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Field Validation of Octave Band Sound Modeling for Wind Turbines

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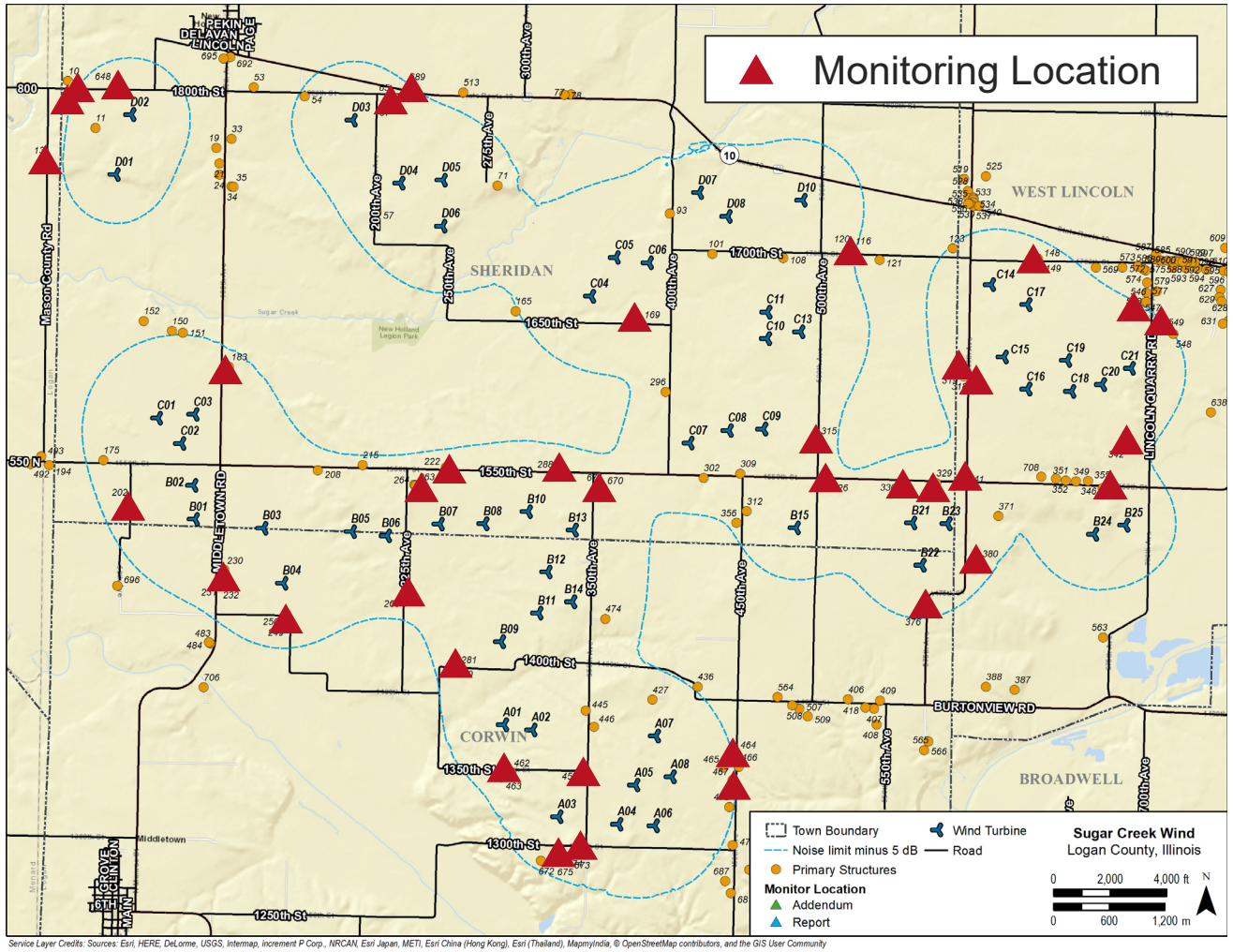
Sugar Creek Wind Postconstruction Sound Monitoring

The Sugar Creek Wind Project is a 57-turbine wind farm in Logan County, Illinois, with a capacity of up to 202 megawatts. RSG conducted preconstruction sound modeling of the final project layout in July 2019. Postconstruction sound monitoring occurred in the fall of 2021.

