furthermore it is not possible to draw conclusions from self-reports regarding effects related to sleep quality, which the individuals might be unaware of.

van den Berg (2004, 2005) showed that prediction models of wind turbine noise may underestimate the actual night time exposure. The main reason is that stable atmospheric conditions, occurring during the evenings and at night, result in increased emission and immission levels of wind turbine noise which occur in combination with a decrease of the background noise levels. Thus, even if predicted levels are as low as 40 dB L_{Aeq} during night, actual levels may be higher and potentially sleep disturbing.

5. Other health effects

Various symptoms and diseases have been mentioned in discussions on wind turbines and health, often with reference to exposure to infrasound or LFN.

The book 'The Wind Turbine Syndrome' by Pierpoint (Pierpoint 2009) argues that wind turbine noise can cause a variety of serious symptoms. The study relies on interviews with 38 individuals from ten families living near wind turbines. Several of the people interviewed reported serious symptoms, including insomnia, headaches, tinnitus, dizziness, nausea, panic attacks and palpitations, which they developed after the wind turbines were erected near to their homes. According to Pierpoint, these symptoms were caused by LFN and vibrations from wind turbines affecting the body's balance system. The study has several limitations, which makes the conclusion unjustified. For example, the lack of acoustic measurements, no comparison group of people with no or low wind exposure and no investigation of the subjects prior to the wind turbines were constructed (prior health status was estimated retrospectively). In addition, the results, which are based on a very small sample, are contradicted by results from the cross-sectional studies described above, which included a total of more than 1600 people. Except for noise annoyance, and possibly self-reported sleep disturbance, no consistent associations were found between wind turbine noise exposure and symptom reporting, e.g. chronic disease, headaches, tinnitus and undue tiredness (Pedersen 2011).

Alves-Pereira and Castelo Branco (2007a) have argued that infrasound and LFN from wind turbines may cause 'vibroacoustic disease' (Castelo Branco and Alves-Pereira 2004, Alves-Pereira and Castelo Branco 2007b). The authors list a variety of symptoms, including increased risk of epilepsy and cardiovascular effects such as increased risk for coronary artery surgery. The authors have reported on vibroacoustic disease for many years, but the syndrome has attracted limited attention from other researchers. The problem may only be relevant at high occupational exposures, such as aircraft maintenance (Castelo Branco and Alves-Pereira 2004), and hardly at the low dose exposures by wind turbines. Discussion of vibroacoustic disease remains at a hypothetic stage and evidence of problems related to noise from wind turbines is lacking.

Salt and Hullar (2010) hypothesized from previous research that the outer hair cells are particularly sensitive to infrasound even at levels below the threshold of perception. In their article, the last paragraph mentions that wind turbines generate high levels of infrasound, with reference to three articles, two of which are not relevant to exposure in residential environments (Jung and Cheung 2008, and Sugimoto *et al* 2008). No references were made to published compilations of knowledge that indicates that the infrasound to which humans are exposed to by wind turbines is moderate and not higher than what many people are exposed to daily, in the subway and buses or at the workplace (e.g. Leventhall 2007, Jakobsen 2005). It is therefore hard to see that Salt and Hullars' results are relevant for risk assessment of wind turbine noise in particular.

There have been no epidemiological studies of wind turbine noise and cardiovascular risk. However a number of studies in recent years have demonstrated a correlation between road traffic and aircraft noise exposure and elevated blood pressure (WHO 2011, Babisch 2008, Babisch and van Kamp 2009). There are also some studies that demonstrate a link between road traffic noise and increased risk of myocardial infarction (Babisch *et al* 2005, Selander *et al* 2009) and recently also a similar relation for aircraft noise (Huss *et al* 2010). Increased risk was observed for exposures of 55 dB L_{Aeq} equivalent level for road traffic noise and 60 dB L_{Aeq}

for aircraft noise (WHO 2000, Huss *et al* 2010), which is significantly higher than typical exposure from wind turbine noise. This speaks against a corresponding association between wind turbine noise and cardiovascular disease. On the other hand, the effects on the cardiovascular system by noise are assumed to be stress related and triggered by noise annoyance and sleep disturbance (Babisch 2002). Wind turbine noise is causing noise annoyance, and possibly also sleep disturbance, which means that one cannot completely rule out effects on the cardiovascular system after prolonged exposure to wind turbine noise, despite moderate levels of exposure.

6. Conclusions

The dominant source of wind turbine low frequency noise, LFN (20–200 Hz), is incoming turbulence interaction with the blade. Infrasound (1–20 Hz) from wind turbines is not audible at close range and even less so at distances where residents are living. There is no evidence that infrasound at these levels contributes to perceived annoyance or other health effects. LFN from modern wind turbines are audible at typical levels in residential settings, but the levels do not exceed levels from other common noise sources, such as road traffic noise. Although new and large wind turbines may generate more LFN than old and small turbines, the expected increase in LFN is small.

Wind turbine noise is associated with residential noise annoyance. It has been found that 10–20% of residents are annoyed, and about 6% are very annoyed by wind turbine noise at levels between 35 and 40 dB (L_{Aeq}, at 8 m s^{-1} wind speed at 10 m height). The main cause of annoyance seems to be the pulsating swish sound produced when the blades pass through the air. This sound has its main energy in the frequency range of 500–1000 Hz.

Except for noise annoyance, no consistent effects on health due to wind turbine noise have been reported. However, a statistically significant association between wind turbine noise and self-reported sleep disturbance was found in two studies.

It has been argued that infrasound and low frequency noise from wind turbines may cause serious health effects in the form of 'vibroacoustic disease', 'wind turbine syndrome' or harmful infrasound effects on the inner ear. However, empirical supports for these claims are lacking.

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Sonus Pty Ltd
17 Ruthven Avenue
ADELAIDE SA 5000
Phone: (08) 8231 2100
Facsimile: (08) 8231 2122
www.sonus.com.au
ABN: 67 882 843 130

WIND FARMS TECHNICAL PAPER

Environmental Noise

Prepared for

CLEAN ENERGY COUNCIL
Suite 201, 18 Kavanagh Street
SOUTHBANK 3006

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INTRODUCTION

Australian wind farms currently provide 1841MW of power or enough energy to power 772,286 homes (Clean Energy Council Renewable Energy Database, April 2010). With this level of generation comes a need to ensure their advantages are balanced against the amenity of the communities that live in their vicinity.

This Technical Paper has been prepared to provide the latest information to communities, developers, planning and enforcement authorities and other stakeholders on environmental noise from wind farms and includes:

- An explanation of the sources of noise from a wind farm and its characteristics;
- A summary of the various Australian wind farm noise standards and guidelines and a comparison of the local and International approaches;
- A description of the methodology associated with a detailed environmental noise assessment prepared for a wind farm in accordance with the relevant standards and guidelines;
- A description of the various terms used in those assessments including the ambient noise environment, background noise levels and characteristics such as modulation, tonality, infrasound and low frequency;
- A summary of the research conducted into a range of issues including:
    - Health impacts and annoyance;
    - Infrasound and low frequency;
    - Amplitude modulation; and
    - Sleep disturbance

EXECUTIVE SUMMARY

Virtually all processes generate noise, including wind farms. The response to noise by individuals can be wide and varied. Noise is often the most important factor in determining the separation distance between wind turbines and sensitive receivers. The assessment of noise therefore plays a significant role in determining the viability of and the size of wind farms.

Australian jurisdictions presently assess the noise from wind farms under a range of Standards and Guidelines applicable to each individual State or Territory.

The Standards and Guidelines used in Australia and New Zealand are stringent in comparison to other International approaches. They are also the most contemporary in the World, with recent updates and releases of the main assessment approaches occurring in both late 2009 and early 2010.

Notwithstanding the above, there are community concerns relating to both annoyance and health impacts associated with environmental noise from both planned and operating wind farms. As such, the Clean Energy Council has engaged Sonus to make an independent review of the available information relating to noise from wind farms.

The information in this Technical Paper results in the following key conclusions:

- The standards and guidelines used for the assessment of environmental noise from wind farms in Australia and New Zealand are amongst the most stringent and contemporary in the World;

- There are inherent discrepancies associated with a number of different approaches from jurisdiction to jurisdiction;

- The rate of complaints relating to environmental noise emissions from residents living in the vicinity of operating wind farms is very low;

- There are complaints relating to environmental noise emissions from residents living in the vicinity of operating wind farms. These complaints generally relate to concerns regarding low frequency noise and health related impacts; and

- There is detailed and extensive research and evidence that indicates that the noise from wind farms developed and operated in accordance with the current Standards and Guidelines will not have any direct adverse health effects.

THE NOISE FROM A WIND FARM

The acoustic energy generated by a wind turbine is of a similar order to that produced by a truck engine, a tractor, a large forklift or a range of typical earthmoving equipment. However, a wind turbine is a stationary source that operates in conjunction with other turbines in a generally windy environment, is located high above the ground and has different noise characteristics compared to these other noise sources.

