WIND TURBINE NOISE AND METEOROLOGICAL INFLUENCES

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INTRODUCTION

Wind turbines and wind farms produce power from the forces of wind. The prevailing wind, in addition, generates ambient sound levels that can mask the no-wind ambient sound levels. It has been argued that such masking may not be a real phenomenon and is influenced by meteorological wind classes. A simple analysis is presented based on a three-month wind conditions during the summer in a typical Ontario location.

NOISE IMPACT ASSESSMENT

The Ontario Ministry of the Environment (MOE) has implemented a very simple procedure to assess the noise impact of a wind farm, consisting of a group of wind turbines [1]. The process is: a) identify the locations of the wind turbines within the wind farm as well as all the sensitive receptors within an influence zone of 1 km; b) calculate the noise levels of the wind turbine from the posted sound power data of the turbine at each wind speed; c) the turbine sound power data is evaluated as per the IEC standard procedures and referenced to the 10 m high wind speed [2]; d) evaluate the noise levels at all identified receptor locations by using a standardized propagation model such as ISO-9613 Part II; e) establish the ambient sound levels at each 10 m high wind speed from the data provided in Reference 1; and f) establish the noise impact by comparing the sound levels established in Steps (d) and (e) above.

The procedure applied by MOE is simple in its intention and assumed neutral wind conditions. The procedures also allowed the potential masking effect of the prevailing wind noise. The above aspects provided an avenue for criticism based on the work of van Den Berg [3]. One of the main contentions of Reference 3 is that the IEC method of estimating power referenced to the 10 m high wind speed is flawed because the actual hub-high wind speed can be higher than predicted by the typical logarithmic wind profiles. The sound power levels of the turbines and thereby, the wind farm, can be higher than predicted during stable and very stable wind classes, a usual night time phenomenon. The wind speed measurements of Botha was conducted at four different sites and showed contradicting results of speeds with heights [4]. The wind speed variation with height is, therefore, strongly dependent on local terrain conditions. The assertive contention of van Den Berg was thus seen to be not valid for all locations even if the meteorology condition was in the very stable class. The field studies of Howe and McCabe showed large variations in receptor location noise levels [5].

The main conclusion evident from the results of the previous work is that the local conditions such as the terrain variations, and wind directions have strong dominance on the resulting noise levels generated by wind farms. To investigate the influences of local conditions on the generated noises levels, a simple simulation study was conducted. The details of the model are described below.

MODELLING AND SIMULATION

A 10 km square area near Lake Huron was chosen for the simulation. The chosen location was within a km of an Environment Canada's weather station. Twenty-one wind turbines, capacity of 1.8 mW each, were spaced at 500 metres apart within the 10 sq.km wind farm. The noise levels at eight points of receptions from 500 m to 2 km distances from the wind farm boundary, four in the easterly direction and four in the northerly direction, were evaluated using the software, CADNA-A. A schematic detail of the wind farm with 21 turbines and 8 receptor locations is shown in Figure 1.

Meteorological data, wind speed and direction, were obtained as one-hour averages from the weather station, near the wind farm. The data is summarized in Figures 2 thru' 5. The wind rose data of Figure 2 shows that maximum speed levels were mostly from the lake (225°-NE; and 330° -SW) and the evening and night time average wind speeds are not substantially lower than the day-time wind speeds. The averaged wind speed for three summer months showed that local conditions in Ontario have preponderance of neutral classes compared to stable and very stable classes, disproving one of the main contentions of Reference 3.

The wind speed data for Ontario was adjusted using the results of Reference 4 for the flat terrain sites. The wind speed variation with heights for these two Australian sites didn't follow the IEC Standard's logarithmic wind profiles. The wind speeds at 10 m high were converted to a hub-height of 80 m (shown in Table 1A) and then reconverted back to the 10 m high wind speeds (Table 1B). The results show that at night time, it may be possible to have a higher than expected wind speeds at the hub, thereby generating more noise levels than expected.

Table 1. Wind Speed Data, m/sec. (References 2 and 4)

A) 80 m high wind speeds;

Wind Speed @ 10 m	4	8	12
Day	5.6	11.2	16.8
Night - IEC	5.6	11.2	16.8
Night - Botha	7.2	14.4	21.6

B) 10 m high wind speeds;

Wind Speed @ 80 m	7.2	14.4	21.6
Night - IEC	5.1	10.3	15.4
Night - Botha	4	8	12

The above wind speed changes indicate that for a typical 1.8 mW turbine the sound power levels can increase by .2 dBA at 4 m /sec, by 3 dBA at 8 m/sec and actually decreases at 12 m/sec speeds at 10 m height.

The noise level generated by the wind farm (21 turbines) at the eight locations were evaluated for four different wind conditions: A – all downwind propagation; B- wind is from the west; C – wind is from 225°; and D – wind is from 330°. The results are presented in Table 2 for one north and one east receptor respectively. The results show that noise level variations of ± 5 dBA can be expected depending on the local meteorological conditions.

