Heritage Wind Project

Case No. 16-F-0546

1001.15 Exhibit 15

Public Health and Safety

Table of Contents

EXHIBIT 15. PUBLIC HEALTH AND SAFETY

The Article 10 regulations require the assessment of potential risks associated with the operation of the Facility, which in the case of wind projects such as the Facility, are generally limited to effects associated with movement of the blades and electrical components within the nacelle. Some of the unlikely risks associated with wind power include ice shedding, tower collapse, blade failure, and fire in the turbines. To the best of the Applicant's knowledge, there are no known instances where a member of the general public was injured by an operating wind farm in the United States. Proper siting, including setbacks from dwellings, roads, and other existing facilities such as those proposed by the Applicant, all but eliminate the potential risks from these types of incidents.

(a) Gaseous, Liquid, and Solid Wastes to be Produced During Construction and Operation

One of the advantages of producing electricity from wind is that it generates no gaseous wastes and only minimal amounts of liquid waste (oil from wind turbine gearboxes and electrical transformers) and solid waste (cardboard, packaging material, and general refuse) during operation. With respect to construction, gaseous, liquid and/or solid waste will be primarily limited to standard construction-related wastes and will be handled by the Balance of Plant (BOP) contractor in accordance with all applicable laws and regulations pertaining to such wastes.

During construction, sanitary facilities used by workers will consist of portable toilets, which will be emptied on an as needed basis. During operation of the Facility, the operation and maintenance (O&M) building is anticipated to be served by individual on-site water (i.e., well) and wastewater treatment (i.e., septic) systems designed per local and county guidelines (see Exhibits 23, 38, and 39 for details).

Facility construction will generate relatively minor amounts of solid waste consisting primarily of plastic, wood, cardboard and metal packing/packaging materials, construction scrap, and general refuse. This material will be collected from turbine sites and other Facility work areas, and deposited in dumpsters located at the construction staging area(s). A private contractor will empty the dumpsters on an as-needed basis, which is expected to be no less frequently than weekly, and dispose of the refuse at a licensed solid waste disposal facility. The nearest landfill that accepts both municipal solid waste and construction and demolition debris is the Mill Seat Landfill, located in Bergen, NY, near the border of Orleans and Monroe County.

Facility construction will be initiated by clearing woody vegetation from all designated areas as indicated on the Final Construction Drawings (to be prepared following issuance of the Certificate). Trees cleared from the work area will be cut into logs and either stockpiled on the edge of the work area or removed from the defined work area, while limbs and brush will be chipped and spread in upland areas (safely away from water resources) on-site so as not to interfere with existing land use practices. The Applicant will coordinate with landowners under the terms of the lease to locate suitable upland locations to bury stumps or place wood chips. Additionally, chipped stumps may be used in erosion control practices or sold to local mulch bulk dealers, to the extent authorized by law. In addition to on-site disposal, there are five registered land clearing debris landfills in NYSDEC Region 8 (NYSDEC, 2016), should off-site disposal be required. All wood waste management activities will comply with any applicable laws limiting the movement of timber to avoid the spread of invasive species.

(b) Anticipated Volumes of Wastes to be Released to the Environment

No wastes will be released into the environment during construction and operation of the Facility. As described in Exhibits 11 and 21, the Applicant has designed the Facility to balance cut and fill, thus eliminating or minimizing the need for off-site soil disposal. In addition, soil displaced during construction of the Facility will be managed consistent with the New York State Department of Environmental Conservation's (NYSDEC) State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity, a state-issued permit that limits releases of soil/sediment into the environment associated with stormwater discharges. As discussed in Exhibit 23, to comply with the stormwater general permit, the Applicant must prepare a Stormwater Pollution Prevention Plan (SWPPP) identifying the erosion and sediment control measures to be implemented during construction and operation of the Facility to minimize stormwater-related pollutant discharges. (See Appendix 21-E, Preliminary Stormwater Pollution Prevention Plan for details). The small quantities of liquid and solid wastes generated during construction and operation of the Facility will be managed/disposed of off-site in accordance with all applicable laws and regulations as discussed in Section (a) above.

(c) Treatment Processes to Minimize Wastes Released to the Environment

As discussed in Section (b) above, no wastes from the Site will be released to the environment; accordingly, no treatment processes are necessary.

(d) Procedures for Collection, Handling, Storage, Transport, and Disposal of Wastes

See Section (a) above for a discussion of waste disposal practices.

(e) Wind Power Facility Impacts

With respect to short-term (construction) and long-term (O&M) worker safety, the Applicant has developed various plans designed to protect the health and safety of workers and the community, including, but not limited to:, a comprehensive Preliminary Emergency Action Plan (EAP), a Site Security Plan, and an Operation and Maintenance (O&M) Plan. Copies of the EAP and Site Security Plan were supplied to local emergency response providers and the New York State Department of Homeland Security on November 18, 2019 in accordance with the consultation requirements set forth in Exhibit 18.

Exhibits 6 and 31 of the Article 10 Application include a discussion of applicable setbacks as they relate to the protection of public health and safety.

(1) Blade Throw and Tower Collapse

A potential public safety concern with wind power projects is the possibility of a wind turbine tower collapsing or a rotor blade dropping or being thrown from the nacelle. While extremely rare, such incidents have occurred; however, to the best of the Applicant's knowledge, no member of the public has ever been injured as a result of these incidents, and setbacks have been standardized and are generally sufficient to protect area homes and public roads.

