COMPARISON BETWEEN MODELLED AND MEASURED SOUND LEVELS FOR A SOUTHERN ALBERTA WIND FARM

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1 Introduction

As an approval condition by the Alberta Utilities Commission (AUC) for a 23 wind turbine generator (WTG) expansion with substation a Comprehensive Sound Level Survey (CSL) was conducted. Three receptor locations were included, where the noise[1] impact was predicted to be within 1 dB of the nighttime (10 PM – 07 AM) threshold of 40 dBA. A CSL with a duration of 38 days was conducted. This article will summarize some of the lessons learnt.

The wind farm (WF) is located in Southern Alberta on an elevated plain. Other WFs are located in the vicinity. The area is mostly used for cattle grazing. There are no major highways or railroads in the area, nor are there frequent aircraft flyovers; roads serve mostly local traffic. The WTGs installed in the expansion are Vestas V90-3 MW, with a hub height of 80 m and a rotor diameter of 90 m.

The power output and noise production from a WTG are correlated. At the kick-in wind speed, the rotor will start to turn and produce both power and noise. Both will increase up to a certain wind speed.

Noise propagation is related to multiple atmospheric conditions. Wind direction is a major influence; being downwind from a noise source typically results in (close to) the highest noise levels for a specific operational setting.

2 Method

2.1 Modelled Noise Impact

Noise Impact According to AUC Rule 012.

In Alberta, noise from power-related facilities is regulated by the AUC. The AUC published Rule 012, *Noise Control* (Rule 012) [1] that prescribes thresholds, assessment methods and reporting requirements. Summarized, the noise impact is defined as the cumulative total of the (assumed) ambient sound level and the noise from all energy-related facilities (Power and Oil & Gas) that might affect noise levels at a noise sensitive receptor. This cumulative noise impact should not exceed a Permissible Sound Level (PSL) under summertime conditions. For rural Alberta, the nighttime (10 PM – 07 AM) PSL is typically 40 dBA, and the daytime (7 AM – 10 PM) PSL is 50 dBA. The assumed ambient sound level is 5 dB less than the PSL, thus 35 dBA for the nighttime period and 45 dBA for the daytime period. The noise impact from a proposed facility needs to be assessed under representative conditions and according to international standards such as ISO 9613 [2]. That standard was applied in this assessment. "Representative" was interpreted as requiring that all WTGs should be modelled as simultaneously operating at their maximum operational settings under summertime atmospheric conditions, and propagation is calculated as all receptors being downwind from all modelled noise sources.

The predicted nighttime noise impact at the receptors considered are included in Table 1. Also included are the downwind directions from the two closest WTGs towards each receptor.

Table 1: Predicted Nighttime Noise Impact (dBA)

Receptor	Ambient	Facilities	Noise Impact	Downwind Direction
1	35	37	39	NNW or SW
2	35	37	40	NNE or SE
3	35	38	40	E or SE

Comprehensive Sound Level Survey

Rule 012 also contains provisions for CSLs. Key requirements were that a CSL must be conducted under representative summertime conditions, and that at least three hours of valid data must be acquired in both the daytime and nighttime period. It is not explained in the Rule where this requirement is based upon. The current version of Rule 012 contains provisions allowing the use of statistical methods to assess whether or not sufficient data was collected for ambient noise measurements, conducted to assess wind noise at various wind speeds. Other jurisdictions include different requirements for the amount of data; to assess compliance, Ontario initially requires at least one hour of measurements, yielding 20 minutes of data to be included in the assessed noise level [3]. Only if this program indicates non-compliance a more extensive measurement program is requested. It is not stated in Rule 012 whether data should be collected in a consecutive period, or in the same 24-hour period. "Representative conditions" were understood to include operation of the closest or second closest WTGs for each receptor at or near their maximum operational setting, with the receptor being downwind from the closest WTGs. Based on historical weather data late July was selected as providing the best chance to experience the required wind directions. The program was to include a full week of measurements.

Typically, noise data (L_{eq}) is collected in one-minute intervals. Simultaneously weather data is collected and audio recordings are made. Data is analyzed for valid data that fall within the right weather and operating conditions and erroneous one-minute samples (e.g. people talking nearby, loud aircraft fly-overs) are removed from analysis.

