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This review of the FEIS filed by the Lead Agency (Town of Allegany Planning Board) on April 27, 2011 was conducted on behalf of Concerned Citizens of Cattaraugus County (CCCC). It is provided as a supplement to previous statements made by E-Coustic Solutions earlier in this proceeding.

The review found several deficiencies in the FEIS that do not comply with the zoning ordinance and guidelines of the Planning Board or will result in insufficient protection for residential properties and people living near or in the footprint of the proposed Allegany Wind Project. Rather than address each specific issue as it appears in the FEIS this review will address them by topic.

Those topics include:

- An Overview summarizing deficiencies in the various reports, letters, and other communications provided by Everpower's acoustical consultant, Hessler and Associates, Inc. regarding background noise and computer modeling studies.
- Failure to apply tolerances to modeling and background testing results as is the accepted practice when reporting findings from scientific studies. No measurements or prediction methods are precise. All have confidence limits. these were not included or even discussed in the Hessler and CRA reports to the Planning Board.
- Description of wind turbine noise as a distinctively annoying source of environmental noise exposure for humans based on current science.
- Confirmation bias in the FEIS regarding conclusions that can be drawn from information on the record. And,
- Evidence that the Allegany Wind Project noise will exceed the permitted levels.

This reviewer has previously identified a number of deficiencies in the reports and information presented by Hessler background sound levels in the community, proper interpretation of generally accepted standards for acoustical measurement procedures, computer modeling of wind projects, and impact of noise, both audible and inaudible, on people occupying residential homes near the project boundaries. These prior criticisms remain because Hessler and Associates, CRA, and the FEIS do not address them.

First, the Hessler model did not include the tolerances/confidence limits for Sound Power Level testing and computer modeling. The IEC 61400-11 test procedures used to estimate a wind turbine's sound emissions for 'normal' daytime operation typically report confidence limits of +/- 2 dB that should be added to the sound power levels used as input into the computer model. The ISO 9613-2 modeling procedure states confidence limits of ± 3 dB for models that meet all assumptions and conditions of the procedure. Hessler's model did not meet those conditions. The noise source was too high above the receiver and the distances involved exceed the limits for the procedure. If the confidence limits are +/ 3 for models that meet the ISO 9613-2 requirements and the Hessler model does not meet those requirements it is reasonable to assume that the confidence limits would be even higher, for example,+/- 5 dB. But the Hessler model does not include any confidence limits choosing instead to assert that its results are "conservative."

The Hessler report acknowledges that the model is out of the range of the procedure but then ignores what that means to the accuracy of the model and applies no tolerance or confidence limits to the predictions. The NYDEC raises this issue also and the FEIS appears to ignore both E-CS and NYDEC's criticisms. The Hessler model is presented as if the results are accurate to some fine resolution of 1 dB or less but if the tolerances for both measurement errors in estimating the sound power levels and the modeling method were applied the predicted values would have been a minimum of 5 dBA higher (+2 for IEC and +3 for ISO standards). If the Hessler model had included these tolerances the results shown on the contour maps and tables of their report would be 5 dB higher than stated.

Third, the sound propagation modeling software used for the sound models is a general purpose model designed for modeling noise from common urban noise sources like industrial plants, roads, and railways. The ISO Standard limits use of this model to noise sources that are no more than 30 meters above the receiving locations. A wind turbine with a hub height of 80 meters exceeds this ISO limitation by 50 meters. Locating the turbine on a ridge high above the receiving properties is a condition that is clearly outside the bounds of the ISO 9613-2 standard's procedures. The Hessler report did not disclose this limitation or make any effort to account for the errors that may accrue from the noise source exceeding the source height limits. Cadna/A (the model Hessler used) is based on the ISO standard and thus limitations to the standard apply equally to the Cadna/A model. Any assertions that the Hessler model is "conservative" must be ignored since the model was constructed using tools and input data that do not apply for the real-world conditions Hessler claims to represent.

The result of these three failings (related to model predictions) is the Hessler model does not represent the audible noise from wind turbines that is produced at night as a result of the summer night time wind speed profile. The model does not represent the nighttime high wind shear conditions that studies show produce the most objectionable noise. If the model had correctly addressed tolerances and the need to increase the IEC61400-11 sound power levels to account for increased sound emissions at night the contour map and tables would be at least eight (8) dBA higher, possibly even 11 dBA higher. This increase would have expanded the boundary of the 40 dBA threshold to include many of the homes around the perimeter of the Allegany Wind Project.

Although both Hessler and Associates and CRA may support the procedures used to measure background sound promoted in the British Wind Industry guidelines (ETSU-R-97) these guidelines do not meet standards used in the US developed by independent experts for assessing background (residual) sound levels for use in determining land use compatibility."

Properly modeled this project would not comply with Allegany's noise ordinance at many receiving properties. The claim that a model that has confidence limits greater than +/- 5dBA is "conservative" is not supported by any generally accepted definition of scientific precision.

Additional errors were introduced by the flawed procedures used to determine background sound levels. Although both Hessler and Associates and CRA may support the procedures used to measure background sound promoted in the British Wind Industry guidelines (ETSU-R-97) these guidelines do not meet standards used in the US developed by independent experts for assessing background (residual) sound levels for use in determining land use compatibility. ANSI/ASA standards are available to assure quality and uniformity of results for measurements taken outside. They include measurements that are observed (S12.9 Part 3) and long-term unobserved measurements (S12.9 Part 2).