The Applicant has conducted a literature review to identify the potential public health and safety concerns associated with potential blade throw and tower collapse. The reasons for a turbine collapse or blade throw vary depending on conditions and tower type. The main causes of blade and tower failure are a control system failure leading to an over speed situation, a lightning strike, or a manufacturing defect in the blade (Garrad Hassan America, Inc., 2010). Technological improvements and mandatory safety standards during turbine design, manufacturing, and installation have significantly reduced the instances of blade throw (Garrad Hassan, 2007). The reduction in blade failures coincides with the widespread introduction of wind turbine design certification and type approval. The certification bodies perform both quality control audits of the blade manufacturing facilities and strength testing of construction materials. These audits typically involve a dynamic test that simulates the life loading and stress on the rotor blade (Garrad Hassan America, Inc., 2010).

Modern utility-scale turbines are certified according to international engineering standards. These include ratings for withstanding different levels of hurricane-strength winds and other criteria (ASCE & AWEA, 2011). The wind turbines ultimately used for this Facility will meet all applicable engineering standards and will be equipped with state-of-the-art braking systems, pitch controls, sensors, and speed controls on wind turbines, all of which greatly reduce the risk of blade throw. It is anticipated that the wind turbines to be used for the Facility will be equipped with two fully independent braking systems that allow the rotor to be brought to a halt under all foreseeable conditions. Additionally, it is anticipated that the turbines will automatically shut down at wind speeds over the manufacturer's threshold. The turbines will also cease operation if significant vibrations or rotor blade stress is sensed by the monitoring systems. For all of these reasons, the risk of catastrophic blade throw is minimal.

Although the risk of blade throw or tower collapse is minimal, the Applicant will have procedures in place in the event of a blade throw or tower collapse incident. These procedures will include emergency shutdown procedures, post-event site security measures, immediate notification of State and local officials, and the implementation of turbine manufacturer-specific blade throw/tower collapse safety procedures, if any. In addition, the Applicant will conduct annual training for operating staff as well as local first responders on the procedures to be implemented in the event of a blade throw or tower collapse incident.

Given the low risk of tower collapse and blade throw and the Facility's current setback distances from permanent residences, adjacent property lines and other features, the potential risk to public safety from tower collapse and blade throw is negligible. See Exhibit 6 for a discussion of setback distances for the Facility.

(2) Audible Frequency and Low Frequency Noise

The frequency range 20 to 20,000 Hertz (Hz) is commonly described as the range of audible noise. The frequency range of low frequency sound is generally from 20 Hz to 200 Hz, and the range below 20 Hz is often described as "*infrasound*". The Facility is not anticipated to result in adverse effects to public health and safety due to audible sound or low frequency and infrasound. See Exhibit 19 for details about the Applicant's noise impact analysis.

In addition to the noise impact analysis in Exhibit 19, the Applicant has performed a literature review of government, scientific, and peer-reviewed professional studies regarding audible sound and low frequency and infrasound as detailed below.

<u>World Health Organization</u>

A useful guideline for putting sound levels in perspective is the "Guideline for Community Noise" (World Health Organization, 1999). Table 4.1 in this document states that daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. The time base for these World Health Organization (WHO) sound levels is 16 hours for daytime and 8 hours for nighttime. In other words, they are not 10-minute averages, but averages calculated over a longer period of time. The 16-hour and 8-hour timeframes are considered short-term time periods (WHO, 1999).

In 2009, the WHO released another report entitled "Night Noise Guidelines for Europe." The 2009 WHO report recommends a Night Noise Guideline (NNG) of 40 dBA. However, the 40 dBA guideline is an "$L_{eq,\ night,\ outside}$" descriptor, which is NOT the same as a short-term measurement. $L_{eq,\ night,\ outside}$ is defined as the A-weighted long-term average sound level determined over all the night periods of a year; in which the night is eight hours (23:00 to 07:00 local time). Thus, the $L_{eq,\ night,\ outside}$ is an annual average, and is not appropriate for use as a permit compliance criterion.

An annual design goal is not a standard and should not be a permit condition given the complexity of measuring sound over the course of 365 nights. Since $L_{eq,\ night,\ outside}$ considers 365 nights of operation, there will be some nights the wind turbines do not operate at all and many others where they will operate at a level below maximum sound level. Therefore, the $L_{eq,\ night,\ outside}$ sound level will always be lower than the worst-case (highest) short-term sound level measured on a given night. In other words, the $L_{eq,\ night,\ outside}$ guideline of 40 dBA, is not a 10-minute or 1-hour sound level, but is an average annual level.

It is important to note that the 1999 and 2009 WHO guidelines were developed with a focus on transportation sound, and were not developed specifically for wind turbines.

In 2018, the WHO released another report "Environmental Noise Guidelines for the European Region" (WHO, 2018), which did include guidelines for wind turbines. This document proposes an annual average guideline of 45 dBA L_{den} (day-evening-night) over all days, evenings, and nights for wind turbines. However, this recommendation is "conditional," which "requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply."

The key findings of the 2018 WHO report related to health outcomes found no evidence that wind turbine noise is related to heart disease, hypertension, and sleep disturbance and only low quality evidence that wind turbine noise causes annoyance. The evidence is considered low quality due to inconsistencies and imprecision in the studies. The studies show that annoyance is due to many other factors besides noise (visual, blinking lights, shadow flicker). Neither the Wind Turbine Noise and Health Study conducted by Health Canada, nor the 2018 Lawrence Berkeley National Laboratory studies, both of which found no health impacts from wind turbines, were included in the 2018 WHO report (see Section 4.6 of this PNIA for a discussion of these reports). The 2018 WHO report did note that the latest environmental noise guidelines for the European Region supersede the 1999 WHO guidelines except in the area of indoor guideline values.

