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Comment on "Health Impacts and Exposure to Wind Turbine Noise: Research Design and Noise Exposure Assessment"

The incorporated Association to Protect Amherst Island has, as its present priority, the goal of stopping a proposed wind development on Amherst Island. The reason is the very high density of turbines and the close proximity (less than 1 km) of turbines to over half the homes on the island. Nevertheless, we believe that we can present a fair presentation on the adverse health effects of wind turbines.

First, we welcome a Health Canada impact assessment of living in proximity to wind turbines. We will comment in a separate report on the proposed cross-sectional field study. Here we would like to express concern regarding the apparent bias against there being adverse health effects shown by the authors, Michaud et al., in the assessment document. To assure confidence in the outcome, the Minister of Health needs to have the assessment chaired by a scientist with a more obvious open mind. Examples of bias follow:

Impact on Sleep

On page 3, Michaud et al. write: *"There are studies which report that this sound may be exceeded at some residences, suggesting the potential for WTN to disturb sleep among sensitive individuals (Pedersen and Waye, 2004; Pedersen et al., 2009; Krogh, 2011; Harry, 2007; Shepherd, 2011; Pierpont, 2009)[1]. Some studies have been criticized for having poor methodology and some did not find impacts on sleep (Pedersen and Waye, 2007; Knopper and Ollson, 2011)."*

Pedersen and Waye could not have criticized these studies published 2 to 4 years after their 2007 publication. Knopper and Ollson make no reference to Krogh et al. (2011), Harry (2007) or Shepherd (2011). Nowhere in Knopper and Ollson is there mention of studies that find no impacts on sleep. To the contrary, in their conclusion they write:
"In the peer-reviewed studies, wind turbine annoyance and some reported health effects (e.g., sleep disturbance) have been statistically associated with wind turbine noise especially when found at sound pressure levels greater than 40 dBA, but found to be more strongly related to subjective factors like visual impact, attitude to wind turbines in general and sensitivity to noise."[2]

[1] Note: A more recent reference is Frey and Hadden (2012).
[2] The topic of subjective factors is dealt with below.

Earlier in the paper, Knopper and Ollson write:
"Sleep interruption, however, was associated with sound level and annoyance (OR and 95%CI > 1)." There follows some hypothesising concerning cognitive stress theory.

Michaud et al. do not make reference to the peer-reviewed editorial in the 8th of March 2012 edition of the prestigious British Medical Journal. In this editorial the authors, Hanning and Evans (2012), write:
"Shortly after wind turbines began to be erected close to housing, complaints emerged of adverse effects on health. Sleep disturbance was the main complaint (Krogh et al., 2011). Such reports have been dismissed as being subjective and anecdotal, but experts contend that the quantity, consistency, and ubiquity of the complaints constitute epidemiological evidence of a strong link between wind turbine noise, ill-health, and disruption of sleep."
Later, they write:
"A laboratory study has shown that low frequency noise is considerably more annoying than higher frequency noise and is harmful to health – it can cause nausea, headaches, disturbed sleep, and cognitive and psychological impairment (Møller and C. Pedersen, 2011). A cochlear mechanism has been proposed that outlines how infrasound, previously disregarded because it is below the auditory threshold, could affect humans and contribute to adverse health effects (Salt and Kaltenbach, 2011)."

Field Studies
Michaud et al. write, on page 3:
To date there have been no field studies that have included objective health measures in their study design (that) could lend support to some of the self-reported claims derived from questionnaires."
While strictly true in the sense that medical diagnostic tools have not been used, it is wrong to dismiss the large-scale field work undertaken by Eva Pedersen and her colleagues. The World Health Organization includes annoyance as an adverse health effect and that is what these field studies investigated.