The Hessler and CRA background studies did not even attempt to comply with either one of the US standards, choosing to follow the British Wind Industry Guidelines (ETSU-R-97) instead. In earlier submittals this reviewer demonstrated that the wind industry sponsored ETSU procedures are deeply flawed and that even in the U.K. are challenged by independent acoustical experts as producing biased results that raise the measurement results above the true background (residual) sound levels. Since the background sound level is used in the Allegany rules set by the Town Board to establish the maximum allowable increase of sound wind turbines can produce (e.g., background level+3 dB) this upwards bias of the alleged background (residual) sound levels is a benefit to the developer at the expense of the adjacent residential property owners.

Comments by the NYDEC indicate that they share the same concerns as the above. The FEIS does not respond to these comments with any substantive rebuttal. Instead the FEIS ignores NYDEC's call for a penalty to account for the blade swish/thump modulation attempting instead to make the condition appear to be infrequent or otherwise "sporadic." The FEIS uses similar diversionary responses to address NYDEC's call for including tolerances, quality of the background study and application of NYDEC's guidelines regarding the sound level of a new noise source increasing the community background sounds by over 10 to 20 dB. In general, the FEIS is non-responsive to the valid criticisms brought by both this reviewer and the NYDEC.

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As discussed earlier in this review the sound propagation modeling presented by Hessler and used as the basis for conclusions about the impact of the Allegany Wind project on nearby properties and residences underestimates the sound levels that will be received on the properties and homes adjacent to the wind turbine utility. The sound propagation modeling software used for the sound models (Cadna/A and others) are general-purpose commercial packages for use in modeling noise from noise sources like industrial plants, roads, and railways, not wind turbines. Although this does not completely preclude the use of the Cadna/A software package, it does call into question the implied assertion by Hessler in representing the sound levels to a 1 dB precision and presumption that they are "conservative." We need to apply reasonable safety factors and give consideration to the known tolerances and limits to the accuracy of the procedures in our conclusions.

Projects such as roads, bridges and other structures are not designed with 0 safety factors. Why should wind energy utilities be allowed to design their projects without a safety margin for errors? Further, it must be understood that there are other computational methods and algorithms that can be used to model wind turbines other than the ISO method that produce different results.

Hessler does not include any offset for the tolerance associated with instrumentation and measurement error from the IEC 61400 – 11 test protocol for measuring the sound power produced by wind turbines. Hessler also does not include the three (3) dB tolerance associated with errors when applying the ISO-methodology (See Table 5 from the ISO standard on previous page).

Table 5 — Estimated accuracy for broadband noise of L_{AT}(DW) calculated using equations (1) to (10)

Height, h [a]	Distance, d [a]	
	$0 < d < 100$ m	100 m $< d < 1\,000$ m
$0 < h < 5$ m	± 3 dB	± 3 dB
5 m $< h < 30$ m	± 1 dB	± 3 dB

[a] h is the mean height of the source and receiver.
d is the distance between the source and receiver.

NOTE — These estimates have been made from situations where there are no effects due to reflection or attenuation due to screening.

If Hessler had included the three (3) dB tolerance for the ISO methodology, and the two (2) dB tolerances for measurement of sound power under the IEC standard the results of the model and accounted for increased sound power when operating at night with a stable atmosphere the results would have shown many of the homes proximate to the project being exposed to sound levels over 40 dBA. ISO 9613-2, Table 5, Section 9, "Accuracy and limits of the method" (Figure above labeled "Table 5…."), shows the tolerance as plus/minus 3 dB for predictions. This applies when the noise source is at a height greater than 5m and less than 30 m above the receiver and the receiver is within 1000 m. of the noise source. Inspection of Table 5 shows that the ISO standard is limited to receivers within 1000 m also limits it to situations where the noise source is no more than 30 m above the receiver. Mr. Hessler claims that the absence of any tolerances for the conditions he modeled is not important. Yet, when interpreting standards it must be assumed that conditions that are outside the tolerances of the procedure do not fit the model and thus the model should not be used.

It essential to include the three (3) dB tolerance in the predictions. Further, the predicted values should be viewed as estimates, not precise values.

Sound power levels must represent the conditions that cause the intrusive blade swish that is commonly associated with nighttime sleep disturbance and complaints. The manufacturer's reported power levels represents a standardized value for 'typical' conditions of a neutral atmosphere with a moderate wind shear gradient. This is a daytime weather condition, not a nighttime weather condition. The Hessler report made no attempt to address this deficiency.

This is a significant fault and results in predicted sound levels that underestimate the sound levels that will be received on the properties and at homes adjacent to the wind turbine utility under nighttime stable atmospheric conditions. The Hessler model assumes that the atmospheric conditions are "neutral.[1]" The IEC tests results are only applicable for the weather conditions under which the turbines are tested and those conditions are specified as having a wind shear of 0.2 or less. A wind shear of 0.2 or lower also represents a neutral atmosphere where the wind speed gradually increases as the height changes from ground surface to wind turbine hub level. These conditions are present on sunny afternoons but do not occur, as a general rule, at night.