Two key observations taken directly from the 2018 WHO report are:

- Very little evidence is available about the adverse health effects of continuous exposure to wind turbine noise, and
- Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

Based on these findings, a 45 dBA annual L_{den} sound level is not appropriate as a design goal or permit condition, and thus will not be evaluated as part of this Application. This decision is consistent with the recent Order Granting a Certificate for the Baron Winds LLC Project (Case No. 15-F-0122), in which the Siting Board ruled that the WHO 2018 guidelines should not be imposed because of the limitations of the guidelines themselves. The Siting Board noted "…the application of the WHO 2018 guidelines is unnecessary in order to avoid or minimize the Facility's impacts related to noise and, for the reasons described . . . [in the Order], may not be practical." In addition, the Siting Board in the Number Three Wind decision stated "…we do not believe that the WHO 2018 guidelines provide a sound basis for establishing a lower short-term noise standard. Where we have found that a regulatory limit is sufficiently protective, we will expect the parties in future cases to adhere to it, unless and until developments in the relevant science suggest that an additional increment of protection is necessary."

<u>Amplitude Modulation</u>

With respect to wind turbines, amplitude modulation is a recurring variation in the overall level of sound over time. The modulation sound is typically broadband, and it comes from interactions of the blade with the atmosphere, wind turbulence, directionality of the broadband sound of the blades, or tower interaction with the wake of the blade. This modulation is not infrasound; rather, it is variation in audible sound that is synchronized to the passage of the turbine blades. The current body of work on amplitude modulation (AM) indicates that it is not possible to predict or forecast its occurrence. Design considerations for minimization, and practical post-construction operational mitigation options are in the early phases of development.

The Massachusetts Study on Wind Turbine Acoustics measured amplitude modulation in detail and provides a description of the phenomenon (RSG, 2016)

The study showed that the fundamental frequency of the modulations is usually coincident with the rotational speed of the turbine multiplied by the number of blades:

Modulation frequency = (RPM x Number of blades)/60 seconds per minute

The rotor speed (RPM) varies according to the type of wind turbine and operating conditions. For example, if a three-bladed turbine is turning at 15 rpm, the fundamental modulation frequency would be 0.75 Hz. The time it takes for a complete modulation cycle (the period) is 1/frequency. In this case, the cycle time would be about 1.33 seconds.

The greater the modulation in sound level, the greater the "modulation depth." The modulation depth is often measured from the minimum sound level to the maximum sound level, or "crest-to trough level". Half of this level is called the *amplitude* of the sine wave. For the perfect sine wave, the rms (root-mean-square) value defined above is equal to the modulation depth multiplied by the square root of two (1.414). The standard deviation is also approximately equal to the rms average level of the signal. This is important, as some of the methods used to quantify amplitude modulation of a signal use the rms of standard deviations.

Normal amplitude modulation from wind turbines is generally characterized as "swishing," which is a broadband modulated sound. Under some circumstances, it is characterized as "thumping," which has a faster rise time and is composed of sound at lower frequencies. A "churning" sound has also been described, which is made up of broadband mid-frequency sound, but with a faster rise-and-fall rate.

The primary conclusions with respect to amplitude modulation from the *Massachusetts Study on Wind Turbine Acoustics* (RSG, 2016) are as follows:

- Data analyzed for this study indicate that low-frequency sound and infrasound from the wind turbines are not modulated for the most part, and sounds in the frequency range from about 250 Hz to 2 kHz are amplitude-modulated.
- The technique of calculating a spectrogram from A-weighted sound levels and one-third octave band levels is very effective at revealing the signature of amplitude modulated wind turbine sound. A logging interval of 125 milliseconds or faster is required.
- The maximum observed increase in modulation depth was at 500 Hz.
- The measured sound level, wind speed, and distance to turbine have the greatest impact on modulation depth.
- Approximately 90% of all measured AM depth was 2 dB or less while over 99.9% was 4.5 dB or less.

- Wind turbulence, wind shear, and yaw error have a lesser, but statistically significant, effect on amplitude modulation depth compared to distance and sound level.
- The turbulence intensity does not show any trend with respect to the sound levels.

Another reference reviewed for AM in this Application is the "Wind Turbine AM Review: Phase 2 Report" (DECC, 2016). This report reviews research into the effects of and response to the acoustic character of AM. The report notes that "the setting of a threshold for excessive AM is not straightforward. The available research does not identify a clear onset of increased annoyance from AM." Nonetheless, a proposal is put forth in the Report to possibly "control" AM by establishing a "penalty scheme" for excessive AM during periods of complaints. There would be no penalty for AM depths of 0-3 dB, a sliding scale penalty (3-5 dB) for AM depths of 3-10 dB, and a 5 dB penalty for AM depths greater than 10 dB. The report also concludes that "it is not possible to predict whether AM will or will not be present on a site." This paper does not relate specific levels of wind shear or turbulence to AM levels.

NARUC Reports

The National Association of Regulatory Utility Commissioners (NARUC) Grants & Research Department published a report entitled "Wind Energy & Wind Park Siting and Zoning—Best Practices and Guidance for States" (NARUC, 2012). Part of the report presents guidelines for wind power development, including recommended approaches to several critical issues such as noise. The 2012 NARUC study concluded that, for long-term mean sound levels, a planning guideline of 40 dBA is an ideal design goal, and 45 dBA is an appropriate regulatory limit outside a residence at night. The report does not provide a recommendation for an annual average.

