3.0 HUMAN HEALTH ASSESSMENT

3.1 Hazard Characterization in Scientific Literature

There are three human health hazard categories that have been associated with Wind Turbine Processes in the scientific literature. They are: audio effects; visual effects; and physical damage. There are two more hazards that have been discussed in the public comments submitted concerning this project. They are electromagnetic field effects and “wind turbine syndrome”. These later two hazard categories are not discussed in the scientific literature concerning wind turbine facilities. All five categories are discussed in this section of the assessment.

3.1.1 Audio Effects

Most of the identified potential human health effects associated with the operation of wind turbines, mentioned in the scientific literature are linked to noise generated by the operations of the turbines (USNRC, 2007). Noise from turbines comes from two major sources: 1) mechanical noise caused by the gearbox and the generator; and 2) aerodynamic noise caused by the interaction of the turbine blade and the wind. Mechanical sounds from a turbine are emitted at “tonal” frequencies associated with the rotating machinery in the nacelle, including the generator and the gearbox. Aerodynamic noise, produced by the flow of air over the rotating turbine blade, generates broadband noise. Both mechanical and aerodynamic noise is often loud enough to be heard by people. Older “downwind” turbines emitted some low frequency “infrasound” vibrations each time the rotor blade interacted with the disturbed wind behind the tower.

Noise from the wind turbines is typically expressed in terms of sound pressure on the ear, measured in decibels [db(A)]. A single utility-scale turbine typically generates sound pressures between 50-60 db(A) at a distance of 36.5 m (120 feet). Noise levels from on-land wind turbines today typically fall into the 35-45 db(A) range at a distance of 275 - 300 m (900 - 1,000 ft). This represents sound levels less than the noise in a busy office (roughly 60 db(A) but slightly higher than night-time ambient background noise levels in the countryside (20-40 db(A)). Besides the amplitude of the noise from turbines, the frequency of the sound can also be important and human perception of sound can be different at different frequencies. Wind turbines have been found to generate broadband, tonal and flow frequency noise. “Broad-band” noise from a wind turbine is the swishing or whooshing sound resulting from the continuous rotations of the turbine blade (frequencies greater than 100 Hertz). “Tonal noise” consists of a hum or pitch occurring at distinct frequencies (USNRC, 2007). Another noise phenomena is what has been termed amplitude modulation (AM); wind turbine noise with a greater than normal degree of regular fluctuations (Morehouse et al., 2007). Older wind turbines also cause low-frequency or infrasound noise, which is noise in the range of 1.5 to 200 Hertz. (HGC Engineering, 2007) “Infrasound” consists of vibrations that are inaudible or barely audible (Leventhall, 2003, 2007) and has been associated with aerodynamic noise generated by wind turbines.

The World Health Organization (2007) has developed guidelines for avoiding adverse effects from noise in readily audible range (greater than 20 Hertz) in the environment around houses. The guidance is based on measurements designed to best represent noise in the audible range. They recommend that outdoor daytime decibel levels should be 55 db(A) or less and night time outside levels should be 45 db(A) or less. At noise levels greater than these, effects such as sleep disturbance, inability to hear conversations completely and annoyance can be expected in some individuals.

Most of the literature with regard to human health effects from noise generated by wind turbine developments appears to be based on anecdotal testimony from residents living in proximity to operational wind turbines and reporting readily audible noises. Annoyance (or nuisance) appears to be the primary category for complaint. (Frey and Hadden, 2007; Moorehouse et al., 2007). According to USNRC (2007), various measures to reduce the readily audible noise from wind turbines suggest that noise should not be a major concern for residents at distances of 800 metres or more. Moorehouse et al. (2007) suggest that in the context of the issue of industrial noise, noise from wind farms is very low in incidence rate and in relation to other noise problems makes further research difficult to justify. They also point out that the causes of amplitude modulation are not known and the incidence of amplitude modulation is not predictable.

