Development of Regulatory Requirements for Wind Turbines in Alberta

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ABSTRACT

The process of developing regulations of any type is extremely challenging in that they must be relatively simple, easy to understand, technically correct, defensible in their need and approach, and enforceable. The Energy and Utility Board (EUB) recognized that the use of wind turbines for electrical generation in Alberta was growing at an alarming rate and that noise was going to be a significant issue for individuals and communities situated near wind farms. This paper examines the considerations that were taken by the EUB to understand the issues around noise and what ultimately influenced the regulatory requirements that will be incorporated in the new edition of the province's Noise Control Directive.

RÉSUMÉ

La procédure de développement de réglementation de tous types pose un énorme défi. En effet, les réglementations doivent être relativement simples, faciles à comprendre, techniquement appropriées, défendables dans leur besoin et approche, et réalisables. L'EUB a reconnu que l'utilisation des éoliennes pour la production d'électricité a crû à un taux alarmant et que le bruit deviendrait un problème significatif pour les individus et les municipalités situées près des parcs d'éoliennes. Cet article se penche sur les études faites par l'EUB pour comprendre les problèmes reliés au bruit et ce qui ultimement influence les requis pour les réglementations qui seront incorporées dans la nouvelle édition la « Directive de Contrôle de Bruit » de la province.

1. INTRODUCTION

In Alberta, like much of Canada, alternative forms of energy are being considered with ever greater scale to serve society's needs. The desire for clean, renewable energy using the existing distribution infrastructure makes wind turbines a logical source for electrical generation. Improvements in wind turbine technology have also contributed to this increased popularity by reducing the generation costs to be more competitive with traditional carbon based processes (coal, oil, and natural gas). Consequently, developers have seized on this opportunity and are planning large scale wind turbine farms that maximize investment. Statistics from the Canadian Wind Energy Association given in Figure 1 show the growth of Wind energy production in Canada which is expected to continue to increase at an aggressive rate.

When the first wind turbine energy generation occurred in Alberta (in the 1980s), there was no legislation in place for this type of project. The Energy Banking System was developed to handle small independent generation projects. It was similar to a banking system where the power was sent to the grid and the operator was allowed to take out the same amount.

In 1989, the Alberta Energy & Utilities Board (EUB) was asked to recommend a method to handle small power generation projects. The result was the Small Power Research and Development Act. This Act allowed for provisions for wind-related power generation projects up to a maximum of 50 MW for Alberta. In 1993, the 50 MW was reached peaking at 8 applications that year. In 1996, The Electric Utilities Act was created and it addressed wind-related power generation. It was an open market where projects could sell power to the Alberta grid. The average pool price was approximately $30/MW-hr and only existing operators applied for new projects.

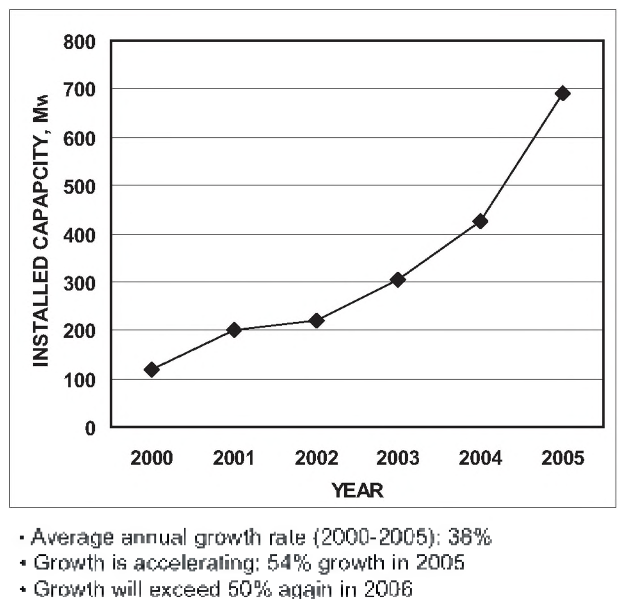

Figure 1. Rapid Growth of Wind Energy.