Pedersen et al. (2009) presented the results of a 2007 field study in the Netherlands and related it to an earlier Swedish study. From a list of almost 18,000 addresses of residents living in proximity to turbines almost 2000 were selected for the field study. The response rate was 37%. All turbines were 500 kW or larger; however, this cut-off is small in comparison to the 2.3 MW and larger turbines that are now being installed. The surveys were constructed to hide the purpose of the field study[3]. The respondents were grouped according to the predicted turbine noise level at their home: <30, 30-35, 35-40, 40-45 and >45

[3] The title of the survey (translated into English) was *"Study of the Perception of the Living Environment".* The purpose of the survey was:
"To provide knowledge of the perception of wind turbines by people living close to wind farms; To evaluate human responses to audio and visual exposures from wind turbines and to give insight in(to) possibilities to mitigate the local impact of wind farms."

dBA for a wind speed at 10 m of 8 m/s. For reference, the Ontario noise limit at 8 m/s is 45 dBA[4]. Figure 1 shows, for those without economic benefit, the dependence of the fraction of respondents annoyed as a function of the predicted noise level at their homes. The five noise bands correspond to <30, 30-35, 35-40, 40-45 and >45 dBA.

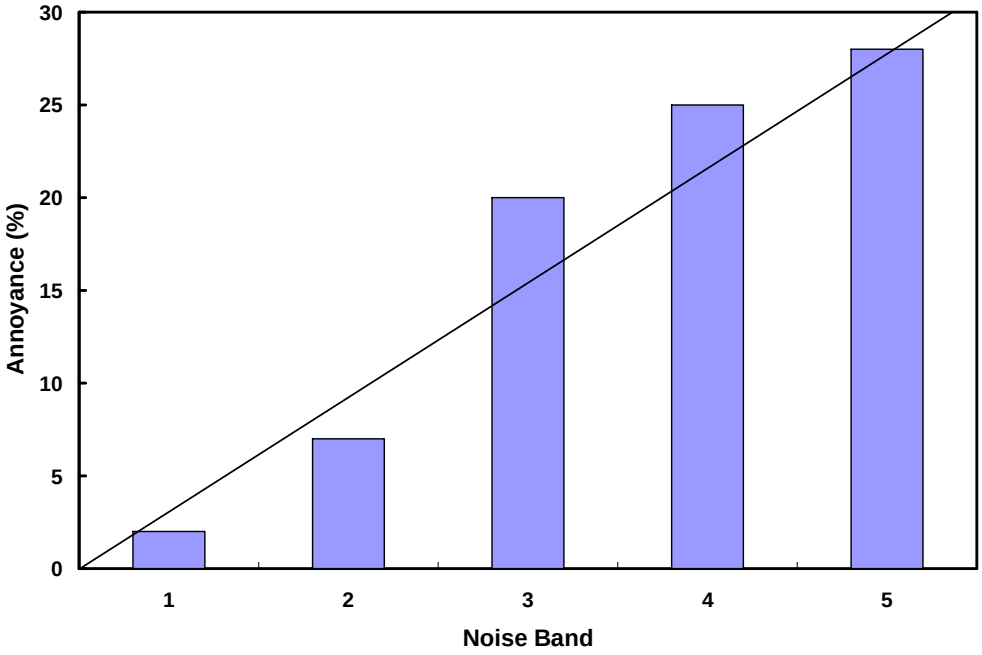

Figure 1. Dependence of Those Annoyed upon the Sound Pressure Level

The clear picture that emerges is that annoyance of residents is linearly related to the noise at the residence. That is, turbine noise causes annoyance which is acknowledged to be an adverse health effect. The results fully support the extensive evidence of Harry, Krogh et al., Pierpont, McMurtry, Frey and Hadden, and others.

World Health Organization Night Noise Guidelines

On page 4 Michaud et al. acknowledge that the WHO's Night Noise Guidelines are based on transportation noise sources. They then go on to state, without attribution, that *"current science shows that the same levels are applicable to noise emitted from wind turbines."* We know of no such current science. On the contrary, what we do know is that at the same sound pressure level wind turbine noise is significantly more annoying than traffic noise. Miedema and Vos (2004), in their field study of the response to traffic noise, found 2 to 4% annoyed at the 40 dBA sound pressure level. This compares to between 20 and 25% annoyed by wind turbine noise at the same 40 dBA sound pressure level (Pedersen et al., 2009).

[4] However, the reality in Ontario is that the noise limit of 40 dBA at a wind speed of 6 m/s will determine the setback. See the 2008 Ontario Ministry of the Environment wind turbine noise guidelines.