This section provides information relating to the level and characteristics of noise from a wind farm.

Noise is inherently produced by moving elements. There are two main moving elements that generate the environmental noise from a wind turbine, being the external rotating blades and the internal mechanical components such as the gearbox and generator.

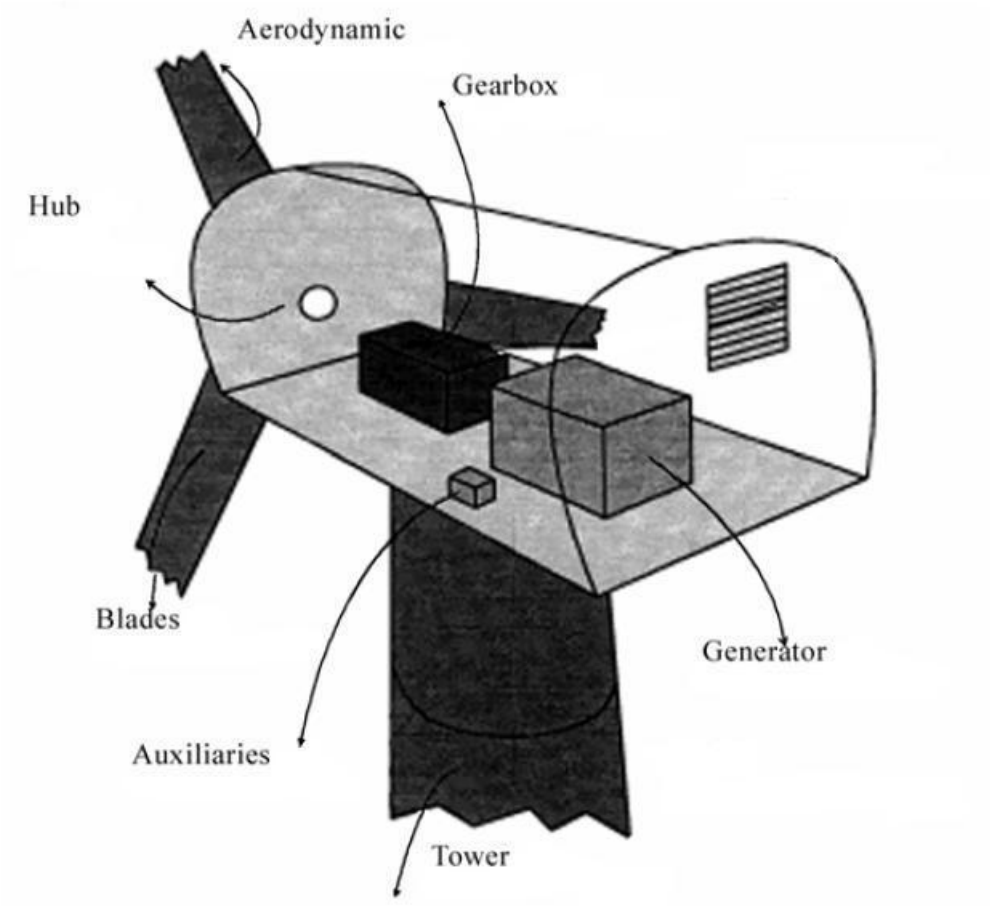

Figure 1 - (Modified from Wagner 1996)

The noise from the blades and the internal machinery are commonly categorised as aerodynamic and mechanical noise respectively.

Mechanical Noise

Mechanical noise sources are primarily associated with the electrical generation components of the turbine, typically emanating from the gear box and the generator. Mechanical noise was audible from early turbine designs. On modern designs, mechanical noise has been significantly reduced (Moorhouse et al., 2007), such that aerodynamic noise from the blades is generally the dominant noise emission from a wind turbine.

Aerodynamic Noise

Aerodynamic noise typically dominates the noise emission of a wind turbine and is produced by the rotation of the turbine blades through the air.

Turbine blades employ an airfoil shape to generate a turning force. The shape of an airfoil causes air to travel more rapidly over the top of the airfoil than below it, producing a lift force as air passes over it. The nature of this air interaction produces noise through a variety of mechanisms (Brooks et al., 1989).

In general terms, the noise we hear in any environment is a combination of energy at different frequencies. There are noise sources that have their dominant content of energy present in the higher frequencies, such as a whistle, and noise sources that have their dominant content in the low frequencies, such as a diesel locomotive engine. Most noise sources are “broadband” in nature; that is they possess energy in all frequencies. A typical broadband noise is music, where the bass content is in the low frequency region, and the voices and general melody are in the middle and higher frequencies.

Aerodynamic noise is broadband in nature and present at all frequencies. Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. Therefore, the A-weighted network (dB(A)) is the network used in wind farm standards and guidelines.

Aerodynamic noise can be further separated into the following categories, generally termed “characteristics”:

Amplitude Modulation

Amplitude modulation is most commonly described as a “swish” (Pedersen, 2005). “Swish” is a result of a rise and fall in the noise level from the moving blades. The noise level from a turbine rises during the downward motion of the blade. The effect of this is a rise in level of approximately once per second for a typical three-bladed turbine as each blade passes through its downward stroke.

It was previously thought that “swish” occurred as the blade passed the tower, travelling through disturbed airflow, however, a recent detailed study indicates it is related to the difference in wind speed over the swept area of a blade (Oerlemans and Schepers, 2009).

Other explanations for the rise in noise level that occurs on the downward stroke relate to the slight tilt of the rotor-plane on most modern wind turbines to ensure that the blades do not hit the tower. An effect of the tilt is that when the blades are moving downwards they are moving against the wind. Conversely, when moving upwards they are moving in the same direction as the wind. Therefore, with the effective wind speed being higher on the downward stroke, it is suggested that a higher noise level is produced (Sloth, 2010).

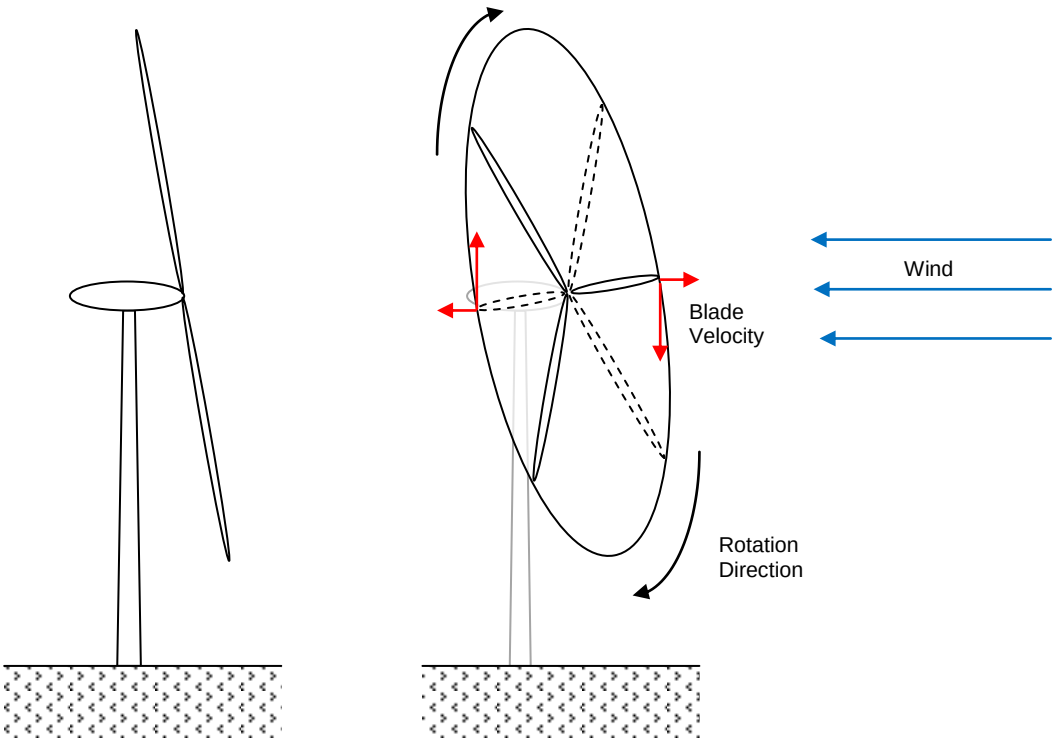

Figure 2 - Blade Velocity due to Tilt

Low Frequency Noise

Noise sources that produce low frequency content, such as a freight train locomotive or diesel engine; have dominant noise content in the frequency range between 20 and 200 Hz (O'Neal et al, 2009). Low frequency noise is often described as a "rumble".

Aerodynamic noise from a wind turbine is not dominant in the low frequency range. The main content of aerodynamic noise generated by a wind turbine is often in the area known generically as the mid-frequencies, being between 200 and 1000Hz.