Details behind the sound level recommendations in the 2012 NARUC report are found in an October 2011 NARUC report. It is important to note that the 40 dBA and 45 dBA targets listed above are long-term mean sound levels from data collected over a period of "several weeks." In other words, these are not short-term maximum sound levels and are not directly comparable to the short term or annual average design goals established for this Facility. For example, the NARUC modeling methodology does not add the wind turbine manufacturer uncertainty, or "K" factor, which is typically 2 dBA. Therefore, a NARUC modeled result of 45 dBA would be the same as a 47 dBA modeled result when the "K" factor is included. The PNIA (Appendix 19-A) incorporates the "K" factor in the modeling results and is therefore a more conservative approach than the NARUC methodology.

According to the NARUC report, these sound levels were based on experience with wind turbine project operation and sound monitoring, and were intended to minimize adverse reaction (annoyance) and sleep disturbance. The report notes that these levels do not mean the project sound will be inaudible or completely insignificant, only that its noise would generally be low enough that it would probably not be considered objectionable by the vast majority of neighbors. Another reason these numerical values cannot be compared with the proposed design goals for the Facility are that, according to NARUC, the L_{90} statistical measure should be used to determine sound levels from wind turbines instead of the L_{eq} as the L_{90} captures the consistently present sound level during relatively quiet periods between identifiable noise events like passing cars or planes flying overhead. However, the L_{eq} is used to evaluate project sound levels since the design goals and criteria are stated in terms of an L_{eq}.

Low Frequency and Infrasound

Although concerns are often raised with respect to low frequency or infrasonic noise emissions from wind turbines, most research showing excessively high levels of low frequency sound and infrasound studied older wind turbine designs which placed the rotor behind the tower. When the rotor passed through the wake of the tower, it would result in an infrasonic and low frequency impulse. Modern pitch-regulated upwind-tower wind turbines of the type proposed for this Facility produce lower levels of infrasound and low frequency sound than these early turbines. Research on modern turbines has shown that at typical receiver distances, infrasound levels are lower than some other common environmental noise sources, such as vehicle traffic, and generally well below established hearing thresholds (RSG et al., 2016); thus, newer turbine models do not have negative health impacts on humans (McCunney et al., 2014; Leventhall, 2013). Although low frequency sound levels from modern turbines are lower than earlier models, they are frequently still audible, exceeding the human audibility threshold between 25 and 125 Hz (McCunney et al., 2014; RSG et al., 2016). However, at the sound pressure levels experienced at typical receiver distances, low frequency noise has not been shown to cause adverse health effects (McCunney et al., 2014). The level of infrasound at receiver distances is lower than some other environmental noise sources, such as vehicle traffic.

The results of Epsilon Associates, Inc.'s research indicate that there is no audible infrasound either outside or inside homes at 1,000 feet from a wind turbine. Wind turbine sound levels meet the ANSI standard for low frequency noise in bedrooms, classrooms, and hospitals and meet the ANSI standard for thresholds of annoyance from low frequency noise. There should be no window rattles or perceptible airborne induced vibration of lightweight walls or ceilings within homes. In homes there may be slightly audible low frequency noise beginning at around 50 Hz (depending on other sources of low frequency noise); however, the levels are below criteria and recommendations for low frequency noise within homes (O'Neal et. al, 2011).

Annex D in the American National Standard ANSI S12.9-2005/Part 4 identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB. According to the standard, annoyance to sounds with strong low frequency content is virtually only an indoor issue.

These levels have been used as design goals to minimize low frequency and infrasound from the project (see Exhibit 19).

Section 6 of the American National Standard ANSI/ASA S12.2-2008 discusses criteria for evaluating indoor low frequency room noise. These criteria assess the potential to cause perceptible airborne induced vibration and rattles. Outdoor low frequency sounds that are high enough can cause building walls to vibrate and windows to rattle. Window rattles are not low frequency noise, but may be caused by low frequency noise. ANSI/ASA S12.2 presents limiting levels at low frequencies (16, 31.5, 63 Hz) for assessing (a) the probability of *clearly* perceptible acoustically induced vibration and rattles in lightweight wall and ceiling constructions, and (b) the probability of *moderately* perceptible acoustically induced vibration in similar constructions.

Vibration

While not studied nearly as extensively as airborne vibration, the potential for wind turbines to create adverse ground-borne vibration has been investigated. Measurement of ground-borne vibration associated with wind turbine operations can be detectable with instruments but is below the threshold of perception, even within a wind farm.

ANSI S2.71-1983 presents recommendations for magnitudes of ground-borne vibration which humans will perceive and possibly react to within buildings. A basic rating is given in Table 1 of the standard for the most stringent conditions, which correspond to the approximate threshold of perception of the most sensitive humans. From the base rating, multiplication factors should be applied according to the location of the receiver; for continuous sources of vibration in residences at nighttime, the multiplication factor is 1.0 – 1.4. For spaces in which the occupants may be sitting, standing, or lying at various times, the standard recommends using a combined axis rating which is obtained from the most stringent rating for each axis. Measurements in each of the 3 axes should be compared to the combined axis rating. Table 4-4 in Appendix 19-A of Exhibit 19 presents the base response velocity ratings for the combined axis. The velocity ratings are for root-mean-square (RMS) values.

OSHA

The Occupational Safety and Health Administration (OSHA) protects against the effects of noise exposure in the workplace. Permissible noise exposure levels for an 8-hour day are 90 dBA. At sound levels above 85 dBA over an 8-hour workday, employers must provide hearing protection to employees. Sound pressure levels as generated by Facility construction and operation at sensitive sound receptors will be well under this threshold, so the Facility will be in compliance with OSHA standards. See Exhibit 19 for additional information.

