E-Coustic Solutions LLC
NOISE CONTROL ● SOUND MEASUREMENT ● CONSULTATION
COMMUNITY ● INDUSTRIAL ● RESIDENTIAL ● OFFICE ● CLASSROOM ● HIPPA ORAL PRIVACY
P.O BOX 1129, OKEMOS, MI, 48805

RICHARD R. JAMES
PRINCIPAL
TEL: 517-507-5067
RICKJAMES@E-COUSTIC.COM

Comments on Recommended Amendments to Section 4.3.76 Shiawassee County Zoning Ordinance, Article 4, Specific Use Regulations

Prepared On Behalf of:

Regulated Wind of Shiawassee County (RWSC)

By: Richard James, E-Coustic Solutions LLC, Okemos, MI

Date: March 27, 2018

INTRODUCTION

This statement has been prepared at the request of Mr. Josh Nolan, attorney for Regulated Wind of Shiawassee County (RWSC). It:

- Provides comments on the August 2017 and March 2018 drafts of the regulations prepared by the Planning Director,
- Provides support for the suggested changes in Mr. Nolan's March 2018 redline comments on the March 20, 2018 revised draft of the proposed regulations,
- Provides a review of new research showing the impact of operating wind utilities on people in other communities, and
- Rebuts representations in the documents submitted by RSG and Hankard Environmental on behalf of DTE Energy and Trade Wind Energy regarding wind turbine noise characteristics, proper thresholds to prevent annoyance and adverse health impacts, and suggestions for measurement procedures, that are incomplete, misleading, or misrepresent the recommendations of the sources upon which their opinions are founded.

QUALIFICATIONS

This statement was prepared by Richard R. James, principle acoustician, E-CS LLC, with over 45 years of experience with community noise from manufacturing operations. A summary of qualifications is provided as the first attachment to this statement. Testimony was provided earlier in this process to the Shiawassee County Planning Commission in April of 2017. A written document dated April 26, 2017, was also provided to expand on my oral testimony titled: "Shiawassee County Planning Commission, Comments in Support of Proposal 2".

NEW INFORMATION RELATING SOUND LEVELS AND DISTANCE TO ANNOYANCE AND AUDIBILITY

Before I address the proposed sound level criteria in the two drafts of the Shiawassee regulations, and the comments and suggestions from Mr. Nolan and RWSC, the three wind energy companies,

and their consultants, I would like to briefly review new information regarding criteria, annoyance, audibility and appropriate distances between wind turbines and properties that may be used for residential purposes. Selecting a threshold for the Shiawassee County regulation may only repeat mistakes of the past unless we consider what has been learned about annoyance and audibility over the past several years as projects have been constructed and operated.

PRIMARY CHARACTERISTIC OF WIND TURBINE SOUND THAT REQUIRES LIMITS

Most complaints about wind turbine noise audibility and annoyance center on the fluctuating sounds produced during commonly occurring weather and operating conditions. This is seen in the top part of Figure 1 (see attached Figures) where the dBA level for the wind turbines is modulating as much as 8 dBA over a period of less than one minute. The rising and falling sound levels are associated with the "whooshing" and "thumping" sounds reported in complaints by people living in proximity to industrial wind turbines.

It should be noted that fluctuation in sound level is known to increase annoyance above what is expected for steady sounds. This characteristic often incurs a 5-dBA penalty in community regulations. If wind turbines did not have this characteristic, and instead produced a steady and non-tonal sound all the time, simple averaged sound level criteria might be useful as methods to limit complaints of annoyance and audibility. However, experience has shown that fluctuating sound is a primary characteristic of modern utility scale wind turbines, rendering "average" sound level limits inadequate.

In Figure 1 the modulation is in the range of 3-5 dBA about every 1.3 seconds (depends on hub rotation speed) and over the short period presented has a modulation depth of eight (8) dBA.

Looking at the graph at the bottom showing the sound pressure level at each 1/3rd octave band, we find that the lowest frequencies (the ones on the left side) are significantly higher than those in the middle (speech frequencies) or high frequencies (the ones on the far right). Starting at the left side, the first five (5) octave bands, from 6 Hz to 16 Hz, have the highest sound pressure levels and cover the range considered to be infra sound. Then, over the range of 20 Hz to 200 Hz the low frequency sound pressure levels continue to drop as frequency increases. This is the second characteristic of wind turbine sound that should be noted - it is dominated by infra and low frequency sound content that propagates further and can be heard inside homes even at considerable distances. Thresholds that only consider dBA weighted sound levels cannot control for the low frequencies, which is why criteria using dBC weighting is required to properly regulate wind turbine sound. In the section below on Annoyance we will see that new research has demonstrated the importance of limiting these fluctuations to protect against annoyance and sleep disturbance.

It is the fluctuating character of wind turbine noise that has led to calls for criteria based on the

maximum sound level (LAMax) as is being considered in the Shiawassee proposal. It is the infra and low frequency sound content that has led to suggestions by RWSC for criteria that consider that characteristic by setting a dBC weighted threshold.

RECENT DEVELOPMENTS IN SOUND CRITERIA

Regarding thresholds using averaged sound levels, 40 dBA Leq is a common limit in many countries. That limit has not prevented the installation and operation of wind turbines in those jurisdictions. Careful planning and, if necessary, agreements with adjacent land owners has allowed for operation of wind projects in all of these jurisdictions. For example, Canada, U.K., Australia, New Zealand, Denmark, Netherlands, Germany, and here in the US, states, counties and townships have set thresholds of 40 dBA Leq or less.