Noise reduces over distance due to a range of factors including atmospheric absorption. The mid and high frequencies are subject to a greater rate of atmospheric absorption compared to the low frequencies and therefore over large distances, whilst the absolute level of noise in all frequencies reduces, the relative level of low frequency noise compared to the mid and high frequency content increases. For example, when standing alongside a road corridor, the mid and high frequency noise from the tyre and road interaction is dominant, particularly if the road surface is wet. However, at large distances from a road corridor in a rural environment, the remaining audible content is the low frequency noise of the engine and exhaust.

This effect is exacerbated in an environment that includes masking noise in the mid and high frequencies, such as that produced by wind in nearby trees.

A typical separation distance between wind farms and dwellings is of the order of 1000m. At similar distances, in an ambient environment where wind in the trees is present, it is possible that only low frequencies remain audible and detectable from a noise source that produces content across the full frequency range. This effect will be more prevalent for larger wind farms because the separation distances need to be greater in order to achieve the relevant noise standards. A greater separation distance changes the dominant frequency range from the mid frequencies at locations close to the wind farm to the low frequencies further away, due to the effects described above.

The low frequency content of noise from a wind farm is easily measured and can also be heard and compared against other noise sources in the environment. Low frequency sound produced by wind farms is not unique in overall level or content and it can be easily measured and heard at a range of locations well in excess of that in the vicinity of a wind farm. The C-weighting network (dB(C)) has been developed to determine the human perception and annoyance due to noise that lies within the low frequency range.

Infrasound

Infrasound is generally defined as noise at frequencies less than 20 Hz (O'Neal et al., 2009). The generation of infrasound was detected on early turbine designs, which incorporated the blades 'downwind' of the tower structure (Hubbard and Shepherd 2009). The mechanism for the generation was that the blade passed through the wake caused by the presence of the tower.

Audible levels of infrasound have been measured from downwind blade wind turbines (Jakobsen, J., 2005). Modern turbines locate the blades upwind of the tower and it is found that turbines of contemporary design produce much lower levels of infrasound (Jakobsen, J., 2005), (Hubbard and Shepherd 2009).

Infrasound is often described as inaudible, however, sound below 20 Hz remains audible provided that the sound level is sufficiently high (O'Neal et al, 2009). The thresholds of hearing for infrasound have been determined in a range of studies (Levanthall, 2003).

Non-audible perception of infrasound through felt vibrations in various parts of the body is not possible for levels of infrasound that are below the established threshold of hearing and only occurs at levels well above the threshold (Moeller and Pedersen, 2004).

Weighting networks are applied to measured sound pressure levels to adjust for certain characteristics. The A-weighting network (dB(A)) is the most common, and it is applied to simulate the human response for sound in the most common frequency range. The G-weighting has been standardised to determine the human perception and annoyance due to noise that lies within the infrasound frequency range (ISO 7196, 1995).

A common audibility threshold from the range of studies is an infrasound noise level of 85 dB(G) or greater. This is used by the Queensland Department of Environment and Resource Management's (DERM's) draft Guideline for the assessment of low frequency noise as the acceptable level of infrasound in the environment from a noise source to protect against the potential onset of annoyance and is consistent with other approaches, including the UK Department for Environment, Food and Rural Affairs (DEFRA., Leventhall, 2003).

Whilst the aerodynamic noise from a rotating turbine blade produces energy in the infrasound range, measurements of infrasound noise emissions from modern upwind turbines indicates that at distances of 200 metres, infrasound is in the order of 25 dB below the recognised perception threshold of 85 dB(G) and other similar recognised perception thresholds (Hayes Mckenzie Partnership Ltd, 2006). A 25 dB difference is significant and represents at least a 100 fold difference in energy content. Infrasound also reduces in level when moving away from the source, and separation distances between wind farms and dwellings are generally well in excess of 200m.

Notwithstanding the above, there are natural sources of infrasound including wind and breaking waves, and a wide range of man-made sources such as industrial processes, vehicles and air conditioning and ventilation systems that make infrasound prevalent in the natural and urban environment (Howe, 2006).

Future Designs

A wind turbine converts wind energy into rotational energy (which in turn becomes electricity) and acoustic energy. An efficient wind turbine converts more of the wind energy into rotational energy with all other factors, such as blade angles, being equal. Therefore, it is in the best interests of wind turbine manufacturers to research and make available quieter turbines, as this indicates an increase in the available electricity generating capacity as well as the benefits of lower noise levels:

> *The sound produced by wind turbines has diminished as the technology has improved. As blade airfoils have become more efficient, more of the wind energy is converted into rotational energy, and less into acoustic energy. Vibration damping and improved mechanical design have also significantly reduced noise from mechanical sources.*
> *(Rogers et al, 2006)*

STANDARDS AND GUIDELINES

Australia presently assesses the noise from wind farms under a range of Standards and Guidelines applicable to each individual State or Territory, shown below in Table 1

Table 1 – Summary of Australian State Standards and Guidelines for Wind Farms

State or Territory	Assessment Procedure	Comments
South Australia	SA EPA Wind Farms Environmental Noise Guidelines July 2009	The 2009 Guidelines is an updated version of the original 2003 Guidelines. The release follows a review process initiated in 2006
New South Wales	SA EPA Wind Farms Environmental Noise Guidelines February 2003	New South Wales has not automatically endorsed the 2009 version of the Guidelines, and at this stage retains the 2003 version as the primary assessment procedure.
Western Australia	SA EPA Wind Farms Environmental Noise Guidelines February 2003	The document EPA Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise Draft May 2007 refers to the 2003 version as the primary assessment procedure. The WA Government has not endorsed the 2009 version of the Guidelines at this stage.
Queensland	No formal assessment procedure	The New Zealand Standard and the South Australian 2003 Guidelines have been referenced by the Queensland Government in the past.
Victoria	New Zealand Standard NZS 6808:1998 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*	The document Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria refers to the 1998 version of the New Zealand Standard as the primary assessment procedure. The 2010 version of the Standard has not been endorsed in the Guidelines at this stage.
Tasmania	Department of Primary Industries, Water and Environment (Tasmania) *Noise Measurement Procedures Manual 2004*	The document does not provide objective criteria and therefore the use of one of the assessment procedures noted for the States above will be required in conjunction with the 2004 Manual.
ACT and Northern Territory	No formal assessment procedure	To be assessed on a case by case basis.

In addition to the above, Australian Standard AS4959 – 2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators* has been released recently. The Standard does not provide any objective criteria, but rather it aims to provide a suitable framework to develop a method for the measurement, prediction and assessment of noise from wind farms.

Based on the above, a wind farm proposal could be subject to a range of assessment procedures depending on the jurisdiction. Whilst there are consistent elements in the different procedures, there are inherent and important discrepancies.

Objective Standards

In general terms, the noise from a wind farm increases with wind speed up until the rated power (electrical output capacity) of the particular turbine, when the noise then remains constant or even reduces at higher wind speeds. The increase in wind turbine noise as the wind speed increases normally plateaus, or even potentially diminishes, occurs in an environment where the background noise level continues to increase, the effect of which is to assist in masking the wind farm noise.

Therefore, wind farm standards and guidelines in Australia and New Zealand set a base noise limit that generally applies at lower wind speeds when the background noise is relatively low, and a background noise related limit that allows the wind farm to generate higher noise levels as the wind speed increases.

In circumstances where the background noise levels are sufficiently low, the base noise limit applies. This generally occurs at lower wind speeds and/or at dwellings that are not subject to a sufficiently high background noise environment, such as might occur at a dwelling deep in a valley with little to no surrounding vegetation.

In circumstances where the background noise levels increase sufficiently, the background noise related limit applies. This generally occurs at higher wind speeds and/or at dwellings that are subject to a high background noise environment, such as might occur at a dwelling on a ridge top surrounded by trees.

Where the wind farm is able to achieve the base line noise limit at higher wind speeds, the masking effect of the background noise environment does not need to be taken into account. This is because the base line noise limit is generally established to ensure there are no adverse noise impacts, even in a low background noise environment when the masking effects are limited.

The objective standards provided by the various assessment procedures is summarised in the table below:

Table 2 - Objective Standards

Assessment Procedure	Objective Standard	Comments
Government of South Australia Wind Farms Environmental Noise Guidelines February 2003	Base noise limit: 35 dB(A) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are an equivalent (or effectively an average) noise level.
Government of South Australia Wind Farms Environmental Noise Guidelines July 2009	Base noise limit: 35 dB(A) (Rural living locality) Base noise limit: 40 dB(A) (in other localities including general farming and rural areas) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The base noise level limit has been increased to 40 dB(A) to ensure consistency with the assessment limits applied by the *South Australian Environment Protection (Noise) Policy 2007* to other noise sources in a general farming or rural locality.
New Zealand Standard NZS 6808:1998 *Acoustics – The Assessment and Measurement of Sound from Wind Turbine Generators*	Base noise limit: 40 dB(A) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	Whilst there is conflicting information in the Standard, the limits are taken to be an equivalent noise level.