The number of applications changed dramatically after 2000 (Figure 2) when the average pool price for the year was greater than $100/MW-hr. This created a peak in application in 2001 where the EUB received 33 wind-related applications. The applications included new plants, alterations to existing plants, connection applications, etc. Since then, the number of applications has decreased; however, the applications are much larger in scale (current pool price averages between $60/MW-hr to $70/MW-hr). Naturally these new wind turbine farms will likely come in direct contact with existing rural residents resulting in some level of inevitable impact.

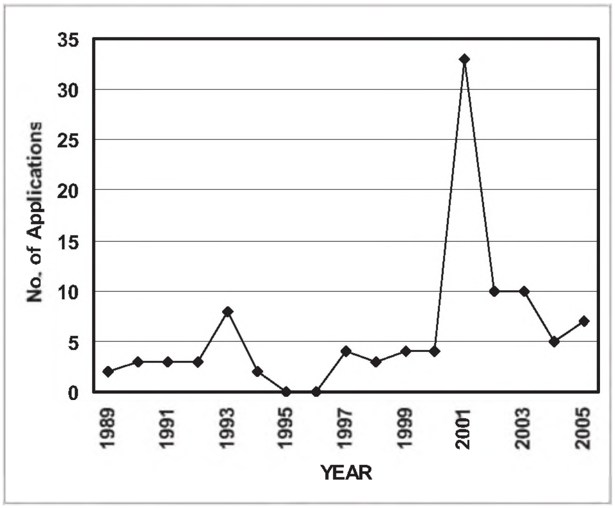

Figure 2. Wind Related Applications in Alberta

Wind turbine noise is one such potential impact and the mandate to regulate the energy industry in Alberta falls to the EUB. Although the EUB has had noise control regulations in place since 1973, they have typically been applicable to continuous mechanical noise from equipment that operates 24 hours a day every day and is not dependant on the weather. Wind turbines on the other hand are somewhat of an enigma in comparison to traditional energy industry requirements in that turbine noise increases nearly in direct proportion to increased wind noise (which is slightly higher as shown in Figure 3 below) from increased wind speeds.

This masking effect therefore, creates significant challenges in modeling and monitoring wind turbine noise for new and existing installations. The EUB realized that the noise control legislation needed to be modified to remain effective and account for this growing sector of the industry. Over the course of several years technical specialists and staff from the EUB have undertaken a systematic approach to learn more about the noise emitters associated with wind turbines including conducting extensive literature reviews on estimating and measuring wind turbine noise, and finally on what other jurisdictions are doing to ensure noise impacts are kept to acceptable minimums for nearby residents.

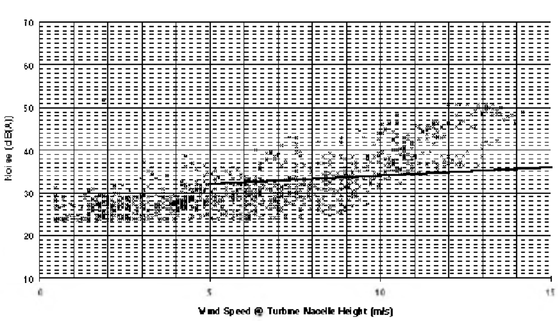

Figure 3. Wind Speed Effects on Turbine Noise and Ambient Noise.

Note: ..... Ambient Sound; -- Turbine Noise
X Axis -Wind Speed and Y Axis - Noise Level in dBA

This paper looks at the information that was gathered and how it influenced the suggested regulatory changes proposed by the expert multi-stakeholder committee charged with the review, upgrade, and consolidation of EUB Noise Control Directive ID 99-08 and companion Guide G-38 into the new Directive 38.

