ADDRESSING LOW FREQUENCY SOUND AND INFRASOUND FROM WIND TURBINES

Brian Howe[1], Nick McCabe[2], and Ian Bonsma[3]
[1]HGC Engineering, 2000 Argentia Road, Plaza One, Suite 203, Mississauga, ON, L5N 1P7, bhowe@hgcengineering.com
[2]HGC Engineering, nmccabe@hgcengineering.com [3]HGC Engineering, ibonsma@hgcengineering.com

1. INTRODUCTION

Wind power increasingly forms part of the renewable energy strategy in Ontario, but it is not without opposition from some individuals and groups. One of the key issues is sound, and there is a debate concerning the health impact of low frequency sound and infrasound from wind turbines.

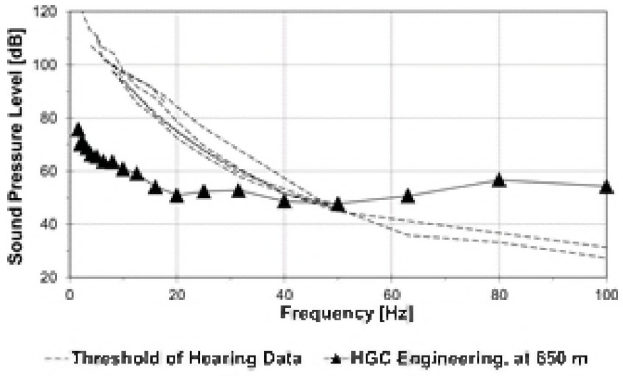
Of significance in this debate was an appeal to the Environmental Review Tribunal (ERT) of the Ministry of the Environment's (MOE) approval of a wind farm near Chatham. Although the ERT concluded that the appellants had not shown that the wind farm will cause serious harm to human health, and dismissed the appeals, they did note in their decision that "the research in this area is at quite an early stage and that our collective understanding of the impacts of wind turbines on human health will likely progress as further research and analysis is undertaken".

HGC Engineering was retained by the MOE to appear at the hearing and to provide a literature review of materials related to low frequency noise and infrasound associated with large, modern, upwind wind turbine generators. Research focused on journal articles, and technical papers and reports presented at conferences, as well as guidelines or regulations from other jurisdictions. The aim of the study was to provide recommendations and guidance to the MOE, as the approving body under the Renewable Energy Act, on how best to address low frequency sound and infrasound from wind turbines. This paper summarises the key findings and presents the recommendations from that study.

2. SUMMARY OF FINDINGS

Modern wind turbines produce broadband noise, with the dominant sound source related to turbulence at the trailing edge of the blades. In relation to human perception of the sound, the dominant frequency range is not the low frequency or infrasonic ranges, but low frequency sound will routinely be an audible component of the acoustic impact. The degree of audibility depends on the wind conditions, the degree of masking from other noises and the distance from the wind turbines. In instances where audible acoustic tones are present, typically related to mechanical or gearbox noise, the frequency of these tones can be within the low frequency range.

In the infrasonic range, at frequencies less than about 20 Hz, there is strong evidence that the sound pressure levels produced by modern upwind turbines will be well below (on the order of 20 dB below) the average threshold of human hearing, at the setback distances typical in Ontario.



Sample Sound Levels at Low and Infrasonic Frequencies

Although some authors have raised concerns, most literature dealing with the subject indicates that infrasonic noise below the threshold of hearing will have no effect on health. It should be acknowledged that this does not conclusively eliminate the possibility that under exceptional circumstances – rare atmospheric conditions or some alternate turbine designs – infrasound levels could be heard. There are also large variations in individual sensitivities to infrasound.

Publications by medical professionals indicate that, at the typical setback distances in Ontario, the overall magnitude of the sound pressure levels produced by wind turbine generators does not represent a direct health risk. This includes noise at low and infrasound frequencies.

The audible sound from wind turbines at the closest typical receptor distances in Ontario is nonetheless expected to result in a non-trivial percentage of persons being highly annoyed. As with sounds from many sources, research has shown that annoyance associated with wind turbines can be expected to contribute to stress related health impacts in some persons. The relationship between the sound level and the prevalence of annoyance is complicated, and is often influenced by other non-acoustic factors. This situation does not relate exclusively to the low frequency component of the audible noise impact of wind turbines. In many instances, the amplitude modulation of the broadband sound is noted as the most prevalent audible characteristic.