In 2012, Massachusetts formed an expert panel to determine the thresholds for wind turbines, which at that time were primarily 1.5 and 2.0 MW models. Table 4 from that study (See Figure 2 in the Figures Attachment) presents suggested limits of less than 40 dBA Leq for properties with residential development. In 2013, two well respected acousticians who have influenced many community noise regulations in the US over their careers, George Hessler, Sr., (Hessler and Associates) and Dr. Paul Schomer, (Emeritus Director of the Acoustical Society of America's Standards Committee) recommended that a wind turbine sound limit of 40 dBA Leq or less be set to protect against adverse health effects.[1] They used different methods to arrive at this threshold. However, both concluded that 40 dBA Leq was the highest limit that should be permitted to protect public health[2].

Limits that exceed 40 dBA Leq are found in some regions of the US, especially where the regulations were established prior to any experience with wind energy projects. But, not all regions accepted high thresholds and recently they are trending downward. For example, Oregon has had a limit of 35 dBA (L_{50}) since the early 2000s, while Vermont just recently reduced its limits to less than 40 dBA Leq. Other jurisdictions are also finding that limits allowing higher sound levels result in significant public complaints. Consider for example, the situation in Huron County, Michigan, where townships have passed regulations with lower limits than the county to prevent annoyance and other forms of complaints. Experience in that county shows that if Shiawassee County elects to

---

[1] Criteria for wind-turbine noise immissions, ICA 2013 Montreal, June 2013 published by the Acoustical Society of America

[2] "Hessler comes up with a single, 24-hour A-weighted average criterion of 40 dB, and Schomer comes up with a 24-hour, A-weighted average criterion of 39 dB."

set a threshold using 45 dBA Leq or higher, the County can expect that wind turbine noise complaints will lead to similar results. Does Shiawassee County plan to have similar debate and political unrest as has occurred in Huron County? That can be expected if it elects to promulgate wind project sound limits insufficient to limit complaints and that do not allow for easy enforcement.

As we will see in the review that follows of recent research regarding annoyance, limits specified as Leq (averaged) sound levels, even those where the limit is 40 dBA Leq, have not resulted in acceptable levels of wind turbine sound at residential properties. This is because criteria in dBA Leq do not control the most troublesome characteristics of wind turbine noise. Permitting higher thresholds than 40 dBA Leq will produce higher levels of complaints. Higher limits reduce the setback distance between wind turbines and homes putting people's property and homes closer to the machines making the sound received higher.

RECENT STUDIES OF ANNOYANCE AND AUDIBILITY

Much of the literature on wind turbine noise and its impact on people centered on European research that focused on earlier models of wind turbines installed in the late 1990s and early 2000s. The wind turbines being installed today are much larger in size, especially blade length and height than those of the early studies. In the past two years, new studies have been conducted that look at the impact of wind turbines as large as 3-5 MW and also the smaller ones with capacities of 1.5 MW and above.

Before presenting the results of those test we need to understand the meaning of phrases like "Very" or "High" Annoyance. Annoyance, in the way it is used in acoustical and social research is different from the "annoyance" we associate with common daily irritations. This is a phrase used in the studies to represent a level of aggravation that is sufficient to be considered an adverse health effect. It is a higher threshold than mild annoyance. Mild annoyance does not often result in complaints to public officials or cause adverse impacts on a person's health.

The percent of the study population with High Annoyance is abbreviated as %HA. Since 2016 several new studies based on interviews with people living near wind turbines have been published. Two of the studies presented here correlate the %HA to the sound level at the receiving property predicted using computer models. That makes them particularly useful for thresholds in Shiawassee County intended to establish design goals. The developer's will use similar computer models in their applications for permits.

The graphics to support the following are included as Figures 3 to 5 of the attached Figures. In Figures 3 and 4 High Annoyance is represented as the percent of the population (%HA). In Figure 5 the phrase "Very Annoyed" is used to represent the most annoyed class of respondents.

The first study was conducted by Health Canada of people living in and around wind projects in

Ontario where the limit is 40 dBA Leq. Health Canada plays an equivalent role in Canada to the Centers for Disease Control in the US. Figure 3 of the Figures Attachment shows a graph of the study's findings regarding High Annoyance (vertical axis) versus the sound level predicted by the computer models (horizontal axis). The red annotation was added for this document. The vertical red line at the 40 dBA Leq level shows 10%HA. That is a large increase in the %HA from the 1-2%HA seen for Leq's of less than 40 dBA. However, relaxing the sound limits to permit 45 dBA Leq the annoyance increases from 10% to almost 14%. Higher levels would be expected to increase the %HA even more.

The second graph presents the findings of a study done by researchers in Finland using data for wind projects in Germany. Figure 4 of the Figures Attachment shows a graph similar to what we see from the Health Canada study. It also shows a sharp rise in %HA as predicted sound levels increase from under 40 dBA Leq. Extrapolating the trend line the red markup shows that at 40 dBA Leq the %HA is over 10%. For Leq's under 40 dBA the %HA is lower, approximately 2-3% at 35 dBA Leq.

