Saddleback Ridge Wind, LLC // Natural Resource Protection Act (NRPA) and Site Location of Development Act applications

- Licensee Exhibit 5
  Memorandum from RSG to Andy Novey
  (February 23, 2011)

RSG INC.
RESOURCE SYSTEMS GROUP, INC.

MEMORANDUM

To:	Andy Novey
From:	Kenneth Kaliski, INCE Bd. Cert. Emily Eros, INCE
Subject:	RSG Rebuttal -- Petition for a Public Hearing, Saddleback Ridge Wind Project
Date:	23 February 2011

Thank you for forwarding to me the Request for a Public Hearing filed by "Friends of Maine's Mountains" (FMM) in the Saddleback Ridge Wind Project (SRW) proceedings. That request included an attorney's brief summarizing issues related to the noise impact study we prepared for the project. That Brief was supported by an Exhibit 2, "Critical Issues in the Patriot Renewables 'Noise Study of the Saddleback Ridge Wind Project'", prepared by Rick James of E-Coustic Solutions, and Exhibit 3, "Independent Peer-Review," prepared by Robert Rand and Stephen Ambrose. This memorandum responds to issues from the Brief and exhibits and touches on the following topics:

1. Problems with Cadna/A (Limitations on use of ISO 9613-2 algorithms)
2. Line vs. point source models
3. Atmospheric stability
4. Amplitude modulation/SDRS
5. Turbulence from turbine configuration
6. NRO modes
7. Low frequency noise
8. Wind turbine annoyance
9. Use of Normalized Day-Night Average

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1. Problems with Cadna/A (Limitations on ISO 9613-2 algorithms)

FMM questions the accuracy of the Cadna/A software and ISO 9613-2 methodology, particularly in modeling ridge-mounted turbines. FMM states that RSG should have included a 3 dB tolerance associated with errors in applying the ISO-9613-2 methodology and offers an alternative formula for predicting sound levels.

Like any model, sound models have uncertainties associated with them. However, so long as one knows what those uncertainties are and accounts for them, the model results can be valid within the stated uncertainty range. In this case, we used the Cadna/A computer program, which implements the only current international standard for outdoor sound propagation, ISO 9613.

In its filing, FMM refers to several applications for wind projects in Maine where the modeling included a ground absorption factor of 0.5 with 5 dB added to the result to account for uncertainties. The modeling in this case uses a different, but similarly conservative approach. We used a ground factor of 0 with a +2 dB correction. A ground factor of 0 represents hard non-porous ground, like pavement, over the entire modeling area. This results in a ground attenuation factor (Agr) of -3 to -4 dB, meaning, in this case, that 3 to 4 dB is added to the overall sound level, depending on frequency, source and receiver height, and propagation distance to account for ground absorption, or in this case, reflection.

We calibrated this model on actual data from an operating wind farm and published our results.[1] The chart below shows the monitored sound levels at 2,000 feet from the closest turbine and the modeled sound levels using the same parameters used in the Saddleback project. On average, the modeled level is 4.8 dB higher than the monitored level. Clearly the model we are using to estimate sound levels for this wind farm has a conservative bias, which

[1] Kaliski, K. and Duncan, D., "Propagation Modeling Parameters for Wind Power Projects," Sound & Vibration Magazine, December 2008

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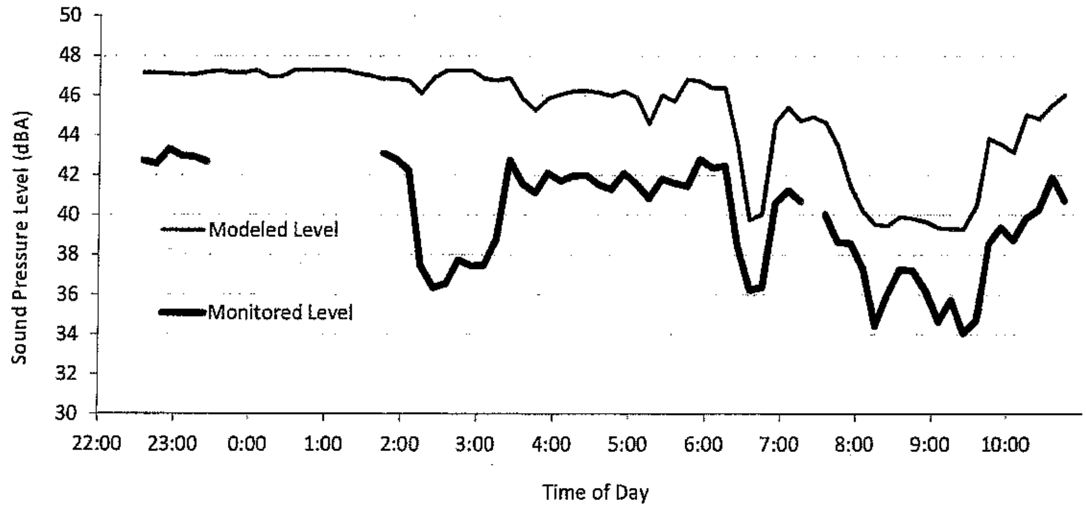
means the noise levels will have been overestimated in comparison to actual levels, as demonstrated in Figure 1.