Audible Sound

With respect to audible frequency sound, several studies of human response to wind turbine sound were conducted in Europe in the early 2000s. Pedersen and Wayne found a dose-response relationship between calculated A-weighted sound levels from wind turbines and noise annoyance. Noise annoyance was related to other subjective factors such as attitude and sensitivity. Attitude towards the visual aspect of wind turbines was strongly correlated to annoyance (Pedersen and Wayne, 2004). Another study found that high turbine visibility enhanced a negative response and that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, even at the same sound levels (Bakker et al., 2012). The same study found that of all sound sources that might disturb sleep in rural areas, 70% were not disturbed, 12% were disturbed by people/animals, 12% were disturbed by traffic/mechanical sounds, and 6% were disturbed by wind turbines (Bakker et al., 2012).

Potential effects from audible sound include hearing damage and speech interference. The U.S. Environmental Protection Agency (USEPA) and the WHO identify sound levels of 70 decibels (dBA) over a 24-hour period as protective against hearing loss from intermittent sources of environmental noise (USEPA, 1974 and WHO, 1999). According to the WHO guidelines, the threshold for hearing impairment is 110 dBA (Lmax, fast) or 140/140 dBA (peak at the ear) for children and adults (WHO, 1999). The USEPA states that at an outdoor level of 55 dBA (L_{dn}) there is 100% sentence intelligibility indoors and 99% sentence intelligibility at 1 meter outdoors. This includes a 5 dBA margin of safety and is the maximum sound level below which there are no effects on public health and welfare due to interference with speech or other activity.

The Facility will comply with the WHO and USEPA standards discussed above. The highest sound level at a non-participating receptor as a result of Facility operations is 45 dBA, which meets the 45 dBA nighttime limit at a non-participating receptor established by the WHO. See Exhibit 19 for additional detail on predicted sound levels as a result of construction and operation of the Facility. Based on discussions with the Town of Barre, no current land development plans are proposed within the Facility Site or adjacent areas. It is not anticipated that the Facility would have an effect on future uses.

In light of the above, the Facility is not expected to result in any public health and safety issues due to infrasound and audible low frequency noise.

(3) Ice Throw

Ice shedding and ice throw refer to the phenomena that can occur when ice accumulates on rotor blades and subsequently breaks free and falls to the ground. Although a potential safety concern, no serious accidents caused by ice being "thrown" from an operating wind turbine have been reported (Garrad Hassan Canada, Inc., 2007; Baring-Gould et al., 2012; Gipe, 2013). However, in theory, ice shedding and ice throw could occur and could represent a potential safety concern.

Under certain weather conditions, ice may build up on the rotor blades and/or sensors, slowing the rotational speed, and potentially creating an imbalance in the weights of the individual blades. Such effects of ice accumulation can be sensed by the turbine's computer controls and would typically result in the turbine being shut down until the ice melts. Field observations and studies of ice shedding indicate that most ice shedding occurs as air temperatures rise and the ice on the rotor blades begins to thaw. Therefore, the tendency is for ice fragments to drop off the rotors and land near the base of the turbine (Morgan et al., 1998; Ellenbogen, et al., 2012). Ice can potentially be “thrown” when it begins to melt and stationary turbine blades begin to rotate again; if ice falls from a stationary turbine during very high wind conditions that are strong enough to carry the ice some distance; or in the event of a failure of the turbine’s control system.

The distance traveled by a piece of ice depends on a number of factors, including the position of the blade when the ice breaks off, the location of the ice on the blade when it breaks off, the rotational speed of the blade, the shape of the ice that is shed (e.g., spherical, flat, smooth), and the prevailing wind speed. The risk of ice landing at a specific location is found to drop dramatically as the distance from the turbine increases. The European Union Wind Energy in Cold Climates research collaborative has studied ice throw at operational wind farms throughout Europe. The data gathered show that ice fragments typically land within 410 feet (125 meters) of the wind turbine (Seifert et al., 2003). Ice throw observations are also available from a wind turbine near Kincardine, Ontario, where the operator conducted approximately 1,000 inspections between December 1995 and March 2001. Thirteen of these inspections noted ice build-up on the turbine. No ice pieces were found on the ground further than 328 feet from the base of the turbine, with most found within 164 feet (Garrad Hassan Canada, Inc., 2007). Studies conducted in the Swiss Alps found that the maximum throwing distance was 302 feet (Cattin et al., 2008 and 2009). Almost fifty percent of the ice fragments weighed 0.1 pound or less (Cattin et al., 2007) and the heaviest ice fragment weighed nearly four pounds (Cattin et al., 2008 and 2009). While the height of wind turbines is also a factor to be considered in assessing the risks associated with ice throw, the “Wind Turbine Health Impact Study” prepared by an independent expert panel for the Massachusetts Department of Public Health concluded that, “ice is unlikely to land farther from the turbine than its maximum vertical extent” (Ellenbogen et al., 2012).

Public health and safety impacts related to ice shedding are unlikely because any ice is likely to fall within established setbacks (see Exhibit 6 for details about siting policies for the Facility). Moreover, the effects of ice accumulation can be sensed by the turbine's computer controls and typically result in the turbine being shut down until the ice melts. As ice builds up on the blades of an operating wind turbine, it can lead to vibration, caused by the mass of the ice or the aerodynamic imbalances. Modern commercial turbines are equipped with vibration monitors, which shut the machine down when vibrations exceed a pre-set level. Most modern wind turbines also monitor the wind speed to power output ratio. If ice accumulates on the blades, this ratio becomes too high and the turbine will stop itself.

