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Audit report: literature reviews on wind turbine noise and health

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Summary

Wind turbines can harm humans if placed too close to residents. Health effects are most frequently associated with wind turbine noise. At typical setbacks and sound levels in Ontario Canada a non-trivial percentage those exposed to wind turbine sound will be highly annoyed which can be expected to contribute to stress related health impacts. In recent years a number of literature reviews have been produced which purport to examine the plausibility of wind turbine noise induced health effects. Some of these literature reviews have been sponsored by governments or organizations with policies which support wind energy development. Members of and/or consultants for the wind energy industry frequently cite literature reviews to support the claim wind turbine noise does not pose a risk to human health. Various literature reviews on wind turbines and health are examined using standard audit procedures. Findings reveal that while some literature reviews provide a balanced assessment other literature reviews contain errors of omission and/or commission and lack completeness, accuracy, and objectivity. These findings support the conclusion that a rigorous audit should be conducted before literature reviews on wind turbine noise and health can be relied upon.

1.0 Introduction

Some individuals living in the environs of industrial wind turbines (IWTs) experience negative health effects. Reported effects include annoyance and/or sleep disturbance and/or stress related health impacts and/or reduced quality of life. [1,2,3,4,5,6,7,8,9,10,11,12] In some cases families have effectively abandoned their homes; been billeted by wind energy developers; negotiated financial agreements with wind energy developers. [13]

Unwanted sound (noise), visual impacts (shadow flicker), stray voltage and social economic impacts are identified as plausible causes of annoyance and/or other adverse effects.

In order to address public concerns and assess the plausibility of reported adverse health effects, a number of literature reviews (IWT Reviews) have been commissioned by various organizations. While some of the IWT Reviews provide a balanced assessment and draw reasonable scientific conclusions, others contain errors and should not be relied on to make informed decisions. This paper employs standard audit procedures to verify the accuracy, completeness and objectivity of literature reviews which explore the health effects of IWTs.

2.0 Errors of omission

For audit purposes an error of omission is identified when information is omitted which results in a failing in completeness and/or accuracy and/or objectivity.

For example when reporting on the potential health impacts of IWTs a failure to fully disclose the indirect health risks of noise represents an error of omission.

2.1 Wind turbines can harm humans

A 2011 Ontario Environmental Review Tribunal considered evidence and testimony under oath and found that wind turbines can harm humans if they are placed too close to residents. The ERT decision stated:

> "This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree." [14]

Unwanted sound produced by IWTs can harm humans if place too close to residents. That is why jurisdictions develop noise limits in the first place.

National Research Council (2007) states:

> "…to the extent that wind-energy projects create negative impacts on human health and well-being, the impacts are experienced mainly by people living near wind turbines who are affected by noise and shadow flicker." [15]

Although National Research Council (2007) is sometimes listed as a reference in IWT Reviews the above statement is not typically disclosed.

IWT Reviews should disclose that IWT facilities can harm humans if placed too close to residents.

2.2 What definition of health are you using?

Most authors of IWT Reviews do not disclose the definition of health they used for their assessment of "health" effects.

The World Health Organization (WHO) states: "Members of the United Nations may become members of the WHO by accepting its Constitution." [16]

The WHO constitution defines health as:

> "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." [17]

The WHO constitution also states:

> "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition." [17]

Dr. Christopher Ollson and Dr. Loren Knopper provide consulting services for members of the wind energy industry. In their IWT Review, Knopper and Ollson (2011), the authors cite the

WHO definition of health and suggest the "mental and social well-being" of some individuals exposed to wind turbines be traded off "… against the larger demand for energy and its source." [18]

Chatham-Kent's (former) Acting Medical Officer has participated in IWT Reviews and other references which discuss IWT health effects. [19,20,21,22]

In 2011 when questioned about the WHO definition of health Chatham-Kent's (former) Acting Medical Officer testified under oath:

> "… the World Health Organization came up with that platonic definition of "health" in the post-World War II feel-good hubris of general exaltation, and it – that particular definition of "health" is not applicable to any human being on the planet." [23]

Australia, Canada, New Zealand, the United Kingdom and the United States of America are among the 194 listed WHO member states and by definition accept the WHO constitution. [16]

IWT Reviews written for a WHO Member State audience should be applying the WHO definition of health.