Assessment Procedure	Objective Standard	Comments
New Zealand Standard NZS 6808:2010 *Acoustics – Wind Farm Noise*	Base noise limit: 35 dB(A) (High amenity area) Base noise limit: 40 dB(A) (Other areas) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are expressed explicitly in the Standard to be a 90th percentile level (L_{A90}). The L_{A90} is inherently less than the equivalent noise level and therefore the limits are higher (less stringent) than those in the South Australian Guidelines. A high amenity area is related to a review of the planning system and the specific requirement in the relevant plan to maintain a high degree of protection to the "sound environment". If the area is deemed to be of high amenity, then the L_{A90} 35 dB(A) base noise level limit applies only during the night period, and for wind speeds less than 6 m/s or other defined threshold for that specific proposal.
Australian Standard AS4959 – 2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators*	Deferred to the relevant jurisdiction.	Notes that the jurisdiction should have a base noise level limit and a background noise level limit.
Environment Protection Heritage Council (EPHC) prepared Draft National Guidelines October 2009 and July 2010	Deferred to the relevant jurisdiction.	Notes that the jurisdiction should have a base noise level limit and a background noise level limit.

Comparison of the objective standards with International approaches

The objective standards provided by a range of International assessment procedures is summarised in the table below (Reference 1 unless noted otherwise):

Table 3 – Summary of International Standards

Assessment Procedure Country of Origin	**Objective Standard**	**Comments**
Sweden	Base noise limit: 40 dB(A) Low background areas: 35 dB(A)	The approach does not provide a definition for a low background area.
Denmark	Noise limit: 44 dB(A) @ 8m/s 42 dB(A) @ 6m/s For sensitive areas such as institutions, allotment gardens and recreation: Noise limit: 39 dB(A) @ 8m/s 37 dB(A) @ 6m/s	No background noise limit is applied. The noise limits are determined for wind speeds taken at 10m above the ground.
France	Background noise limit margin: 5 dB(A) – day time Background noise limit margin: 3 dB(A) – night time	Based on a background noise measurement made at a wind speed of 8m/s
The Netherlands	Noise limit: 40 dB(A) at night increasing incrementally up to 50 dB(A) at 12m/s	

Assessment Procedure Country of Origin	**Objective Standard**	**Comments**
United Kingdom	Base noise limit: 40 dB(A) (day time) Base noise limit: 43 dB(A) (night time) Background noise limit margin: 5 dB(A). The greater of the above limits applies.	The limits are a 90th percentile level (L_{A90}). The L_{A90} is inherently less than the equivalent noise level. The UK assessment procedure indicates the L_{Aeq} from a wind farm is typically of the order of 2 dB(A) greater than the L_{A90} The procedure notes that the recommended noise levels take into account "swish".
USA (Illinois) (Reference TD178-01F06)	Base noise limit: 55 dB(A) (day time) Base noise limit: 51 dB(A) (night time)	The noise limits are determined for an 8 m/s wind speed taken at 10m above the ground. There are no uniform noise standards in the USA, with local counties establishing their own approaches which vary considerably.

In broad terms, the Standards and Guidelines used in Australian jurisdictions include the following common elements:

- Objective standards that provide a base noise limit and a background noise related limit, with the exception of the EPHC draft Guidelines and the Australian Standard;
- A background noise and wind speed measurement procedure to determine the applicable background noise related limits at each dwelling;
- A noise level prediction methodology to enable a comparison of the predicted noise level from the wind farm against the noise limits at each dwelling;
- The required adjustments to the predicted noise levels to account for any special audible characteristics of the wind farm noise;
- A compliance checking procedure to confirm the operational wind farm achieves the predicted noise levels at each dwelling.

In addition, Australian jurisdictions are amongst the most stringent and the most contemporary in the World.

Noise Levels

A common issue for people considering the environmental noise from wind farms is the ability to place the wind farm's noise levels and characteristics in context compared to the ambient environment.

A site visit to an operating wind farm at different times and at typical separation distances between a wind farm and a dwelling, starting from the order of 700m from the nearest turbine, greatly assists in providing this context.

To assist in providing context for typical noise levels from a wind farm, Chart 1 (below) provides the order of noise level in the vicinity of a modern wind turbine. It should be noted that the noise levels presented in the chart will vary according to a range of variables discussed in further detail in the noise propagation section of this Paper.

The base noise level requirement of 35 or 40 dB(A) provided in the main assessment tool in Australia, the South Australian EPA Wind Farm Guidelines, represents a low (stringent) noise level in an environmental noise context. It is significantly more stringent than the World Health Organisation's recommended guideline value of 45 dB(A) for sleep disturbance effects and than the recommended noise levels for road or rail infrastructure development that might occur in a rural environment, where levels of the order of 55 and 60 dB(A) respectively are typically recommended.

The base noise level requirements also need to be considered in the context of the ambient environment. Wind farms are generally located in a rural environment, where the associated planning system often envisages and promotes activity associated with primary industry.

A wind farm is also inherently located in areas where wind is present and therefore background noise levels from wind in the trees and around structures such as houses and sheds can be elevated. The effect of elevated background noise levels is to provide masking of other noise sources in the environment.

Regardless of the stringency of the base noise level or the available masking effect of the ambient environment, wind farm standards and guidelines are not established to ensure inaudibility. The ability to hear a wind farm designed and operated in accordance with the standards and guidelines in Australia will vary according to a range of variables such as the influence of the ambient environment, the local topography, the distances involved and the weather conditions at the time.

All noise, from any noise source including wind farms, which is audible, will result in complaints from some people. In addition, recent research indicates the potential for complaints, annoyance and its associated stress and health impacts may be exacerbated by rhetoric, fears and negative publicity (Colby et al, 2009). There is a significant amount of mis-information and negative publicity about the impacts of wind farms available in the broader community.

Only a few field studies on noise annoyance among people living close to wind turbines have been conducted and further investigations have been recommended by these studies. The European studies (Pedersen, 2005) indicate correlation between the noise level and annoyance, but stronger correlation with factors such as overall sensitivity to noise, attitude towards the noise source, attitude towards the area as a pristine place or a place for economic development, influence over the proposal, daily hassles, visual intrusion and the age of the turbine site.

Tickle (2006) compared the incidence of complaints in Australia and New Zealand, about noise from wind farms and complaints about noise in general and found that once wind farms are built the rates of complaints are very low in Australia and New Zealand.

Notwithstanding the above reasons or information, if a noise source can be heard, then annoyance can result for some people, regardless of the noise level or the standard or guideline that applies.

Figure 3 below provides some relative noise level information and compares wind turbines against common community noise levels:

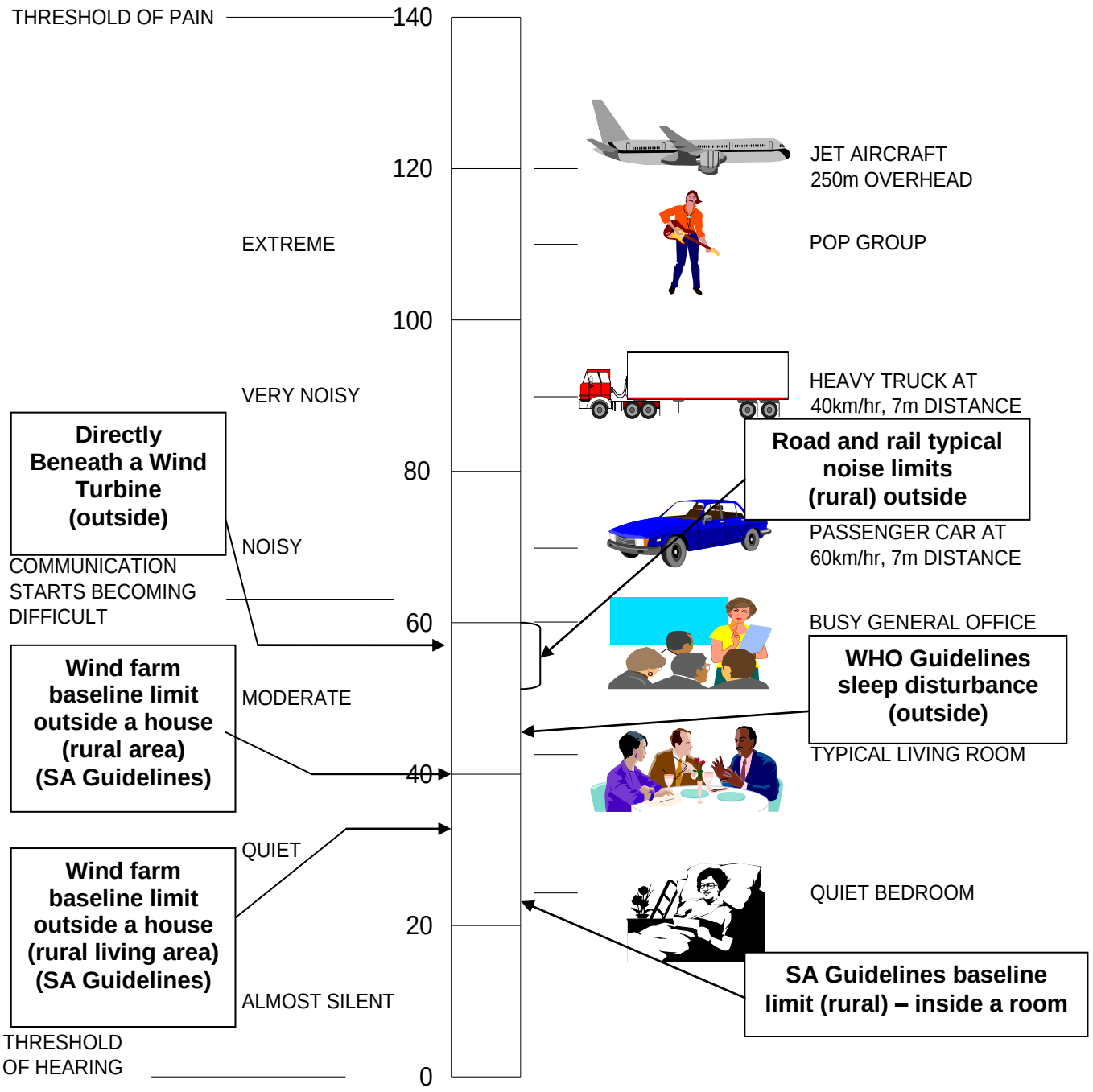

Figure 3 – Subjective Comparison of Noise Levels

ASSESSMENT METHODOLOGY

Whilst each Australian jurisdiction is subject to its own Standards and Guidelines and associated detailed requirements, the broad methodology for an environmental noise assessment of a wind farm proposal is similar amongst jurisdictions.

This section of the Technical Paper provides the background to the assessment process to assist in interpretation and understanding of the technical information that will generally be provided as part of a wind farm proposal and assessment.

Environmental Noise Assessment

Noise is often the most important factor in determining the separation distance between wind turbines and sensitive receivers. The assessment of noise therefore plays a significant role in determining the viability of and the size of wind farms.

The developer of a wind farm makes an assessment of the environmental noise from the proposed layout and to determine any necessary modifications to ensure compliance with the relevant Standard and Guidelines. The modifications during the planning and design phase of the project might comprise the removal or relocation of some turbines or the operation of certain turbines at reduced speeds or “modes” that correspond to lower noise levels. The assessment is generally made by an independent acoustic engineer specialising in the prediction and assessment of noise and vibration impacts across a broad range of sectors, including wind farms.

Methodology

The broad methodology associated with an environmental noise assessment of a wind farm proposal is as follows:

1. Review the proposed layout to identify dwellings where the relevant criteria might be exceeded;

   The purpose of the identification is to determine the locations at which background noise monitoring will be conducted.

   The background noise monitoring is a measurement method used to establish the existing ambient noise environment at a dwelling. The technical definition of the background noise is the noise level that is exceeded for 90% or 95% of the measurement period. In subjective terms, it represents the "lulls" that occur in the environment, in between intermittent events such as the overhead passage of an aircraft, a dog barking, wind gusts in trees, or the occasional passing of a vehicle on a nearby road. This is because the background noise excludes all noise level data that is not present for at least 90% (or 95% depending on the Standard or Guideline used) of the time. A common term used in the assessment is the "ambient" noise. The ambient noise is generally taken to include all the intermittent events, whilst the background noise effectively removes these events and represents the noise environment in their absence.

   The background noise at a dwelling is important because it can mask the noise of a wind farm, and the level of that masking can be an important factor in the assessment. The most general source of background noise level masking, particularly at higher wind speeds, is wind in nearby trees.

   The land owners who have a turbine on their land are also identified during this process, as the assessment criteria applied to them are relaxed by most Standards and Guidelines in comparison to dwellings without an association with the proposed wind farm.

Land holdings where a development approval exists to construct a dwelling are also generally identified as most Standards and Guidelines define these as locations where the relevant criteria need to be met.

Once those dwellings and land holdings are identified, the locations that best represent the range of dwellings in the locality are selected. These are generally defined as dwellings that are closest to the wind farm. The Standards and Guidelines generally allow a single dwelling to represent a range of dwellings that are either in the near vicinity or expected to be subject to a similar background noise environment.

A term that is commonly used in the Standards and Guidelines is "relevant receiver location". These locations are generally:

- Where someone resides or has development approval to build a dwelling; and
- Where the predicted noise level exceeds the base noise level for wind speeds up to the rated power of the wind turbine; and
- Representative of the worst case location when considering the range of dwellings, such as a dwelling that is located amongst a similar group in the near vicinity and is the closest to the wind farm.

2. <u>Conduct a background noise monitoring regime at the relevant receiver locations;</u>

The measurement of background noise levels is a critical aspect of the environmental noise assessment as it is the method by which criteria are determined.

The exception to the need to conduct a background noise monitoring regime is in circumstances where the wind farm is able to achieve the base noise level limit (or a prescribed noise level that is less than the base noise level) at wind speeds where the noise output of the particular turbine is at its maximum. This is because the base noise level limit is generally established to ensure there are no adverse impacts even in a low background noise environment where the masking effect is limited or negligible.

Notwithstanding compliance with the base noise level limit, a background noise monitoring regime may still be conducted as it the means by which compliance checking procedures are generally based upon. The compliance checking procedure is discussed in further detail in a dedicated section below.

Where conducted, the background noise monitoring can be over a range of the order of 10 days to 4 weeks, depending on the particular requirements of the relevant Standard or Guideline. The period of monitoring can also be extended where excessive wind or rain adversely affect the data. The apparatus used to continually measure and record the background noise levels over this period is known as a "logger".

The location of the logger is typically at least 5m from the building facade to remove the effects of large reflecting surfaces. The location is also required to be representative of background noise levels and this is generally achieved by placing the logger at an equivalent distance to tall trees as the facade of the house. The logger is also generally placed on the windfarm side of the dwelling to enable any future compliance checking measurements at dwellings to be taken at the same point.

Photographs and a GPS grid reference are typically used to identify each noise logging location. A typical installation is shown in Figure 4 below. The noise logger, comprising a sound level meter and batteries within a weatherproof container connected to a pole mounted microphone, is located in the centre of the photograph.

Figure 4 – Typical Noise Monitoring Installation

Some Standards and Guidelines explicitly require the removal of adverse data and data outside of the wind speed operating range of the turbines and it is considered good practice to do so. The 2003 and 2009 SA Guidelines require data points where rain has occurred and when wind on the microphone has had an impact on the measured noise levels to be removed. A way of measuring the occurrence of these factors is to place a weather logger adjacent to one of the background noise loggers to record rainfall, wind speed and wind direction. If in close proximity, a local Bureau of Meteorology weather station can also be used to identify adverse weather periods.

An acoustic engineer would take of the order of one hour to set up the noise logging equipment at each location. Access is normally organised directly with the land holder or dwelling occupier in accordance with established project protocols. Clearly, a land holder or occupier does not need to grant access to their property, however, an advantage of doing so is the ability to confirm compliance, or otherwise, of the operational wind farm against the relevant Standards or Guidelines at a point in the future.

3. Analyse the background noise monitoring data to determine the noise level criteria;

Following the removal of data adversely affected by local weather conditions, the remaining data points are correlated against the wind speed collected at the same time and for the same period as the background noise levels. The background noise level is determined for every ten minute period throughout the 2 to 4 week monitoring regime.

The wind speed is measured by the developer or another independent expert at a representative location within the wind farm by erecting a wind mast with anemometers, sometimes at a number of different heights. There may be more than one wind mast depending on the size of a wind farm.

Earlier Standards and Guidelines required the wind speed to be measured at 10m above the ground, however, recent requirements relate to measurements at or near the proposed hub height of the wind turbine, which may be of the order of 80m above the ground. The reason for the 10m measurement height was to provide correlation with the way the sound power level of a wind turbine is measured in accordance with IEC 61400 – 11 (IEC, 2002)[1], whereas the increase to at or near hub height has been introduced to better represent actual operating scenarios.

The purpose of the correlation of the two sets of data, being the wind speed measured at the wind farm site (data set one) and the background noise levels measured at a relevant receiver (data set two), is to establish the relationship between the operating wind farm and the average background noise level at dwellings in the vicinity, and in turn, to determine the applicable criteria at those dwellings. That is, the correlated data will determine whether the wind farm will be operational during periods when the background noise levels are on average low, providing limited masking, or when the background noise levels are on average high, providing a greater level of masking.

A best fit regression analysis is conducted on the two sets of data. An example plot produced from background noise measurements is given in Figure 5 below.