Nighttime conditions after a sunny day are described as "stable atmosphere" where a cool layer of air forms over the surface of the ground when solar heating of the earth's surface stops. This cool layer disconnects the lower level winds from upper level (hub height) winds. It is common for this nighttime condition to result in calm winds at the surface producing no wind noise in trees or vegetation while at the hub the winds are at full operating power. The Hessler model completely ignores this common nighttime condition and only presents results that would apply for a sunny afternoon. The Sound Power data used in the sound propagation models does not represent the noise produced by wind turbines during nighttime operations with high wind shear and stable atmospheric conditions. The IEC 61400-11 test standard collects data under neutral atmospheric conditions that do not cause these louder "thumping" or "whooshing" type of noise emissions. The fact that wind turbine noise is more of a nighttime problem than a day time problem is ignored by the Hessler study. Thus, Hessler's model does not represent a "worst case" condition but instead a "best case" condition.

In "Effects of the wind profile at night on wind turbine sound" G.P. van den Berg states:

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[1] Section 2.6 "Wind Speed As A Function Of Elevation Above Ground Level" of Hessler Report No. 1827-111308-D

> "....measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference wind speed in daytime. Moreover, especially at high rotational speeds the turbines produce a 'thumping', impulsive sound, increasing annoyance further. It is reasonable to conclude that prediction of noise immission at night from (tall) wind turbines is underestimated when measurement data are used (implicitly) assuming a wind profile valid in daytime."[2]

The "thumping" referred to in the Van den Berg paper occurs in synchronization with blade rotation (about one "thump" or "whoosh" per second assuming the hub is rotating at 20 rpm). "Thumping" does not referring to the blade "swish" of 1-3 dBA present when the turbine is operating in a neutral atmosphere. This "swish" is included as part of the wind turbine sound power ratings provided by the manufacturer. The "thumping" of concern is the much louder noise that is not accounted for in the manufacturer's test data. This occurs typically at night under a stable atmosphere where there is high wind shear (0.4 and higher). This "thumping" can modulate by 5 to 10 dBA or more and is caused by increased sound power emissions from the wind turbine blades during periods of non-optimum alignment with the in-flow air stream.

Based on this reviewer's experience the nighttime noise is increased by at least 5 dBA over what is observed for similar hub level wind speeds during the day under a neutral atmosphere. If the increased sound power caused by the nighttime atmospheric conditions had been added to the manufacturer's sound power for neutral atmospheric conditions the predicted values would be 5 dBA or more higher than what is shown in the Hessler report tables and contour map without even considering the 5 dB for confidence limits mentioned above.

It is common for people to look at wind turbines as a separate type of noise source. However, some of the problems associated with them are easier to understand if we view wind turbines as a special case of very large exposed-blade industrial fan. For example, if we take a look at the spectrum from a fan, as shown in Figure 1, there are certain characteristics that all fans have in common. There is maximum energy at the blade passage frequency, tones above the blade passage frequency, and broadband noise. The harmonics of that tone have somewhat lower energy content. The broadband spectrum starts above the range where the tones no longer dominate. The energy is highest at the blade passage frequency and drops off as frequency increases.

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[2] Van den Berg, G.P., "Effects of the wind profile at night on wind turbine sound" Journal of Sound and Vibration, 2003

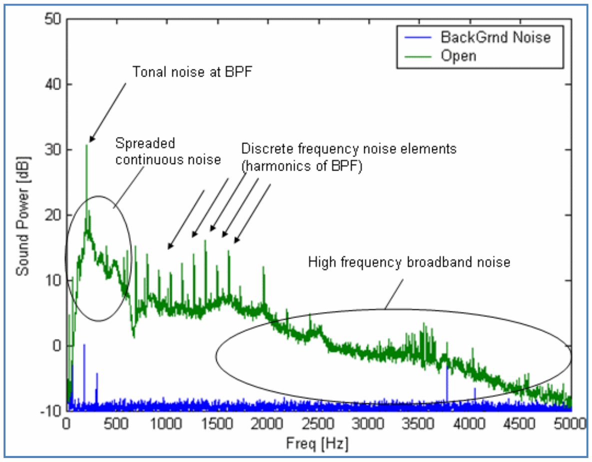

Figure 1-Typical Fan Noise Spectrum

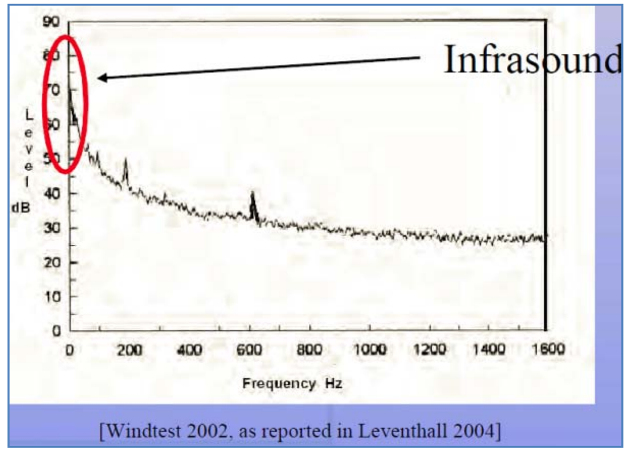

Figure 2-Vestas V-52 Spectrum (From NREL)

In Figure 2, the wind turbine spectrum for a Vestas V-52 shows some of the same spectral characteristics. It does not show the tones and harmonics at the blade passage frequency (BPF) because for industrial scale upwind turbines this is usually between 1 and 2 Hz and the harmonics occur below 10 Hz. Because this is a difficult range of frequencies to measure, especially in field test situations, most information about the spectral characteristics do not show the infrasound range (0-20Hz) sound pressure levels (SPL). This is further obscured by the practice of wind industry acoustical consultants to present data using of A-weighting (dBA). The practice masks the spectrum shape by creating a visual impression of minimal low-frequency sound content. Even when octave band (1/1 or 1/3) SPLs are presented the reports normally ignore frequencies below 31.5 or 63 Hz. The wind industry and its consultants often conclude that there is little or no infra or low frequency content. If that is true, then the customary reporting practices are understandable. But, if those assumptions are not accurate, then these practices mask a potential source of significant problems.