2. HUMAN PERCEPTION OF NOISE

Most people find it pleasant listening to the sound of waves at the seashore, and quite a few of us are annoyed with the noise from the neighbour's radio, even though the actual sound level may be far lower. Apart from the question of your neighbour's taste in music, there is obviously a difference in terms of information content. Sea waves emit random "white" noise, while your neighbour's radio has some systematic content which your brain cannot avoid discerning and analyzing. If you generally dislike your neighbour you will no doubt be even more annoyed with the noise.

"Noise," when one is talking about wind energy projects, basically means "any unwanted sound." Whether a noise is objectionable will vary depending on its type (tonal, broadband, low frequency, impulsive, etc.) and the circumstances and sensitivity of the individual who hears it (often referred to as the "receptor"). As with beauty, often said to be "in the eye of the beholder," the degree to which a noise is bothersome or annoying is largely in the ear of the hearer. What may be a soothing and relaxing rhythmic swishing sound to one person may be quite troublesome to another. Since the distinction between noise and sound is a highly psychological phenomenon, it is not easy to make a simple and universally satisfactory model of sound phenomena. Because of this, there is no completely satisfactory and impartial way to measure how upsetting a noise may be to any given person. In fact, a recent study done by the Danish research institute DK Teknik seems to indicate that people's perception of noise from wind turbines is governed more by their attitude to the source of the noise, rather than the actual noise itself. The EUB has found that this has also been true in a very small number of the mainstream energy industry noise complaints as well making resolution of the matter extremely difficult and in rare instances impossible. Still, it is possible to objectively measure how loud a noise is and that must remain a key component to determining compliance and thus acceptability.

It should be noted that while the regulatory requirements could not account for perception issues, they would be based on the best information on what are deemed to be annoyance levels as published in peer reviewed psycho-acoustic studies as a way to minimize potential psychologically based reactions.

Noise from wind turbines can more or less be distinguished depending on the difference between noise from the wind turbine and the background noise. The background noise, for example traffic noise, noise from industries and the whistling in bushes and trees, vary from site to site and also from day to night. The local environment at the dwelling can also cause a difference in wind speed between the wind turbine and the listener. Also less extreme local physical circumstances such as the placing of houses, may shelter the site from wind on the ground, lowering the background noise so that the noise from the wind turbine will be more easily heard. Only a few field studies on noise annoyance among people living close to wind turbines have been carried out. One study suggested that noise produced by the blades lead to most complaints and most of the annoyance was experienced between 4 p.m. and midnight. Another study was able to identify four variables that had an impact of noise annoyance: stress caused by wind turbine noise, daily hassles, perceived effects of wind turbines in the landscape (visual intrusion) and the age of the turbine site (the longer it has been operating, the less annoyance). If left unchecked, extreme annoyance can ultimately result in health problems.

3. WIND TURBINE NOISE AND HEALTH

According to the definition made by the World Health Organization (WHO), health is a state of complete physical, mental and social well-being and not merely the absence of infirmity. The WHO Guidelines for Community noise lists specific effects to be considered when setting community noise guidelines: interference with communication; noise-induced hearing loss; sleep disturbance effects; cardiovascular and psycho-physiological effects; performance reduction effects; annoyance responses; and effects on social behaviour. Interference with communication and noise-induced hearing loss is not an issue when studying effects of noise from wind turbines as the exposure levels are too low. No studies have been found exploring cardiovascular and psycho-physiological effects, performance reduction effects and effects on social behaviour specifically with regard to noise from wind turbines. A number of articles have though explored the relationships between exposure of other sources of community noise (road traffic, aircraft, railway traffic) and health effects. Evidence in support of health effects other than annoyance and some indicators of sleep disturbance is weak.

On the basis of Swedish studies on effects of noise from aircraft and road traffic, there is some evidence of noise causing psychosocial or psychosomatic nuisance. The effects are related to individual factors (sensitivity to noise and capacity to cope with stress) and to annoyance rather than to sound pressure level. Annoyance itself is an undesired effect on health and well-being. In a review of studies performed in 1993-1998 to evaluated adverse physiological health effects of occupational and community noise, most of the studies concern sources of noise with higher sound pressure levels than those of wind turbines. Even so, it was difficult to find correlation between exposure and cardiovascular or immunological effects. The limited data shows that the observed threshold for hypertension and ischaemic heart disease was at outdoors sound levels above 70 dBA. One can only infer from the results of these studies that there is no conclusive evidence that noise from wind turbines could cause cardiovascular and psycho-physiological effects.