Causal Relation – Noise and Visual Impact

Michaud et al. downplay the correlation between annoyance and wind turbine noise in the work of Pedersen and colleagues. Knopper and Ollson (2011) have used the same approach. Both attribute the annoyance to visual intrusion and attitude to the visual intrusion. Figure 2 gives the lie to the conclusion that it is visual impact attitude that causes the annoyance[5]. It is based upon the data set published by Pedersen et al. (2009). It shows the dependence of those with a negative visual impact attitude on their level of annoyance. The data set includes only those without economic benefit.

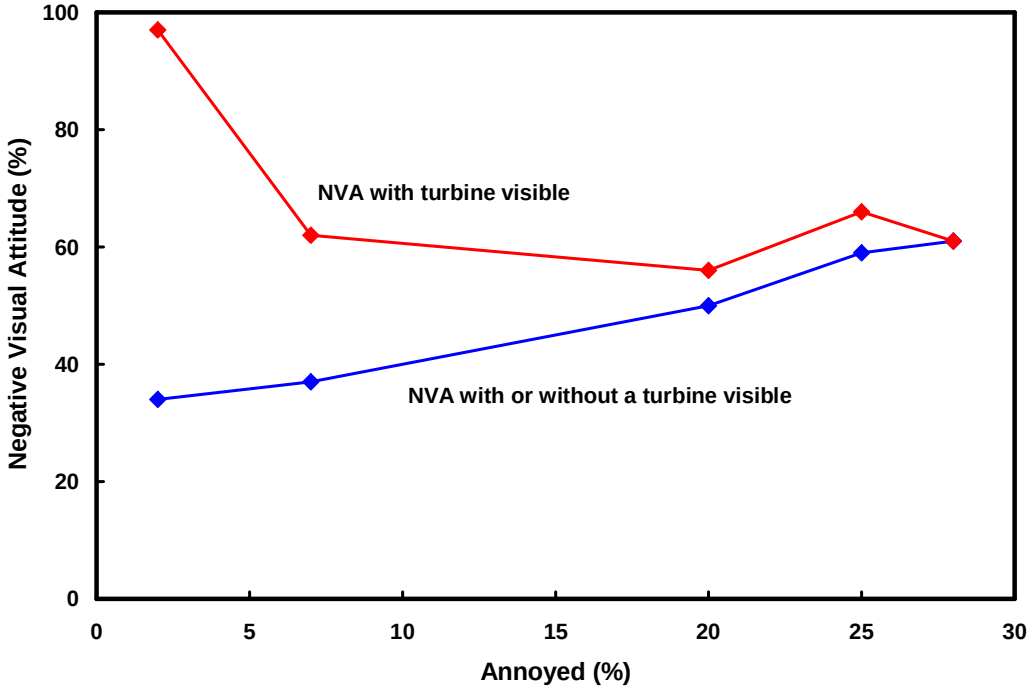

Figure 2. The Relation between Negative Visual Attitude (NVA) and Annoyance.

The lower curve is for those with and without a turbine in view from their homes. The upper curve is confined only to those with a turbine in view from their homes. The five data points on each curve correspond to the five noise bands described earlier. It is clear that there is not a linear relation between annoyance and negative visual attitude. For instance, for those in the lowest noise band (<30 dBA), just 2% are annoyed and yet between 33% and 97% have a negative visual impact attitude. In general about 60% of the respondents have a negative visual impact attitude without regard to how close to the wind turbines they live or how noisy the turbines are at their homes.

Much has been made of this negative attitude to wind turbines and their visual impact on residents who are having the turbines shoe-horned among them. There is indeed a negative attitude and who can blame them. The turbines are

[5] See the Appendix for the basis for Figure 2.

an intrusion into a rural or semi-rural area, they cause property values to plummet and they have an impact on wild-life. However the large field studies conducted by Pedersen and colleagues provide no support for this attitude causing annoyance, sleep deprivation and consequent adverse health effects.