In summary, studies/field observations at other wind power projects and other evidence indicate that ice throw does not pose a risk to public health and safety (Garrad Hassan Canada, Inc., 2007; Baring-Gould et al., 2012; Gipe, 2013). Modern turbine technological controls, the implementation of setback limits, and restrictions on public access to turbine sites should adequately protect the public from the risk of falling ice. Recent data collected by the Wind Energy Foundation (2014) indicate that worldwide there were more than 268,000 turbines in operation by the end of 2014, and more have been constructed since. Even with all of these turbines in operation, there has been no reported injury caused by ice being thrown from a turbine. The available evidence thus indicates that the risk from ice throw or shedding to public health and safety is minimal to nonexistent.

(4) Shadow Flicker

Shadow flicker is the intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer can experience repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine. Otherwise, there is no shadow flicker. A stationary wind turbine only generates a stationary shadow similar to any other structure.

A shadow flicker analysis was conducted by Environmental Design & Research, Landscape Architecture, Engineering & Environmental Services, D.P.C. (EDR) for the proposed Facility (see Appendix 15-A). The analysis used *WindPRO 3.2* software and its associated Shadow module, which is a widely accepted modeling software package developed specifically for the design and evaluation of wind power projects. The *WindPRO* software allows for the inclusion of a wind turbine curtailment plan, which the Applicant provided. The curtailment plan was considered in assessing the predicted shadow flicker impact of the Project. The final flicker times calculated and discussed below thus take into account the stops defined in the curtailment plan for given turbines.

Operational reduction includes turbine stoppage outside of the turbine operational cut-in/out wind speeds. In reality, there will be times when the wind speed will be below the cut-in or above the cut-out wind speeds. An operational reduction analysis was conducted to include times when wind turbines may not be operating at the receptors evaluated at the receptors evaluated in the curtailment data analysis.

There are no federal, state, or local standards for allowable frequency or duration of shadow flicker from wind turbines at the proposed Facility Site. A limit of 30 hours per year has been adopted by multiple jurisdictions in the United States. In addition, in the recent proceedings for the siting of the Cassadaga Wind Project, Baron Winds Project, Eight Point Wind Project, Number Three Wind Project, and Bluestone Wind Project, the New York State Board on Electric Generation Siting and the Environment (Siting Board) issued certificates establishing a standard of 30 hours of shadow flicker annually at non-participating residential receptors as a condition to the operation of the facility (Siting Board, 2017, 2019a, 2019b, 2019c, 2019d). Consistent with these precedents, the Applicant has established a design goal of 30 hours per year at non-participating sensitive receptors for purposes of assessing shadow flicker. The Applicant will continue to work and refine the project design including the use of curtailment to meet that goal with the final design and operation protocol.

A summary of the projected shadow flicker at each of the 703 potential sensitive receptors located within 1,620 meters (10 rotor diameters) of all proposed turbine locations for the turbine model under consideration for the Facility (i.e., the shadow flicker study area) is presented below and in detail in Appendix 15-A. The receptors studied include, but are not limited to, known residential structures with a certificate of occupancy (both year round and seasonal), schools, office buildings, storefronts, hospitals or nursing homes or high-use public recreation areas located within the shadow flicker study area. The Vestas V162-5.6 turbine represents the largest turbine model under consideration and displayed the greatest amount of annual duration of shadow flicker among all of the turbines included in the analysis. The final design to limit flicker to design goals will be completed upon the final turbine selection. The modeling results showed that 87 receptors would be expected to have over 30 hours of shadow flicker per year. Forty-one of those 87 receptors are on participating parcels, while the remaining 46 are on non-participating parcels. Following the curtailment plan, of the 87 receptors with 30 hours or more of expected annual average shadows:

- 40 are year-round residences on non-participating properties,
- 18 are year-round residences on participating properties,
- 4 are unknown structures on non-participating properties,
- 3 are unknown structures on participating properties,
- 1 is a seasonal residence on a participating property,

- 2 are dilapidated residences on participating properties,
- 1 is a public structure (cemetery),
- 18 are commercial properties (one of which is on non-participating property).

Information regarding maximum daily minutes of shadow flicker exposure can be found in Appendix 15-A.

The operational reduction analysis indicated that four additional non-participating receptors (one year-round residence, two unknown, and one commercial) should be reduced below the 30-hour per year threshold due to the percentage of time that wind speeds are below the cut-in speed or above the cut-out speed.

Based on the current design and operation of typical modern wind turbines, shadow flicker impacts are generally an annoyance issue and not a health effects concern. Although shadow flicker has been alleged to cause or contribute to health effects, blade pass frequencies for modern commercial scale wind turbines are very low. According to the Epilepsy Society, approximately five percent of individuals with epilepsy have sensitivity to light (Epilepsy Foundation, 2017). Most people with photosensitive epilepsy are sensitive to flickering around 16-25 Hz (Hertz or Hz = 1 flash per second), although some people may be sensitive to rates as low as 3 Hz and as high as 60 Hz. Modern wind turbines (including the Vestas V162-5.6 model used for shadow flicker modeling purposes) typically operate at a frequency of 1 Hz or less, and there is no evidence that wind turbines can trigger seizures (Ellenbogen et al., 2012; Merlin et. al., 2015; DECC, 2011).

Other health effects alleged to be caused by wind turbines are the symptoms associated with so-called "Wind Turbine Syndrome" including insomnia, headaches, tinnitus, dizziness, nausea, panic attacks, and palpitations. Based on a detailed review of scientific literature and other reports, an expert panel found that, "there is limited scientific evidence of an association from prolonged shadow flicker (exceeding 30 minutes per day) and potential transitory cognitive and physical health effects" (Ellenbogen et al., 2012). Ellenbogen et al. (2012) also concluded, "there is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a 'Wind Turbine Syndrome.'" The primary concern with shadow flicker is the annoyance it can cause for adjacent homeowners. As set forth in Appendix 15-A and below, the Applicant is proposing to implement various mitigation measures to address shadow flicker impacts. For those non-participating residences that continue to exceed the 30-hour annual design goal, the Applicant will address shadow flicker complaints through the following process:

- Meeting with the homeowner to determine the specifics of their complaint.
- Investigating the cause of the complaint.
- Providing the homeowner with reasonable mitigation alternatives including, as appropriate, shades, blinds, awnings, or plantings to significantly reduce the number of hours of shadow flicker inside the home.