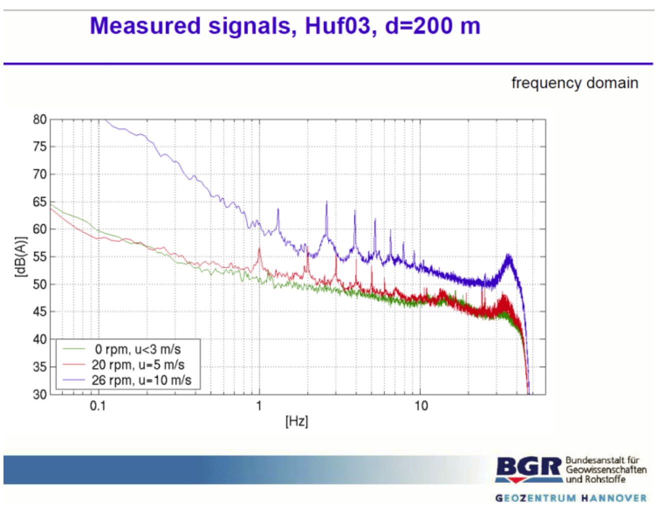

Figure 3-Wind Turbine Infrasound

Figure 3 is expanded in the lower frequency range to show a wind turbine sound spectrum for the frequency range of 0-10 Hz. Now the tones and harmonics are clearer. Also, note the correlation of the frequency of the tones to rotational speed. This graph is from a study conducted by the Federal Institute for Geosciences and Natural Resources, Hannover, Germany, titled: “The Inaudible Noise of Wind Turbines” presented at the Infrasound work shop in 2005 (Tahiti).

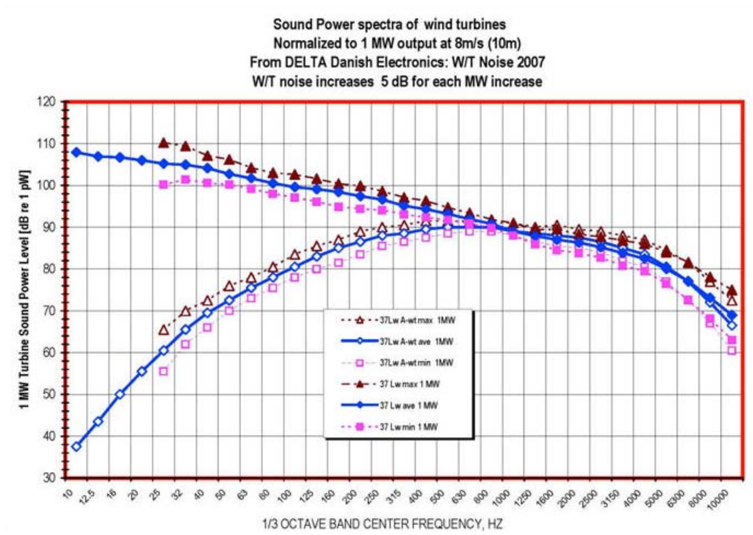

Figure 4-Sound Power Level of 37 Turbines Normalized to 1MW

Are the sound emission characteristics similar or different for different models and makes of wind turbines? Figure 4 shows the general spectrum shape of 37 modern upwind turbines representing the type and sizes being located in the Allegany Wind Project. This graph shows the sound power data after normalizing the data for each turbine to 1 MW of power output.[3] It is clear that there is little deviation in spectral shape between any of the various models that is not related to power produced. However, as seen in the A-weighted curves of the same data, the use of A-weighting masks the low frequency energy content. All modern upwind industrial scale wind turbines have similar high sound pressure levels and tones in these lowest frequencies.

There have been several studies, primarily conducted in European countries with a long history of wind turbines, showing that at the same sound pressure (decibel) level or less, wind turbine noise is experienced as more annoying than airport, truck traffic or railroad noise[4,5][6]. There are several reasons why people respond more negatively to wind turbine noise that are directly a result of the dynamic modulations of the noise, both audible and inaudible, more than the absolute level of the sounds received.

It is not clear which characteristic of wind turbines makes them more annoying than other common sounds in the community. Whether it is the distinctive rhythmic, impulsive or modulating character of wind turbine noise (all synonyms for “thump” or “whoosh” or “beating” sounds); its characteristic low frequency energy (both audible and inaudible, and also impulsive); the adverse health effects of chronic exposure to wind turbine noise (especially at night); in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized); or some combination of all of these factors that best explains the increased annoyance is not fully understood. One or more of these characteristics are

3 DELTA, Danish Electronics, Light & Acoustics, “EFP-06 Project, Low Frequency Noise from Large Wind Turbines, Summary and Conclusions on Measurements and Methods,” April 30, 2008

4 E. Pedersen and K. Persson Waye, “Perception and annoyance due to wind turbine noise: a dose–response relationship,” J. Acoust. Soc. Am. 116, 3460–3470 (2004).

