Epsilon
ASSOCIATES INC.

March 20, 2009 Ref. 2549-WTS-0901

Title: Response to "Wind Turbine Syndrome"

Prepared For: NextEra Energy Resources, LLC

PRINCIPALS

Theodore A Barten, PE

Margaret B Briggs

Michael E Guski, CCM

Samuel G Mygatt, LLB

Dale T Raczynski, PE

Cindy Schlessinger

Lester B Smith, Jr

Victoria H Fletcher, RLA

Robert D O'Neal, CCM

ASSOCIATES

Andrew D. Magee

Michael D Howard, PWS

Laura E Rome

3 Clock Tower Place, Suite 250

Maynard, MA 01754

www.epsilonassociates.com

978 897 7100

FAX 978 897 0099

Summary

A review of the draft book[1,2] and testimony[3] by Nina Pierpont, was conducted by Epsilon Associates Inc. (Epsilon). It is Epsilon's position that the Pierpont study does not reliably demonstrate a cause and effect relationship between low frequency sound and infrasound from wind turbines, and health effects to residents near wind farms.

Although numerous pages have been omitted from the publicly available draft copy, the focus of the book appears to be an examination of the symptoms of people living in the vicinity of various wind farms. There are no acoustical data collected or provided with respect to the participants in the study. The possible adverse effects from low frequency noise (LFN) cited by Pierpont from other reports occur at levels higher than those that will be experienced by residences due to wind turbines at the proposed Lee-DeKalb wind farm.

We are in agreement with Pierpont's recommendation contained on page 53 of the 3-5-09 draft: "…I would hope that the developers… would accept noise level criteria recommended by such agencies as the World Health Organization…" The World Health Organization recommends a nighttime external LAeq of 45 dBA and further analysis of low frequency noise. At distances greater than 1000 feet, our data and analysis indicate that there is no significant low frequency noise from the GE 1.5xle wind turbines. Given the nature of wind turbine noise and the findings in our study, there is no need to follow her other recommendations.

1 *Excerpts from Draft "Wind Turbine Syndrome: A Report on a Natural Experiment" by Nina Pierpont (10/17/08 draft) ["Book1"]*

2 *Excerpts from Draft "Wind Turbine Syndrome: A Report on a Natural Experiment" by Nina Pierpont (3-4-09 draft) ["Book 2"]*

3 *"Wind Turbine Syndrome: Noise, Shadow Flicker, and Health" by Nina Pierpont, August 1, 2006 Testimony before the New York State Legislature Energy Committee March 7, 2006. ["Testimony"]*

Claims, Additional Information, and Conclusions

1 - Claim:
Pierpont challenges that annoyance to noise is affected by respondents' attitudes to the source. Pierpont states, "At least one developer has put forward the hypothesis that a negative attitude or worry towards turbines is what leads people to be disturbed by turbine noise.[10]"[p14, Book1]

Footnote 10 [Book1] in part: "...It's also worth noting that studies have shown [no references provided in source document] that a person's attitude toward a sound – meaning whether it's not 'wanted' or 'unwanted' sound – depends a great deal on what they think and how they feel about the source of the sound. In other words, if someone has a negative attitude to wind turbines, or is worried about them, this will affect how they feel about the sound. However, if someone has a positive attitude toward wind energy, it's very unlikely that the sounds will bother them at all."

1 – Additional Information:
The quote in the footnote clearly does not state "attitude is what leads people to be disturbed by noise"; instead it says that attitude will affect how they feel. Pierpont complains that no references are provided. This is well known among noise control engineers, and the US EPA Levels document in 1972 describes it in page D1:

"Environmental noise may interfere with a broad range of human activities in a way which degrades public health and welfare, such activities include:

- Speech Communication in Conversation and Teaching.
- Telephone Communication.
- Listening to TV and Radio Broadcasts.
- 4, Listening to Music,
- Concentration During Mental Activities.
- Relaxation,
- Sleep,

Interference with listening situations (items I-4) can be directly quantified in terms of the absolute level of the environmental noise and its characteristics. The amount of interference in non-listening situations (e.g.,) is often dependent upon factors other than the physical characteristics of the noise. These may include attitude towards the source of an identifiable noise, familiarity with the noise, characteristics of the exposed individual, and the intrusiveness of the noise."