Figure 1: Monitored vs modeled sound levels for a receiver 2,000 feet downwind of a 67-turbine wind farm using a ground absorption factor of 0 and a 2 dB confidence interval on the sound power levels



The FMM filing also states that the ISO standard is limited to receivers within 1,000 meters and situations where the noise source is no more than 30 meters above the receiver. To demonstrate this, FMM's Exhibit 2 presents a table from ISO 9613-2 that provides an estimate of accuracy for various distances up to 1,000 meters away and with a mean propagation path of 30 meters. By only providing accuracy figures up to 1,000 meters, the ISO standard does not mention or imply that it is limited to 1,000 meter distances. Moreover, the 30 meter height does not refer to the difference in height between the noise source and receiver, as FMM's Exhibit 2 states. The table copied from ISO 9613-2 in FMM Exhibit 2 clearly states that this distance, h, is the mean height of the source and receiver. In this case, the turbine hub height is 85 meters and the receiver height is 4 meters, resulting in a mean height of (85 + 4)/2 = 44.5 meters. This is still larger than the 30 meter distance but the methodology can be applied if propagation effects at higher heights are taken into account. Based on the calibration study results mentioned above, the model and methodology used by RSG has been demonstrated to predict sound levels from wind turbines with a conservative bias.

Mr. James states that Cadna/A and RSG's methodology should not be used to model noise sources located on a ridgeline. To investigate this question, RSG performed a calibration study for Stetson Wind, New England's largest utility-scale wind farm, located along a ridgeline in Washington County, Maine. RSG modeled Stetson Wind using the same parameters as Saddleback Ridge: G=0, spectral ground attenuation, and a +2 dB confidence interval. We compared our results to a 2009 operations compliance sound level study conducted by Resource Systems Engineering (RSE)[1]. RSE collected continuous sound level data over the period of 19 to 21 May 2009 at four receiver locations near the south end of the turbine string. Project engineers monitored 10-meter wind speeds and wind turbine power output levels for the duration of the period.

RSE analyzed the data to find periods during the night when 10-meter wind speeds were low (at or below 6 mph) and the turbines were operating at their maximum sound power level (at or above 900 kW of power output) to conform with the approved measurement protocol. This represents stable meteorology with full sound power from the turbines, the assumed worst-case scenario. From the selected time periods, RSE analyzed 10-minute Leq data to determine the sound pressure levels at each receiver.

We then compared RSE's monitoring results to modeled sound levels using G=0 and a +2 dB correction for the as-built wind farm. Results are presented in Figure 2.

Figure 2 shows that actual monitored sound levels are at least 3 dB below RSG's modeled levels. As winds were blowing from the west and southwest during the monitoring period, Receiver 4 was directly downwind of the turbine string and is therefore the best test site in the scenario. At this location, the monitored sound levels are 4 dB below RSG's modeled levels. As a result, this calibration clearly shows that the modeling parameters used for Saddleback Wind are conservative estimates of worst-case sound levels, regardless of topography.