2.3 Focus on direct physiological health effects

Noise can harm human health directly (i.e. hearing loss) and indirectly (i.e. annoyance, sleep disturbance). [24]

WHO (2009) discusses the indirect pathway stating:

> "Physiological experiments on humans have shown that noise of a moderate level acts via an indirect pathway and has health outcomes similar to those caused by high noise exposures on the direct pathway. The indirect pathway starts with noise induced disturbances of activities such as communication or sleep." [25]

The 2011 Ontario Environmental Review Tribunal decision found that ""serious harm to human health" includes … indirect impacts (e.g., a person being exposed to noise and then exhibiting stress and developing other related symptoms). This approach is consistent with both the WHO definition of health and Canadian jurisprudence on the topic." [14]

One reoccurring error of omission is that some IWT Reviews limit the scope to "direct" health effects and omit assessment of IWTs health effects that can occur via the "indirect" pathway.

For example in 2010 the Ontario Chief Medical Officer of Health released *The Potential Health Impact of Wind Turbines*. [22] However, the lead author of the review acknowledged under oath that Chief Medical Officer of Health (2010) looked only at direct links to human health. [26]

Documents obtained through a Freedom of Information request show the qualifier of "direct" causal links was intentionally added to Ontario Chief Medical Officer of Health references as a "… studies would support a link through 'annoyance'" [27]. (See Section 2.5 and 7.1 Appendix 1 – Chief Medical Officer of Health – Indirect causal link)

IWT Reviews should fully disclose the indirect health impacts of human exposure to IWTs.

2.4 Happy to accept the symptoms

Pierpont (2009) documented symptoms reported by individuals exposed to IWTs and coined them "Wind Turbine Syndrome". The symptoms include: sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering when awake or asleep. Pierpont (2009) proposes the cause of these symptoms to be IWT low-frequency noise or vibration stimulation of receptors of the human balance system. [6]

The American Wind Energy Association and Canadian Wind Energy Association sponsored a literature review to consider existing literature on wind turbine noise and health. Colby et al. (2009) challenges the hypothesis that IWT low-frequency noise or infrasound is the cause. Colby et al. (2009) determined the symptoms of "Wind Turbine Syndrome" "… are not new and have been published previously in the context of "annoyance"…" and are the "… well-known stress effects of exposure to noise …". [19]

Dr Geoff Leventhall, is a Colby et al. (2009) co-author and, in a 2009 reference states:

> "I am happy to accept these symptoms, as they have been known to me for many years as the symptoms of extreme psychological stress from environmental noise… what Pierpont describes is effects of annoyance by noise – a stress effect" [28]

To summarize two wind energy trade associations retained IWT Review authors who acknowledge a link between "Wind Turbine Syndrome" symptoms and noise. However, subsequent IWT Reviews [22,29,30,31,32] omit disclosure of this industry sponsored finding even though they cite and rely on Colby et al. (2009).

IWT Reviews should fully disclose the authors of Colby et al. (2009) reported wind turbine syndrome symptoms are the well-known stress effects of exposure to noise.

2.5 Fess up or delete - full disclosure please

Chief Medical Officer of Health (2010) is an example of an IWT Review which cites and relies on Colby et al. (2009) but fails to disclose the authors of Colby et al. (2009) reported wind turbine syndrome symptoms are the well-known stress effects of exposure to noise.

Chief Medical Officer of Health (2010) states:

> "While some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects." [22]

Chief Medical Officer of Health (2010) was released to the public on May 20, 2010. On May 19, 2010 an information sheet "*WIND TURBINES Q & A*" prepared by the office of the Chief Medical Officer of Health was transmitted to Ontario medical officers of health by the chair of the Council of Ontario Medical Officers of Health.[33] The May 19, 2010 "*WIND TURBINES Q & A*" information sheet states:

> "Although some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, available scientific evidence does not demonstrate a direct causal link to wind turbine noise. It is possible that these symptoms are a result of annoyance with the noise." [27]

Chief Medical Officer of Health (2010) omits disclosure to the public that it is possible that reported IWT symptoms are a result of annoyance with the noise. This failure to disclose a potential health impact of wind turbines should be considered an error of omission. (See 2.3 and 7.2 Appendix 2 – Chief Medical Officer of Health – Fess up or delete)

2.6 Its not a disease – its a health effect

Colby et al. (2009) discuss annoyance and state:

> "It is important to note that although annoyance may be a frustrating experience for people, it is not considered an adverse health effect or disease of any kind." [19]

Some IWT Reviews comment that noise induced annoyance is not considered to be a "disease". [29]

Sound, regardless of source, becomes a risk to human health if it is perceived as noise.