It is the noise that causes the annoyance. As noted above, the turbine noise is significantly more annoying than noise at the same sound pressure level arising from road, rail and air traffic. The reason is that the turbine noise is incessant, is amplitude modulated, is predominantly low frequency as the higher frequency components are absorbed in the atmosphere, is enhanced by the blades turning in turbulent air (from atmospheric or wake turbulence), and is under-estimated by current prediction algorithms. The problem of low frequency noise will only get worse as the turbines get larger. Møller and Pedersen (2011) demonstrate a downward shift in frequency of one-third octave on going from less than 2 MW turbines to larger turbines in the range 2.3 to 3.6 MW. Low frequency noise can penetrate into homes and be amplified by resonance effects.

Wind Turbine Noise

The last paragraph on page 4 notes that up-wind turbines have overcome many of the noise problems of the previous generation, leaving the impression that low frequency sound and infrasound is not such a problem anymore. The modern wind turbines are most certainly not without problems. The amplitude modulation remains. This is clear from the work of van den Berg (2005) and the "Salford Report" published by the British Wind Energy Association (Moorhouse, 2007). It was acknowledged by the Ontario Ministry of the Environment in the 2008 noise regulations. Leventhall (2006), a frequent consultant to wind energy developers, has written: *"A time-varying sound is more annoying than a steady sound of the same average level and this is accounted for by reducing the permitted level of wind turbine noise"*. Unfortunately this reduction has not happened. The consensus is that amplitude modulation is of the order of 5 dBA.

Wind turbine noise does contain infrasound which propagates with insignificant absorption by the atmosphere. On average this infrasound is below the threshold of audibility. However, Bray and James (2011) have demonstrated that the infrasound output is highly variable on the short timescale with peaks above the audibility threshold[6]; Salt and Hullar (2010) and Salt and Kaltenbach (2011) have demonstrated an alternate pathway (outer hair cells) for perception of infrasound, significantly below the threshold for audibility.

Madsen (2008) has compared calculation of turbine noise for up-wind blade and down-wind blade turbines. He confirms with his model that up-wind blade turbines are quieter. However, when comparing actual measurements with the calculated sound pressure levels for an up-wind turbine, the measurements were 40 dBA higher in the frequency range 10 to 40 Hz. This he attributed to turbulent inflow aerodynamic noise. In Europe this low frequency noise source is

[6] The ear perceives sound on the short time scale; it does not average over 10 minutes.

acknowledged as a problem but is not as yet included in calculations of turbine noise at receptors.

Modern wind turbines can have tower heights of 100 metres and blade diameters of over 100 metres. Yet ISO-9613 and its derivatives are still used to calculate the noise at homes and other receptors. ISO-9613 is quite specific in having been designed for traffic and industrial noise and being limited to noise sources at and below 30 metres above ground level. It has no allowance for possible cylindrical spreading of turbine sound beyond several hundred metres; this does occur when certain atmospheric conditions promote refraction of the sound.

Wind turbine noise remains very much a problem. We are pleased to note that both the sound power levels of the turbines and the sound pressure levels at up to 5 km will be tested. Testing of the transmission of sound through walls with windows partially open is important but by having the noise source indoors rather than the other way will miss the importance of resonance effects in establishing large low frequency vibration and sound in the home.

It is interesting that the parallel is drawn with the noise produced in buildings by heating, ventilation, and air-conditioning systems. One of two consistent causes of the "sick-building syndrome" was identified with the infrasound and low frequency sound generated by these systems (Niven et al., 2000[7]; Schwartz, 2008). Of particular significance is the recent historical review (James, 2011)[8] in which he draws the parallel between the adverse health effects caused by poorly designed and installed heating and ventilation systems and those being caused now by living in proximity to wind turbines. There were sound commercial reasons for developers to solve the sick-building syndrome; they were losing clients as companies were moving their operations and personnel out of the sick buildings.

Summary

We believe that the authors of the background paper for the Federal Health Wind Turbine Impact Assessment have biased the document so as to mitigate what is already known about the adverse health effects associated with living in proximity to wind turbines. They have:

Wrongly implied poor methodology for the sleep studies and that there are studies showing no impact on sleep;

Denied the importance of the field studies of Pedersen et al. which demonstrate a clear dependence of annoyance upon turbine noise;

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[7] To quote from the conclusion*: "In conclusion, this study has shown consistent relations between dust particulates and noise to symptoms compatible with the sick building syndrome. Other factors are inconsistently associated and vary between buildings."*

[8] This peer-reviewed paper should be required reading for all those involved in the design and siting of wind turbines: manufacturers, regulators, developers and their consultants.