Later on page D-17 in the US EPA levels document and in Table D-7, there is about a 5 dB adjustment for expected reaction based on attitude towards the noise source.

Pedersen (EuroNoise 2008) found several non-acoustic factors that significantly affected the amount of annoyance toward wind turbine noise. The largest single factor was whether the respondent received an economic benefit; respondents who benefited economically from the wind turbines were less annoyed by wind turbine sound than other respondents, despite higher exposure levels. Other significant non-acoustic factors significantly affecting annoyance with wind turbine noise include: visibility (with an odds ratio [OR] of 12.5), attitude towards wind turbines in general (OR of 3.2) and visual attitude (OR of 4.1). Surprisingly background or ambient sound had no influence on annoyance due to wind turbine sound (OR of 1.0). "Respondents who could see at least one wind turbine from their dwelling were more likely to be annoyed by noise than those who could not see any turbines." "A negative attitude towards wind turbines was associated with noise annoyance." Although no cause and effect was studied, Pedersen says "meta-analyses of other response to community noise have revealed that the direction is dual", and "there is no reason to believe that it is otherwise in the case of wind turbines."

It is clearly demonstrated in recent papers by Pedersen that the non-acoustic effects (Economic benefit, shadow flicker) are as significant as the acoustic levels in determining annoyance to wind turbine noise.

1 - Conclusions:
Attitude towards a noise source affects a person's reaction to the noise especially with respect to concentration, relaxation, and sleep. Attitude and non-acoustic factors play a significant role in the level of annoyance towards wind turbine noise.

2 – Claim:
Pierpont describes effects of LFN at levels higher than threshold and above wind turbine noise. [Book 1, pgs 45-46]

Pierpont describes studies from the NASA low frequency test facility in which subjects had adverse effects from exposure to low frequency noise:

"At a NASA test facility in the 1960's, healthy young men were exposed to low frequency noise in the 1-50 Hz frequency range at 110 to 150 dB for 2-3 minutes (high amplitude and short duration). Over the full 1-50 Hz frequency range they experienced fatigue and took longer to perform assigned tasks. At frequencies less than 25 Hz there was an "annoying tickling" in the ear. In the same frequency range there were modulations of speech, moderate vibrations of the chest, and fullness in the hypopharynx with an annoying gag sensation. "In regard to the opinions of those tested, it was indicated that the sensations involved were impressive.[149]"

2 – Additional Information

The NASA report (TND-3204)[4] [149] states, "At frequencies below 25 cps, there was a touch pressure sensation within the ear. This sensation has been described as an annoying tickling within the ear and has been compared with the effect one experiences undergoing altitude changes associated with motoring in the mountains."

Levels of exposure at Langley were 110 – 150 dB 1/3 octave band random noise; these lower levels are 35 – 50 dB greater than wind turbine farms measured in the 1 Hz to 25 Hz range at 1000 feet, and the upper levels are 75 – 90 dB greater. Figure 1 demonstrates this clearly with a comparison of wind turbine one third octave band noise in the 1 – 50 Hz compared to the NASA data (shaded "PRESENT") in the same frequency range. Thus the feeling of pressure and tickling were present at levels greater than hearing threshold [Moeller and Pederson (N&H 2004)] and even significantly greater than those from wind turbines.

