A JUSTIFICATION FOR USING A 45 dBA SOUND LEVEL CRITERION FOR WIND TURBINE PROJECTS

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1. INTRODUCTION

When required, Health Canada provides advice based on well-accepted scientific evidence for a link between noise exposure and health. Such advice may be requested by Responsible Authorities designated under the *Canadian Environmental Assessment Act* (CEAA) [1] to determine whether it is likely that noise related to a project will cause significant adverse effects. The intent of the CEAA is to ensure that actions are taken to promote sustainable development without causing significant effects. A change in percentage highly annoyed with noise ($\%HA_n$) has been used as one of the measures to determine health impacts in environmental assessments for noise [2], including noise generated by wind farms.

Wind energy is projected to increase to 10000 MW by 2015 in Canada, placing a growing demand on Health Canada to provide health effects advice for proposed wind turbine projects (see refs in [3]).

This paper summarizes how Health Canada derived a noise criterion of 45dBA as the level at which mitigation is recommended for wind turbines operating in quiet rural areas. This criterion is intended to avoid noticeable rattles, sleep disturbance and an increase in $\%HA_n$ greater than 6.5%.

2. HISTORY OF $\%HA_n$ AND ITS CURRENT USE BY HEALTH CANADA IN ENVIRONMENTAL ASSESSMENTS

In 1978, Schultz published a synthesis of international research on community reaction to transportation noise that provided a relationship between the $\%HA_n$ as a function of day-night sound level (Ldn) of the transportation noise source under study. Updates to the Schultz curve (reviewed in [2]) have included the ISO 1996-1:2003 standard [4] (adopted without change by CSA in 2005) where the relationship between the rating level (RL) and $\%HA_n$ is given by:

$$\%HA_n = 100/[1+\exp(10.4-0.132*RL)] \qquad \text{Eq.1}$$

The RL in Eq. 1 is typically an adjusted Ldn, with adjustments made depending on the type of noise source and source characteristics. ISO 1996-1:2003 notes that research has shown that there is a greater expectation for and value placed on "peace and quiet" in quiet rural areas. This may be equivalent to a RL adjustment of up to 10 dB. If, as is usual, a wind farm is situated in a quiet rural community, then a quiet rural area adjustment is a basis of Health Canada's proposed criterion.

Based on the characterization of a "severe" noise impact in a report developed by Hanson et al [5] for the U.S. Department of Transportation, Health Canada has recommended that noise mitigation be considered when a *project-related*, long-term increase (from baseline), in the calculated $\%HA_n$, exceeds 6.5%. Eq. 1 is used, with RL derived from all potential adjustments for source type, source characteristics, time of day and if the impacted community is a quiet rural area. Additional rationales for using a change of 6.5% in the $\%HA_n$ have been reviewed by the authors elsewhere [2]. Essentially, in the scenario where a project-related increase in noise level increases baseline levels from a normally acceptable urban living environment (i.e. 60 Ldn) to a normally unacceptable urban living environment (i.e. 65 Ldn) the corresponding calculated increase in $\%HA_n$ is nearly 6.5%. It is then assumed that the same change in $\%HA_n$ can be used to define the change from normally acceptable to normally unacceptable living environments for a broader range of initial noise environments.

The non-linear nature of the dose-response relationship for $\%HA_n$ between 43 Ldn and 77 Ldn, makes the threshold for the increase in sound levels to achieve a severe noise impact (i.e. a 6.5% increase in $\%HA_n$) smaller as the baseline sound levels increase.

3. USING A CHANGE IN $\%HA_n$ TO EVALUATE THE POTENTIAL HEALTH EFFECTS OF WIND TURBINE NOISE

Keith et al [3] described how Health Canada's proposed sound level criterion is based, in part, on the project-related changes in $\%HA_n$, using Eq.1, where RL for wind turbines is taken to be Ldn, the same as for other

industrial noise sources and road traffic noise. ISO 1996-1:2003 recommends RL = Ldn for these latter two sources. These changes are evaluated in terms of changes in $\%HA_n$ from anthropogenic sources without the wind turbine(s), to the noise environment with the wind turbines, as per Eq. 1. For quiet rural areas, the Ldn is adjusted by +10 dB in Eq.1.

Examples of quiet rural areas include, but are not limited to, those with a dwelling density of less than 8 dwellings per square kilometre with day and night background levels less than 45 dBA and 35 dBA, respectively. In these areas, Health Canada has proposed that mitigation be considered, if, at a height of 1.5 m, at the most exposed façade of a noise sensitive receptor, the predicted sound level produced by wind turbine operations exceeds 45 dBA.

This proposal represents a cautious one because the predicted noise levels are meant to be evaluated at the wind speed that produces the *highest* wind turbine sound power level, while background noise is evaluated in calm winds. This accounts for sheltering by obstructions as well as pronounced wind shear effects that have been observed under stable atmospheric conditions. Based on the assumption that the turbines operate continuously at approximately their maximum sound power output, the same criterion value is applied to day and night time Leq values.

Table 1 shows how, using Eq. 1, the proposed criterion level compares to a level that guards against an increase in the $\%HA_n$ of more than 6.5%.

Table 1. The change in $\%HA_n$ in quiet rural areas with operational wind turbine noise levels set at 43.5dBA (rounded to 45 dBA in text).

	Lday	Lnight	Ldn	Adj.	%HA
Baseline	45.0	35.0	45.0	--	1.1
Operation	43.5	43.5	49.9	+10	7.6

Operational levels of 45 dBA in quiet rural areas should adequately protect against low frequency noise impacts from wind turbines. ANSI specifies that in the 63 Hz octave band, moderately noticeable vibrations are associated with a sound level of 70 dBZ, or 44 dBA (reviewed in [3]). Also, a 45 dBA Leq for constant noise is below all specified World Health Organization guideline levels for effects from sleep disturbance, speech disturbance, moderate annoyance, or hearing impairment [6].

It could be argued that it would be more appropriate to use published dose response relationships for wind turbine noise [7] [8], rather than Eq.1, as described above. However, the first published curve [7] was relatively small in its scope. Also, the second publication [8] showed a dose response relationship only for percentage annoyed, not $\%HA_n$. As discussed in Keith et al [3], the data for wind turbines is not convincingly different from Eq.1 with a +10 dB quiet rural area adjustment for Ldn.

4. COMPARISON TO EXISTING PROVINCIAL GUIDELINES, POLICIES & LEGISLATION

Ontario, Alberta and British Columbia (BC) are the only Canadian provinces with guidance specific to wind turbines. For Ontario, in quiet areas, for wind speeds below 6 m/s, the noise limit is 40 dBA, or the minimum hourly background, and at 11 m/s the noise limit rises to 53 dBA. In a quiet rural area, application of Alberta's Energy Utilities Board Directive 038 would yield a criterion with a night time Leq of 40 dBA for wind speeds between 6-9 m/sec, the only speeds for which the Directive prescribes predictions. The province of BC adopted a "*Land use operational policy, wind power projects on Crown land*", which specifies the maximum sound levels from wind turbines is 40 dBA determined at constant wind speeds (e.g. 8-10 m/sec) (see refs in [3]). Therefore, under most situations, the Alberta and BC limits are both more restrictive than the current proposal. Only under conditions where wind speeds are high enough to increase sound levels by 5 dBA would this generalization change.

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