PROJECT SUMMARY

- Attended sound measurements conducted at 38 sites during nighttime hours
- Measured octave band sound levels were then compared to modeled levels and sound limits

Sound Monitoring Locations

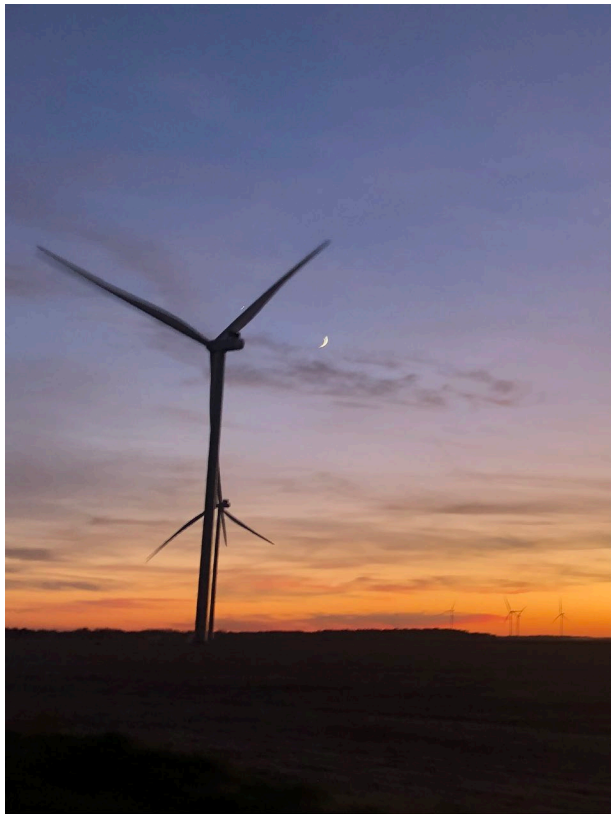


SITE SELECTION

- Sites selected based on sound exposure & permissions
- 38 sites met this criteria

*The County required **attended monitoring** at **all "primary structures" within 5 dB** of modeled nighttime sound limits at any frequency whose land-owners had given **written permission** to access their property.*

Methodology



METHODOLOGY DETAILS

- Modeling: ISO 9613-2 implemented in CadnaA
  - G=0.5, 4 m receptor height, +2 dB uncertainty factor
- Measurements:
  - Acoustical data: 1-sec from 6.5 Hz to 20 kHz, recordings
  - Meteorological data: temp., wind speed, humidity
  - SCADA data (provided by APCo): turbine hub height wind speed and turbine power output
- Nighttime measurements—reduced background sound levels, improved wind shear

Data Processing

DATA EXCLUSIONS

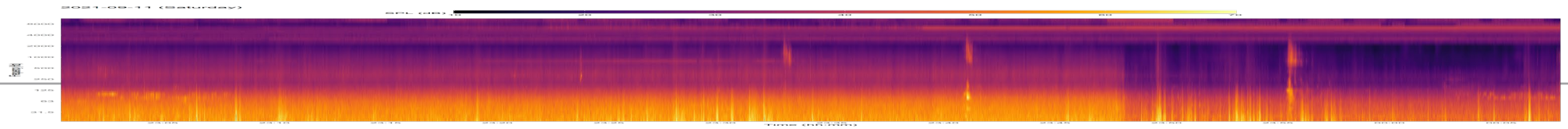
- High ground wind speeds and other anomalies
  - Biogenic sounds (insects and birds) removed through background subtraction
- Turbines not within 1 dB of maximum sound output
  - Adjustments made if turbines not at maximum, but within 1 dB