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1 Resource Systems Engineering, "Operations Compliance Sound Level Study," July 27, 2009

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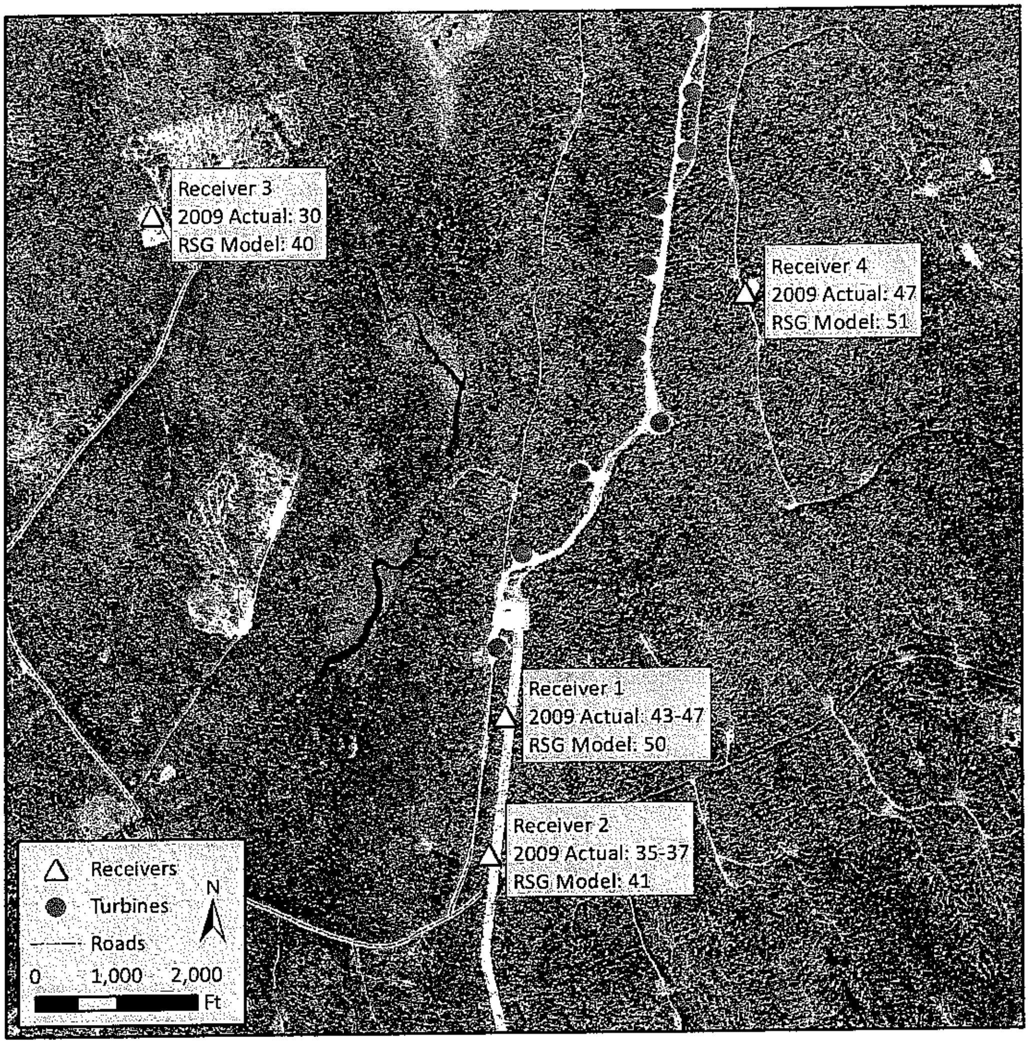
Figure 2: 2009 Measured and 2011 Modeled Leq Sound Pressure Levels (dBA) at Stetson Wind



2. Line vs. point source models

FMM Exhibit 2 offers an alternative formula for modeling a wind turbine string as a line source rather than as a point source. Mr. James' modeled levels are higher than RSG's modeled levels.

First, the model proposed in FMM Exhibit 2 cannot be accepted as valid for the Saddleback Ridge project. The equation is taken from a paper concerning the modeling of offshore wind turbine arrays. It is well known that sound propagation over large bodies of water is different than over land due to a variety of factors, including surface flow resistivity and meteorology. As it applies to wind turbines, for example, the Swedish wind turbine modeling standard, Ljud-Fran-Vindkraftverk, uses a different propagation model for terrestrial and ocean environments. As another example, the ISO 9613-2 methodology is limited by its authors to use over terrestrial environments. The use by FMM of an alternative algorithm is not a valid approach in this case.

The model for this project was run by representing each wind turbine as a point source at hub height. The discussion in Section 3.4 of the Saddleback Ridge noise report concludes that a line source and closely spaced point sources behave similarly within a specified range from the source. Thus, a line source can be modeled as closely spaced point sources. Closely spaced point sources exhibit line source attenuation (i.e. 3 dB per doubling of distance) between distances of about D/3 and L/3 perpendicular from the source string, where D is the spacing between the point sources and L is the length of the string of sources. For Saddleback Ridge Wind, we see roughly 3 dB per doubling of distance out to about 1,900 feet perpendicular from the turbine string. The attenuation rate increases as one moves beyond this as a result of both the mechanism discussed above and atmospheric absorption.