The type of noise called "infrasound" has been the most controversial category of potential noise impacts, especially since it is difficult to measure and has a lower degree of scientific consensus concerning its effect on human health. Branco and Alves-Pereira (2004) suggest that long-term exposure to Low Frequency Noise (LFN) (infrasound) can impact the body causing irreversible organ damage referred to as vibro-acoustic disease (VAD). Originally, these authors reported that people were at risk of VAD if they were present for significant periods of time in occupational settings with high-intensity sound over 110 dB, coupled with low-frequency sounds below 100 Hz. Examples of occupations at risk were disk jockeys and workers in the aircraft and aerospace industries including those working at airports and ship machinists. The symptoms associated with this disease were reported by these authors to include thickening of cardiovascular structures and mutagenic changes in cell structure potentially leading to cancers. Qibai and Shi (2004) presented data to support the observations of effects on blood pressure and heart rate and on state of mind (fretful, headache, tiredness). According to Sienkiewicz (2007) there is a relative paucity of recent information regarding the long-term health consequences associated with exposure to infrasound. Progress is hindered by the lack of agreement on appropriate measurement techniques and protocols.

Alves-Pereira and Branco (2007) have lowered their definition of the frequency range for VAD to below 20 Hertz and now suggest that wind farms might be a risk factor for VAD. At this point there appears to be one home that has been measured for low frequency noise by these authors. Measurements of energy levels in this range are very difficult. In general, there are no other researchers who appear to have presented data that would confirm the Alves-Perera and Branco claims of adverse health effects for low frequency sounds of low pressure (i.e. below 20 Hz and 110 db) (Leventhall et al., 2003; Leventhall, 2006, 2007;

Duck, 2007). The general consensus is that protection from exposure to 85 to 100 dB for the 20 Hertz range is sufficient for protection against infrasound risk (Leventhall et al, 2003; Duck, 2007). According to HGC Engineering (2007), modern turbines do not produce infrasound. Ramarkrishnan (2007), reviewing the available literature, concluded that wind turbines do not produce infrasound that is perceptible. According to Morehouse et al. (2007), previous investigation of wind turbines in the United Kingdom had reported that noise complaints were not a result of low frequency noise but from amplitude modification of aerodynamic noise. Thus, at this point in time, the question of VAD associated with wind farms can best be characterized as an untested hypothesis.

3.1.2 Visual Impacts

A particular phenomena identified in the literature with the operation of wind turbines is “shadow flicker”. Flicker occurs when the blades of the turbine rotate in sunny conditions, casting moving shadows on the ground resulting in alternating changes in light intensity (NRC, 2007). Shadow flicker intensity is defined as the difference or variation in brightness at a given location in the presence and absence of shadow. Shadow flickering is a function of: 1) the location of people relative to the turbine; 2) the wind speed and direction; 3) the daily variation in sunlight; 4) the geographic location of the turbine; 5) local topography; and 6) presence of any obstruction in the line of sight.

Shadow flicker is most pronounced at distances from the turbines of less than 300m (1,000 feet) particularly during sunrise and sunset when the sun’s angle is lower and the resulting shadows are longer. Shadow flicker is typically problematic for short periods each day – rarely more than a half-hour at sunrise and sunset. The phenomenon is more a problem in the winter than the summer due to the sun’s lower position on the horizon in winter months in North America (NRC, 2007). There is a concensus that shadow flicker is not considered a nuisance issue at distances greater than 10 times the diameter of the rotor blades (Bolton, 2007). In the case of Enercon E-82 turbines the rotor diameter is 82 m and therefore the influence of shadow flicker would be limited to approximately 820 m. There are no residences are located within this distance.

“Strobing” is also mentioned in association with the operation of wind turbines. Strobing can occur when the turbine blades catch the sun and reflect it back towards the viewer. Since the turbine blade can be in a position where this reflection takes place up to 60 times per minute, the effect is like a strobe light. Unlike shadow flickering, strobing evidently can occur any time of the day and happen anywhere turbines can be seen.

Aeronautical lighting might be considered another source of strobing. Aeronautical lighting is required on some turbines. These lights are mounted on the top of the nacelle and flash at a frequency of less than once per second.