Mistakenly applied the World Health Organization's Night Noise Guidelines for traffic noise to wind turbine noise;

Wrongly attributed the annoyance from living in proximity to wind turbines to an attitude to the visual aspect of the turbines;

Left the impression that the turbine noise problem was solved by the change from down-wind to upwind placement of the turbine blades.

APAI welcomes the federal study but requests that the Director of the study should be a scientist with an unbiased attitude to the problem of the adverse health effects of wind turbine noise. Health Canada needs to seek advice from the Canadian Institute for Health Research (CIHR) on candidates for the position of Director. Health Canada also needs to add balance to the study team with health specialists and acousticians who have recognized the impact of living in proximity to wind turbines on the health of residents. Names that come to mind are: Dr. Robert McMurtry (Canada), Dr. Christopher Hanning (UK), Dr. Carl Phillips (USA), Ms. Carmen Krogh (Canada), Dr. Daniel Shepherd (New Zealand), Mr. Richard James (USA), Dr. Robert Thorne (Australia).

We also request that the Federal Government investigate the adverse effect of shadow-flicker as the sun passes behind the rotating blades of a wind turbine. The common, but not universal, regulation in Europe is that shadow-flicker is limited to 30 hours per year[9] (Parsons Brinckerhoff, undated). There is no regulation in Canada, Federal or Provincial.

References

W. Bray and R. James (2011), "Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception". Proceedings of Noise-Con 2011, Portland, Oregon, 25-27 July 2011. Curran Associates, 2011.

B. J. Frey and P. J. Hadden (2012) "Wind turbines and proximity to homes: The impact of wind turbine noise on health" (unpublished). http://docs.wind-watch.org/Frey_Hadden_WT_noise_health_01Jan2012.pdf

C. D. Hanning and A. Evans (2012) "Wind turbine noise", British Medical Journal **344**, e1527

A. Harry (2007), "Wind turbines, noise and health". Report available at: http://www.wind-watch.org/documents/wind-turbines-noise-and-health/

[9] Subject to the ideal conditions of no cloud, turbine operating and blades facing the receptor.

R. R. James (2011) “Wind turbine infra and low-frequency sound: warnings signs that were not heard” Bulletin of Science Technology & Society published online 15 December 2011, DOI: 10.1177/0270467611421845, http://bst.sagepub.com/content/early/2011/11/07/0270467611421845

L. E. Knopper and C. A. Ollson (2011) “Health effects and wind turbines: A review of the literature”, Environmental Health **10**, 78 (2011).

C. Krogh, L. Gillis, N. Kouwen and J. Aramini (2011) “WindVOiCe, a self-reporting survey: adverse health effects, industrial wind turbines and the need for vigilance monitoring.” Bull. Sci. Tech. Soc. **31** 334-339.

G. Leventhall (2006) “**“**Infrasound from wind turbines – fact, fiction or deception?” Canadian Acoustics **34**, 29-36.

H. A. Madsen (2008) “Low frequency noise from MW wind turbines – mechanisms of generation and its modelling”. Report: Risø-R-1637(EN)

McMurtry R. (2009). “Deputation to the Standing Committee on General Government regarding Bill C-150”. http://www.wind-watch.org/documents/deputation-to-the-standing-committee-on-general-government-regarding-bill-c-150/

H. M. Miedema, & H. Vos (1998). “Exposure response relationship for transportation noise.” Journal of the Acoustical Society of America **104** 3432-3445.

H. Møller and C. S. Pedersen (2011) Low frequency noise from large wind turbines. J Acoust. Soc. Am. **129**, 3727-44.

A. Moorhouse, M. Hayes, S. von Hünerbein, B. Piper, M. Adams (2007) “Research into aerodynamic modulation of wind turbine noise”. http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file40570.pdf

R. McL. Niven, A. M. Fletcher, C. A. C. Pickering, E. B. Faragher, I. N. Potter, W. B. Booth, T. J. Jones, P. D. R. Potter (2000), “Building sickness syndrome in healthy and unhealthy buildings: an epidemiological and environmental assessment with cluster analysis.” Occup. Environ. Med. **57** 627–634.