5 Vandenberg, G., Pedersen, E., Bouma. J., Bakker, R. “WINDFARMperception Visual and acoustic impact of wind turbine farms on residents” Final Report, June 3, 2008.

6 Pedersen, E. J., 'Why Is Wind Turbine Noise Poorly Masked By Road Traffic Noise," Invited paper, InterNoise 2010

likely present depending on atmospheric and topographic conditions, (especially at night)[7] as is the individual susceptibility of each person to them.

Nevertheless, reports based on surveys of those living near wind farms consistently find that, compared to surveys of those living near other sources of industrial noise, annoyance is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels 10 dBA or more below the sound level that would cause equivalent annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA. Given that wind turbine utilities are often permitted to cause sound levels of 40 or higher at the outside of homes adjacent to or inside the footprint of wind utilities the negative reactions to wind turbines from many of those people is understandable[8]. Their reactions provide objective evidence from currently operating wind utilities that a substantial number of people who live near the Allegany project will complain that the noise level they experience is both causing nighttime sleep disturbance and creating other problems once operation commences.[9] [10]

Although there remain differences in opinions about what causes the amplitude modulation of audible wind turbine noise most of the explanations involve high wind shears and/or turbulence as it moves into turbine's blades[11]. There are a number of explanations that have been presented to explain this noise. For example, eddies in the wind, high wind shear gradients (e.g. different wind speeds at the higher reach of the blades compared to the lower reach), slightly different wind directions across the plane of the blades, and interaction among turbines, have each been identified as causes of modulating wind turbine noise from modern upwind turbines.[12]

Consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation model's represent "worst-case" conditions. The IEC 61400-11 test procedures used to derive this data states that the turbine's reported sound power levels represent the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind conditions. These weather conditions require a neutral atmosphere where the wind shear fits the assumptions of the power law for winds at 10 meters and the hub level. This condition is often associated with a warm, sunny afternoon. That is reasonable given that the purpose of these tests is to produce standardized data to permit a prospective buyer of turbines to compare the sound emissions from various makes and models. This needs to be understood as being similar to the standardized gasoline mileage tests for new vehicles. One does not get the mileage posted on the vehicle sticker since each person's driving habits are different. The same is true for wind turbines and the environments in which they operate.

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[7] G.P. Van den Berg, "The beat is getting stronger: The effect of atmospheric stability on low frequency modulated sound on wind turbines," Noise notes 4(4), 15-40 (2005) and "The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise" Thesis (2006)

[8] Janssen, S.A., Vos, H., Eisses, A.R., Pedersen, E, "Predicting Annoyance to Wind Turbine Noise," Invited paper InterNoise 2010.

[9] Kamperman and James (2008); James (2009b); Minnesota Department of Health (2009), pp. 19-20.

[10] Bajdek, Christopher J. (2007). *Communicating the Noise Effects of Wind Farms to Stakeholders*, Proceedings of NOISE-CON (Reno, Nevada), available at http://www.hmmh.com/cmsdocuments/ Bajdek_NC07.pdf

[11] Van den Berg (2006, pp. 35-36); Oerlemans/Schepers (2009).

[12] Bowdler, "Why Turbine Noise Annoys – Amplitude Modulation and other things," Where Now with Wind Turbines, Environmental Protection U.K. Conference, Sept. 9, 2010 Birmingham, U.K.

The IEC test data does not account for the increased noise from turbulence or other weather conditions that cause higher sound emissions. A review of the IEC 61400-11, Wind Turbine Systems-Part 11: Acoustic Noise Measurement Techniques' assumptions in the body and appendices (esp. Appendix A) show that the IEC test data reported to turbine manufacturers is not 'worst case' for real world operations. Weather can introduce additional deviations from model results along its propagation path. ANSI standards for outdoor noise caution that turbulence in the air can increase the downwind sound levels by several decibels. It should be clear that any assertions by the acoustical modeler that the models represent "worst case" sound level estimates rely on careful phrasing or ignorance of the underlying standards and methods.

Impulsive sound was considered more problematic for older turbines that had rotors mounted downwind from the tower[13]. The sound was reduced by mounting the rotor upwind of the tower, common now on all modern turbines[14]. Initially, many presumed that the change from downwind to upwind turbine blades would eliminate amplitude modulated sounds (whooshes and thumps) being received on adjacent properties. However, in a landmark study by G. P. van den Berg[15], it was shown that the impulsive swishing sound increases with size because larger modern turbines have blades located at higher elevations where they are subject to higher levels of wind shear during times of ground level "atmospheric stability." This results in sound fluctuating 5 dBA or more between beats under moderate conditions and 10 dBA or more during periods of higher turbulence or wind shear[16].

This author has confirmed night time amplitude modulation (blade thumping) at every wind project he has investigated. During periods of high turbulence or wind shear levels the sound levels produced by blade "thump" have been as high as 10-13 dBA. Figure 5's graph shows the rise and fall of the A-weighted sound levels from blade swish measured inside a closed entry vestibule to a home. This test site is approximately 1500 feet from two (2) turbines with sound emission characteristics similar to the turbines proposed for the Allegany Wind project. It should be noted that other tests measured sound levels exceeding 40 dBA inside the home in the rooms facing the turbines with a window partly open.