Studies of these visual phenomena indicate that shadow flickering is not an issue at greater than 300m (1000 feet) from the turbine except during the morning and evening when shadows are longer which are typically not more than one half hour periods. Flicker frequency due to the turbine rotor frequency is on the order of 0.6 to 1.Hz. This is harmless to humans. According to the Epilepsy

Foundation, only flicker frequencies above 10 Hertz are likely to trigger epileptic seizures (NRC, 2007).

3.1.3 Physical Effects

If utility scale wind turbines are operating in icing conditions, ice may collect on the rotor blades and could result in two types of physical phenomena, "ice throw" and "ice shed". Ice throw occurs when fragments of accumulating ice are thrown off an operating turbine due to melting combined with aerodynamic and centrifugal forces. Ice shed involves accumulated ice slumping off of rotors and towers as the ice melts from a stationary turbine. Ice throw appears to be the more severe hazard for the public. A distance of 150 m (500 feet) appears to be considered a "safe distance" based on operating experience.

3.1.4 Extremely Low Frequency Electric and Magnetic Field Effects

In 1999, the US National Institutes of Environmental Health Sciences of the U.S. National Institutes of Health published a review of the scientific evidence suggesting that extremely low frequency electromagnetic field (ELF-ELM) exposures may pose any health risk (NIEHS, 1999). They concluded at that time that the evidence was weak but there were epidemiology studies, which indicated that there might be some risk, especially to children in relation to childhood leukemia. The NIEHS pointed out that nearly everyone in the United States is exposed at some level to ELF-ELM and thus the issue merits research. Regulatory action was not recommended at that time and little to none has been forthcoming since then.

Health Canada (2004) states that there is no need to take action regarding typical daily exposures to electric and magnetic fields at extremely low frequencies. They also state that there is no conclusive proof of any harm at levels normally found in Canadian living and working environments. The risks assessment recently published by the World Health Organization (2007) comes to an almost identical conclusion as that of NIEHS (1999) and supports that conclusion of Health Canada. According to WHO (2007), exposures up to 100 kHz requires protection while the evidence for chronic effects is too weak to require standards, guidelines or other strong regulatory action.

3.1.5 Wind Turbine Syndrome

Wind turbine syndrome is being put forward by Dr. Nina Pierpont, MD, Ph.D. (www. tubinesyndrome.com). According to her website, the symptoms of this syndrome include "sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory and panic episodes associated with sensations of internal pulsations or quivering which arise while awake or asleep." People with pre-existing migraine disorder or inner ear damage (pre-existing tinnitus, hearing loss or industrial noise exposure) are identified as being at significant risk. Dr. Pierpont proposes that wind farms create a disturbance to balance and position sense due to low frequency noise or vibration, a syndrome similar to that associated with vestibular dysfunction. People with pre-existing migraine disorder, motion sensitivity or other inner ear damage are considered to be at greater risk.

Dr. Pierpont has draft portions of a self-published book which is not yet available for sale on her new website (www.turbinesyndrom.com). Her work is heavily referenced. Her data appears to be drawn primarily from sources of anecdotal information, her own study of 38 people and self-published research reports from a number of individuals from around the world who she reports have a wide variety of academic credentials. The individuals or "subjects" or her book are stated to live between 1000 to 1500 feet (304 to 457 metres) from wind turbine facilities. Dr. Pierpont suggests a distance of 2 km may be a safe set back distance although she is equivocal even about that. This value also appears to be based on anecdotal reports.

Dr. Pierpont states that her research takes the view that self-reported symptoms are more important that physical measurements. Unfortunately, this approach to epidemiological analysis requires that all self-reported symptoms be accurate and that a causal link can be established based solely on self-reported proximity to a wind turbine. Self-reported symptom questionnaires and interview data are generally held by the scientific community to be very difficult data to work with. The difficulty is compounded when, as in this case, the spectrum of symptoms reported is broad. This type of research is good for setting up hypotheses but not very good for establishing causality (Michael et al. 1984). Dr. Pierpont appears to be skeptical of publishing her work in established scientific journals and thus peer review is not available. Unfortunately, she also appears to have taken the position that most peer review is suspect because the reviewers may either have potential conflicts of interest or be unqualified in the medical sciences. The existence of the "wind turbine syndrome", although alarming in its presentation, is best classified as highly credentialed speculation.