Annoyance response however is probably the most studied health effect regarding wind turbines. Noise annoyance appears even at low sound pressure levels. Another health effect that may be relevant for people living near wind turbines is sleep disturbance. The WHO guidelines for community noise recommend that the outdoor noise levels in living areas should not exceed 45 dBA Leq at night, as sleep disturbance may occur at higher sound levels with open windows.

Although there is limited information on wind turbines, a review of health effects of road traffic noise, finds that there is no evidence that indicates that environmental noise could provoke psychiatric disease. Nevertheless we do know that noise is a factor of stress, and can induce symptoms among sensitive individuals. Regardless further research is needed especially in sleep disturbance as noise from wind turbines can have a unique characteristic (amplitude modulation, swishing) that is easily detected from normal background noise and this may increase the probability for annoyance and sleep disturbance. The combination of different environmental impacts (intrusive sounds, visual disturbance and the unavoidable source in the living environment) may also contribute to a low-level stress-reaction.

Summarizing the findings, there appears to be no solid scientific evidence that noise at levels emitted by wind turbines could cause health problems other than annoyance. Therefore the regulatory requirements should attempt to reduce the potential for annoyance and any ancillary stressors that may result.

4. CHARACTERISTICS OF WIND TURBINE NOISE

The noise output from a modern wind turbine contains energy spread across the audible frequency range and, like most sounds in the environment, has some (inaudible) energy in the infrasound range. Early wind turbines installed in the USA in the 1980s, however, were designed with the blades located downwind of the turbine tower such that the wind had to travel past the tower before it struck the blades. This caused the sound output from this type of turbine to generate a strong low frequency pulse, which also had significant levels of energy in the infrasound range. Largely as a consequence of this, wind turbine design was subsequently changed such that the blades were moved upwind of the tower. Coupled with this, the stand-off distance between the blades and the tower was increased in order to minimize any residual possibility that the blades may interact with disturbed air flow upwind of the tower. The consequence of these developments was to dramatically reduce tower interaction effects and the generation of high levels of low frequency noise by wind turbines. Noise from modern wind turbines is normally clearly audible on a wind farm site and a listener may readily perceive that the sound does not contain any of the strong low frequency pulsing described above, although the sound does change slightly close to an individual wind turbine as the blades pass through the air and change their distance from the listener. As the listener moves away from the site, the noise level decreases due to the increasing distance.

The noise character is also likely to change due to air absorption, which increases with increasing frequency, meaning that although the energy across the frequency range is reduced, higher frequencies are reduced more than lower frequencies. This effect may also be observed with road traffic noise or natural sources, such as the sea, where higher frequency components are diminished relative to lower frequency components at long distances. Wind turbines are not, therefore, a significant source of low frequency or infrasonic noise but, as with noise from any other sound source, the high frequency components are reduced when heard from a distance and overall levels are very low.

The noise from a wind turbine comes from both the mechanical gearing and from the aerodynamic properties of the rotating blades. The former can to a degree be controlled and insulated thus making some makes of turbines quieter than others.

Mechanical noise, i.e. metal components moving or knocking against each other may originate in the gearbox, in the drive train (the shafts), and in the generator of a wind turbine. Machines from the early 1980s or before do emit some mechanical noise, which may be heard in the immediate surroundings of the turbine, in the worst cases up to a distance of 200 m (600 ft.).

A survey on research and development priorities of Danish wind turbine manufacturers conducted in 1995 showed that manufacturers considered mechanical noise not to be a problem any longer, and therefore, no further research in the area was considered necessary. The reason was that within three years, noise emissions had dropped to half their previous level due to better engineering practices.