The pressure and tickling sensation described by Edge and mentioned by Pierpont only occur at levels significantly above hearing threshold for low frequency sounds. This is described by Moeller and Pedersen p39, "There is no doubt that the ear is the organ that is the most sensitive to sound at these [low] frequencies. This is seen from the fact that hearing thresholds are the same, whether the body or only the ears are exposed. It is more difficult to determine whether the sensory pathway belongs to the auditory system or not. Bekesy (1936) noted that it is difficult to distinguish whether the sensation is of a pressure or tactile nature, or of an auditory nature. He concluded that it is an auditory sensation. However, he also observed that at higher sound pressure levels the auditory sensation is accompanied by a "true" sensation of

---

[4] *Edge PM, Mayes WH. 1966. Description of Langley low-frequency noise facility and study of human response to noise frequencies below 50 cps. NASA Technical Note, NASA TN D-3204. 11 pp.*

touch at each of the ears. If the level of the sound is increased even further, a sense of tickling or prickling is observed. That the sensation at low levels is further supported by the fact that perception thresholds for deaf people are much higher than for people with normal hearing."

2 - Conclusions:
NASA study levels and findings are at levels 35 – 90 dB greater than wind turbine sound levels and above thresholds of audibility. The NASA sound levels are so much higher than wind turbine sound levels as to be an irrelevant comparison.

3 – Claim:
Low sound levels of low frequency noise cause vehement complaints. "They found that noises which in many cases induced vehement complaints were to a large extent of rather low sound levels." [Book 1, p 46, in the section on low frequency sound]

3 - Additional Information:
The authors of the referenced paper were referring to "low levels" of A-weighted sound, and not to low levels of low frequency sound. There is insufficient data in the cited paper to determine levels of low frequency sound; however information is supplied to imply that it is in the 31 Hz octave band. ANSI S12.9 Part 4 and ANSI S12.2 have criteria for infrasound and low frequency noise in the 16 Hz, 31 Hz, and 63 Hz octave bands to prevent more than minimal annoyance, rattles, and perceptible vibrations.

3 - Conclusion:
Low levels of low frequency sound are not causing "vehement complaints".

4 – Claim:
Pierpont's draft book quotes van den Berg, "Wind turbines produce noise in the low and infrasonic frequency ranges." [Book p 47] [Reference: van den Berg 2004]

4 – Additional Information:
Pierpont cites levels measured by van den Berg at 100 m (on ground) from a wind turbine and near home at 750 m. Near home measurements may have been affected by wind noise and are significantly higher than measured by Epsilon (at 1000 feet under low wind conditions). (Epsilon measurements at 1 Hz at 1000 feet are approximately 75 – 78 dB under maximum noise and van den Berg measured an Leq of 94 dB at 1 Hz.) Pierpont fails to state van den

Berg conclusions: 1). "Infrasound harmonics from the blade passing frequency of modern, tall WT [wind turbine] must be considered inaudible." 2) "Low frequency in-flow turbulence sound may be audible, but wind turbine sound is loudest at medium to high frequencies." Pierpont incorrectly asserts that the swishing described by van den Berg is the cause of feeling of pulsations some of her subjects felt in their chests. Van den Berg in JSV 2004 does describe how there are pulses from wind farms caused by synchronization of three turbines at 1/sec when turbines rotating at 20 rpm (3 blades = 1 Hz blade passage frequency. Pierpont's study participant lives in line with the turbines, whereas the residences, van den Berg describes are perpendicular to the line of turbines. If the turbines are in-line, the level from each turbine would be less and the effect would be less. Van den Berg states this will not occur when near a single turbine.

Pierpont incorrectly describes pulsation as "low frequency pressure fluctuations" when in fact they are fluctuations of higher frequency sounds at a low frequency rate. She claims these pulsations may "synchronize with the feeling of pulsation some subject felt in their chest. The wind turbine pulsations, if they exist at a particular residence, are not high enough to create feelings in subject's chests according to criteria in Moeller and Pedersen.

4 - Conclusion:
Pierpont makes a conclusion not supported by any data in van den Berg. Claims of feeling in the chest for levels lower than threshold are contrary to scientific studies on effects of low frequency noise and the levels required to have those feelings.

5 – Claim:
Pierpont believes that noise models are inadequate in predicting sound levels from wind turbines.