According to the WHO noise is unwanted sound [24] and:

> "Noise seriously harms human health and interferes with people's daily activities at school, at work, at home and during leisure time. Traffic noise alone is harming today the health of almost every third European. The main health risks of noise identified by WHO are:
>
> •pain and hearing fatigue;
> •hearing impairment including tinnitus;
> •annoyance;
> •interferences with social behaviour (aggressiveness, protest and helplessness);
> •interference with speech communication;
> •sleep disturbance and all its consequences on a long and short term basis;
> •cardiovascular effects;
> •hormonal responses (stress hormones) and their possible consequences on human metabolism (nutrition) and immune system;
> •performance at work and school." [34]

Health Canada (2005) [35] and other references acknowledge annoyance to be an adverse health effect. [3,36,37]

In the 2005 article *Noise annoyance in Canada*, Health Canada's Dr. David Michaud states

> "According to the World Health Organization (WHO), health should be regarded as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity" (World Health Organization 2001). Under this broad definition, noise induced annoyance is an adverse health effect." [38]

Based on the findings of the WHO pan-European LARES study Maschke and Niemann (2006) state:

> "The results of the LARES study in relation to severe annoyance by neighbourhood noise demonstrate that neighbourhood noise must be classified as a serious health endangerment for adults." [39]

Symptoms associated with noise annoyance include stress, sleep disturbance, headaches, difficulty concentrating, irritability, fatigue, dizziness or vertigo, tinnitus, anxiety, heart ailments, and palpitation. [40],[41],[42]

IWT Reviews should fully disclose that annoyance is considered a health effect and can seriously harm human health.

2.7 Wind turbine noise is more annoying

Peer reviewed studies consistently document IWTs produce sound which is perceived by humans to be more annoying than transportation noise or industrial noise at comparable sound pressure levels. [1,5] Annoyance to IWT noise starts at dBA sound pressure levels in the low 30's and rises sharply at 35 dBA. [43,44]

Some IWT Reviews conclude that existing noise guidance is sufficient to prevent health effects but do not provide conclusive evidence to support this. For example National Health and Medical Research Council (2010) states "…any potential impact on humans can be minimised by following existing planning guidelines …" [31] but does not provide specific planning guidelines which will minimize the impacts.

Internationally IWT noise limits vary significantly from one jurisdiction to another. Knopper and Ollson (2011) report "…rural residential noise limits are generally set at 35 to 55 dB(A)." [18]

IWT Reviews should fully disclose that based on existing IWT dose response relationships it is expected sound from wind turbines, in most jurisdictions, will result in a non-trivial percentage of persons being highly annoyed.

2.8 The plausible explanations for IWT noise annoyance

Some IWT Reviews do not disclose the IWTs sound characteristics which are identified as plausible causes for annoyance and/or other health effects.

These characteristics include IWT amplitude modulation (swooshing); [19,45,46,47,48] audible low-frequency noise; [49,50,51] infrasound; [52,53] tonal noise, impulse noise; [9] and night time noise.[5]

IWT Reviews should fully disclose the IWT noise characteristics which are identified as plausible causes for annoyance and/or other health effects.

2.9 They cited an internet blog?

Quality information is typically preferred when assessing the health impacts of an exposure. Some IWT Reviews cite references from the Canadian, American, British, or Danish wind energy associations or their listed members, while omitting relevant peer reviewed articles.

National Health and Medical Research Council (2010) omit relevant peer reviewed articles but include a citation from an internet posting on "croakey the Crikey health blog." [31]

IWT Reviews should cite high quality references in preference to low quality references.

2.10 The limit is 51 dBA - not 40

Some literature reviews provide incomplete information which can be result in the reader not being fully informed. For example both Knopper and Ollson (2011) and Chief Medical Officer of Health (2010) provide incomplete information which suggests regulations in Ontario Canada are designed to limit IWT noise to 40 dBA in keeping with WHO (2009) recommended guidelines.