IDENTIFICATION OF VALID DATA

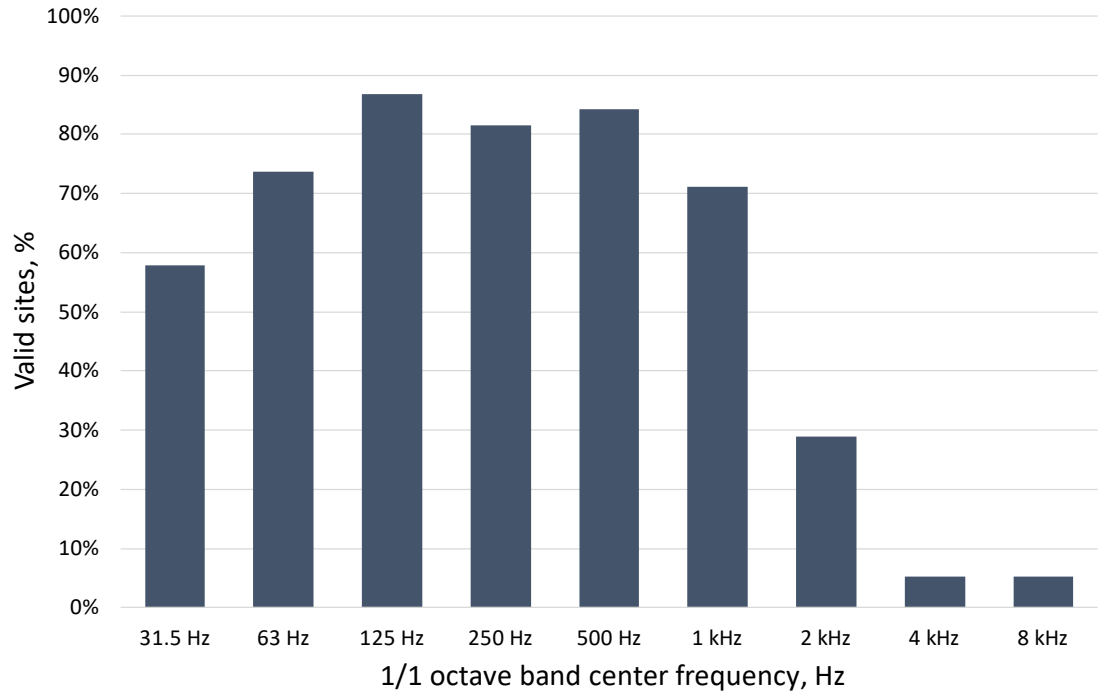
- Minimum of 15 min. turbine-on data & 5 min. turbine-off data

CALCULATION OF TURBINE-ONLY DATA

- Corrections to turbine-on data applied based on difference from turbine-off data