Parsons Brinckerhoff (undated but recent) “Update of UK shadow flicker evidence base”. Report prepared for the UK Department of Energy and Climate Change. http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/1416-update-uk-shadow-flicker-evidence-base.pdf

E. Pedersen and K. P. Waye (2004) “Perception and annoyance due to wind turbine noise”, J. Acoust. Soc. Am. **116**, 3460-3470.

E. Pedersen and K. P. Waye (2007) “Wind turbine noise, annoyance and self-reported health and well-being in different living environments”, Occup. Environ. Med. **64**, 480 – 486.

E. Pedersen, F. van den Berg, R. Bakker and J. Bouma (2009), “Response to noise from modern wind farms in the Netherlands”, J. Acoust. Soc. Am. **126**, 634 – 643). See also the report which formed the basis for the peer-reviewed paper: F. van den Berg, E. Pedersen, J. Bouma and R. Bakker, “WINDFARMperception: Visual and acoustic impact of wind turbine farms on residents” (2008). http://www.epaw.org/documents/WFp-final-1.pdf

Pierpont, N. (2010), “*Wind turbine syndrome: a report on a natural experiment*”, K-Selected Books, Santa Fe, NM.

A. N. Salt and T. E. Hullar (2010), “Response of the ear to low frequency sound, infrasound and wind turbines”, Hearing Research **268,** 12-21.

A.N. Salt and J. Kaltenbach (2011) “Infrasound from wind turbines could affect humans”, Bull. Sci. Tech. Soc. **31**, 296-303.

D. Shepherd, D. McBride, D. Welch, K. N. Dirks and E. M. Hill (2011) “Evaluating the impact of wind turbine noise on health-related quality of life”, Noise and Health **13**, 333-339.

S. Schwartz (2008), “Linking noise and vibration to sick building syndrome in office buildings”, em, The Magazine for Environmental Managers, March 2008, 26-28.
http://www.sandischwartz.com/samplework_files/EM_Magazine_final_printed_article.pdf

G. P. van den Berg (2005) “The beat is getting stronger: The effect of atmospheric stability on low frequency modulated sound of wind turbines” .J. Low Frequency Noise, Vibration and Control **24**, 1

Appendix

The purpose of this appendix is to question the contention that annoyance is caused by the attitude to the visual impact of wind turbines. It is based upon the data base assembled by Pedersen et al. (2009). The table shows a sub-set of the data base. The first row is the predicted sound pressure level at the home, based upon the ISO 9613-2 methodology and checked against other models.

The second row shows the percentage of respondents with economic benefits from the turbines. Additionally it is reported that these respondents had some control over the turbines, including one report of being able to shut down the turbine when annoyed. The third row shows the percentage of respondents for whom the turbines were visible. The next two rows show the percentages annoyed, for the whole sample and for those without economic benefit. Again, following Pedersen et al. the number annoyed includes those rather annoyed and those very annoyed. The final three rows are those with a negative attitude towards the look of the turbines (negative visible attitude). First, for the whole sample, then for those without economic benefit assuming that those with economic benefit do not have a negative attitude. To derive this number we divided the percentage for the complete sample by the fraction without benefit. The final row is based upon the assumption that those without a view of the turbines will not have a negative visual attitude! The reality will be somewhere between the final two rows.

Predicted SPL (dBA)	<30	30-35	35-40	40-45	>45
Economic Benefit (EB) (%)	2	3	10	34	67
Wind Turbine Visible (%)	35	60	90	89	100
Annoyed (%)	2	7	18	18	12
Annoyed (%) No EB	2	7	20	25	28
NVA (%)	33	36	45	39	20
NVA (%) No EB, estimated	34	37	50	59	61
NVA (%) No EB, turbine visible, est.	97 (?)	62	56	66	61

APAI, August 2012