- Having the landowner sign a good neighbor agreement and become a Facility participant.
- Investigating continued operational controls at appropriate wind turbines contributing to greater than 30 hours per year of shadow flicker.

(f) Public Health and Safety Maps

See Figure 15-1 for Public Health and Safety maps, which depict publicly available data[1] within a 5-mile radius of the Facility, including:

- Fire/police/EMS stations
- Hospitals and emergency medical facilities
- Emergency services mobile land sites
- USEPA-regulated facilities
- Bridges
- Regulated dams
- Existing known hazard risks (flood hazard zones, storm surge zones, areas of coastal erosion hazard, landslide hazard areas, areas of geologic, geomorphic or hydrologic hazard).
- NYSDEC Remediation Sites

The maps were prepared using data from the NYS GIS Clearinghouse, Federal Emergency Management Agency (FEMA), local municipalities, NYSDEC, New York State Department of Health, and the U.S. Geological Survey, as well as local sources for emergency response resources, including the Orleans County GIS website.

(g) Significant Impacts on the Environment, Public Health, and Safety

As indicated above in subsections (a) through (d), the Facility is not expected to result in any significant public health or safety concerns associated with gaseous, liquid, or solid wastes. As discussed in subsection (e) above, concerns relating to the operation of wind turbines include blade throw and tower collapse, audible frequency and low frequency noise, ice shedding/ice throw, and shadow flicker. However, none of these concerns will result in significant impacts to the environment, public health, or safety.

[1] Available public water supply and well information is presented in Exhibit 23 and filed under confidential cover. Additionally, locations of buried water lines owned by the Town of Barre Water Districts are described in Exhibit 4.

(h) Unavoidable Adverse Impacts and Appropriate Mitigation/Monitoring Measures

The proposed Facility will result in significant long-term economic benefits to participating landowners, as well as to the Town of Barre, the local school districts, and Orleans County (see Exhibit 27). When fully operational, the Facility will provide up to 184.8 MW of clean electric power generation. Despite the positive effects anticipated as a result of the Facility, its construction and operation will necessarily result in certain unavoidable impacts to the environment. The majority of these environmental impacts will be temporary, and will result from construction activities. One long-term unavoidable impact associated with operation and maintenance of the Facility is turbine visibility from some locations within the area. While the presence of the turbines will result in a change in perceived land use from some viewpoints, the overall contrast with the landscape, as determined through evaluation by registered landscape architects, was considered minimal to moderate (see Exhibit 24). Facility development will also result in an increased level of sound at some receptor locations (residences) within the study area (see Exhibit 19). However, Facility sound levels are not expected to exceed 45 dBA at any non-participating residences. Other impacts include loss of forest land, minor wetland impacts, wildlife habitat changes, and some level of avian and/or bat mortality associated with bird/bat collisions with the turbines. However, as evaluated through site-specific expert analysis presented in Exhibit 22 of the Application, these impacts are not considered significant, and are outweighed by the benefits of providing a source of clean, renewable energy. See Exhibit 2 for an overview of the relative costs and benefits of the Facility.

Although adverse environmental impacts will occur, they have been and will be minimized through the use of various general avoidance and minimization measures, as well as site-specific mitigation measures. These avoidance, minimization, and mitigation measures are spelled out in the appropriate Exhibits to this Application. With the implementation of these measures, the Facility is expected to result in positive, long-term impacts that will offset the adverse effects that cannot otherwise be avoided. Should avoidance and mitigation measures fail, and adverse impacts occur, the Applicant will evaluate the use of operational controls to ensure that the Facility operates in a socially responsible manner.

(i) Irreversible and Irretrievable Commitment of Resources

The proposed Facility will require the irreversible and irretrievable commitment of certain human, material, environmental, and financial resources. For the most part, the commitment of these resources will be offset by the benefits that will result from construction and operation of the Facility. Human and financial resources will be expended by numerous entities including the Applicant, the State of New York (i.e., various State agencies), Orleans County, and the Town of Barre for the planning and review of the Facility. The Applicant has submitted intervenor funding monies to offset the cost of legal and technical assistance during the Article 10 process. The expenditure of funds and human resources will continue throughout the permitting and construction phases of the Facility (e.g., environmental reviews and certification, environmental compliance monitoring, and construction inspections).

The Facility also represents a commitment of land for the life of the Facility, proposed to be 25 or more years, with the potential for longer if the Facility is recommissioned at the end of its useful life. Specifically, the land to be developed for wind turbines, access roads, the O&M building, meteorological towers, collection substation and other ancillary facilities will not be available for alternative purposes for the life of the Facility. In addition, as a result of the implementation of the Facility, there will be relatively minor impacts to environmental resources such as soils, forest and wildlife habitat, wetlands and streams, and agricultural land (see Exhibits 22 and 23 for details). However, because the turbines/towers may eventually be removed, and the land reclaimed for alternative uses upon Facility decommissioning (see Exhibit 29), the commitment of this land to the Facility is neither irreversible nor irretrievable.