The findings of a third study are presented in the two slides of Figure 5. This study was conducted by RSG, who also provided comments on behalf of DTE Energy. The graphics are two slides from a presentation on the study presented as a webinar in February 2018. The slides are not presented as graphs but instead report the findings of the study for various setbacks, from 3-5 miles (top) to under ½ mile (bottom). The most relevant class is the group who live within ½ mile of a wind turbine. This study's findings are similar to those of the two studies above but expressed in terms of distance instead of sound levels.

Table 1-Summary of New Research below merges the proposed criteria for wind turbine noise to sound levels showing that the noise has impacts from severe to modest depending on sound levels at the receiving property, which can be correlated to separation distance. The table organizes the findings reported in each of the three studies to permit visual inspection for trends.

Table 1-Summary of New Research

Leq (dBA)	Leq+10=Lmax (LAMax)	Approx. Setback[5] needed to meet dBA criteria (feet)	% Highly Annoyed (Health Canada [1])	% Highly Annoyed (Finland /Germany[2])	% Very Annoyed (US study by DTE's RSG[3])	% Hearing Audible WT Outside/Inside (US study by DTE's RSG[3])
35 Leq	**45 LAMax**	3700 ft. per RSG	1%HA	1-3%HA	At least 3% Very Annoyed 20% Mildly Annoyed (1/2-1 mile)	At least 40% Outside 20% Inside (1/2-1 mile)
40 Leq	**50 LAMax**	1850 ft.	10%HA	>10%HA	(less than ½ mile) 20% Very Annoyed 20% Mildly Annoyed	(less than ½ mile) 75% Outside 50% Inside home
45 Leq	**55 LAMax**	925 ft.	13.7%HA	20%%HA		
50 Leq	**60 LAMax**	460 ft	Limited data[4]	Limited data[4]		

1 Michaud D, et al, "Exposure to wind turbine noise: Perceptual responses and reported Health Effects,"

March 2016, JASA, A study conducted for Health Canada.

2 Hongisto V, Oliva D, Keranen J, "Indoor noise annoyance due to 3–5 megawatt wind turbines—An exposure–response relationship," Oct. 2017, JASA

3` Haac R, Kaliski K, Landis M, (RSG), Hoen B (Lawrence Berkeley National Laboratory), "Predicting Audibility of and Annoyance to Wind Power Project Sounds Using Modeled Sound," For Wind Energy Technologies Office of USDOE, February 27, 2018 Webinar

4 Regulatory thresholds of 40 dBA Leq or lower in countries studied so data for annoyance to higher sound levels is limited. Observed trends can be expected to continue.

5 Distances have been estimated based on this commentator's experience gained from reviewing numerous Noise Impact Studies conducted for other projects in the US, Canada and other countries. The assumption is: starting with RSG's statement that a 35 dBA Leq limit would require a setback of 3700 feet. The sound levels increase by about 5 dBA for each halving of the setback distance required to meet that criteria.

The first two columns show the Leq and LAMax sound levels that can be used for siting thresholds. There is a 10-dB difference between them established using RSG's comment in the DTE documents that a LAMax limit would be 10 dB higher than a Leq limit. In the same document, RSG notes that for the situation of a 35 dBA Leq limit would require a 3700-foot separation distance. This was used to establish the starting point in column 3 for the setback distances needed for each threshold in the two left hand columns. It is then assumed that for each 5 dBA increase in the threshold sound level, the separation distance will decrease by half.

Thus, for the 40 dBA Leq threshold (50 LAMax) the distance scales to 1,850 feet (less than ½ mile), for the 45 dBA Leq threshold (55 LAMax) the distance scales to 925 feet and then to 460 feet at 50 dBA Leq (60 LAMax). Based on this analysis, setting the threshold at 45 dBA Leq would permit a wind turbine to be as close as 925 feet to a non-participating property.

The right hand four columns present the findings of the three studies discussed above aligned to the criteria levels and distances in the three left columns. In each case, we find that when the permitted threshold exceeds 35 dBA Leq (45 LAMax) the percent highly annoyed (%HA) rises from 1-3% to over 10%. **Selecting criteria that allows exposing 10% or more of the population to noise that poses such high levels of annoyance and risks of adverse health effects is a failure to protect the health, safety and welfare of the population**. As seen in the two far right columns showing results of the RSG study, even at distances of over ½ mile 3% are very annoyed, 20% can hear the wind turbines inside their homes and 40% can hear them on their property. This shows that criteria above 35 dBA Leq (45 LAMax) that result in separation distances of less than ½ mile are inadequate to protect public health and welfare.

This observation is supported by a fourth study conducted in a Sleep Laboratory. Test subjects slept in a room where wind turbine sounds were reproduced, including fluctuating and low frequency characteristics. This study: "Physiological effects of wind turbine noise on sleep" by Smith, Ogren, Thorsson, Pedersen, and Persson-Waye, published in the Proceedings of the 22nd International Congress on Acoustics in September of 2016 concluded:

"Physiological measurements indicate that nights with low frequency band amplitude modulation and LAEq,8h =45 dB, slightly open window (LAEq,8h=33dB indoors) impacted sleep the most. The presence of beats and strong amplitude modulation contributed to sleep disturbance, reflected by more electrophysiological awakenings, increased light sleep and wakefulness, and reduced REM and deep sleep"

This confirms what the studies in Table 2 are showing. Leq, or averaged sound levels, are not related to the characteristic of wind turbine noise that causes the complaints. It shows why a threshold set as not to exceed limits is necessary and specified for both dBA and dBC weighting. First, to limit the fluctuations in the sounds received at non-participating properties, and second, to limit the low frequency content of the sound.