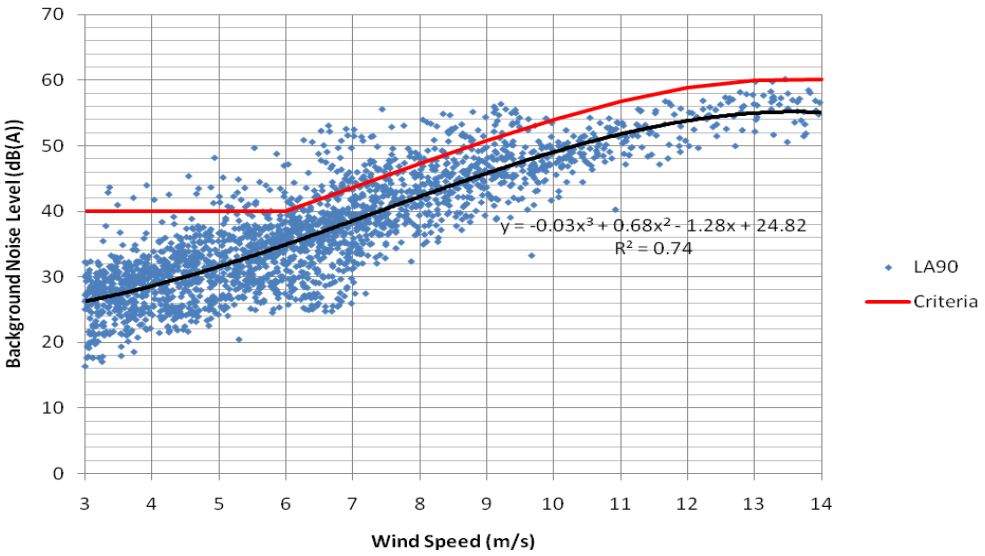

Figure 5 – Example Regression Analysis Plot

[1] An expected revision of the IEC standard will include reference to a hub height measurement position

Whilst most regression analyses will show the trend of the background noise level increasing with an increasing wind speed at the wind farm, the analyses will vary for each individual dwelling. Figure 5 shows a strong relationship between the background noise level and the wind speed at the wind farm, but this will not be the case in all circumstances. Some dwellings may be located such that they are shielded from the effects of the wind at the wind farm site.

The red line in the figure shows how the correlated data is used to determine the applicable noise level criteria at a dwelling. In this example, the base noise level limit is 40 dB(A), and this is not increased until the average background noise level increases sufficiently to provide a suitable level of masking. In this example, the background noise level becomes suitably high at wind speeds at the wind farm site that are at and above 6 m/s.

An important feature of the regression analysis is that it represents a line of best fit or effectively an "averaging" of the data. Therefore, there will be times when the environment provides more masking than indicated by the line of best fit, and other times when the environment provides less masking.

4. Predict the noise level from the proposed wind farm;

The prediction of noise from a wind farm can be made at any location from a range of available models, and the various Standards and Guidelines provide flexibility with respect to the selection of that model and the assumptions that are made.

In broad terms, the most basic noise models determine the noise level at a location based on the acoustic energy of the noise source, in this case the wind turbine, and the attenuation of noise over distance. These types of noise models do not account for other attenuation factors such as ground absorption, meteorological effects and screening due to ground contours and as such are considered to be inherently conservative (predicting higher noise levels than expected in situ). Basic models are often used by developers to establish a preliminary layout of a wind farm. The more complex and refined models include attenuation due to the factors noted above.

Wind Turbine Sound Power Levels for input to the noise model

The acoustic energy of the noise source is commonly termed the “sound power level”, and for wind turbines it is determined in accordance with the International Standard IEC 61400-11 “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques”. The sound power level is generally provided for each integer wind speed ranging from the speed that the turbine “cuts in” for operation through to the speed at which it approaches its rated power. The sound power level increases with wind speed and then remains constant or even reduces in higher wind speeds. The sound power level is a constant that does not alter with location for a given wind speed.

The final selection of the wind turbine to be used at a site is typically subject to a competitive tendering process. The tendering process generally occurs in the design and development phase of the project after project approval is granted. This is consistent with a range of other industries and sectors, where plant and equipment contracts are not finalised until after project approval is granted, when all conditions of that approval are known and commitments to outlay significant capital cost can be made.

In addition, lead times between the project approval and procurement stage of a major project can be over a period of years, in which time there may be changes in the turbine models, their available technology and their noise levels. Therefore, it is common practice that noise assessments conducted for the purposes of project approval are made based on representative turbines, rather than a final selection.

The selection of the representative turbines is often made by the proponent or by the proponent in conjunction with an acoustic engineer, to ensure the turbines used are representative of the final turbine selection.

It is in the best interest of a proponent in any major wind farm project to select representative turbines for noise assessment purposes during the project approval stage, as any approval granted is likely to result in conditions and site constraints based on that selection and subsequent assessment. These constraints need to provide sufficient flexibility to invite a range of suppliers to tender for the project as part of a competitive process during the design development and documentation stage of a project.

It is a common arrangement for the wind turbine manufacturer to guarantee a sound power level of a particular make and model of a turbine to a wind farm developer. This guarantee is then confirmed in situ repeating the methodology provided by the International Standard (IEC, 2002).

Attenuation factors for input to the noise model

The attenuation factors are generally chosen to represent the "worst case" situation, such as assuming that the wind is blowing from the turbine to the dwellings or "downwind", however, there is flexibility in the Standards and Guidelines with respect to the factors used for inputs to the models, provided the rationale for these inputs is included in the assessment. Ultimately, the selection of the model and its input factors must be conservative enough to ensure compliance of the operational wind farm. A requirement to conduct a "compliance checking" procedure is included in the Standards and Guidelines used in Australia.

A typical approach to the modeling process is to conduct initial predictions with a simple model that provides a preliminary estimate of the noise. This assists in confirming the proposed background noise logger locations and the preliminary wind farm layouts. These initial predictions are then refined after the background noise monitoring has been completed with a more complex model. In Australia, this is typically either the CONCAWE or ISO-9613 noise propagation model using conservative assumptions.

Joule (*Reference*) has conducted a study of the accuracy of the ISO-9613 model as it relates to wind farms and found that:

> *The accuracy of output from the ISO model is impressive. Agreement with sound pressure levels measured under conditions of an 8 m/s positive vector wind speed has been measured to within 1.5dB(A) on flat, rolling and complex terrain sites.*

As with any model, the accuracy is subject to its inputs which are summarised in the Joule Paper (Bass et al, 1998*)* and in other summary works (Bowdler et al, 2009). These include the temperature and humidity to be used, how hard or soft the ground should be taken to be, the relative height of the receiver and the amount of "barrier" attenuation that should be applied to the ground contours.

Provided these inputs are applied to the ISO 9613 model, the Joule study found that the calculated sound pressure levels are validated to agree to within 2dB(A) of noise levels measured under practical 'worst case' conditions at distances of up to 1000m from a noise source, and that due to the

> *observed scatter of measured sound pressure levels under these same conditions*, ….. *an 85% level of confidence can be placed on the noise levels measured in practice not exceeding the calculated level by more than 1dB(A).*

A 1 dB(A) difference is negligible in terms of perception.

The ISO 9613 model assumes that a receiver is downwind from all wind turbines. In some circumstances such as where the turbines are on opposite sides of a dwelling but at similar distances this will provide a conservative outcome (a predicted noise level higher than that expected in situ). The Standards and Guidelines used in Australia therefore provide the flexibility to use other models that account for an upwind scenario.

5. Compare the predicted noise levels with the criteria;

A comparison is made between the predicted noise levels and the noise level criteria established by the background noise monitoring regime. This comparison is made for each integer wind speed, generally within the operating range of the wind turbine.

Where the predicted noise levels achieve the criteria, then the process and results are summarised in a report suitable for submission to the relevant authority. The extent of information provided in the reports is summarised in Step 6 below.

Where the predicted noise levels do not achieve the criteria, then mitigation options are considered. The options considered will depend on the number of locations the criteria are exceeded at, the difference between the predicted noise level and the criteria, and the number of integer wind speeds at which the predicted noise level exceeds the criteria. The mitigation options include:

- The operation of wind turbines under reduced noise level modes for particular conditions;
- The consideration of alternative turbines with lower sound power levels;
- The adjustment of the wind turbine layout;
- The consideration of removing turbines from the layout.