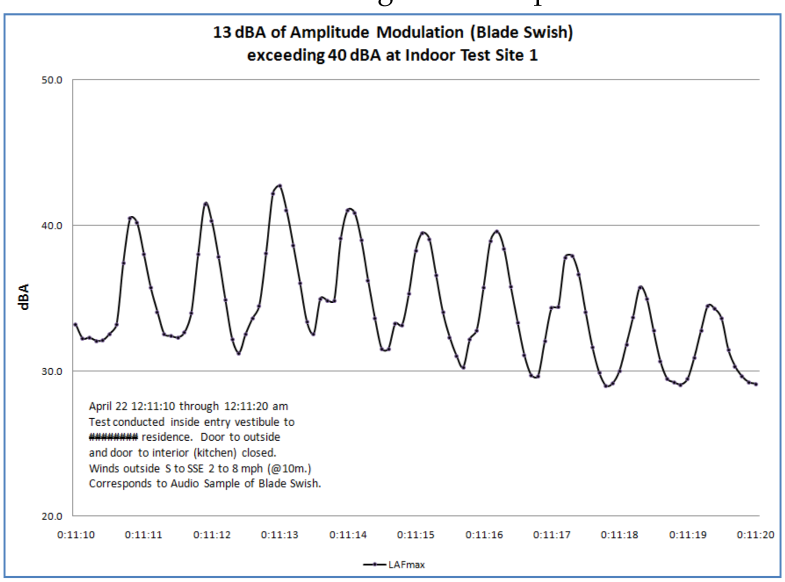

Figure 5-Audible Blade Swish inside home from New York Wind Utility

To compensate for the added annoyance of fluctuating or impulsive sound, the sound power levels of the turbine must be increased above what is reported for neutral atmospheric conditions under IEC 61400-11. The impact of this increased annoyance from short term fluctuations in sound levels

13 Rogers (2006, p. 10)
14 *Id.*, pp. 13, 16; Van den Berg (2006), p. 36.
15 Van den Berg (2006, p. 36)
16 *Id.*,

is cited in the Minnesota Department of Public Health report of 2009.[17] The evidence collected by this reviewer as demonstrated in Figure 5 shows that this increase in noise emissions is generally applicable. It is the days and nights when the amplitude modulation is at its worst that cause complaints. It is not the 1-3 dB swishes of a summer afternoon, but the 6-9 dB whooshes of a late evening or the 10 -14 dB thumps during warm season night time weather with high turbulence or wind shear that matter. These conditions are common in warm weather months and at any time when significant vertical and horizontal turbulence and wind shear may occur.

The phenomenon of wind shear coupled with ground level atmospheric stability refers to the boundary that forms between calm air at ground level and winds above the boundary at a higher altitude. "*A high wind shear at night is very common and must be regarded a standard feature of the night time atmosphere in the temperate zone and over land.*"[18] A paper presented at the 2009 Institute of Noise Control Engineers, Noise-Con 2009 conference in Ottawa, Canada on background noise assessment in New York's rural areas noted: "*Stable conditions occurred in 67% of nights and in 30% of those nights, wind velocities represented worst-case conditions where ground level winds were less than 2 m/s and hub-height winds were greater than wind turbine cut-in speed, 4 m/s.*"[19]

Based on a full year of measurements every half-hour at a wind farm in Germany, Van den Berg found:

> "*the wind velocity at 10 m[eters] follows the popular notion that wind picks up after sunrise and abates after sundown. This is obviously a 'near-ground' notion as the reverse is true at altitudes above 80 m. . . . after sunrise low altitude winds are coupled to high altitude winds due to the vertical air movements caused by the developing thermal turbulence. As a result low altitude winds are accelerated by high altitude winds that in turn are slowed down. At sunset this process is reversed.*[20]"

In other words, when ground-level wind speed calms after sunset, wind speed at typical hub height for large wind turbines (80 meters, or 262 feet) commonly increases or at least stays the same. As a result, turbines can be expected to produce noise while there is no masking effect from wind-related noise at the ground where people live. "*The contrast between wind turbine and ambient sound levels is therefore at night more pronounced.*[21]" The blade angle is calculated for the average wind speed (at the hub) but the wind speeds at the top and bottom can require different settings to avoid producing noise. As the turbine's blades sweep from top to bottom under such conditions the blade encounters different wind velocities that do not match the blade's angle of attack resulting in rhythmic swishing noise from the parts of the rotation where blade angle mismatches occur[22]. Such calm or stable atmosphere at near-ground altitude accompanied by wind shear near turbine hub height occurred in the Van den Berg measurements 47% of the time over the course a year on average, and most

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[17] Van den Berg (2006), p. 106; Minnesota Department of Public Health (2009), p. 21. *See also* Pedersen, "Wind turbine noise, annoyance and self-reported health and well being in different living environments," 2007, p. 24)
[18] Van den Berg (2006, p. 104). *See also* Cummings (2009)
[19] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Noise-Con 2009
[20] (Van den Berg 2006, p. 90)
[21] *Id.*, p. 60
[22] *Id.*, p. 61. *Cf. also* Minnesota Department of Public Health (2009), pp. 12-13 and Fig. 5.

often at night[23].