5 – Additional Information:
Van den Berg said at 400 m, the measured immission levels match perfectly sound levels calculated based on measured emission levels (based on turbine rotation rate). Van den Berg claims prediction model underestimates level by 3 dB at night at distances 1 – 2 km – limitations due to models inability to handle actual nighttime stable atmosphere. If models based on actual wind speeds at a height of 10 meters, they may significantly underestimate Lp values during stable night-time conditions; in Dutch that is about 33% of the nights. The DeKalb noise assessment by TetraTech is based on maximum

output (included +2 dB “K” factor); therefore, there is no underestimate of sound levels.

Pierpont states that inadequacy of model is due in part to low frequency components attenuating less with distance; however this is included in ISO 9613-2 propagation models. (Cadna A and WindPro). Pierpont attributes the description of inadequacies “brisk, laminar airflow” to van den Berg; however, there is no mention of this in van den Berg’s paper.

5 - Conclusion:
Properly applying models (Cadna/A and WindPRO) which follow ISO 9613-2, lead to accurate modeling results which do not underestimate wind turbine noise. Low frequency propagation is handled by the models.

6 – Claim:
“The Academy of Medicine of France has recommended a 1.5 km (0.96 mile) setback because of noise and health issues [30].” [Testimony, p 9].

6 – Additional Information:
The French National Academy of Medicine recommended “as a precaution construction should be suspended for wind turbines with a capacity exceeding 2.5 MW located within 1500 m of homes.”[5] [French Academy of Medicine (2006)]. However, this recommended setback is not because of definitive health issues but a precaution because of the following reasons:

- Sound levels one km from some wind turbine installations “occasionally exceed allowable limits” for France (even though the allowable limits are long term averages)
- Current French prediction tools for noise assessment do not take into account sound levels created with wind speeds greater than 5 m/s, thus not being able to predict and assess maximum noise conditions.
- Wind turbine noise has been compared to aircraft noise [even though the sound pressure levels of wind turbine noise are significantly lower], and exposure to high level aircraft noise “involves neurobiological reactions associated with an increased frequency of hypertension and cardiovascular illness. Unfortunately, no such study has been done near wind turbines.”[6]

---

[5] *French National Academy of Medicine, "Le retentissement du fonctionnement des éoliennes sur la santé de l'homme" (“Repercussions of wind turbine operations on human health"), March 2006, available at http://ventdubocage.net/documentsoriginaux/sante/eoliennes.pdf*

[6] *Gueniot, Chantal, ”Wind Turbines: The Academy Cautious”, Panorama du Médecin , March 2006*

6 - Conclusion:
The French restriction on distance is not necessary since our prediction tools use maximum turbine noise and since aircraft noise is significantly greater than wind turbine noise.

7 - Claim:
"Sensitivity to low frequency noise is a potential risk factor. Some people sense low-frequency noise as pressure in the ears rather than heard as sound, or experience a feeling or vibration in the chest or throat [19]." [Testimony. p 4]

7 - Additional information:
From H. Moeller and C. S. Pedersen[7] (2004) – [Pierpont reference 19]: "Despite the general understanding that infrasound is inaudible, humans can perceive sound also below 20 Hz. This applies to all humans with a normal hearing organ, and not just to a few persons. The perceived character of the sound changes gradually with frequency. For pure tones the tonal character and the sensation of pitch decrease with decreasing frequency, and they both cease around 20 Hz. Below this frequency tones are perceived as discontinuous. From around 10 Hz and lower it is possible to follow and count single cycles of the tone, and the perception changes into a sensation of pressure at the ears. *At levels 20 – 25 above the threshold it is possible to feel vibrations in various parts of the body*, e.g., the lumbar, buttock, thigh and calf regions. *A feeling of pressure may occur in the upper part of the chest and the throat region*." [emphasis added]

7 - Conclusion:
Only at levels significantly above threshold can low frequency sound or infrasound be felt as vibrations or feel a pressure in the chest or throat region. Wind turbine sound levels are well below the thresholds required to "feel" LFN at a distance of 1000 feet or more.