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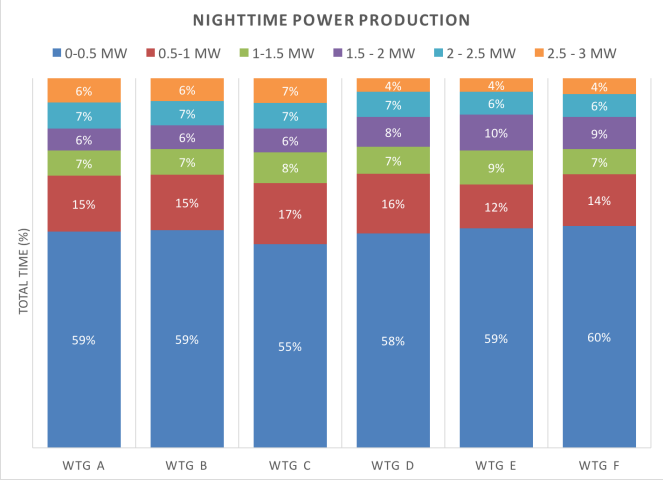
[1] Noise is defined as unwanted sound

The L_{eq} is calculated for the remaining samples for the valid duration only.

2.2 Program Duration

Analysis of the collected data after the first week revealed that insufficiently representative (wind direction and power output) data was available. The field program was therefore extended in to a total of 38 days. Analysis of the power output data of the WTGs over the full 38-day period revealed that the WTGs operated most of the time below their peak output. See Figure 1.

Figure 1 Nighttime Power Production in 500 kW Intervals



Power output between 2 kW and 3 kW during nighttime hours only occurred 10%-13% of the time; 55% - 60% of the time the WTGs have an output of less than 500 kW.

3 Results

After 38 days, not a single 24-hour period was available yielding 3 hours of valid data in the nighttime period or daytime period, but several multiple day periods were available that would yield sufficient data within each of those periods for either the closest or next closest WTG. The highest measured noise levels for the nighttime period are included in Table 2, together with the power output of the upwind WTG and compared to the calculated noise impact. The measured daytime noise impact is comparable within 2 dB of the nighttime noise impact.

The project was audible under downwind conditions for receptor 1, intermittently audible for receptor 2 and not audible at all for receptor 3. Results demonstrate compliance with PSL with a substantial margin. Measured results are well below the predicted noise impact.

Table 2: Comparison Measured Predicted Nighttime Noise Impact (dBA)

Receptor	Measured Noise Impact	Power Output (kW)	Predicted Noise Impact	Downwind from Closest or Next-closest WTG
1	35	1500 - 2250	39	Next Closest
2	35	50 - 1100	40	Next Closest
3	37	50 - 1500	40	Next Closest

4 Discussion

It turned out to be very challenging to simultaneously meet the conditions of conducting measurements downwind at a specified location and having the closest WTGs operate at or near maximum power output for at least three hours. Downwind conditions from either the closest or second closest were achieved between for 2% and 9% during nighttime hours. In future revisions of Rule 012, it could be considered to allow for measurements at an alternative and comparable location when testing for compliance. This would allow to take advantage of actual wind conditions instead of having to wait for a specific and maybe rare wind direction.

The program revealed that the WTG's only operated near maximum power levels (2,500 kW – 3000 kW) for approximately 5-6% of the time during the survey. It could be considered to take the typical wind resource of the season into account when assessing WTG noise; Rule 012 is aimed at summertime conditions.

It is unclear why a minimum of three hours of valid data is required. As an alternative a statistical assessment of the gathered data could be considered. Such a statistical method is already included in Rule 012 for ambient noise measurements with varying wind speeds in preparation for a C class adjustment to the PSL for WTGs, taking wind noise into account.

When predictions according to ISO 9613-1996 indicate compliance with a narrow margin, considering wind direction in prediction may provide more realistic results.

References

[1] AUC Rule 012, Noise Control, version valid from March 24, 2009 to February 22, 2010.

[2] ISO 9613-1996, Attenuation of Sound During Propagation Outdoors – Part 2: general method of Calculation.

[3] Compliance Protocol for Wind Turbine Noise, Guideline for Acoustic Assessment and Measurement, Ontario Ministry of the Environment.