LESSONS LEARNED MONITORING NEAR AND FURTHER FROM WIND TURBINES

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1 Introduction

Without wind to turn them, wind turbines can be almost a silent neighbour. Yet, when rotating, we ask if what we hear is the wind, the impact of wind on surroundings, or wind on the turbines. Hypotheses have been advanced why some people say they are annoyed by wind turbines [1]. These hypotheses leave unresolved questions why the annoyance is not present at all times.

The intent of this study was to investigate the conditions present when residents report annoyance, to test some existing hypotheses for annoyance, and to determine if an alternative criterion could add to understanding.

2 Méthode/Method

2.1 Acoustic data gathering

A 135-day monitoring program was carried out at a "near" site 537 metres from the nearest wind turbine, with 19 turbines within 3 km. Residents have filed annoyance complaints since the array started operation in 2008. Complaints are often filed when the wind speed at 10 metres is under 6 metres per second.

Acoustic data gathering at the "near" site used a SAM Scribe Mk. II monitoring system with two microphones flat from 1 Hz to 8 kHz, calibrated with an IEC942 Class 2 Lutron SC-941 1000 Hz 94 dB calibrator. 10 minute data files, were recorded on an external hard drive.

The acoustic data was collected during two phases, the first recording 85 days of data, and the second a futher 50 days of data. The second phase used the SAM Scribe, verified by an ACO Pacific microphone, an Earthworks M30BX measurement microphone, and a pair of Superlux ECM999 measurement microphones. The verification microphones used a Scarlett 2i2 interface and a MacBook 5.2 computer running Audacity 2.1.0. All microphones were fitted with 90 mm primary and 450 mm secondary windscreens.

Simultaneous monitoring was conducted over 14-days during Phase 2 at the "near" site and at a second "further" site 6 km from the nearest wind turbine in the same array. Other than for proximity to wind turbines, the two sites were similar. Both are on open terrain, at similar proximity to paved township roads, and are subject to similar environmental conditions. The wind turbines in proximity to the "near" site are visible from the "further" site.

During the initial data gathering at the "near" site, the provincial COVID-19 "stay-home" order was in effect, so microphone calibration could only be checked before beginning data collection and at the end some 6 months later, but were unchanged. During Phase 2, microphone calibrations were checked approximately weekly, and remained unchanged.

Acoustic conditions were processed using the application electroacoustics toolbox version 3.9.10, on an iMac computer. This permitted calculating calibrated values of LA10, LA90, LAeq, LZ10, LZ90, LZeq, as well as charting one-third octave band and FFT analysis.

2.2 Wind turbine output data gathering

The hourly generation of the wind turbine array was collected from the Independent Electrical System Operator (IESO) Generator Output and Capability Reports. This was supplemented by observations of the residents at the "near" site, who recorded times the wind turbines changed operational state. The turbines at this site are constant speed turbines when synchronized to the electrical system.

2.3 Environmental data gathering

The primary source of environmental data for both data collection sites was the Environment Canada hourly record for Saugeen Shores, approximately 16.5 km from the "near" site, and 12.5 km from the "further" site. The record for Saugeen Shores is derived from the attended Environment Canada weather monitoring station at the Wiarton Airport. This weather data was generally close to that seen on a local monitor at the "further" site. Local observations of wind conditions and temperature were also noted at the "near site" when reports were logged with the Ministry.

2.4 Resident annoyance level monitoring

Residents provided a copy of the reports they filed with the Ministry for sample conditions considered annoying. After 14 years of operation, residents do not log every condition of annoyance, but only sample sitiations. With each report, the residents identify an annoyance level ranging from 1 to 9. Although there is no specific criterion level specified by the Ministry, residents have developed their own criterion, from 1 - of no concern, to 9 - of major concern. A 9 generally implies a situation such as when the wind turbine blades are icing and the noise level is very severe. Residents only report conditions ranging from 7 to 9, when the wind turbines are audible above the ambient wind, at an increasing level of annoyance.

3 Résultats/Results

Analysis of microphone recordings near wind turbines showed a correlation between the results and conditions identified as annoying by residents. Annoyance was not necessarily correlated to maximum sound amplitude, but to situations when the difference (LA10-LA90) was $\leq$ 3 dBA while at the same time the difference (LZ10 - LZ90) was $\geq$ 6

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dBZ. At these times, sound from the wind turbines was prominent, and dominated noise from the wind, or the wind on the surroundings.

3.1 Initial results – phase 1 Dec. 2020-March 2021

During phase 1 the complaints the residents filed for which data is available are shown in Table 1.

