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NOISE MODELING STUDY
AND
ENVIRONMENTAL IMPACT ASSESSMENT

ROARING BROOK WIND FARM PROJECT

LEWIS COUNTY, NY

PREPARED FOR:

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1.0 INTRODUCTION

Hessler Associates, Inc. has been retained by PPM Energy, Inc. to evaluate potential noise impacts from the proposed Roaring Brook Wind Farm Project in Lewis County, NY a few miles west of the Town of Martinsburg. As it is currently envisioned, the project consists of 39 Gamesa G90 wind turbine generators with 90 m rotors on 100 m tubular towers.

This project is somewhat unusual for New York State in the sense that is it located in a remote area on a single tract of wooded, largely undeveloped private land. The nearest permanent residence to any of the turbines is over 2 miles away. Because the site is so isolated and there are essentially no residential receptors close enough to be significantly impacted by operational noise, a field study of background masking sound levels was considered unnecessary. In essence, it was immediately clear from an inspection of the site area that project sound levels would be very low at the nearest potentially sensitive receptors and that the amount of sound masking by existing environmental noise was unlikely to be relevant to the analysis.

In order to quantitatively look at potential impacts in absolute terms, a modeling study of worst-case project sound levels was carried out to determine what specific sound levels could be expected at the nearest receptors.

The discussion below first explains the technical basis for the model and its inherent assumptions and then evaluates the model results.

2.0 MODELING METHODOLOGY

2.1 MODELING ASSUMPTIONS

Using the turbine sound power level spectrum obtained from Gamesa for the G90 turbine model (discussed below in Section 2.2), an estimated worst-case noise level contour plot for the site was calculated using the Cadna/A®, ver. 3.5 noise modeling program developed by DataKustik GmbH (Munich). This software enables the project and its surroundings, including terrain features, to be realistically modeled in three-dimensions. In this case, the topography has been assumed as flat because the minor undulations that do exist are fairly insignificant with respect to such elevated sources and would not have any real bearing on sound propagation. Each turbine is represented as a spherical point noise source at a height of 80 m above the ground surface.

The program calculates distant sound levels in strict accordance with ISO 9613-2 *Acoustics – Attenuation of Sound during Propagation Outdoors*, which considers the geometrical spreading of sound waves from a source and all other natural attenuation mechanisms that might come into play such as barriers, sound wave interaction with the ground surface, air absorption, etc. In this instance, only geometric spreading (distance loss), air absorption under ISO "standard day" conditions (10 deg. C, 70% RH) and ground absorption were considered in the model.

A ground absorption coefficient of 0.7 has been assumed in the model since all of the intervening terrain between the turbines and any potentially sensitive receptors is wooded with a few open fields here and there. The ISO ground absorption coefficient ranges from 0 for water or hard concrete surfaces to 1 for absorptive surfaces such as farm fields, wooded areas or sand. Consequently, a higher ground absorption coefficient on the order of 0.9 or 1.0 could be justified here because the landscape is wooded; however, for conservatism the value of 0.7 has been used. It should be noted that ground absorption is the interaction of sound waves with the ground surface and quantifies how much of the incident sound energy is absorbed rather than reflected. The ground surface in wooded areas is normally porous and therefore acoustically absorptive. This is a completely different attenuation mechanism than the blockage or scattering of sound by foliage. No credit has been taken in the calculations for this, separate propagation loss since a significant portion of the forests around the project area are deciduous and would provide little attenuation during the winter.

Although wind direction effects can be modeled with this software, to be conservative the noise level from each turbine is assumed to be the maximum, downwind sound level in *all directions simultaneously*. In other words, although physically impossible, an omni-directional 8 m/s wind is assumed. This approach yields a contour plot that essentially shows the maximum possible sound level at any given point and sometimes also shows levels that cannot possibly occur – such as between two adjacent turbines, since the wind would have to be blowing in two opposing directions at the same time. In a more realistic scenario with, for example, a wind out of the west the contour lines would occur closer to the turbines on the west side and would remain largely as shown on the east.

At the risk of overestimating potential project sound levels, the various conservative assumptions have been applied to help ensure that actual project noise levels do not exceed the predicted levels – including during times when atmospheric conditions may favor noise propagation relative to average conditions. Sound levels that are somewhat lower than those predicted in the modeling plots are actually expected to occur much of the time. The model represents a theoretical worst-case condition at any given receptor point that would require a convergence of the following conditions to occur:

- **Wind Direction –** from *all* the turbines towards the receptor point
- **Wind Speed** – 8 m/s wind speed worst-case. Impact thresholds would contract all other wind speeds (see Section 2.2)
- **Low Ground Porosity** – normally wooded areas are more absorptive than assumed in the model
- **Observer Outside –** the plotted sound levels occur outside; sound levels inside of any dwelling will be 10 to 20 dBA lower

2.2 INPUT TURBINE SOUND POWER LEVEL

At the present time, the Model G90 wind turbine produced by Gamesa Eólica is planned for the project.