Table 2. Noise Levels at Point of Reception, dBA

Condition and Wind Speed @ 10 m	4 m/sec	8 m/sec	12 m/sec
A - East – 500 m	40.8 dBA	46.7 dBA	47.6 dBA
A - North -500 m	40.0 dBA	45.9 dBA	46.8 dBA
B - East – 500 m	45.7 dBA	46.7 dBA	52.9 dBA
B - North -500 m	41.2 dBA	45.9 dBA	48.4 dBA
C - East – 500 m	44.8 dBA	51.2 dBA	52.0 dBA
C - North -500 m	44.8 dBA	50.7 dBA	51.5 dBA
D - East – 500 m	44.3 dBA	50.8 dBA	51.6 dBA
D - North -500 m	34.2 dBA	40.1 dBA	40.5 dBA

SUMMARY AND CONCLUSIONS

Simple simulation model applying local meteorological conditions to a typical wind farm was generated to evaluate point of reception noise levels. The results show that local conditions do not follow any set patterns and there can be substantial variations in evaluated noise levels.

REFERENCES

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4. P. Botha, "The Use of 10 m Wind Speed Measurements in the Assessment of Wind Fram Developments." Proceedings of Wind Turbine Noise 2005, Berlin, October 2005.
5. B. Howe and N. McCabe, "Assessment of Noise and Infra-sound at the Pubnico Point Wind-Energy Facility, Nova Scotia." Proceedings of 2007 Spring Conference on Environ-mental and Occupational Noise, Banff, Alberta, May 2007.

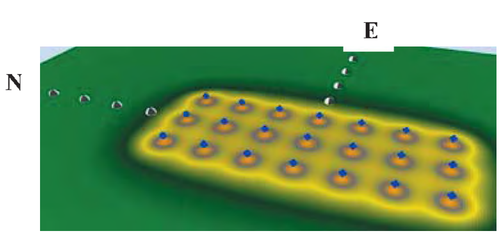

Figure 1. Wind Farm Model – Blue marks 1.8 mW turbine; Black arrow – receptor locations 500 m apart.

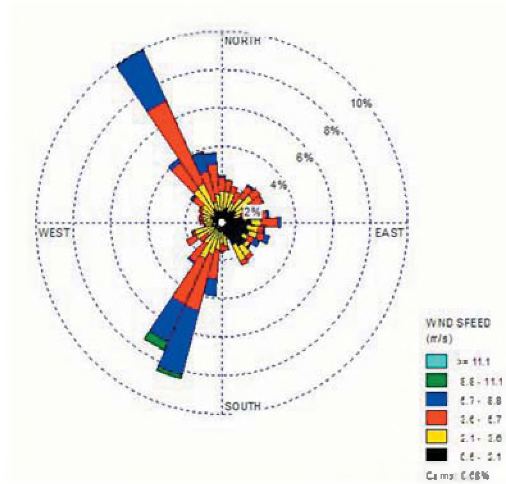

Figure 2. Wind Rose Data of the 10 m high wind speed over three months.

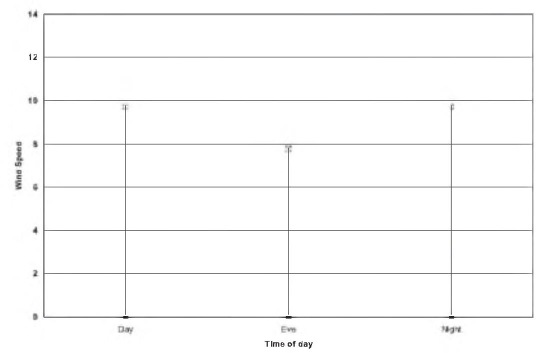

Figure 3. Wind Speed Data at 10 m high for June 2006.

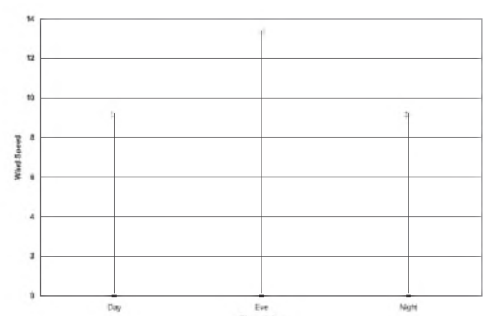

Figure 4. Wind Speed Data at 10 m high for July 2006.

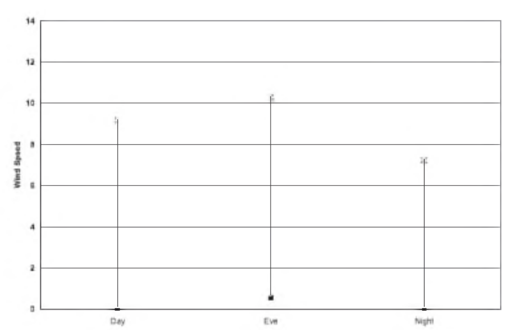

Figure 5. Wind Speed Data at 10 m high for August 2006.