Noise levels, particularly the low-frequency 'thump' each time a blade passes the turbine tower, are the subject of much research. The UK regulatory authority spends more of its budget researching noise from wind turbines than on all other environmental noise problems. "For existing wind farms we are satisfied that there are cases of individuals being subject to near-continuous noise during the operation of the turbines, at levels which do not constitute a statutory nuisance or exceed planning conditions, but which are clearly disturbing and unpleasant and may have some psychological effects." [See British Wind Energy Association 2005]

The genuine difficulty that developers face is that noise levels are very difficult to predict fully in advance - and the industry has had moderate success in controlling blade noise. Development work on turbines has focused primarily on efficiency.

In addition, local resident reaction to wind turbines has not always been kind. This is particularly apparent from New Zealand Standard 6808 [39] Note to paragraph 1.3 "WTGs (Wind Turbine Generators) may produce sound at frequencies below (infrasound) and above (ultrasound) the audible range" and the statement from the Darmstadt Manifesto: "More and more people are describing their lives as unbearable when they are directly exposed to the acoustic and optical effects of wind farms. There are reports of people being signed off sick and unfit for work and there are a growing number of complaints about symptoms such as pulse irregularities and states of anxiety, which are known to be from the effects of infrasound." [See Australian EPA 2003 and Anderson et. al. 1997].

Recent reports from Denmark indicate government buy-back of residential property in an increasing radius from wind turbines, particularly down-wind.

5. TURBINE TECHNOLOGY

Almost all wind turbines that produce electricity for the grid consist of a tower between 40 and 80 metres high, a nacelle (housing) containing the gearbox and generator mounted on top of the tower, and three blades that rotate around a horizontal hub protruding from the nacelle. This type of turbine is referred to as a horizontal axis machine.

There are two potential sources of noise: the turbine blades passing through the air as the hub rotates, and the gearbox and generator in the nacelle. Noise from the blades is minimized by careful attention to the design and manufacture of the blades. The noise from the gearbox and generator is contained within the nacelle by sound insulation and isolation materials. Standing next to the turbine, it is usually possible to hear a swishing sound as the blades rotate, and the whirr of the gearbox and generator may also be audible. However, as distance from the turbine increases, these effects are reduced. Wind turbines may also be designed in different ways and many of the differences have come about from a desire to minimize noise emissions.

Upwind & Downwind Machines: The majority of horizontal axis turbines are designed in such a way that the blades are always upwind of the tower. This has the effect of minimizing any airflow changes as the blades pass the tower. Some turbine designs, particularly some of those installed in the USA, have the turbine blades downwind of the tower. With this type of design, a strong pulse can sometimes be heard with each passing of a blade behind the tower. However, most turbines currently operating in Alberta are of the upwind design.

Twin Speed and Variable Speed Machines: Most horizontal axis turbines rotate at a constant speed, usually between 25 and 50 rpm, irrespective of wind speed. However, twin speed machines operate at a reduced speed when the wind is light. This produces less noise and means the noise of the turbine is also significantly lower by up to 10 dB(A). Variable speed machines change speed continuously in response to changes in wind speed and, although noise output may be higher at higher wind speeds, it is lower at low wind speeds where the low background levels occur.

Direct Drive Machines: Direct drive turbines are the latest design concept in turbine technology. Simply put, these machines have no gearbox or drive train, and consequently no high speed mechanical (or electrical) components. Direct drive turbines are therefore much quieter than gearbox machines as they do not produce mechanical or tonal noise.

When planning a wind turbine project, careful consideration must be given to any noise that might be heard outside nearby houses. Inside, the level is likely to be much lower even with windows open. The potential noise impact is usually assessed by predicting the noise that will be produced when the wind is blowing from the turbines towards the houses. This is then compared to the background noise that already exists in the area without the wind farm operating.

There is an increase in turbine noise level as wind speed increases. However, the noise from wind in nearby trees and hedgerows around buildings and over local topography also increases with wind speed but at a faster rate. Thus, it is difficult to detect an increase in turbine noise because of the increase in the background sound level. Also, wind turbines do not operate below a specified wind speed referred to as the cut-in speed (usually around 15 km per hour). Wind data from typical sites suggests that wind speeds are usually below the cut-in speed for about 30% of the time.