To further investigate line versus point source propagation, RSG re-modeled the project as a line source. A line source was created that ran from the southern end of the project to the northern end, with vertices at the hub of each turbine, and an assigned sound power level over the length of the line source equal to all of the turbines combined. This line source model was run using the same ground absorption factor, temperature, and humidity as the point source model run in the noise report. It included the same calibration factor of +2 dB.

Figure 3 shows the difference between the line source and point source results. The line source results are lower to the north and south of the project because the sound power from the northern- and southern-most turbines is distributed along the line rather than concentrated in points (turbines) at both ends of the project layout. At homes to the east and southeast, there is essentially no difference between the point and line source model results. The line source results are higher in between the turbines. This is expected, as the line source method models sound emissions in places where there are no point sources (i.e. in between turbines).

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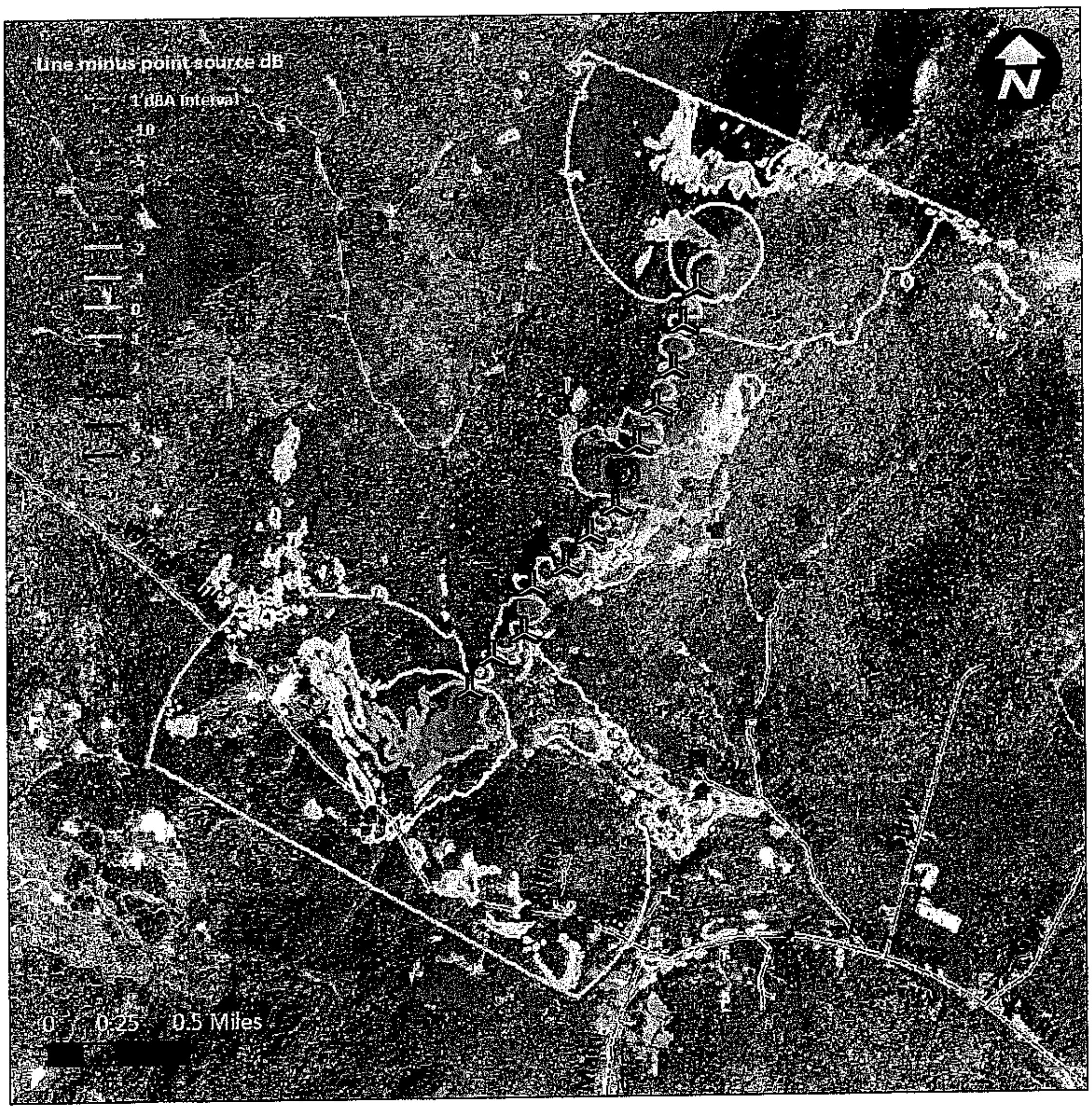
While both models give roughly equivalent results perpendicular to the turbine string, we believe the line source model does not accurately represent impacts along the turbine string axis. As a result, the point source model, as used in the Saddleback Ridge Wind application, represents the better approach to modeling sound propagation from the wind farm.