3.2 Exposure Assessment

3.2.1 Audio Effects

Local non-participant residences are located at distances greater than 1.4 km. At these distances, audible sound levels attributed to the wind turbines are below those levels which are considered to be normal background sound levels (40 db(A)) (see Figure 2.3).

Enercon E-82 wind turbines are a modern design which face up-wind and do not have transmissions. Therefore, the conditions which may generated infra-sound or LFN are not present. There is no evidence that these turbines produce LFN at levels approaching 100 db.

3.2.2 Visual Impacts

In the case of the Enercon E-82 turbines, the rotor diameter is 82 m and therefore 820 m is 10 times the distance of the rotor diameter. There are no residences located within this distance. The locations of the turbines at a distance of 1.44 km is more than four times the distance considered to have pronounced effects due to intensity of shadow flicker.

The frequency at which shadow flicker will occur is less than 1 hz. The flash frequency of the aeronautical lighting is less than 1 hz.

3.2.3 Physical Effects

Should conditions form ice on the surfaces of a wind turbine and particularly on the blade, the system controls will shut down the turbine and the blade will cease to rotate. Operations of the turbine will begin when the icing conditions cease and the ice on the turbine melts.

It is noted that the turbines are located at distances from receptors greater than the maximum distance noted in the literature for ice throw.

3.2.4 Extremely Low Frequency Electric and Magnetic Field Effects

Each wind turbine generates up to 2 mw of electrical energy. EMF in the turbine is effectively cancelled by the generation of three phase power in the turbine (pers. comm. N. Easton, P.Eng.). The output from each turbine will be carried on a network of 35kva 3 phase power lines to a transformer station near the transmission line L-6511. The output of the transformer station will be provided to an intertie Station which is the responsibility of NSPI. All electrical components and equipment will meet both ANSI/IEEE and CSA certification.

There are no residences within 2.5 km of the transformer station and the collector lines are more than 1.25 km from the nearest residence. NSPI's 138 kVA line L-6511 has been in place for more than a decade and potential impacts associated with its presence are outside the terms of reference for this Project.

3.2.5 Wind Turbine Syndrome

There is no scientific evidence to support the "Wind Turbine Syndrome" as an identifiable medical syndrome. Migraine triggers are numerous, personal and unpredictable. The presence and activity of wind turbines has not been identified in the medical or other scientific literature as an identifiable trigger for migraine headaches.

3.3 Risk Characterization

3.3.1 Health Risks Due to Acoustic Effects

The levels of noise are modeled to be less than 40 db(A) at any residences. Therefore, effects on health from readily audible ranges are negligible. The distance from the turbines to the homes of residents is greater than 1km and therefore no infra-sound is measurable. This means that the facility would not be a candidate for further study of vibro-acoustic disease.

3.3.2 Health Risks Due to Visual Effects

The frequency of strobe effects due to turbine blades and navigation lights will be significantly less than those frequencies suggested as being a trigger for epileptic seizures. Therefore, the risk to human health is negligible.

The risk of nuisance (annoyance) is negligible as the distance between turbines and residences exceeds that distance at which nuisance might occur.

3.3.3 Health Risks Due to Physical Effects

All homes are located beyond 600 m of the nearest turbine. Therefore, potential impacts due to physical effects due to ice throw are considered negligible

3.3.4 Health Risks Due to EMF

These systems are similar to other power transmission systems presently used in both urban and rural areas throughout North America. The frequencies produced within the power lines from the turbines are well within the frequencies studied by all regulatory agencies and scientific consensus organizations. Therefore, the risks of adverse effects from EMF are negligible.

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