Indoors, low frequency components of the sound can become emphasized by room and structural characteristics. Complaints of low frequency noise described in the literature are commonly related to indoor noise.

The measurement of infrasonic sound pressure levels is more difficult than the measurement of sound levels in the

audible range. Sophisticated instrumentation, transducers, and analysis are required to extend the range down to a very low frequency, on the order of 1 Hz. In addition, the wind itself can strongly excite the microphone, leading to acoustic signals at frequencies in the infrasonic range. Conducting infrasound measurements using an in-ground system, such as that developed by NASA, or conducting measurements within residences can reduce this influence.

Issues related to low frequency noise and infrasound can be caused by noise from many different industrial and transportation related sources. Some countries, such as Denmark and Sweden, have developed comprehensive regulatory guidelines which address generic low frequency noise and infrasound assessment. Other countries have guidelines specifically addressing audible sound from wind turbines, but do not specifically address low frequency noise and infrasound. For instance, the recent New Zealand guideline addresses tonality, but does not provide cautionary low frequency limits due to the "paucity of evidence" of related health impacts.

There is audible sound in the low frequency range associated with the sound of wind turbines. Nonetheless, because the outdoor sound level impact is not chiefly a low frequency issue, the use of overall A-weighted criteria is still appropriate for the assessment of overall sound impact. The concept of penalizing the acoustic impact if the sound from the wind turbines is tonal – often a low frequency problem – is also appropriate. Currently, the MOE uses a 5 dB penalty, and the identification of a tone is a subjective judgment; other jurisdictions use a quantitative approach.

The MOE has not published measurement procedures or criteria for addressing indoor noise intrusions or infrasound due to wind turbines or other industrial sources of sound. There are only a few jurisdictions which have guidance, instrumentation specifications, or measurement procedures that could be used to appropriately address infrasound.

3. RECOMMENDATIONS

1. A review of the current technical literature and international assessment standards concerning low frequency noise and infrasound does not indicate that there is a need for the MOE to change the fundamental approach used in Ontario for the assessment of wind turbine noise. It is recommended that outdoor A-weighted sound levels at sensitive receptors continue to be used to evaluate the compliance of sound from wind turbines. Additionally, penalties for audibly distinctive characteristics of the sound should continue to be used by the MOE. In particular, sound with strong mechanical tones which often occur within the low frequency range should be penalized.

2. There is some disagreement and uncertainty in the literature of some of the subjects discussed in this review, and research efforts are ongoing. It is recommended that the MOE continue to monitor technical developments in this area and keep informed of regulatory policies that may be introduced in other jurisdictions. Should the MOE develop guidelines in respect of low frequency noise and infrasound, these guidelines should retain a degree of flexibility in order to adapt to changes or improvements offered by international research in the future.

3. Since it is evident that complaints related to low frequency noise from wind turbines often arise from the characteristics of the sound impact indoors, and since the indoor low frequency sound levels and frequency spectra can differ markedly from those outdoors, it is recommended that the MOE consider adopting or developing a protocol to provide guidance for addressing such complaints. Given the significant variation in sound impact from house to house as a function of room layout and sound transmission characteristics, this protocol cannot replace the current compliance guidelines, but would prove helpful in assessing unique situations.

4. Infrasound from wind turbines is not expected to be heard by humans or pose an issue for human health, and as such, routine measurement of infrasonic sound pressure levels from operating wind farms is not warranted to the same degree that the measurement and monitoring of overall A-weighted sound pressure levels are. Nonetheless, there are aspects of infrasound from wind turbines that are not unanimously accepted by all technical and medical practitioners and there remains a degree of public apprehension associated with infrasound. It is therefore recommended that the MOE consider adopting or endorsing measurement procedures described in the literature that could be used to quantify the infrasonic levels in specific situations.

REFERENCES

Erickson v. Director, Ministry of the Environment, Ontario Environmental Review Tribunal Decision, Case Nos 10-121/10-122, (2011).

HGC Engineering, "Low Frequency Noise and Infrasound Associated with Wind Turbine Generator Systems: A Literature Review", Ontario Ministry of the Environment, (2010).

ACKNOWLEDGEMENTS

Input from the Ontario Ministry of the Environment, and in particular Vic Schroter and John Kowalewski, is acknowledged with thanks.