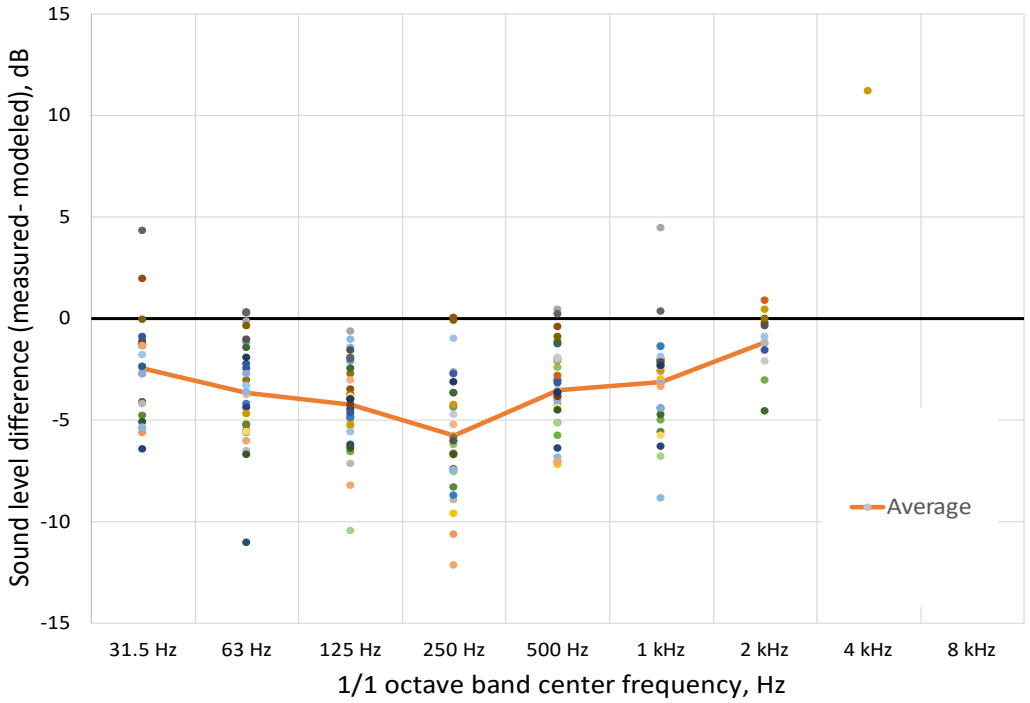
Results



TURBINE-ONLY DATA

- Data @ 4 & 8 kHz determinable at only 2 of 38 sites (5%)
- Data @ 2 kHz determinable at only 11 of 38 sites (29%)

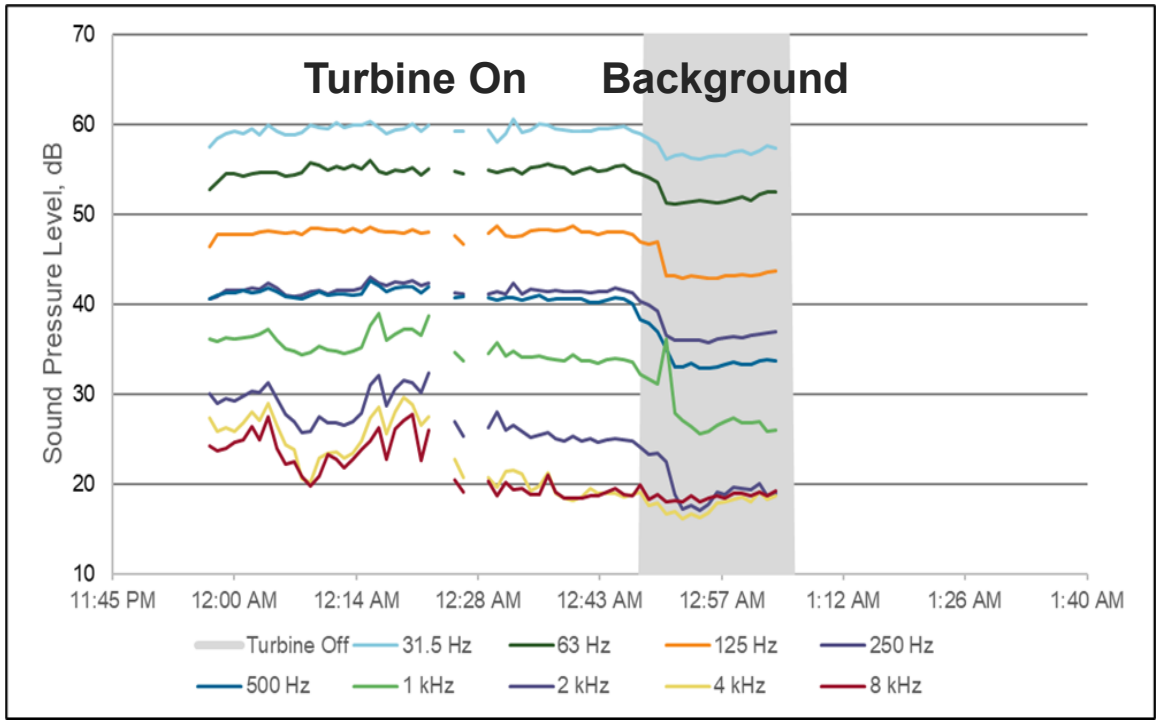
Results



COMPARISON OF MEASURED AND MODELED LEVELS

- Measured levels below modeled levels at all frequencies for almost all sites
- Measured levels on average 1 to 6 dB below modeled from 31.5 Hz to 2 kHz
- 3 sites had measured sound levels exceeding modeled in individual frequency—attributable to background