Figure 3: Difference between line source and point source model results, calculated as line source minus point source grid. Red colors indicate higher and green colors indicate lower levels in the line source model compared with the point source models.



3. Atmospheric stability

FMM Exhibit 2 states that atmospheric stability resulting from temperature inversions is a concern in this area, and that such conditions would cause wind turbines to operate at or close to maximum sound output. It concludes that "the RSG model does not consider the effect of extra noise from turbines operating under these meteorological conditions".

The sound levels identified in RSG's report do indeed represent the worst-case levels under conditions of a stable atmosphere. Modeled conditions reflect a moderate nighttime inversion, the rated maximum sound power, the assumption of essentially paved ground throughout the project area, and a +2 dB correction factor. The modeling parameters have been calibrated and are either consistent with, or more conservative than standard practice. For example, the British DTI/BERR Noise Working Group recommends:

> "On the evidence available, we consider that ISO 9613-2 calculations using either G=0 or G=0.5 ($G_s = G_m = G_r$) will lead to appropriate predication of noise immission[1] levels at typical receptor locations, depending on the input values of other parameters. The use of either (a) G = 0 together with measured (IEC 61400-11 test) sound power levels or (b) G = 0.5 (with a 4 metres receptor height) together with vendor's warranted sound power levels (or measured turbine sound power levels plus an allowance for measurement uncertainty), will generally result in a realistic estimates of noise immission levels at receptor locations downwind of wind turbines. Noise immission levels calculated using these combinations of parameters can generally be relied on for the purposes of noise assessment."[2]

In the case of the assessment done for Saddleback Wind, the model assumed G = 0 plus an allowance for measurement uncertainty. This is more conservative than the British Working Group recommendation.

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[1] "Immission" refers to the level of sound received.

[2] Bowlder, D., Bullmore, A.J, Davis, B, Hayes, M, Jiggins, M., Leventhall, G, McKenzie, A., "Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects," Acoustics Bulletin, Vol 34 no 2, 2009

FMM Exhibits 2 and 3 imply that the +2 dB factor that is added to the sound power level is not sufficient to account for variations in the actual sound power of the turbines under certain unidentified wind shear or turbulence conditions. It is important to note that the +2 dB factor is added to account for the uncertainty in sound emissions for a single turbine. However, when multiple turbines are operating, this confidence interval is narrowed. This is because the probability of all turbines operating at their 95th percentile levels, for example, is small, and diminishes with an increasing number of turbines. In this case, at the worst-case receiver, the confidence interval is reduced from 2.0 dB to 0.7 dB when all turbines are taken into account. That is, the probability of increasing the sound level at a distance receiver due to normal variability in wind turbine sound power is smaller by taking into account the multiple wind turbines that contribute to its overall sound level. In this case, however, we used the full 2 dB for uncertainty. This is an additional conservative factor in the model.

Finally, there is no evidence that this site has meteorological conditions that create a higher sound power than assumed in the Saddleback noise study. The noise study provided MDEP with an analysis of wind shear and turbulence from project met towers, which found that this site is not especially conduce to excessive wind shear or turbulence.

4. Amplitude modulation/short-duration repetitive sounds (SDRS)

FMM Exhibit 2 acknowledges RSG's analysis of wind speed variations as a measure of turbulence but states that amplitude modulation may occur from updrafts, cross drafts, and wake interference. Exhibit 2 states that amplitude modulation is a common and consistent complaint about wind farms and advocates that the 5 dB penalty in MDEP's noise standard should be applied to the project.