Only criteria using LAMax limits can address the fluctuations in wind turbine noise that result in complaints. Setting the thresholds using the LAMax threshold allows the wind utility developer to select wind turbine manufacturers and models that use designs and operating controls that limit fluctuations in sound. Thus, a wind turbine designed so that the maximum sound levels are not more than 5 dBA LAMax above the Leq would be permitted to produce 40 Leq versus 35 Leq for wind turbines that produce fluctuations that exceed the Leq by 10 or more dBA.

Further, a sound limit based on not to exceed sound levels has been tested in court. In Tuscola Wind III, LLC v. Almer Charter Township, Case No. 17-CV-10497, U.S. Dist. Ct. E.D. Michigan, the Court rejected the argument by the wind energy project developer that a "shall not exceed" sound limit of 45 dBA could be interpreted as anything other than an "LMax" sound limit. The Court further rejected the argument that such a sound limit constituted unlawful "exclusionary zoning." Instead, the Court noted that the wind developer was free to lease more ground from the residents, construct smaller turbines, or construct fewer turbines. This decision verifies the right of municipalities to enact "shall not exceed" or "LMax" sound limits for wind turbines as part of a zoning ordinance.

APPLYING WHAT THESE STUDIES SHOW TO THE SHIAWASSEE PROPOSED REGULATIONS

Table 2 summarizes the comments in the documents on Shiawassee's proposed regulations. The first column identifies the regulation topic and section. The next two show the 2017 and 2018 wording proposed by the County Planning Director, the most recent being in response to the comments made earlier on the 2017 draft. The next column presents RWSC's most recent suggestions (Nolan Proposal Redline) and refer to the wording RWSC has suggested for the final regulation for each of the sections. The last three columns present the redline suggestions by the three developers as noted. Only Trade Wind Energy made direct suggestions to change the wording of the 2017 draft.

Table 2- Summary of Various proposals for thresholds and requirements

Section of Regulation	Shiawassee 1st Draft Proposal 8/14/17	Shiawassee 2nd Draft Proposal 3/20/2018	Nolan Proposal Redline with March 2018 Revisions	DTE Energy Proposal per DTE Blue Line Comments	Trade Wind Energy Proposal Per redline comments	Maple Rapids Proposal Per redline comments
Modeling and Pre-operational noise study (4.A.1)	ANSI S12.9 Part 3, ANSI S12.100 Other applicable ANSI standards	No changes	Add ANSI S12.62 (2012) Attenuation of sound during propagation outdoors to S12.9 Part 3 and S12.100.	Not addressed in Blue Line	Suggests adding S1.13, and S12.18 to S12.9 Part 3.	Not addressed in redline
Conducted by (4.A.1.)	"…acoustician acceptable to the County..."	Inserted "…qualified and certified…" Deleted **"…**acoustician acceptable to the County…"	Use language in 8/14/17 draft. The County should have oversight of the selected acoustician	Not addressed in Blue Line	Certified acoustical consultant (INCE)	Not addressed in redline
Noise levels (4.A. 3)	"...shall not exceed forty-five (45) dB(A) LAMax at the closest non-participating property line…."	"...shall not exceed fifty (50) dB(A) LAMax at any Non-Participating Parcel Boundary…"	No change to 8/14/17 language	Not addressed in Blue Line (RSG 45 dBA Leq)	NTE 45 dBA (LAMax) at NP structure NTE 55 dBA (LAMax) at NP P/L 10 minute Leq	Not addressed in redline
NTE means not to exceed NP means Non-Participating						

Beginning with the first row which addresses which standards should be used for models and measurements, Nolan's 2018 redline suggests adding the standard for modeling, ANSI S12.62 (2012) Attenuation of sound during propagation outdoors to the current wording requiring use of S12.9 Part 3 and S12.100. These standards cover the same topics as the S1.13, and S12.18 standards suggested by Trade Wind Energy. They would be redundant and, where there are differences, create potential conflict.

The second row addresses the issue of qualifications for acousticians. The 2018 draft of the proposed regulations inserted "…qualified and certified…" and deleted "…acoustician acceptable to the County…" which had been in the 2017 draft. The wording in the first draft is preferred. Certification does not establish expertise in wind turbine and community noise. That is a very limited sub-field of acoustics. Certified acousticians do not necessarily have the experience needed to effectively and impartially do work on wind turbine noise. This is a specialized topic where experience and lack of bias should be the deciding factor. It is not about certification; it is about qualifications. Nolan's suggestions are to retain the wording of the 2017 draft.

The third row addresses the criteria that should be used to regulate wind energy projects. Given the discussion in the sections above on sound characteristics, thresholds, annoyance and audibility,

thresholds that allow wind turbines within ½ mile present serious risks to public health. As shown in that discussion, thresholds of 45 dBA Leq should not be considered acceptable. In this context, Nolan's suggestion to change the 2018 Shiawassee draft language of 50 LAMax to the 45 LAMax of the 2017 draft is founded on the most current information available, including a study conducted by DTE's acoustical firm, RSG. A threshold of 45 LAMax is both reasonably protective, and does not preclude development of wind energy projects as stated in the Almer Township Court's decision.