It has been suggested by some regulators that turbine noise level should be kept within 5 dB(A) of the average existing evening or night-time background noise level. This is consistent with standard approach the EUB uses for noise impact assessment of energy industry sources, except for construction related noise that currently has no specific limit.

6. A REVIEW OF WIND TURBINE NOISE REGULATIONS IN OTHER JURISDICTIONS

A summary of limits and regulations regarding noise from wind turbines in many countries around the world are consistent with those the EUB has established for typical rural residences in Alberta. From energy industry noise sources of 40 dBA Leq (nighttime) at the receiver location. For example the recommended highest sound pressure level for noise from wind turbines in Sweden today is 40 dBA outside dwellings. In noise sensitive areas as in the mountain wilderness or in the archipelago, a lower value for the highest sound pressure level is preferable. The EUB also allows for lower levels in pristine areas. The penalty for pure tones is 5 dBA. In practice, the sound pressure levels must be predicted for dwellings nearby a planned wind turbine site to meet the noise limits as part of the process of applying for permission to build. Measurements on site are only performed in case of complaints. When this happens, the measurements are taken at the dwelling of the complainant at wind speeds of 8 m/s at 10 m height.

Denmark on the other hand has a special legislation governing noise from wind turbines. The limit outside dwellings is 45 dBA and 40 dBA Leq for sensitive areas. Sensitive areas are areas planned for institutions, non-permanent dwellings or allotment-gardens, or for recreation. In case of complaints noise measurements are performed according to the legislation, i.e. on a plate on the ground at a distance of 1-2 times the hub height of the turbine. Noise levels at the dwelling of the complainant are then calculated.

The legal base for noise pollution in Germany is the Federal clean air act from 1974 (Bundes-Immissionschultz-Gesetzes). BimSchG, Germany, 1974). The limited values for the sound pressure levels are defined in TA Lärm (Technische Anleitung Lärm, Germany, 1998).

Table 3: German Noise Regulation

Area	Day	Night
Industrial Area	70/65 dBA	70/50 dBA
Mixed residential area or Residential area mixed with industry	60 dBA	45 dBA
Purely residential area	55/50 dBA	40/35 dBA
Areas with hospitals, health resorts etc.	45 dBA	35 dBA

Calculation of sound propagation is done according to DIN ISO 9613-2. All calculations have to be done with a reference wind speed of 10 m/s at 10 m heights4.

The French legislation used in the case of wind turbines is the neighbour noise regulation law. This legislation is based on the principle of noise emergence above the background level and there is no absolute noise limit. The permitted emergence is 3 dBA at night and 5 dBA at day. The background noise level has to be measured at a wind speed below 5 m/s. The legislation is not adjusted to wind turbine cases, and in practice, the noise measurements are made at 8 m/s when the wind turbine noise is expected to exceed the background noise levels the most.

New regulations on noise including noise from wind turbines were introduced in the Netherlands 2001. The limits follow a wind speed dependent curve. For the night time period the limit starts at 40 dBA at 1 m/s and increases with the wind speed to 50 dBA at 12 m/s. For daytime, the limit starts at 50 dBA and for evenings at 45 dBA.

In Great Britain, noise limits should be set relative to the background noise and only for areas for which a quiet environment is desirable. More precisely, noise from wind farms should be limited to 5 dBA above background noise for both day- and night-time. The LA90, 10 min descriptor should be used both for the background noise and for the noise from the wind farm. The argument for this is that the use of the

LA90, 10 min descriptor allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources. A fixed limit of 43 dBA is recommended for nighttime. This is based on a sleep disturbance criterion of 35 dBA. In low noise environments, the daytime level of the LA90, 10 min of the wind farm noise should be limited to an absolute level within the range of 35-40 dBA. The actual value chosen within this range should depend upon the number of dwellings in the neighbourhood of the wind farm, the effect of noise limits on the number of kWh generated, and the duration of the level of exposure.