Table 1: Resident complaints filed during phase 1.

Date	Assessment	LZ10-LZ90	LA10-LA90
20-11-28	8/10	13.4	2.3
20-12-05	7/10	7.7	1.8
20-12-09	8/10	13.9	3.0
21-01-23	8/10	9.2	2.5
21-02-20	8/10	13.0	2.5
21-02-24	8/10	15.0	3.1
21-03-01	8/10	13.0	3.0
21-03-06	8/10	8.8	2.3
21-03-09	7/10	13.5	2.6
21-03-26	7/10	7.3	2.6

3.2 Phase 2 results – Jan. 2023 – April 2023

The main emphasis for Phase 2 was to ensure that the annoyance conditions reported and the potential criterion were applicable to sound from the wind turbines, and not just sound from the wind itself. Figures 1 and 2 show the analysis of 5-days of simultaneous monitoring.

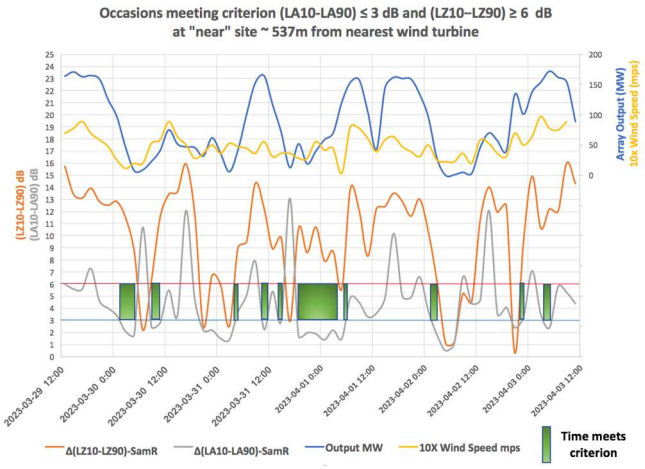

Figure 1: 5-days of data "near" wind turbines

Listening tests confimed that all the times identified as meeting the criterion in Figure 1 for the "near" site exhibited dominant wind turbine sound. Only some of those conditions occured at high turbine output.

Listening tests for the two cases at the "further" site that seemed to meet the criterion in Figure 2, showed they were due a loose microphone rattling inside the windscreen, or rain "drumming". They were not due to wind or wind turbines. Thus none of the "further" cases met the criteron as only due to artifacts.

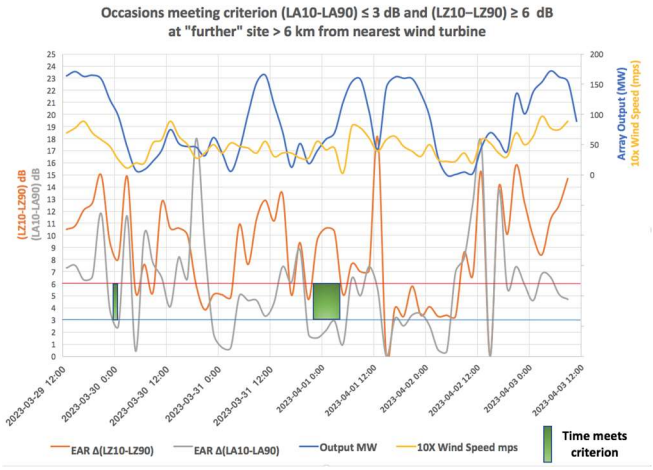

Figure 2: 5-days of data "further" from wind turbines

4 Discussion

It is considered that most people can perceive a change in sound level of > 3 dBA [2]. Thus, a ≤ 3 dBA change between LA10 and LA90, may not be readily perceivable and the sound level may be considered to be unchanged. LA90 represents the background sound level, present over 90% of the time. LA10 represents a higher sound level present less than 10% of the time. However, the annoyance criterion, based on the annoyance reports filed, shows the difference between (LA10-LA90) to be ≤ 3 dBA, and (LZ10-LZ90) to be ≥ 6dBZ. The explanation appears to be that annoyance arises from sound reduced in significance by dBA weighting. When wind speed rises, (LA10-LA90) is > 3 dB, so wind speed is not the reason the criterion is met.

5 Conclusion

The study identified acoustic conditions consistent with reports of annoyance near wind turbines, that did not exist further from wind turbines. They form a screening tool to identify annoyance might occur when (LA10-LA90) is ≤ 3 dBA, and (LZ10-LZ90) is ≥ 6dBZ. This complements, but does not replace criterion based on amplitude alone.

Remerciements/Acknowledgments

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References

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