The level of annoyance produced by wind turbine noise also increases substantially for **low frequency sound,** once it exceeds a person's threshold of perception. Annoyance increases more rapidly than the more readily audible mid-frequency sounds. Sound measured as dBA is biased toward 1,000 Hz, the center of the most audible frequency range of sound pressure. Low frequency sound is in the range below 200 Hz and is more appropriately measured as dBC or using instrumentation that can provide 1/3 octave band resolution of the spectrum sound pressure levels. Sound below 20 Hz, termed infrasound, is generally presumed to not be audible to most people. *See* Leventhall (2003, pp. 31-37); Minnesota Department of Public Health (2009, p. 10); Kamperman and James (2008, pp. 23-24). However, if these criteria are applied to the most sensitive people, the thresholds drop approximately 6-12 dB. Since the wind turbine sounds are a complex mix of tones, all within the same critical band, they will be audible at levels lower than what is required for a single pure tone. The combination of people with extra sensitivity and the presence of a complex set of tones in the range from 0 to 20 Hz puts the infrasound sound pressure levels measured on receiving properties and inside homes within the threshold of perception for a subset of the population.

For many years it has been presumed that only infra and low frequency sounds that reached the threshold of audibility for people posed any health risks. Many acoustical engineers were taught that if you cannot hear a sound, it cannot harm you. Recent research has shown that the human body is more sensitive to infra and low frequency noise (ILFN) and that the organs of balance (vestibular systems) respond at levels of sound significantly lower than the thresholds of audibility.[24]

Dr. Nina Pierpont has conducted a peer reviewed study of the effects of infra and low frequency sound on the organs of balance that establishes the causal link between wind turbine ILFN and medical pathologies. The new research is not from the traditional fields that have provided guidance for acoustical engineers and others when assessing compatibility of new noise sources and existing communities. A recent peer reviewed paper by Dr. Alec Salt, reported that the cochlea responds to infrasound at levels 40 dB below the threshold of audibility.[25][26] These studies show how the body responds to extremely low levels of energy not as an auditory response, but instead as a vestibular response.

In a personal communication, this reviewer asked Dr. Salt the question: "Does infrasound from wind turbines affect the inner ear?" Dr. Salt responded:

> "There is controversy whether prolonged exposure to the sounds generated by wind turbines adversely affects human health. The un-weighted spectrum of wind turbine noise slowly rises with decreasing frequency, with

[23] Van den Berg 2006, p. 96

[24] Alves-Pereira, Marianna and Nuno A. A. Branco (2007a). *Vibroacoustic disease: Biological effects of infrasound and low frequency noise explained by mechanotransduction cellular signalling*, 93 PROGRESS IN BIOPHYSICS AND MOLECULAR BIOLOGY 256–279, available at http://www.ncbi.nlm.nih.gov/ pubmed/17014895>< and,
Alves-Pereira, Marianna and Nuno A. A. Branco (2007b). *Public health and noise exposure: the importance of low frequency noise*, Institute of Acoustics, Proceedings of INTER-NOISE 2007,

25 Salt, Alec, "Responses of the ear to low frequency sounds, infrasound and wind turbines", Hearing Research, 2010. This work was supported by research grant RO1 DC01368 from NIDCD/NIH

26 Salt, A. N., Lichtenhan, "Responses of the Inner Ear to Infrasound," Fourth International Meeting on Wind Turbine Noise, Rome, Italy April 12-14, 2011

greatest output in the 1-2 Hz range. As human hearing is insensitive to infrasound (needing over 120 dB SPL to detect 2 Hz) it is claimed that infrasound generated by wind turbines is below threshold and therefore cannot affect people. The inner hair cells (IHC) of the cochlea, through which hearing is mediated, are velocity-sensitive and insensitive to low frequency sounds. The outer hair cells (OHC), in contrast, are displacement-sensitive and respond to infrasonic frequencies at levels up to 40 dB below those that are heard."

"A review found the G-weighted noise levels generated by wind turbines with upwind rotors to be approximately 70 dBG. This is substantially below the threshold for hearing infrasound which is 95 dB G but is above the calculated level for OHC stimulation of 60 dB G. This suggests that most wind turbines will be producing an unheard stimulation of OHC. Whether this is conveyed to the brain by type II afferent fibers or influences other aspects of sound perception is not known. Listeners find the so-called amplitude modulation of higher frequency sounds (described as blade "swish" or "thump") highly annoying. This could represent either a modulation of audible sounds (as detected by a sound level meter) or a biological modulation caused by variation of OHC gain as operating point is biased by the infrasound. Cochlear responses to infrasound also depend on audible input, with audible tones suppressing cochlear microphonic responses to infrasound in animals. These findings demonstrate that the response of the inner ear to infrasound is complex and needs to be understood in more detail before it can be concluded that the ear cannot be affected by wind turbine noise."