Various types of manufacturing and construction materials and building supplies will be committed to the Facility. The use of these materials, such as gravel, concrete, reinforcement steel, cables etc., will represent a long-term commitment of these resources, which will not be available for other projects. However, some of these materials (e.g., steel and other metals, gravel, cables) may be retrievable for recycling/reuse following the operational life of the Facility as part of the decommissioning process (see Exhibit 29).

Energy resources will be irretrievably committed to the Facility during both construction and operation of the Facility. Fuel, lubricants, and electricity will be required during turbine fabrication and activities associated with the manufacture of turbines and components of the electric collection/interconnect system, as well as operation of various types of construction equipment and vehicles on-site, and for the transportation of workers and materials to the Facility area. However, the energy resources utilized to construct and operate the Facility will be minor compared to the energy generated annually by the Facility (up to 184.8 MW) and made available to the state power grid.

(j) Impact Minimization Measures

Impact minimization efforts begin early in the development of a wind power project, and initially are associated with appropriate siting of the individual wind turbines. General measures to minimize impacts from construction and operation of the Facility include compliance with the conditions of various local, State, and/or federal regulations that will ultimately govern Facility development as well as the commitments made by the Applicant throughout this Application to design and locate the Facility to minimize potential impacts. Adherence to setbacks presented in Exhibit 6 is the chief measure used by the Applicant to minimize the potential impacts to public health and safety resulting from the construction and operation of the Facility. For example, while ice shedding, tower collapse, blade failure, and fire in the turbines are all possible (but unlikely) events that could pose a risk to public health and safety, the risk from these types of incidents has been minimized by siting Facility components away from dwellings, roads, and other existing facilities in accordance with setback standards and requirements. Adherence to the setbacks described in Exhibit 6 also minimizes potential impacts resulting from noise and shadow flicker from the proposed Facility. The public's access to the Facility is limited because the turbines are located on leased private property. In addition, as discussed in Exhibit 18, the Applicant will implement various measures to limit access to the Facility and otherwise promote site security.

The Article 10 regulations require public input into the environmental review of proposed large-scale energy development projects so that potential adverse impacts can be identified prior to implementation and avoided, minimized or mitigated to the maximum extent practicable. This Application was prepared in accordance with these regulations, and provides a primary means by which the potential costs and benefits of the Facility are described and weighed in a public forum. Facility alternatives are evaluated, and potential impacts are identified, avoided, minimized, and mitigated to the maximum extent practicable.

Beyond Article 10, compliance with the other regulations governing the development, design, construction and operation of the proposed Facility also will serve to minimize adverse impacts. For instance, federal permitting required by the U.S. Army Corps of Engineers will serve to protect water resources, along with implementation of a State-approved stormwater permit. Highway permitting at the local, county, and State level will assure that congestion and damage to highways in the area is avoided or minimized and that traffic safety concerns are addressed. For a detailed analysis of impact minimization measures for a given resource, see the appropriate exhibit in this Application (e.g., for impact minimization measures associated with noise see Exhibit 19, for impact minimization measures associated with wetlands see Exhibit 22).

(k) Mitigation Measures

In the Applicant's experience, when a project such as the Facility is properly sited and designed, mitigation measures are generally not necessary because significant impacts to public health and safety typically do not occur. However, in the event that the Facility impacts public health and safety, the facility development and operation will include measures to mitigate the impacts, which generally include the following:

- Adhering to setbacks provided in Exhibit 6.
- Developing and implementing various plans to minimize adverse impacts to air, soil, and water resources (which can directly impact public health), including a dust control plan, a SWPPP, and Spill Prevention, Control, and Countermeasures (SPCC) Plan.
- Documenting existing road conditions and undertaking public road improvement/repair as required to mitigate impacts to local roadways.

- Developing and implementing an Emergency Action Plan.
- Developing and implementing a Site Security Plan.

For a detailed analysis of impact mitigation measures for a given resource, see the appropriate exhibit in this Application (e.g., for impact mitigation measures associated with noise see Exhibit 19; for impact mitigation measures associated with wetlands see Exhibit 22).

In addition, the Applicant will implement a Complaint Resolution Plan (see Appendix 12-B), which will consist of the following:

- Communications protocol and contacts for construction and operation
- Process for registering a complaint
- Process for gathering and analyzing information regarding the complaint
- Complaint response and tracking
- Complaint response follow up
- Documentation.

The Complaint Resolution Plan describes each of these steps and identifies all measures proposed by the Applicant to resolve any verified complaints. A separate complaint resolution plans specifically address sound impacts has also been prepared (see Appendix 19-B).

(l) Proposed Monitoring

The Applicant is committed to develop and operate the Facility in a safe and environmentally responsible manner. In addition to the mitigation measures described/referenced above, an environmental compliance program will be implemented, and the Applicant will provide funding for an independent, third-party environmental monitor to oversee compliance with environmental commitments and permit requirements (see Exhibit 22).

In addition, the Article 10 regulations specifically require monitoring to assess the impacts on particular types of resources. For monitoring associated with a specific resource, see the appropriate exhibit in this Application (e.g., for monitoring associated with wetland resources and agricultural land see Exhibit 22).

As discussed in Exhibit 12, an extensive quality assurance/quality protocol will be implemented to monitor construction of the Facility and ensure that the materials and equipment meet all applicable standards. See Appendix 12-A for the preliminary Quality Assurance/Quality Control Plan. Once the Facility has been constructed, periodic inspections will be conducted as part of the Facility's O&M program. Among other things, the inspections will examine turbine components such as blades and towers for wear and tear and any issues or red flags that could cause a blade failure, tower collapse or other potential health and safety problem. Details regarding the inspection protocol and schedule is provided in the Preliminary O&M plan attached as Appendix 5-D.

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