ARCVERA
RENEWABLES

30 December 2022

Hannah Campbell
The Balsams Resort

Re: Review of "Operating Plan for Wind Turbine Icing"

This Letter Report summarizes my review of the "Operating Plan for Wind Turbine Icing" (the Plan) dated 6 Dec 2022. The Plan is included for reference at the end of this document. The Plan describes how public access to trails within 837 feet (255m) of wind turbines will be managed to address potential icing conditions at the proposed expansion of the Balsams ski area in northern New Hampshire adjacent to the existing wind turbines at Dixville Peak. The amended Plan contains my suggestion to include heated sensors to measure wind speed and direction. In my experience, heated sensors are necessary in icing conditions in order to get an accurate reading of wind speed and direction.

I find the Plan to be comprehensive, conservative, and appropriate for application in this situation.

SCOPE:

In developing the opinion above, I reviewed the following documents:

- 17a. Appendix A - Windtower Setbacks and Operating Plan for Icing Conditions -rev12-12.pdf, which contains the "Operating Plan for Wind Turbine Icing"
- 17b. Appendix A - Expert Opinion Operating Plan for Wind Turbine Icing.pdf
- 17c. Appendix A - aws truepower wind study.pdf
- 17d. Appendix A - dnv-gl wind study.pdf
- 17e. Appendix A - Ski Trail Concept-01-Wind Tower Setbacks.pdf

Dan Bernadett background:

I currently serve as Global Director of Wind Engineering for ArcVera, a global wind energy consulting company. I began my career in wind energy in 1993. I was on-site at Dixville Peak as part of the team that installed the original meteorological towers that confirmed the wind resource estimates used when the existing wind turbines were installed. I have Bachelor's degrees in Mechanical and Aeronautical Engineering and a Master's degree in Mechanical Engineering. I am currently a registered Professional Engineer in New York State.

Analysis of similar projects:

A comparison is made between a wind turbine installed by Jiminy Peak Mountain Resort, LLC ski area in 2007 located in Hancock, Massachusetts and the ski trail configuration proposed by the Balsams near the existing turbines at Dixville Peak in northern New Hampshire. The turbine at Jiminy Peak was installed 150m from an active ski trail. The minimum distance proposed by the Balsams from the existing turbines is 600 feet (182.9m). The ski trail at Jiminy Peak is closer than the trail proposed by the Balsams. Jiminy has not reported ice fall on any ski trail. This creates a useful precedent for reference.

ArcVera spoke to Christie Moran, who is in charge of the wind turbine at Jiminy Peak. Christie reported that during the 15

years of operational experience with their wind turbine, they did not see any ice on any ski trails. Jiminy's Ski Patrol inspects trails prior to opening and throughout the day until the closing of the trails and has not observed any ice shed from the wind turbine. Jiminy staff know what evidence of ice shedding looks like. Since they are responsible for the wind turbine, they have inspected the ground within 1 blade length of the tower after an icing event has passed. At this proximity to the turbine, significant evidence of ice shedding was present.

Jiminy does not shut down the trail during wind turbine icing events and does not independently initiate commands to shut down the turbine during icing events. The turbine shuts down during icing events using its own internal protocols.

Arc Vera notes that the hub height of both the Jiminy Peak and Dixville Peak wind turbines is 80m. However, the rotor diameter of the Dixville Peak wind turbines is 90m while the rotor diameter of the Jiminy Peak turbine is only 77m. In order to account for this difference in rotor diameter, we used the equation given by Siefert et al. (2003) to estimate the maximum throwing distance of ice from a rotating wind turbine on flat terrain:

$d=(D+H)*1.5$

For Jiminy Peak, D (Diameter of Rotor) = 77m and H (Height of the Hub) = 80m. Using the equation above, $d=(77m+80m)*1.5=235.5m$. This means that the maximum throwing distance for ice is 235.5m at Jiminy Peak. The minimum proximity (P) from the turbine to the trail at Jiminy Peak is 150m. The ratio P/d is $150m/235.5m=63.7\%$.

For the Dixville Peak wind turbines, D (Diameter of the Rotor) = 90m and H (Height of the Hub) = 80m. Using the equation from Seifert, $d=(90m+80m)*1.5=255m$ for the Dixville peak turbines. This means that the maximum throwing distance for ice is 255m at Dixville Peak. The minimum proximity (P) from the trail in question to the closest turbine (Turbine 5) is 600 feet (182.9m). The ratio P/d is $182.9m/255m=71.7\%$.

Thus the trail at Jiminy Peak is only 63.7% of the maximum throwing distance, whereas the trail at Dixville Peak is 71.7% of the maximum throwing distance. In other words, after adjusting for differences in hub height and rotor diameter, Jiminy Peak has a trail closer to the turbine than the configuration proposed by the Balsams at Dixville Peak.

ArcVera notes that the elevation of the Jiminy Peak turbine is approximately 634m. The Dixville turbines are much higher, 986m. Since the Dixville turbines are at higher elevation, they are more likely to spend significant time within the cloud layer. Consequently, Dixville is expected to experience icing more often than Jiminy Peak. However, ArcVera finds that the Plan proposed by the Balsams adequately mitigates risk of falling ice by shutting down the trail if icing conditions exist.

Please contact me if any questions arise regarding this analysis.

Sincerely,

D. Daniel W. Bernadett

Daniel W. Bernadett, P.E.
Global Director of Wind Engineering

T · H · E BALSAMS

Operating Plan for Wind Turbine Icing

This Operating Plan sets forth how public access to trails within 837' of wind turbines will be managed to address potential turbine icing conditions.

1- The Balsams will install a weather station at the top of lift 4 or in closer proximity to wind turbines 4, 5 and 6 which will include temperature, relative humidity, and heated sensors for wind speed and direction.

2- Weather data will be monitored and logged in 15-minute increments by Dispatch beginning 30 minutes prior to opening lift 4 and during the time the lift remains open. Weather data will also be logged throughout the night and reviewed in the morning prior to opening.

3- Prior to opening Lift 4:
   a. A visual inspection of blades on Turbines 4, 5 and 6 will be made to detect the indications of icing on the blades.
   b. The ski patrol director or their designee will be responsible for inspection.
   c. All inspectors will be trained to identify indications of icing.
   d. If ice is observed the affected trail will be closed.
   e. If a visual inspection is not possible due to conditions and temperatures are or were 35F or lower during the prior night, the trail will be closed.

4- Once the trail is open:
   a. If the temperature is 35F or below and weather conditions change such that the possibility of icing develops, the turbines will be visually inspected, and the trail closed if icing is observed.
   b. If the temperature is 35F or lower and the turbines become not visible for more than one hour, the trail will be closed.

5- If the trail is closed due to an icing event, it may be reopened when the blades no longer have visible icing.

6- In the event the turbines are not operating the trail will be subject to the normal trail open and closed procedures of the resort.

7- Whenever this plan indicates a trail closure, the wind turbines creating the need for closure may be shut down in lieu of closing the trail.

8- If a wind turbine is restarted while a trail is open and the temperature is 35F or lower, the trail will be closed until the turbine is inspected per #3 above.

Date: 6 December 2022 R1

Mountain Operations: _____