8 - Claim.
"A difference of 10 dB between A and C weighting represents a significant amount of low-frequency noise by World Health Organization standards [24]." [P6 testimony]

8 – Additional information:

[7] *Moller, H, and CS Pedersen. 2004. "Hearing at low and infrasonic frequencies." Noise & Health 6 (23):37-57.*

[24] WHO[8], p 61. "4.3. Specific Environments.... When prominent low-frequency components are present, measures based on A-weighting are inappropriate." No specific low frequency noise criteria are proposed by the WHO. The Guidelines for Community Noise report (WHO, 1999) mentions that if the difference between dBC and dBA is greater than 10 decibels, then a frequency analysis should be performed to determine if there is a low frequency issue.

8 - Conclusion:
WHO does not state that a difference of 10 dB between C weighted and A weighted sound pressure levels represents a significant amount of low-frequency noise; instead WHO recommends a detailed frequency analysis if the difference is greater than 10 dB.

9 - Claim- Pierpont recommendation:
Pierpont's recommends on page 53 of the 3-5-09 draft: "...I would hope that the developers... would accept noise level criteria recommended by such agencies as the World Health Organization..." Pierpont also recommends meeting other criteria such as the ISO criteria and setbacks, regardless of noise level.

9 - Additional information:
The World Health Organization recommends a nighttime external LAeq of 45 dBA and further analysis of low frequency noise if the difference between dBC and dBA sound levels is greater than 10 decibels. At distances greater than 1000 feet, our data and analysis indicate that there is not significant low frequency noise from the GE 1.5xle wind turbines – it meets ANSI low frequency criteria for bedrooms during nighttime hours and other ANSI low frequency criteria.

Pierpont also recommends meeting out of date ISO 1996-1971 criteria; however, the ISO criteria referenced in the Kamperman and James report is no longer valid and was misquoted in the Kamperman and James report. Rigid setback distances as proposed by Pierpont are not necessary to meet the WHO guideline or to meet existing low frequency criteria. Although, "Kamperman and James have convinced me [Pierpont] that a single one-size-fits-all setback distance may not be both protective and fair in all environments with all types of turbines." she still proposes one.

[8] *WHO, 1999. Guidelines for Community Noise*

10 - Conclusion:
We are in agreement with the first part of Pierpont's recommendation contained on page 53 of the 3-5-09 draft: "…I would hope that the developers… would accept noise level criteria recommended by such agencies as the World Health Organization…"

The World Health Organization recommends a nighttime external LAeq of 45 dBA and further analysis of low frequency noise. At distances greater than 1000 feet, our data and analysis indicate that there is not significant low frequency noise from the GE 1.5xle wind turbines. We recommend that the low frequency sound from wind turbines meet the ANSI criteria for low frequency sound.

Overall Conclusion:

We believe that the Pierpont study does not reliably demonstrate a cause and effect relationship between low frequency sound and infrasound from wind turbines and health effects to residents near wind farms. Based on a comprehensive review of publications and our evaluation of infrasound and low frequency sound from wind turbines with respect to existing criteria, there are no health effects, disturbance, or moderately perceptible vibrations expected due to infrasound or low frequency sound from GE 1.5sle or GE 1.5xle wind farms at 1000 feet.

EPSILON ASSOCIATES, INC.

Robert D. Hellweg, Jr.,
P.E., INCE Board Certified
Senior Consultant

Richard Lampeter
INCE
Senior Scientist

Attachment: Figure 1

Figure 1
Comparison of sound levels from NASA TN D-3204, in which subjects experienced non-auditory response in high amplitude test chamber ["PRESENT"], to GE 1.5sle wind turbine noise at 1000 feet at maximum noise conditions.
(Note: scales are the same for both data. Top portion of Figure 1 is from NASA TN D-320-4.)