ADDITIONAL COMMENTS

There are several statements made in the documents supplied by the three developers and their acousticians that warrant rebuttal.

1. In the letter of Dec. 12, 2017 from Mr. Duncan of RSG to DTE he makes the assertion that a 45 LAMax limit would be among the most stringent community noise regulations in the US. First, a limit should be based on what is protective, not what has been done in the past. Our limits and thresholds for pollution change as we learn more about how it impacts people. Second, there are many communities just in Michigan that have limits of 45 LAMax or less, generally in townships where the County has allowed much higher thresholds. It is not important that other regions have higher limits if those limits are not protective.

2. In the same letter, RSG claims that a limit of 40 LAMax would preclude development in the county. That is also not true. A limit of 40 LAMax would require that the developers select the quietest models and ones with blade and operating system designs that limit fluctuating sound levels. They could also make arrangements with adjacent land owners for noise easements.

3. In the same letter RSG claims that Mr. Nolan's recommendation for a dBC limit is not typically used for community noise and that dBC is used only for testing of impulsive sounds and wind turbines do not fall into that category. Both of these statements are incorrect. First, WHO has advocated the use of dBC criteria in community noise since the mid 1990s. They have numerous cautionary statements about the need for dBC measurements when the noise being regulated contains significant low frequency noise. As seen in the section on wind turbine sound characteristics, wind turbine infra and low frequency sound is much higher in sound pressure level than the mid and high frequencies which are regulated with dBA measurements. (See Figure 1 of attached Figures and related discussion above.) Further, RSG's acousticians have attended numerous conferences where presentations have demonstrated that wind turbine noise is dominated by its infra sound energy, including the most recent meeting in Dec. 2017 where Mr. Steven Cooper demonstrated that people could sense these sounds under laboratory conditions at sound levels below the thresholds of

audibility. To claim that infra and low frequency sound is not a primary characteristic of wind turbine sound emissions is incorrect and misleading. Second, while dBC may be useful in assessing impulsive sounds (typically blasting noise), it has a major role in measuring and limiting low frequency noise. To say that it is used only for impulsive sounds is again misleading and incorrect.

4. There is a comment in DTE's redline, page 4 of 11, Comment ED11, that states: "*If an LMax metric is used a higher limit of 55 to 60 dBA is more appropriate per World Health Organization guidelines and other community noise guidelines*." The World Health Organization Guidelines from 2009 state that sound levels outside a home that exceed 40 LAMax at night result in awakenings. They do not set any limit for an acceptable number of such events per night. There is no current WHO Guideline that accepts levels of 55 to 60 dBA as acceptable. This statement is incorrect and misleading.

CONCLUSION

New evidence shows that wind turbine noise causes High Annoyance and other adverse impacts to 10% or more of the people living in projects with separation distances of less than ½ mile and sound levels of 40 dBA Leq or less. Sleep studies show that 45 dBA Leq is not protective against sleep disturbance due to the low frequency and fluctuating nature of the sounds that penetrates into homes even at large separation distances. Shiawassee County Planning Commissioners should consider this new evidence and set the regulatory thresholds and methods of measurement accordingly. They should not repeat the mistakes other jurisdictions have made in the past.

The recommendations of RWSC reflected in Mr. Nolan's most recent redline and the representation of them in this statement support a threshold of 45 LAMax and 55 LCMax. The arguments to the contrary are either based on outdated research or statements that are incomplete and misleading.

Selecting a threshold that allows exposing 10% or more of the population to noise that poses such high levels of annoyance and risks of adverse health effects is a failure to protect the health, safety and welfare of the population.

The County Planning Commission should take these recommendations as the foundation for a regulation that is protective and based on current research and guidelines.

Sincerely,
E-Coustic Solutions LLC

Richard R. James

Attachments: A. Qualifications
B. Figures

Mr. James is the Owner and Principal Consultant for E-Coustic Solutions, LLC, of Okemos, Michigan. He has been a practicing acoustical engineer for over 40 years. He started his career as an acoustical engineer working for the Chevrolet Division of General Motors Corporation in the early 1970s. His clients include many large manufacturing firms, such as, General Motors, Ford, Goodyear Tire & Rubber, and others who have manufacturing facilities where community noise and worker noise exposure occur. In addition, he has worked for many small companies and private individuals. He was actively involved with the Institute of Noise Control Engineers (INCE) since its formation in the early 1970's. He was a full Member from early in the 1990's through 2017.

His academic credentials include a degree in Mechanical Engineering (BME) from General Motors Institute, Flint Michigan (now Kettering Institute). He has been an adjunct Instructor to the Speech and Communication Science Department at Michigan State University from 1985 to 2013 and an adjunct Professor for the Department of Communication Disorders at Central Michigan University from 2012 through 2017. In addition, Mr. James served on the Applied Physics Advisory Board of Kettering Institute from 1997 to 2007.

Specific to wind turbine noise, he has worked for clients in over 60 different communities.

He has provided written and oral testimony in approximately 30 of those cases. He has also authored or co-authored four papers covering wind turbine noise topics including:

- Criteria for wind turbine projects necessary to protect public health (2008),
- Demonstrating that wind turbine sound immissions are predominantly comprised of infra and low frequency sound (2011), and
- A peer reviewed historical review of other types of low frequency noise sources with similar sound emission characteristics, such as large HVAC systems (fans) which caused noise induced Sick Building Syndrome and other noise sources that have known adverse health effects on people exposed to their sound. (2012).
- A peer reviewed literature review of research spanning 40 years showing wind turbines cause risks of adverse health effects from both audible and inaudible sound emissions (2016).