Results

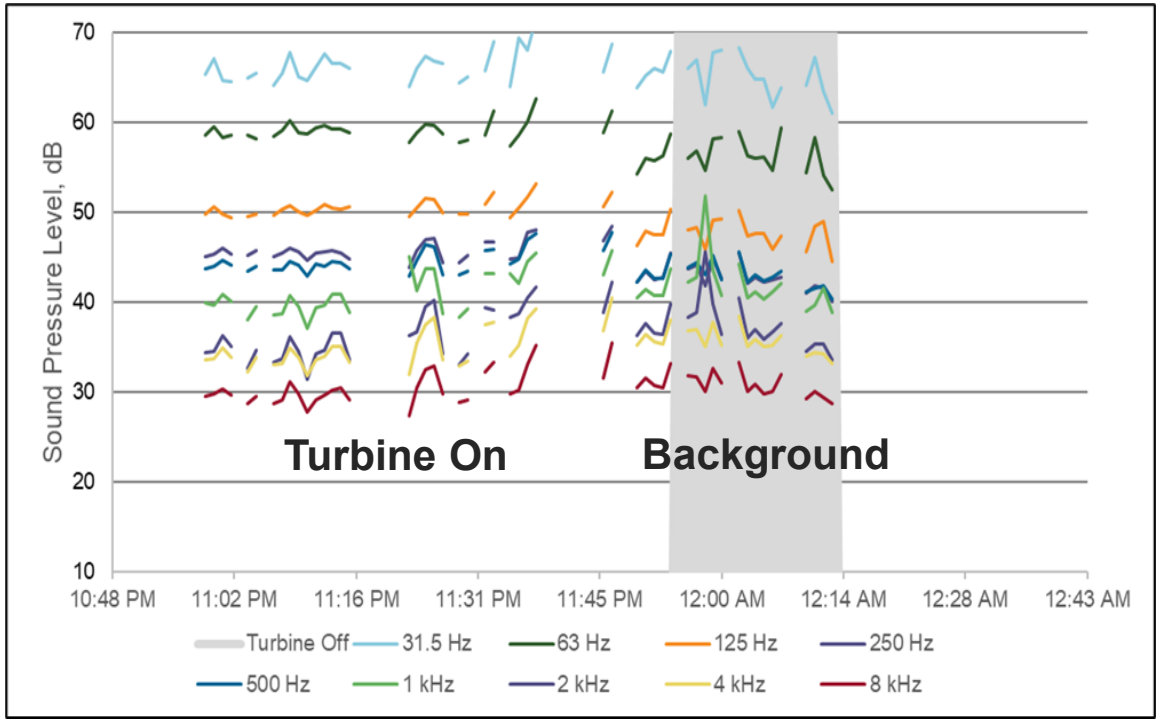


Gaps indicate data excluded from averaging due to anomalous sounds or high wind gusts at the monitoring location. Grayed areas are turbine-off periods.

EXAMPLE SITE 1: VARIED HIGH FREQUENCY DATA

- Varying high-frequency sound levels
- Little to no change when turbines shut down
- High-frequency sounds not discernable in audio due to Nyquist freq.
- Likely background biogenic sounds