The MDEP noise regulations that that, "For short duration repetitive sounds, 5 dBA shall be added to the observed levels of the short duration repetitive sounds that result from routine operation of the development" (MDEP 06-096 Chapter 375: 10.C.1.e.i.). High amplitude modulation and thumping is rare and is not characteristic of a modern, properly-operating wind farm.[1]

As noted above, an analysis of wind shear and turbulence indicate that the Saddleback Ridge site is not conducive to common occurrences of SDRS. No analysis or interpretation of this data was conducted by FMM to show otherwise.

Studies correlate excessive amplitude modulation with excessive wind shear.[2] Updrafts, cross drafts, and wake interference are secondary sources of turbulence that are not expected to create significant issues. Regarding wake interference, modern wind turbines utilize an upwind rotor design to eliminate thumping noises caused by blade-tower interactions, and the turbine spacing is designed to minimize inter-turbine wake interference. As for updrafts, cross drafts, etc, the Petitioner has sited the turbines in consideration of the effects of turbulence. Turbulence can impact a wind farm's energy production, incentivizing developers and operators to prevent and fix potential problems.

Finally, because SDRS cannot currently be modeled with a high degree of accuracy, we are recommending that post-construction monitoring be conducted that addresses this issue. If SDRS is found and it creates a violation of the Chapter 375.10 standard, then it will have to be mitigated by the project operator.

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[1] In a survey in Europe, 75% of respondents who could hear wind turbine sounds at their dwelling described the sound as "swishing/lashing" while 7% described it as "thumping/throbbing" Van den Berg, et al, *WINDFARMPerception – Visual and Acoustic Impact of Wind Turbine Farms on Residents*, FP&-2005-Scence-and-Society-20, Specific Support Action, Project number 044628, 2008.

[2] W. Palmer, *A New Explanation for Wind Turbine Whoosh – Wind Shear*, Proceedings of the 3rd International Conference on Wind Turbine Noise, 2009.

D. Bowdler, *Wind Shear and its Effects on Noise Assessment*, Proceedings of the 3rd International Conference on Wind Turbine Noise, 2009.

G.P. Van den Berg, *The Sound of High Winds: The Effect of Atmospheric Stability on Wind Turbine Sound and Microphone Noise* (Thesis) University of Groningen, 2006.

5. Turbulence from wind turbine configuration

FMM Exhibit 2 cites a personal communication with GE management to claim that there should be an inter-turbine spacing of 5 rotor diameters, otherwise wake-induced amplitude modulation poses a concern.

GE has reviewed and signed off on the site layout for Saddleback Ridge Wind.

6. Problems associated with NRO modes

FMM Exhibits 2 and 3 challenge the premise that NRO modes will reduce nighttime noise emissions. Exhibit 2 states that NRO modes do not work to reduce blade-swish noises.

The very definition of a Noise Reduced Operating Mode is that it reduces noise. Manufacturers guarantee sound power levels for their NRO modes just as they guarantee the sound emissions at full power.

NRO is designed to reduce the overall sound level from a wind turbine and is not designed to address problems, if any, with amplitude modulation.

7. Problems with low-frequency noise

FMM Exhibit 2 states that wind turbines emit high levels of low-frequency sound and that it has significant impacts.

The issue of low frequency noise from wind turbines has been addressed by a number of authors, and the conclusions are consistent; that properly designed and operated wind farms do not generate audible or dangerous levels of low-frequency noise. [1,2,3,4] Regarding audibility, Delta Acoustics' Low Frequency Noise from Large Wind Turbines: A procedure for the evaluation of audibility for low frequency sound and a literature study," (April 2008) concludes, "There is general agreement that wind turbines do not emit audible infrasound. The levels are far below the hearing threshold." High levels of low-frequency sound, such as that over 65 dB at 16 or 31.5 Hz, can occur due to problems with the wind farm, including improper yaw, excessive turbulence, or mechanical failure. However, these are not part of normal operation and can impact energy production at the wind farm.

With regards to hearing below the auditory threshold, the World Health Organization states "There is no reliable evidence that infra sounds below the hearing threshold produce physiological or psychological effects."[5]. Other papers, such as Inukai and Taya's, Unpleasantness and Acceptable Limits of Low Frequency Sound,[6] found no "unpleasantness" response of participants exposed to low frequency sound below hearing thresholds. Moreover, multiple studies show that wind farms generate lower levels of low-frequency noise than common, everyday noise sources. Delta Acoustics' aforementioned study found that road traffic emits low frequency noise at higher levels than those emitted by wind farms. Another study by

[1] Delta Electronics, Light & Acoustics, *Project Report: Low Frequency Noise from Large Wind Turbines – Results from Sound Power Measurements*, Danish Energy Authority project EFP-06, AV 136/08, 2008.