The sound emissions of the G90 have recently been measured in accordance with IEC 61400-11 [Ref. 1] and recently (10/5/07) published by the manufacturer [Ref. 2]. This report gives the A-weighted sound power level as a function of wind speed and hub height. For a 100 m tower height the following power levels are given.

Table 2.2.1 *Gamesa G90 Sound Power Level as a Function of Wind Speed [Ref. 2]*

Wind Speed at IEC Standard Elevation of 10 m, m/s	Sound Power Level (100 m hub height), dBA re 1 pW
3	95.0
4	98.5
5	103.3
6	107.3
7	**108.4**
8	108.4
9	108.4

Beyond a wind speed of 7 m/s at 10 m (or 10.2 m/s at hub height) the noise emissions of the G90 remain constant because the rotor has reached its maximum rotational speed. The point where the sound level first reaches its maximum is where the potential for adverse noise impacts is greatest, since the background sound level is lowest relative to the turbine sound level at that point. At higher wind speeds the background level continues to increase while the turbine sound level remains constant.

The design value used for modeling is this maximum value of 108.4 dBA re 1 pW. It is important to note this value is a sound *power* level and not a sound *pressure* level. Power levels are analytical quantities in units of Watts containing a factor associated with the radiating area of the source and are useful only for modeling purposes in order to predict pressure levels at distant locations. They do not represent the actual sound level that would be perceived immediately adjacent to the turbine as is sometimes mistakenly believed. The sound *pressure* level at the base of a typical turbine is roughly 57 dBA. Sound pressure levels are the values measured by sound level meters and physically perceived by the ear.

The new sound test report [Ref. 2] does not provide any information on the frequency content of the sound and only gives the overall A-weighted sound level. In order to account for the frequency content in the noise model the known spectrum for the very similar Gamesa G87 turbine [Ref. 3] was scaled up by adding 1.6 dB to each octave band value as shown in the following table.

Table 2.2.2 *Gamesa Model G90 Sound Power Level Spectrum Used for Modeling Purposes*

Octave Band Center Frequency, Hz	63	125	250	500	1k	2k	4k	8k	dBA
Max. Sound Power Level G87, dB re 1 pW	111.9	110.6	109.2	104.8	100.5	95.6	91.2	90.5	106.8
Scale-up Factor	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
Assumed Sound Power Level Spectrum for G90, dB re 1 pW	**113.4**	**112.1**	**110.7**	**106.4**	**102.1**	**97.2**	**92.8**	**92.1**	**108.4**

3.0 MODEL RESULTS

The model results are illustrated in **Plot 1**, which show the conservatively predicted sound levels due only to the project (exclusive of any background noise).

The sound emissions from the project are shown out to a limit of 35 dBA because this sound level represents the point where project noise is likely to become insignificant relative to the typical background sound level found in rural areas during moderately windy conditions. Based on many field surveys in New York State and elsewhere, a residual, or L90, background level of between about 35 and 43 dBA is very commonly measured in rural areas during wintertime, leaf-off conditions when the wind is blowing in at around 6 to 8 m/s – the speed when turbine noise usually first begins to be significant. The plot below is a typical regression of the near-minimum, L90 background sound level vs. wind speed measured recently at c rural wind project site in New York. At this comparable site, the mean background sound level during an 8 m/s wind was found to be 41 dBA – meaning that project noise at this other similar site would largely fade into the background around that sound level (41 dBA) and would be difficult to perceive, if not inaudible, by the time it diminished to 35 dBA. Consequently, the cut-off of 35 dBA used in the contour plot for Roaring Brook can reasonably be considered the outermost limit where any potentially adverse noise impact might occur.