During the summer of 2009, this reviewer conducted a study of homes in Ontario where people had reported adverse health effects that they associated with the operation of wind turbines in their communities[27]. The study involved collecting sound level data at the homes and properties of these people, many of who had abandoned their homes due to their problems. This study found that sound levels in the 1/3 octave bands below 20 Hz were often above 60 dB and in many cases above 70 dB. Since the shape of the spectrum for wind turbine sound emissions is greatest at the blade passage frequency which was below the threshold for the instruments used it can be assumed that the sound pressure levels in the range of 0 to 10 Hz exceeded 70 dBA. Given the statement by Dr. Salt that vestibular responses would start at levels of 60 dBG or higher this data supports the supposition that there is a link between the dynamically modulated infra sound and reported adverse health effects. These examples demonstrate that there is evidence to suspect a link between the presence of modulated wind turbine infra and low frequency noise (ILFN) and the reported adverse health effects.

Problems related to inaudible low frequency and infra sound have been encountered before. Acoustical engineers in the Heating, Cooling and Air Conditioning (ASHRAE) field have suspected since the 1980's and confirmed in the late 1990's that dynamically modulated, but inaudible, low frequency sound from poor HVAC designs or installations can cause a host of symptoms in workers in large open offices[28]. The ASHRAE handbook devotes considerable attention to the design of systems to avoid these problems and has developed methods to rate building interiors (RC Mark II) to assess them for these low frequency problems[29]. The report on Ontario by this reviewer includes an Appendix that provides more detail on this aspect of how inaudible infra and low frequency sound can cause adverse health effects.

When infra and low frequency sound is in the less-audible or inaudible range, it is often felt rather than heard. Unlike the A-weighted component, the low-frequency component of wind turbine noise "*can penetrate the home's walls and roof with very little low frequency noise reduction*.[30]" Further, as

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27 James, R. R., "Comments Related to EBR-010-6708 and -010-6516" Comment ID 123842, 2009

28 Persson Waye, Kirsten, Rylander, R., Benton, S., Leventhall, H. G., Effects of Performance and Work Quality Due to Low Frequency Ventilation Noise, Journal of Sound and Vibration, (1997) 2005(4), 467-474.

29 The study also showed that NC curves are not able to predict rumble. This use of NC curves was disproved in the 1997 Persson Waye, Leventhall study. Use of the RC Mark II procedures is more appropriate for this use.

30 Kamperman and James (2008), p. 3.

discussed in the 1990 NASA study the inside of homes receiving this energy can resonate and cause an increase of the low frequency energy over and above what was outside the home[31]. Acoustic modeling for low frequency sound emissions of ten 2.5 MW turbines indicated "*that the one mile low frequency results are only 6.3 dB below the 1,000 foot one turbine example.*[32]" This makes the infra and low frequency sound immissions from wind turbines a potential problem over an even larger area than the audible sounds, such as blade swish and other wind turbine noises in the mid to high frequency range.

The acoustical consultant that does not practice in that field may not be as aware of the problems of amplitude modulated, in-audible low frequency sound identified by the ASHRAE engineers. Many have not integrated these new understandings of how infra and low frequency sound can affect the vestibular organs into their work on community noise.

These are, of course, fairly new findings, and the result of new research. However, the findings are based on accepted scientific methods in a recognized sub-field of acoustics. Because of their recent vintage these findings may be not be considered as firmly established as the ANSI and equivalent standards and methods discussed above, but the Planning Board may nevertheless consider them as a basis for taking a precautionary approach to assessing the potential adverse impacts of this project. A precautionary approach is especially warranted in light of the failure to incorporate a suitable margin of error in the noise assessment and responses to comments presented in the FEIS.

The FEIS is not an objective review of the information on the record. It shows confirmatory bias towards statements made by Hessler and Associates and CRA. Both of these companies have been shown to not follow generally accepted practices in the US for outdoor measurements and have applied modeling methods using input data that are not able to represent the conditions that have been found to cause complaints. (e.g. nighttime noise from wind turbines.) Placing emphasis on the works and words of two consulting firms that have worked with wind turbine developers while ignoring the critiques and suggestions of independent reviewers such as the NYDEC and E-CS is confirmatory bias. The FEIS should not be accepted as an independent, unbiased statement of the record.

The predicted sound levels at homes near the boundary of the Allegany Wind Project are very close to exceeding the limits set by the Town Board (background levels plus 3 dB) and the Planning Committee (not to exceed 40 dBA at any residence). This reviewer's statements, both in this and earlier documents and the NYDEC's statements shine light on the various flaws or misrepresentations made by Hessler and CRA in their attempt to support the Hessler model and background study methods and findings as being "conservative." When scientific precision and appropriate input data is applied to the model's predicted values the model no longer shows compliance. The predicted sound levels of the Hessler model understate the risks of excessive sound on receiving properties by as much as 8 to 11 dBA. Adding this to the modeled results would make it "conservative." It would also result in the model showing that the project is not compatible with the surrounding land-use and local wind turbine noise regulations.

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31 Swinbanks, M. A., "The Audibility of Low Frequency Wind Turbine Noise," Fourth International Meeting on Wind Turbine Noise, Rome, Italy April 12-14, 2011

32 Id., p. 12

It is the opinion of this reviewer, based on his personal experience and the review described in this document that a properly conducted FEIS and would have concluded that the project did not meet the local requirements. It would have shown that many more homes in the vicinity of the wind turbines where the receiving properties will have sound levels that exceed 40 dBA. When adjusted for known tolerances of algorithms and measurements used to construct the model and the increased sound power emitted by wind turbines at night under conditions of high wind shear, a common situation during the warm season receiving properties at the boundaries of the project footprint will exceed the sound levels permitted by the local governing agencies.

End of Review

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For E-Coustic Solutions

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