An example is provided for a dwelling in a low background noise environment:

- *Due to the background noise levels being low on average at the closest dwelling to the proposed wind farm over the required monitoring period, the baseline noise limit applies at all operating wind speeds. In this example, the dwelling is located in a general farming area and the baseline limit is 40 dB(A);*
- *The highest sound power level from the representative turbine selection occurs at a hub height wind speed of 10m/s;*
- *The predicted noise level at wind speeds of 10m/s or greater is 43 dB(A) at the closest dwelling and therefore exceeds the noise level criterion of 40 dB(A);*
- *The options available to reduce the predicted noise level by 3 dB(A) include:*
    1. *Adjusting the layout of the closest turbines to the dwelling;*
    2. *Operating the closest 4 turbines to the dwelling in a low noise mode at wind speeds of 10m/s or greater. This is only required to occur under downwind conditions (wind from the turbines to the dwelling), as the model shows that under upwind conditions (wind from the dwelling to the turbines) the wind farm complies with the baseline limit, even at full mode operation;*
    3. *Selecting an alternative wind turbine with a lower sound power level.*
    4. *Removing the closest turbine to the dwelling.*
- *Of the above, Option 2 is selected, due to the flexibility it provides in the future competitive tendering process for the final wind turbine selection, and the ability of contemporary turbine control systems to implement an operating strategy where certain turbines can be operated in certain "modes" under specific operating conditions like wind speed and/or wind direction.*

Once the predicted noise levels achieve the environmental noise criteria at each relevant receiver and for each operational wind speed, a summary report is prepared that is suitable for submission to the relevant regulatory authority.

6. Prepare a report suitable for submission to the relevant regulatory authority;

A report is prepared by the developer that summarises the above five steps. In general terms, the report would typically provide the following information, subject to the particular requirements of the regulatory authority assessing the development proposal:

- Background noise measurement locations;
- Time and duration of the background noise monitoring regime;
- Wind speed monitoring locations and heights above ground;
- Graphical correlation plot of the wind speed versus background noise level data;
- A summary of the environmental noise criteria for the project at each integer wind speed based on the correlation;
- The make and model of the representative wind turbine/s;
- The positions of the wind turbines;
- The model used to predict the wind farm noise levels;
- The input assumptions and factors used in the model;
- The predicted noise levels at the closest dwellings to the wind farm at each integer wind speed;
- A comparison of the predicted noise levels against the criterion at each integer wind speed for the closest dwellings to the wind farm;
- The modifications or operating strategy required to ensure compliance with all noise criteria for all wind speeds and at all locations;
- A comparison of the predicted noise levels against the criteria at each integer wind speed for the closest dwellings to the wind farm, showing compliance with the proposed modification or operating strategy in place.

The above six steps provide an overview of the typical assessment methodology. The following information provides frequently asked questions during the preparation and finalisation of such an assessment.

Separation Distances

A common request from the surrounding community is to provide a set separation distance between the wind farm and the nearest dwelling.

Where an objective assessment method is used as outlined above, there is no set distance that could be applied with equity to every wind farm. This is because of the range of factors that affect the predicted and the resultant operational wind farm noise level. These factors include the number of turbines, their locations relative to the dwelling, the sound power level of the turbine, the topography between the turbines and the dwelling, the existing background noise environment at the dwelling and the resultant criteria applied by the relevant Standards and Guidelines.

Separation distances between wind farms and dwellings can be of the order of 800 to 1200m. These separation distances will change according the above factors. The separation distances are related to the stringency of the assessment criteria within the relevant Standards and Guidelines.

Assessment Process

An environmental noise assessment for a wind farm needs to contain significant detail to show compliance with Australian jurisdiction's Standards and Guidelines.

As with all assessments, there might be areas that are contended to be at variance with the requirements of those Standards and Guidelines.

Each State Jurisdiction will have its own specific rules with respect to the ability to appeal in situations where the parties do not agree that the assessment provides the necessary information or where a decision of the relevant regulatory authority is in dispute.

A number of wind farms have been considered in the environmental courts in their relevant jurisdictions, including:

- Taralga Landscape Guardians Inc vs Minister for Planning and RES Southern Cross Pty Ltd, NSW Land and Environment Court Proceedings No. 10196 of 2006;
- RES Southern Cross Pty Ltd v Minister for Planning (DOP) and Taralga Landscape Guardians Incorporated (TLG) NSW Land and Environment Court Proceedings No. 11216 of 2007;
- Epuron Pty Ltd & Gullen Range Wind Farm Pty Ltd & Ors vs Parkesbourne / Mummel Landscape Guardians Incorporated (PMLG), NSW Land & Environment Court Proceedings No. 41288 of 2008.

Judgments made in matters such as these provide important clarification in interpretation of the Standards and Guidelines or their general application and scope. Relevant outcomes from the above judgments include:

- An additional 5 dB(A) penalty for excessive amplitude modulation is not necessary when using the SA 2003 Guidelines. However, the application of acoustic treatment to the facades of dwellings in the vicinity might be a precautionary approach for the established presence of such excessive modulation;

- The heightened sensitivity of an individual to noise should not be taken into account in the assessment of a wind farm, but rather the objective and empirical methods of the

relevant Standards and Guidelines adopted by consent authorities and regulators should be relied upon.

The judgment relating to the heightened sensitivity of an individual is important and can be found at Paragraph 154 of the Gullen Range judgment as follows:

> *Inserting subjectivity consent requirements based on an individual's or a group of individuals' reaction to the noise from the wind farm, based on their opposition to the development, is entirely alien to the planning system. Whilst, in some areas such as streetscape impact, individual aesthetic considerations may arise and judgments made upon them, we are unaware of any authority to support the proposition that, where there is a rationally scientifically measurable empirical standard against which any impact can be measured and determined to be acceptable at a particular empirically determined level, that there should be some allowance made for a subjective response to the particular impact.*

Compliance Checking

The assessment process occurs well before a wind farm is operational. Therefore, to confirm compliance with the assessment criteria, a measurement procedure is conducted once the wind farm is operational.

The Standards and Guidelines in Australian jurisdictions all provide a methodology for noise level measurements of an operational wind farm.

The term commonly applied to these measurements is “compliance checking”.

It is common for a planning or relevant regulatory authority to impose a condition of approval for a wind farm development that requires “compliance checking” and reporting thereon within a certain timeframe of commissioning the wind farm.

In general terms, compliance checking can effectively be a repeat of the background noise monitoring regime. The variations that are applied to the compliance checking procedure might include collecting a minimum number of noise level data points under downwind conditions. A comparison is then made of the noise environment before the wind farm and after the establishment and operation of the wind farm.

As wind farm assessments account for the masking effect of the ambient environment, there will be inherent difficulties in identifying the wind farm noise amongst other noise, in particular and most commonly, the background noise generated by wind in the trees. Therefore, compliance checking procedures generally provide a level of flexibility in the methodology, which might include turning the turbines on and off to determine their influence amongst other noise in the environment, or measuring at a location much closer to the wind farm, where the noise from the wind farm is more dominant in comparison to other noise in the environment.

TOPICS OF INTEREST

A range of topics of interest exist for wind farms that are raised by the community, by acoustic engineers, by health professionals, by the industry and by regulatory authorities.

The key topics to be addressed are those that relate to the health of the surrounding community.

There has been extensive research conducted into the relationship between noise levels and characteristics of wind farms and the potential for adverse health impacts, and the research overwhelmingly concludes that wind farm noise does not adversely impact on a person's health.

Health Effects

In 2009 the American and Canadian Wind Energy Associations established a scientific advisory panel comprising medical doctors, audiologists and acoustic professionals from the United States, Canada, Denmark and the United Kingdom to produce "an authoritative reference document for legislators, regulators, and anyone who wants to make sense of the conflicting information about wind turbine sound". (Colby et al, 2009)

The Panel concluded:

> *there is no reason to believe, based on the levels and frequencies of the sounds and the panel's experiences with sound exposures in occupational settings, that the sound from wind turbines could plausibly have direct adverse health consequences.*

The Victorian Department of Health (DH) (WorkSafe, 2010) has examined both the peer-reviewed and validated scientific research and concluded that

> *the weight of evidence indicated that there are no direct health effects from noise (audible and inaudible) at the levels generated by modern wind turbines.*

The Australian Government's National Health and Medical Research Council (NHMRC, 2010) has examined the "evidence from current literature on the issue of wind turbines and potential impacts on human health" and concludes:

> *There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines (NHMRC, 2010).*

Notwithstanding the above, Dr Nina Pierpont (Pierpont, 2009) contends that adverse health outcomes are caused by wind farm noise and in particular, its low frequency content. Pierpont uses the term "wind farm syndrome" to describe the effects, which include headaches, sleeplessness and anxiety. The Pierpont report is not peer reviewed and the hypothesis is based on the assumption that infrasound levels near wind farms are higher than infrasound levels in the general environment.

The American and Canadian Wind Energy Association's panel reviewed the Pierpont report and the "wind farm syndrome" and concluded:

> *"Wind turbine syndrome," not a recognised medical diagnosis, is essentially reflective of symptoms associated with noise annoyance and is an unnecessary and confusing addition to the vocabulary on noise. This syndrome is not a recognised diagnosis in the medical community. There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder. The collective symptoms in some people are more likely associated with annoyance to low sound levels (Colby et al, 2009).*

To this end, the panel's report provides information on "the complex factors culminating in annoyance", which includes the nocebo effect (Spiegel, 1997).

