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Investigation on the Acoustical Signatures of Wind Turbine Noise

Addison J. Wu
Loyalist Collegiate and Vocational Institute, Kingston, Canada
addisonjinaowu@gmail.com

ABSTRACT

Wind energy accounted for more than six percent of the global total energy consumption in 2020, making it one of the most commonly used sources of renewable energy. Several published surveys have connected wind turbine noise exposure to health complications, but there has been a general lack of solid acoustical measurements of wind turbine noise and comparisons of it with other noise sources. The objective of this investigation is to quantify the acoustical signatures of wind turbine noise and perform a comparative study. Quantification is achieved primarily through measurements of the power spectral density (PSD) distribution via the Welch estimation method as implemented in the MATLAB audio and signal processing toolboxes. Mean and time-weighted sound pressure level (SPL) measurements were also obtained. Prior to field measurements, three preliminary tests were performed in controlled settings. Firstly, a calibration test with single and dual sinusoidal tones was conducted, and the PSD results confirmed the adequacy of the microphones and the recording devices in accurately capturing the prescribed frequencies. Although harmonics of the prescribed frequencies were present, they had negligibly small PSD levels at higher frequencies. Secondly, SPL data at varying distances from a strong artificial sound source in a relatively isolated setting were collected. The SPL decay data showed excellent agreement with theory. Thirdly, in order to check the adequacy of the data collection procedure for noise from rotating machines, the acoustic signatures of three household fans at varying rotating speeds and spatial formations were sampled. The effect of the windowing length parameter in the Welch estimation method was investigated through comparison of the PSD results. Wind turbine noise field measurements were conducted at the Wolfe Island wind turbine farm in Ontario on October 9, 2021 (wind 30 km/h, NE), and on December 18, 2021 (wind 15-20 km/h, NW). The microphone sampling frequency was fixed at 48000 Hz. Acoustical data were collected near a relatively isolated turbine by the outskirts of the farm as well as near multiple turbines in the center of a section of the farm. PSD profiles of the isolated turbine exhibit two sets of peaks: one around 1200 Hz and nearly unchanged with wind speed, and the other shifting from 2000 Hz in the fall to 2500 Hz in the winter. PSD data collected from the center of the farm under both weather conditions consistently display high frequency peaks (~3500Hz) that were absent in the standalone turbine signature.