In the Province of Ontario, the Ministry of Environment has established a tiered approach based on the classification of the wind turbine and the area in which it is situated. For example, the lowest sound level limit at a Point of Reception in Class 1 & 2 Areas (Urban), under conditions of average wind speed up to 8 m/s (29 km/h), expressed in terms of the hourly equivalent sound level (Leq) is 45 dBA or the minimum hourly background sound level established in accordance with requirements in Publications NPC-205/NPC-233, whichever is higher. The lowest sound level limit at a Point of Reception in Class 3 Areas (Rural), under conditions of average wind speed up to 6 m/s (22 km/h), expressed in terms of the hourly equivalent energy sound level (Leq) is 40 dBA or the minimum hourly background sound level established in accordance with requirements in Publications NPC-232 or NPC-233, whichever is higher. The sound level limit at a Point of Reception in Class Areas 1 & 2 (Urban) or in Class 3 Areas (Rural), under conditions of average wind speed above 8 m/s and 6 m/s respectively, expressed in terms of the hourly equivalent energy sound level (Leq), is the wind induced background sound level, expressed in terms of ninetieth percentile sound level (LA90) plus 7 dB, or the minimum hourly background sound level established in accordance with requirements in Publications NPC-205/NPC-232/NPC-233, whichever is higher.

The New Zealand Standard NZS 6808 sets the predicted base level (LAeq) at 40 dBA higher than the approach of these guidelines, but the specified propagation model to be used in accordance with that standard does not account for factors such as ground absorption and topography effects that can substantially reduce the noise level in practice. In addition, the New Zealand Standard requires the criteria to be met at all receivers, regardless of their relative amenity or relationship with the wind farm development.

In Australia, the Environment Protection (Industrial Noise) Policy 1994 limits the noise level from non-domestic noise sources including wind farms to 40 dB(A) or the lowest typical background noise level plus 5 dB(A) (whichever is the greater) in rural areas from 2200 hrs until 0700 hrs the following day. This limit applies to existing noise sources and does not necessarily reflect the preferred noise criterion for new (planning) development. The general approach for new development applies a nighttime level of 35 dB(A) to significant development in a rural location. Further, to prevent adverse impacts from the increased noise of wind turbines under high wind conditions, the increasing noise level must also be compared to the corresponding background noise at the relevant receiver.

7 EUB APPROACH TO WIND TURBINE REGULATORY REQUIREMENTS

While wind energy in Alberta has been under development for more than twenty years, it has only been within the last decade that the scale of projects has required a more systemic examination of the noise potential and an integrated approach to its regulation. To accomplish this, EUB has been collecting data, conducting research and investigating what other jurisdictions are doing around the world in hopes of enhancing current requirements and modifying them specifically for wind turbines and wind turbine farms. The key areas that the EUB believed need to be considered were:

- Appropriate models and modeling methodologies that would best reflect the noise potential of wind turbine(s) at a receptor location typical of actual atmospheric and topographical conditions.
- Techniques that would identify the presence of Low Frequency Noise.
- Measurement (monitoring) practices that would provide a realistic quantification of turbine noise without the masking effect of the wind.
- An understanding of the potential impact on human health (annoyance, stress, sleep depravation, etc.) and wildlife indicators (morbidity, mortality, and performance).

From this work, the EUB, together with its multi-stakeholder Noise Directive Review Committee, came to the conclusion that the established energy industry Permissible Sound Levels (PSL) for rural residences in the current legislation would be appropriate for wind turbine(s) which is essentially 5 dBA above the average rural ambient noise level typically resulting in a 40 dBA Leq nighttime limit. These levels, according to the peer reviewed literature, should result in minimum annoyance levels for nearby residents, including potential for stress factors and sleep disturbance; thus, assuring minimum effects on human health.