He has been qualified as an expert in acoustics for hearings and court proceedings in several countries. Examples of recent qualifications are:

Jurisdiction	Before	Qualified as:
Ontario, CA (January 2014)	Ministry of Environment (MOE) and Environmental Review Tribunal (ERT)	Qualified to provide evidence on matters related to acoustics and noise control engineering and wind turbines
Alberta, CA (Dec. 2013)	Alberta Utilities Commission (AUC)	An acoustical engineer and acoustician with expertise in the field of sound including noise, low frequency noise, sounds emitted from industrial wind turbines and human response to noise.
Michigan, US	Michigan Circuit Court	1. acoustician with expertise in measurement of wind turbine noise and its effects on people. (Dec. 2013) 2. acoustician qualified to opine that the plaintiff's symptoms were caused by the defendant's wind turbines. After special Daubert Hearing (Dec. 2013)

Figures

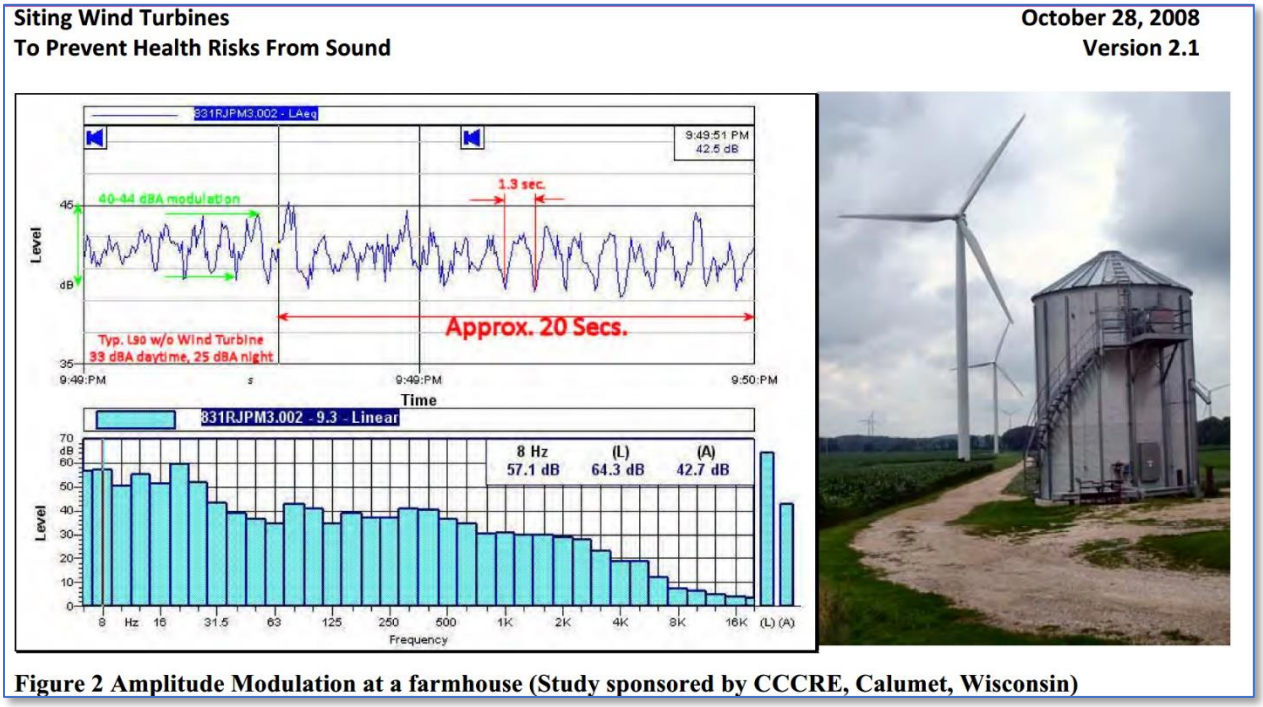


Figure 1-Example of Fluctuating Wind Turbine Sound-Modulation depth of 8 dBA over 30 seconds

Source: Kamperman/James: "The 'How To' Guide to Siting Wind Turbines to Prevent Health Risks from Sound (2008)

Table 4

Promising Practices for Nighttime Sound Pressure Levels by Land Use Type

Land Use	**Sound Pressure Level, dB(A) Nighttime Limits**
Industrial	70
Commercial	50
Villages, mixed usage	45
Sparsely populated areas, 8 m/s wind*	44
Sparsely populated areas, 6 m/s wind*	42
Residential areas, 8 m/s wind*	39
Residential areas, 6 m/s wind*	37

**measured at 10 m above ground, outside of residence or location of concern*

Figure 2-Mass. Expert Panel Report Recommends Criteria of 40 dBA Leq or lower for residential areas (2012)

Source: **Wind Turbine Health Impact Study: Report of Independent Expert Panel, January 2012, Prepared for: Massachusetts Department of Environmental Protection, Massachusetts Department of Public Health**