The nocebo effect is "an adverse outcome, a worsening of mental or physical health, based on fear or belief in adverse effects. This is the opposite of the well known placebo effect, where belief in positive effects on an intervention may produce positive results" (Colby et al, 2009).

With respect to the nocebo effect, the panel concludes:

> *..the large volume of media coverage devoted to alleged adverse health effects of wind turbines understandably creates an anticipatory fear in some that they will experience adverse effects from wind turbines. ….The resulting stress, fear, and hyper vigilance may exacerbate or even create problems which would not otherwise exist. In this way, anti-wind farm activists may be creating with their publicity some of the problems they describe (Colby et al, 2009).*

There is a large amount of publicly available material that deals with alleged adverse health effects of wind turbines regardless of the overwhelming research to the contrary. A recent and relevant example includes an article as part of a series in the Sydney Morning Herald (SMH, 2010) on wind farms which included a quote that linked Hitler's torture methods to noise from a wind farm without any further information regarding the conclusions of recent health related research in the article.

The NHMRC review provides consistent conclusions to the panel with respect to health:

> *It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health (Chapman, 2009)*

Based on the above, it is essential that all stakeholders have access to a source of consolidated information that summarises the topics of interest that are commonly raised and the research that is available on these topics. A broad summary of health effects has been provided above, and the specific topics of interest commonly linked to adverse health effects are addressed in detail below, which include infrasound and low frequency content of a wind farm, amplitude modulation and sleep disturbance effects.

Infrasound and low frequency noise

The hypotheses regarding a link between infrasound from wind farms and the presence of adverse health effects including dizziness, headaches and nausea made by Pierpont (Pierpont, 2009) are not based on measured levels of infrasound from operational wind farms.

Specific International studies that have measured the levels of infrasound in the vicinity of operational wind farms indicate the following:

- The levels of infrasound are significantly below recognised perception thresholds and are therefore not detectable to humans (Hayes McKenzie Partnership Ltd, 2006); and
- The levels of infrasound are of the same order as those measured in residential areas due to general urban activity (Howe, 2006).

Similar studies are currently being conducted in Australia in order to provide an objective assessment and confirmation of the European research.

Notwithstanding the results of the objective assessments, Colby et al, 2009, have critiqued the Pierpont hypotheses and conclude:

> *No foundation has been demonstrated for the new hypothesis that exposure to sub-threshold, low levels of infrasound will lead to vibroacoustic disease. Indeed, human evolution has occurred in the presence of natural infrasound.*

Infrasound is a specific component of low frequency noise that requires a specific measurement methodology to identify it as it is readily affected by wind on the microphone. Wind is a source of natural infrasound.

Whilst the hypotheses regarding adverse health effects often refer to “low frequency noise”, this is often a generic description which is taken to include infrasound.

The low frequency content of noise from a wind farm is easily measured and can also be heard and compared against other noise sources in the environment. Low frequency sound produced by wind farms is not unique in overall level or content and it can be easily measured and heard at a range of locations well in excess of that in the vicinity of a wind farm.

Colby et al (2009) notes with respect to low frequency noise:

> *The low frequency sound emitted by spinning wind turbines could possibly be annoying to some when winds are unusually turbulent, but there is no evidence that this level of sound could be harmful to health. If so, city dwelling would be impossible due to the similar levels of ambient sound levels normally present in urban environments.*

Amplitude Modulation

Amplitude modulation is an inherent noise character associated with wind farms. It should be noted that the ambient environment modulates in noise level by a significantly greater margin and over a significantly greater time period than that which would be audible from a wind farm at a typical separation distance. Notwithstanding, the South Australian Guidelines (2003 & 2009) note that the objective standards include a 5 dB(A) penalty for this fundamental and inherent character of amplitude modulation.

A 5 dB(A) penalty is a significant acoustic impost. To reduce a noise source by 5 dB(A) requires either the distance between the source and the receiver to be approximately doubled, or the noise source to reduce its output by two thirds. In wind farm terms, this means the distance between the farm and the nearest dwellings might need to be doubled, or up to two thirds of the total turbine numbers would need to be removed, compared to a wind farm not subject to such a penalty.

The ability to hear the “swish” (amplitude modulation) depends on a range of factors. It will be most prevalent when there is a stable environment (temperature inversion) at the wind farm and the background noise level at the listening location is low. In addition, amplitude modulation is greater when located cross wind from a wind turbine (Olermans and Schepers, 2009). It is noted that whilst the amplitude modulation is greater at a cross wind location, the actual noise level from the wind farm will be lower than at a corresponding downwind location. These conditions are most likely to occur when wind speeds at the wind farm are low under a clear night sky.

The swish is at its greatest under the above conditions as the change in wind speed at increased heights above the ground is also at its greatest, and this results in an increased difference in wind speed as the blades move through the top of their arc and down past the tower. In addition, if there are several turbines subject to similar conditions, then it is possible this can have an amplifying effect on the modulation. The increase in swish under these specific conditions is termed the Van Den Berg Effect, and it is suggested higher levels of swish might result in higher levels of annoyance and potentially sleep disturbance.

The Van Den Berg effect was observed on a flat site in Europe under specific conditions and in the two matters before the NSW Land and Environment Court (Gullen Range wind farm NSW LEC 41288 of 2008 and Taralga wind farm NSW LEC 11216 of 2007), it has been determined by the relevant experts that the required meteorological conditions to trigger the effect were not a feature of the environment. In Gullen Range (NSW LEC 41288 of 2008), the meteorological analysis prepared by Dr Chris Purton concluded that suitable conditions for this effect are not a feature of the area because of the elevated ridgeline location of the wind farm (Purton, evidence NSW LEC 41288 of 2008).

If suitable conditions did exist to regularly generate high levels of swish, then there is no scientific research to indicate that the existing Standards and Guidelines do not adequately account for it. Indeed, given the conditions are more likely to occur at night, then sleep disturbance would be the main issue to address, and the noise standards applied to wind farms are significantly more stringent than limits established for the potential onset of sleep disturbance. This is discussed in further detail in the following section.

In the first draft of the National Wind Farm Development Guidelines (EPHC, 2009), excessive swish is referred to as one of the potential Special Audible Characteristics (or SACs) along with low frequency, infrasound and tonality. It recommends that:

> *With the exception of tonality, the assessment of SACs will not be carried out during the noise impact assessment phase, that is, pre-construction. This arrangement reflects two key issues:*
>
> *i. There are, at present, very few published and scientifically-validated cases of any SACs of wind farm noise emission being problematic at receivers. The extent of reliable published material does not, at this stage, warrant inclusion of SACs other than tonality into the noise impact assessment planning stage.*
>
> *ii. In the case that reliable evidence did demonstrate merit in assessing such factors during the pre-construction phase, there is a gap in currently available techniques for assessing SACs as part of the noise impact assessment. In part this is due to the causes of most SACs in wind turbine noise emission not yet being clearly understood.*

In summary:

- Swish is an inherent noise characteristic of a wind farm;
- Modulation in noise level is a feature of the ambient noise environment surrounding a wind farm;
- The level and depth of swish can vary with meteorological conditions, and under certain conditions, will be more prevalent;
- The conditions to consistently generate high levels of audible swish have not been established to be a typical feature of Australian wind farms;
- The level, depth, time and testing regime for excessive swish that would justify introducing a more stringent standard have not been established;
- Sleep disturbance is the key issue associated with excessive swish, if it is to occur.

Sleep Disturbance

The World Health Organisation (WHO) establish a recommendation of 30 dB(A) inside a bedroom to prevent the potential onset of sleep disturbance effects (WHO, 1995).

The WHO guidelines indicate a noise level of 30 dB(A) inside a typical bedroom correlates to an external noise level with the windows open of the order of 45 dB(A). The typical baseline limit criterion of 35 dB(A) to 40 dB(A) found in Australian wind farm Standards and Guidelines is therefore significantly more stringent than the WHO guidelines recommendation of 45 dB(A), by a margin of at least 5 dB(A) and up to 10 dB(A).

For comparison purposes, a wind farm that complies with a 40 dB(A) baseline limit could introduce twice as many turbines again onto the site, or move of the order of half as close to the nearest dwelling, and still achieve the WHO recommendations to prevent the potential onset of sleep disturbance.

It should also be noted that the WHO recommendations are considered conservative in that they consider all available research and then use the most stringent approach to indicate the "potential onset" of sleep disturbance effects, which is not defined as full awakening, but rather as a change in the stage of sleep.

The UK Department of Trade and Industry (ETSU, 1997) recognise the above effect and recommend increasing the allowable noise level for wind farms during the night period, based on sleep disturbance effects. The baseline limit for wind farms during the night time in the UK is therefore 45 dB(A).

Based on the above, the baseline limits of Standards and Guidelines in Australia are sufficiently stringent to ensure the potential onset of sleep disturbance effects from the operation of a compliant wind farm does not occur.

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