From the peer reviewed wildlife research, the most significant impact to animals is in avian and bat mortality from contact with the moving blades on the wind turbine. The scientific literature also suggests that a great deal of improvement has been made to blade design to improve visual recognition by birds of the rotating blades resulting in a significant decrease in bird hits. Bats on the other hand have a very acute echo location capability that allows avoidance of turbine blades especially in the fixed speed variety. While any unnecessary loss to wildlife is unfortunate the EUB does not believe that addressing the noise aspect will have any measurable reduction of accidents between birds and wind turbines. It should be noted that an application for wind turbine farms must generally pass a complete environmental impact assessment that takes wildlife impacts into consideration before approval can be granted.

With respect to modeling, the EUB has developed requirements for both modeling of noise and measurement of noise from wind turbines which will be contained in Directive 38 to be released in 2006. In the case of measuring wind turbine noise, current requirements were not effective as the "cut in" wind speed of the turbine exceeded the maximum wind speeds for an acceptable comprehensive sound survey. Therefore, to accurately measure the noise output from the turbines, it was necessary to minimize the wind noise impact on the results. To achieve this, the EUB recommended that noise measurements for comprehensive sound surveys be conducted for wind turbines at speeds between 4 m/s to 6 m/s (approximately 14 km/hr to 22 km/hr) which is typically the "cut in" speed of the turbine. In addition, the measurement of the sound pressure level and wind speeds should be measured at a height above grade that is level with where people may reside (i.e., two story house must have the microphone at the same height as the top floor).

Perhaps the most significant modification to the Noise Control Directive is in the area of Low Frequency Noise (LFN) that is not only a component of concern for wind turbines but for all industrial installations in general. The PSL as noted earlier is acceptable from a human health standpoint except if LFN is present. Research and experience have confirmed that in a small percentage of noise complaints investigated that while the PSL was achieved by industry the impact to residents (annoyance, stressors, and sleep disturbance) was inconsistent with the results. In these cases, LFN could be pinpointed as the culprit, and once addressed, resulted in an improved perception of quality of life factors. The approach to be taken in the new Noise Control Directive is to use a simple C weighting minus A weighting calculation. If the difference is greater than 20 dB and a tonal component exists in the spectrum below 250 Hz, there may exist a LFN problem. As a result, the industrial operator is then required to investigate for possible sources and address accordingly.

Ultimately, the safeguard used by the EUB is to ensure that a new or proposed facility or modification is designed with appropriate noise control considerations in place so that once built, the likelihood of compliance is strong. Therefore, prior to the submission of an application, a Noise Impact Assessment (NIA) must be completed. For example in the case of wind turbine(s), licensees are encouraged to take special care in positioning of wind turbines to maximize the distance to any residences downwind. Also, wind turbines are to be modeled at wind speeds of 6-9 m/s to obtain worst case conditions. At these wind speeds, the wind turbine noise should be greater than or equivalent to the wind noise. At speeds greater that 9 m/s, the wind noise tends to mask the turbine noise. The predicted wind turbine noise will be compared to the PSL.

8. CONCLUSIONS

Currently, the EUB has registered a very small number of noise complaints annually with respect to wind turbines in the operational phase. Typically, concerns are raised by the public during the application stage. Wind turbine farm operators, however, have been provided little guidance so far with respect to the EUB's expectations to environmental noise management as well as other issues that are associated with these types of projects. Consequently, the industry would like more clarity in order to focus on social and regulatory performance measures in a more focused and effective manner.

From the regulatory standpoint, it seems abundantly clear for now that the future of wind turbine electrical generation in Alberta is on a road to significant growth. Some estimates suggest that wind power can contribute between 10 – 20 % of the total electrical demand in the province. Regardless if this is the case, the number of turbines will likely expand by orders of magnitude. It is timely, therefore, to institute effective noise control regulation designed specifically for the potentials presented by wind turbines. The attention given to the noise impacts and associated technological challenges by the Directive Review Committee will ensure that new regulatory requirements remain reasonable, effective and responsible in dealing with wind turbine noise.

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