Results

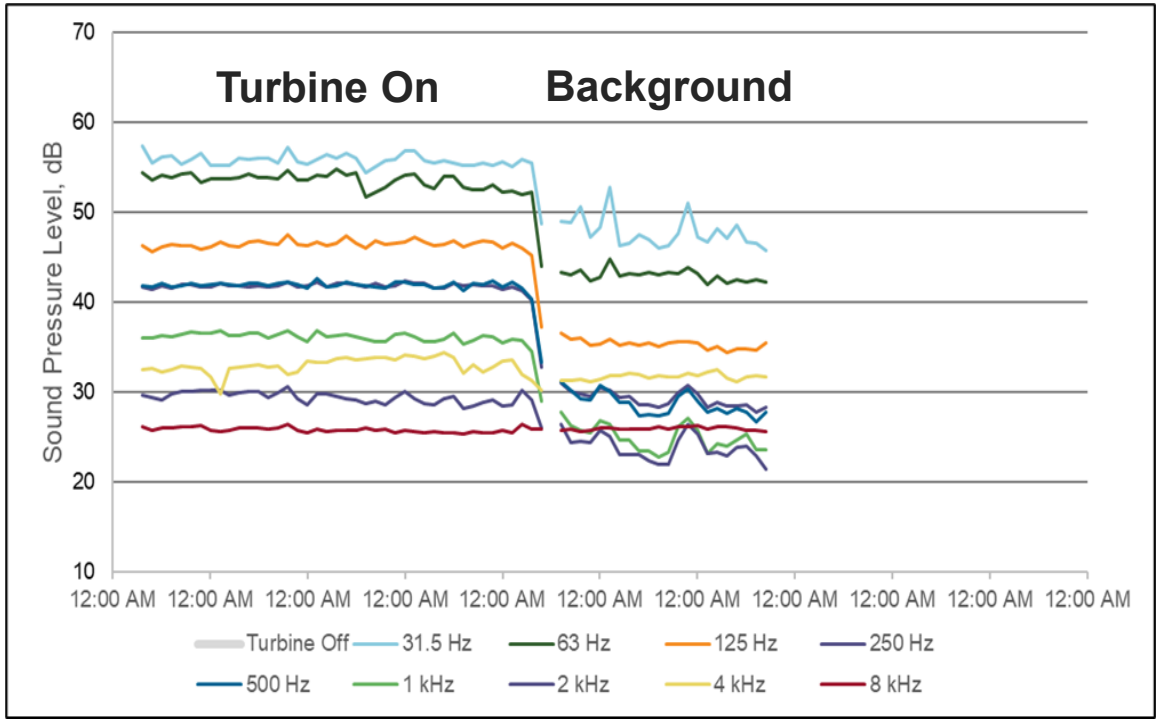


Gaps indicate data excluded from averaging due to anomalous sounds or high wind gusts at the monitoring location. Grayed areas are turbine-off periods.

EXAMPLE SITE 2: BACKGROUND DOMINATES

- Background sound levels not considered in site selection process

Results



Gaps indicate data excluded from averaging due to anomalous sounds or high wind gusts at the monitoring location. Grayed areas are turbine-off periods.

EXAMPLE SITE 3: GOOD SIGNAL-TO-NOISE RATIO

- Clear difference between turbine-on and turbine-off periods at frequencies of 31.5 Hz to 2 kHz
- 4 & 8 kHz data dominated by biogenic sound

Discussion

OCTAVE BAND NOISE STANDARDS

- Sound modeling of octave bands is feasible and conservative using the typical modeling parameters cited in noise standards such as ANSI/ACP 111-1-2022
- High-frequency data (> 2kHZ) not generally valid; atmospheric attenuation reduces sounds below background
- Low-frequency data easily contaminated by wind-induced sound and pseudonoise
- Octave band sound modeling is not supported in ISO 9613-2
- Octave band sound power levels are often not guaranteed/warranted by the wind turbine manufacturer
- Mitigation measures not specific to individual frequencies

RSG Recommendation: Jurisdictions should shy away from octave bands and focus on A-weighted broadband equivalent continuous sound levels.

Discussion

ATTENDED VS. UNATTENDED MONITORING

	Pros	Cons
Attended Monitoring	• Observer to identify anomalous sounds • More sites can be measured	• Difficult to capture favorable weather conditions • Only a short time period is measured • Safety concerns for nighttime monitoring
Unattended Monitoring	• Collects data over wide range of weather conditions	• Time-consuming to identify anomalies • Fewer sites can be measured • Large amount of data

RSG Recommendation: Collect more data at fewer representative sites using unattended monitoring.

Discussion

SITE SELECTION

- Sites for this study based on landowner permissions (county requirement)
- Many sites had turbine sounds levels that were not discernable from background

RSG Recommendation: Select/prioritize sites where a higher signal-to-noise ratio can be achieved for a cost-effective monitoring program.

Conclusions

- Postconstruction sound measurements conducted at 38 sites during nighttime hours
- Measured octave band sound levels compared to modeled levels and sound limits
- Results show that octave bands can be conservatively predicted using typical modeling parameters – but should they be?

Acknowledgments

- The work reported here was funded by Sugar Creek Wind One LLC, a wholly owned subsidiary of Liberty Algonquin Business Services (APCo)
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