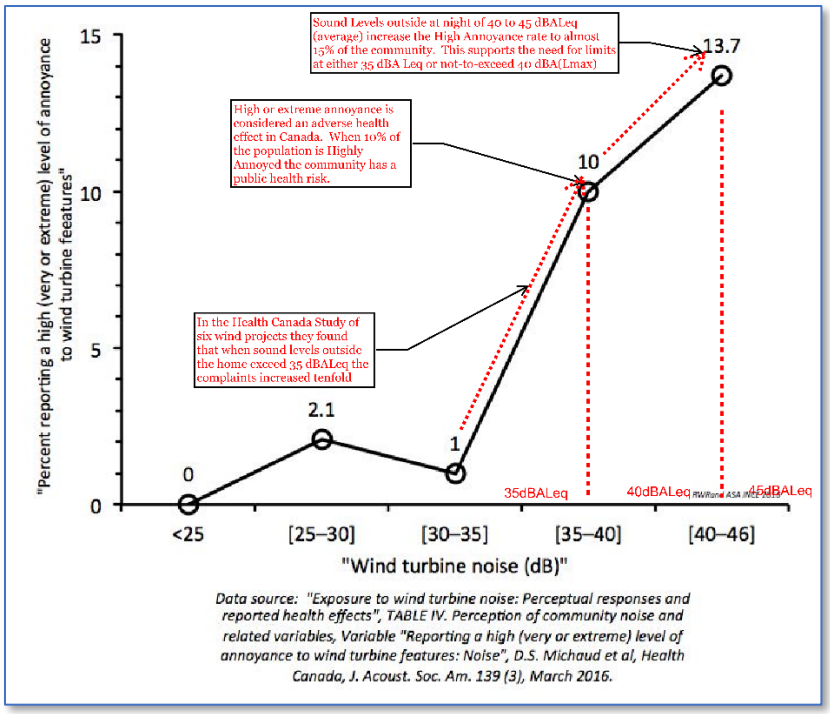


Figure 3 Health Canada Study of Wind Turbines and Annoyance

(Source: Michaud D, et al, "Exposure to wind turbine noise: Perceptual responses and reported Health Effects," March 2016, JASA, A study conducted for Health Canada

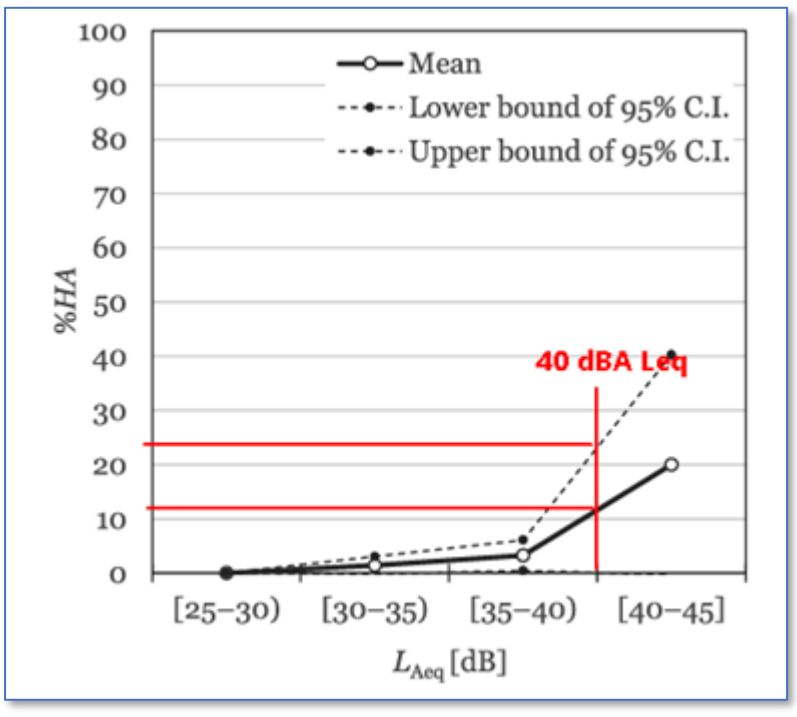
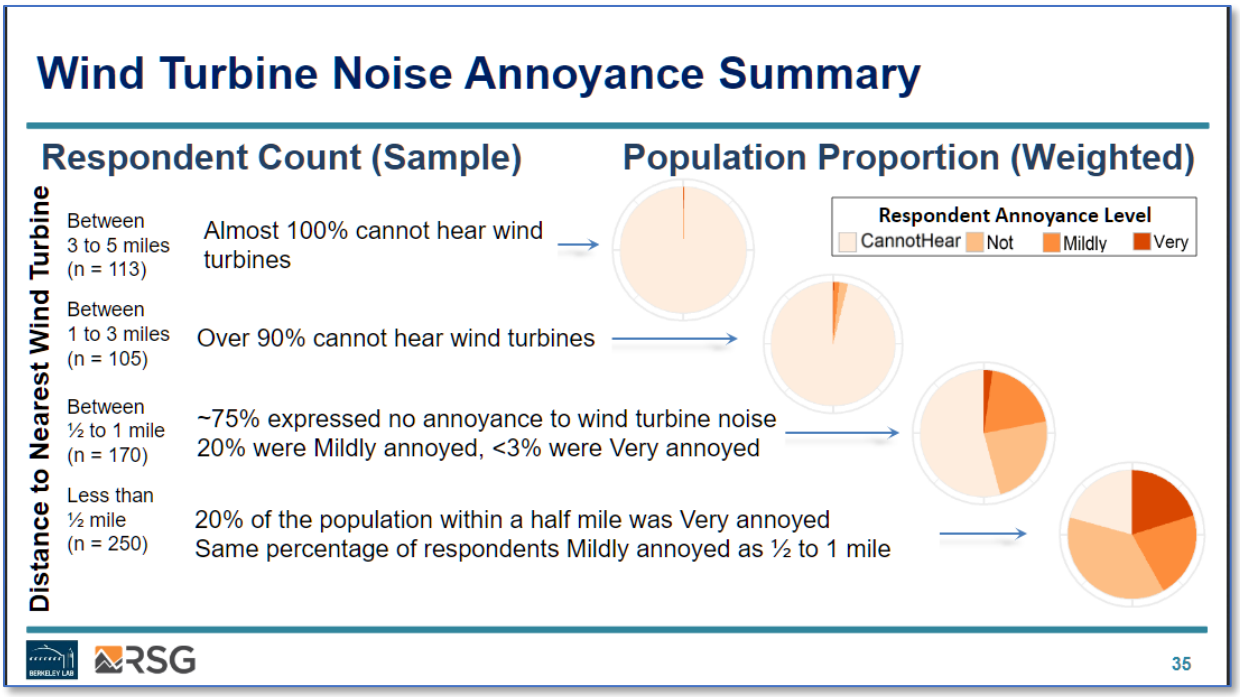