[2] Epsilon Associates, *A Study of Low Frequency Noise and Infrasound from Wind Turbines*, prepared for NextEra Energy Resources LLC, July 2009.

[3] G.P. Van den Berg, *Do Wind Turbines Produce Significant Low Frequency Sound Levels*, 11th International Meeting on Low Frequency Noise and Vibration and its Control, 2004.

[4] University of Salford, *Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report*, U.K. Department for Business Enterprise and Regulatory Reform, Contract no NANR233, 2007.

[5] Community Noise: Berglund et al, Archives of the Centre for Sensory Research Vol 2 (1) 1995: Section 7.1.4: 41

[6] Inukai, I, et al, *Unpleasantness and Acceptable Limits of Low Frequency Sound*, The Effects of Low-Frequency Noise and Vibration on People, Colin Hansen ed., Multi-Science Publishing, UK, 2007.

the British Wind Energy Association came to a similar conclusion[1]. The authors of this report conducted noise assessments at three wind farms in the UK in 2004 and found that low frequency noise associated with road traffic at monitoring sites was greater than sound from neighboring wind farms.

In conclusion, with respect to low-frequency sound below the hearing threshold, the scientific consensus at this time is that there is no health effect from exposure to sub-audible low frequency sound or infrasound.

8. Wind Turbine Noise and Annoyance

FMM Exhibit 2 states that wind turbine noise is more annoying than other common community noise sources because of its low-frequency components and audible amplitude modulation. FMM disputes RSG's background sound monitoring results, stating that a study by Les Blomberg found background sound levels (LA90) in the low 20 dBA range and that RSG's results are unrealistically high.

Low-frequency noise and amplitude modulation have been discussed in this rebuttal and do not pose a significant issue for the project area. The MDEP noise regulation applicable to the project is a 55/45 dBA day/night standard. Based on RSG's modeling results, Saddleback Ridge Wind meets this standard.

Exhibit 2's comments about RSG's noise monitoring are incorrect and irrelevant to this project. To our knowledge, Les Blomberg did not conduct a noise study for this area. We believe that this statement refers to monitoring Mr. Blomberg did in the Northeast Kingdom of Vermont.

9. Use of Normalized Day-Night Average

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[1] Hayes McKenzie partnership; The measurement of low frequency noise at three UK wind farms; Dept of Trade and industry, URN number 06/1412, 2006

FMM Exhibit 3 makes use of an "EPA noise impact assessment method" for determining the level of community reaction to the project.

FMM Exhibit 3 refers to a 1974 EPA document, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." The conclusion of the EPA is that an annual average day-night average sound level of 55 dB for "Residential with Outside Space and Farm Residences" outside protects public health and welfare "with an adequate margin safety." The methodology that is referred to in Exhibit 3 is not a methodology recommended by EPA to be applied to their guideline level. It is simply a methodology referred to by the EPA in an appendix to their report and is not part of their guideline methodology.

Further, even if the methodology were to be used, it is based on an annual average day-night sound level. FMM instead applies this methodology to the 1-hour maximum sound level of the wind farm. Given that the maximum sound level from the wind farm only occurs under a small set of meteorological conditions (downwind or nighttime inversion when the hub height winds are over approximately 8 meters per second), the annual average nighttime sound level would be at least 5 dB lower than the 1-hour maximum sound level.[1]

The authors of the EPA Levels document conclude that "there is no evidence in these 55 cases of even sporadic complaints if the Ldn is less than 50 dB." Using a 5 dB adjustment from 1-hour maximum to annual average nighttime level, the Ldn in this case would not exceed 50 dB.

In conclusion, the Saddleback Ridge Wind project is modeled to meet the EPA 55 dB Ldn guideline at all protected locations.

[1] Kaliski, K., "Calculating annualized sound levels for a wind farm", Proceedings of Meetings on Acoustics, 2010

Conclusions

The noise impact study prepared for the Saddleback Ridge Wind project is complete and accurate. No changes in our conclusions are required in light of the critique provided by FMM. If operated as designed, the project is modeled to meet the applicable noise requirements of Chapter 375.10.