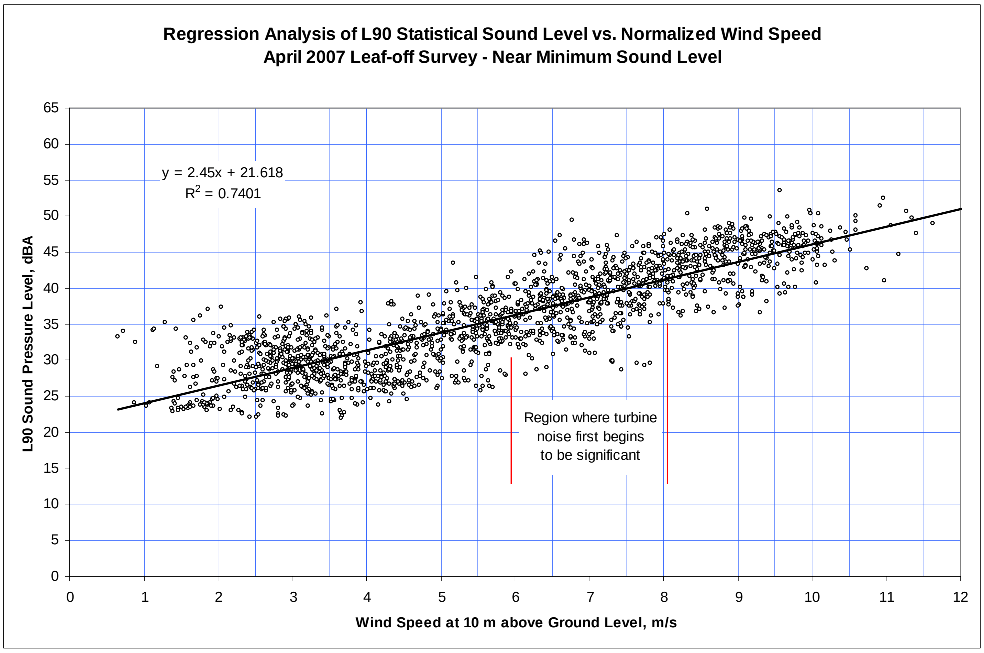


Figure 3.0.1 *Typical Wind Speed – Background Sound Level Correlation from a Comparable Wind Project Site in New York State*

As can be seen from Plot 1, the nearest permanent residence (yellow symbol in the upper right-hand corner of the figure) is well beyond the nominal 35 dBA impact threshold. A theoretical project-only sound level of about 29 dBA is predicted at this house, which is so quiet that project noise is highly unlikely to be noticeable even in the complete absence of any background noise. Consequently, no adverse impact from project noise is expected at this residence.

In addition to this single closest house there are also several seasonal/hunting cabins in the general vicinity of the project site on Carey and Flat Rock Roads. These structures are essentially on the 35 dBA threshold and project noise is not expected to be significant under most normal conditions. There may be times, however, when the atmospheric conditions are more conducive to sound propagation than during "normal conditions" and the turbines may be perceptible.

One additional seasonal cabin exists roughly 800 ft. from Turbine 20 on French Road and a sound level of about 50 dBA is predicted at this structure. At this location, as opposed to the others discussed above, turbine noise will be clearly audible above the natural background levels during moderately windy conditions. It is our understanding that the project has discussed this situation with the owners of this only intermittently occupied cabin and they are unconcerned about any potential noise and have agreed to a setback easement.

4.0 CONCLUSIONS

Potential noise impacts at the remote Roaring Brook Wind Farm Project have been evaluated by conservatively modeling project noise levels at the nearest permanent residence and also at the handful of seasonal cabins in the general vicinity of the site. The expected sound level of 29 dBA at the nearest permanent residence over 2 miles away is so low that it is unlikely that the project will be perceptible under any circumstances. Consequently, no adverse impact is expected.