FIG. 1. The exposure–response relationship for indoor noise annoyance and the related confidence interval (N ¼ 398) in four sound level categories. Laeq corresponds to the predicted equivalent A-weighted sound level of wind turbine noise outdoors during maximum sound emission from the wind power area. %HA is the percentage of highly annoyed participants by wind turbine noise indoors according to definition 1 of Sec. II F. The expected uncertainty of Laeq is negligible based on the results of Table III

Figure 4 Annoyance Study of Wind Turbines in EU countries where limits are 40 dBA Leq or lower

Source: Hongisto V, Oliva D, Keranen J, "Indoor noise annoyance due to 3–5 megawatt wind turbines—An exposure–response relationship," Oct. 2017, JASA



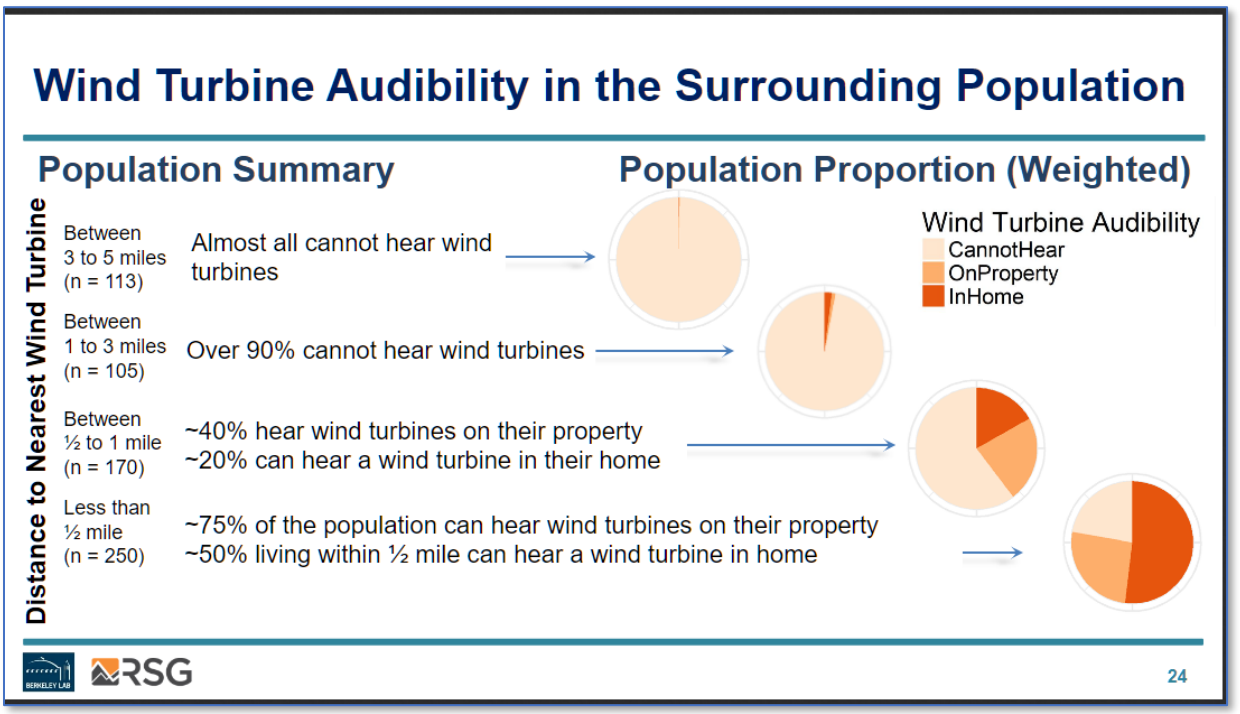


Figure 5 Slides reporting Audibility and Annoyance to Wind Turbine Sounds in the US

Source: Haac R, Kaliski K, Landis M, (RSG), Hoen B (Lawrence Berkeley National Laboratory), "Predicting Audibility of and Annoyance to Wind Power Project Sounds Using Modeled Sound," For Wind Energy Technologies Office of USDOE, February 27, 2018 Webinar