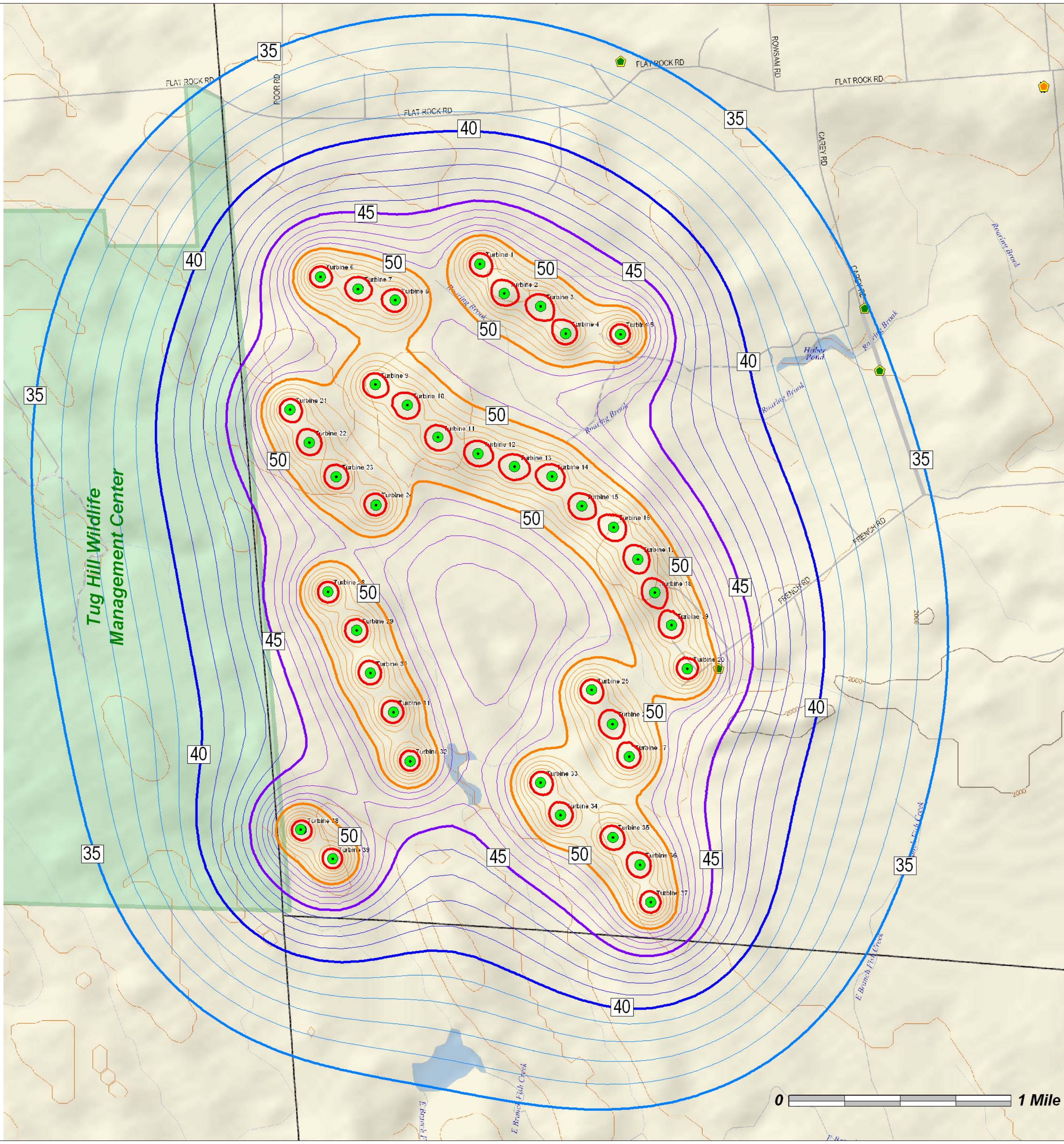
Besides this one home there are several intermittently occupied seasonal cabins in the general vicinity of the project site. Modeling indicates that all but one of these cabins can, under most normal circumstances, expect to see project sound levels of about 35 dBA, which is comparable to or less than the natural background sound level that would typically occur in a rural area during moderately windy conditions. This means that project noise is unlikely to be clearly discernable above the background sound level most of the time but may be intermittently perceptible during certain atmospheric conditions that favor sound propagation over long distances. Nevertheless, the absolute magnitude of project noise even under these worst-case conditions is expected to be quite low and therefore unlikely to constitute a significant adverse impact, especially given the fact that these cabins are only occasionally inhabited.

One such seasonal cabin on French Road exists much closer to the project than any of the others and it is anticipated that turbine noise will be very prominent and audible at this location. It is our understanding that the project has discussed this situation with the owners of this cabin and they are unconcerned about any potential noise. Consequently, no serious impact is anticipated at this location.

REFERENCES

1. International Electromechanical Commission (IEC) 61400-11:2002(E) *Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques*, Second Edition 2002-12.
2. Technical File GD022915-en-es Rev. 0, *G90 2 MW 50/60Hz Wind Turbine Power and Noise Emission Curve*, Gamesa Eolica, October 5, 2007.

3. Theofiloyiannokos, D., Test Report 264-02 *Acoustic Noise Measurements on Gamesa G87 2.0 MW Wind Turbine Operatingat Almendarache Wind Farm*, Centre for Renewable Energy Souces, June 2005.



Scale in Meters

Project:	*Description:*	*Legend:*
Roaring Brook Wind Farm	**Plot 1**	Turbine Location
Prepared for: **PPM Energy, Inc.**	**Prediced Sound Contours (dBA) of G90 Turbines with an Omnidirectional 10 m/s Wind**	Permanent Residence
Date: October 11, 2007 — *Drawing #:* RB-Rev-B-1-1		Seasonal Cabin

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