However, Ontario wind turbine noise guideline limits permit, [54] and projects are being approved for, [55] noise levels of up to 51 dBA (formerly 53 dBA) at a defined noise receptor

(family home). Knopper and Ollson (2011) and Chief Medical Officer of Health (2010) do not disclose these Ontario IWT limits.

Furthermore both Knopper and Ollson (2011) and Chief Medical Officer of Health (2010) cite WHO (2009) to suggest a 40 dBA IWT noise limit is protective of health.

However WHO (1999) [24] and WHO (2009) [25] noise guidance is primarily based on research related to traffic noise; not IWTs.

2.11 Health effects predicted, reported and expected

Since at least 2007 Health Canada employees, Dr Stephen Keith, Dr. David Michaud, and Dr. Stephen Bly proposed "a justification for using a 45 dba sound level criterion for wind turbine projects" [56] and predicted an increase in the percentage highly annoyed. [57],[58]

In June 30 2009 correspondence federal Member of Parliament, the Honourable Rona Ambrose, provided the following statement:

> "Health Canada provides advice on the health effect of noise and low-frequency electric and magnetic fields from proposed wind turbine projects, particularly for environmental assessments done under the Canadian Environmental Assessment Act. To date, their examination of the scientific literature on wind turbine noise is that the only health effect conclusively demonstrated from exposure to wind turbine noise is an increase of self-reported general annoyance and complaints (i.e., headaches, nausea, tinnitus, vertigo)." [59]

Health Canada (2010) is "Published by authority of the Minister of Health." [60] and states:

> "Health Canada considers the following noise-induced endpoints as health effects: noise-induced hearing loss, sleep disturbance, interference with speech comprehension, complaints, and change in percent highly annoyed (%HA)." [60]

HGC Engineering is a listed member of CanWEA. [61] HGC Engineering has conducted sound measurements at Canadian wind energy locations where some Canadians exposed to wind turbine noise reported high annoyance and/or sleep disturbance and/or other adverse effects. Some residents at Canadian IWT projects have retained legal counsel to resolve issues caused by IWT noise and have negotiated an agreement with the wind energy developer to purchase the home.

In December 2011 the Ontario Ministry of Environment released a report prepared by HGC Engineering and signed by Mr. Brian Howe.

HGC (2010) states:

> "Stress symptoms associated with noise annoyance, and in particular low frequency annoyance include sleep interference, headaches, poor concentration, mood swings" [51]

HGC (2010) states in the conclusions:

> "The audible sound from wind turbines, at the levels experienced at typical receptor distances in Ontario, is nonetheless expected to result in a non-trivial percentage of persons being highly annoyed. As with sounds from many sources, research has shown that annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts in some persons." [51]

Notably some IWT Reviews cite and rely on Keith et al. (2008) and/or HGC (2010) but do not disclose the sound levels experienced at typical receptor distances are expected to result in a non-trivial percentage of persons being highly annoyed. Nor do they disclose that research has shown that annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts in some persons.

3.0 Errors of commission

For audit purposes an error of commission is considered reporting information which is incorrect or which is not supported by references and/or data.

For example inappropriately citing or misquoting references to support a statement represents errors of commission.

3.1 Where exactly is the country of AWEA/CANWEA?

It is not uncommon for IWT literature reviews to provide readers with inaccurate and/or misleading information. [62]

A 2013 rapid IWT Review by University of Salford states:

> "Three widely quoted government reviews in 2009 (AWEA/CANWEA, 2009, Minnesota Department of Health, 2009, Roberts and Roberts, 2009) concluded that there are no direct health effects from WTs." [32]

Standard audit procedures demonstrate this one IWT Review sentence contains multiple errors.

For example AWEA/CANWEA 2009 is not a "government review" as University of Salford (2013) states. AWEA/CANWEA, 2009 is an IWT Review prepared for The American Wind Energy Association (AWEA) and Canadian Wind Energy Association (CanWEA). The panel of authors were convened by AWEA and CanWEA. AWEA and CanWEA are industry trade associations. CanWEA represents Canada's "… wind energy owners, operators, manufacturers, project developers, consultants, and service providers, and other organizations and individuals interested in supporting Canada's wind energy industry." [63] CanWEA is also a registered federal lobby organization.

Furthermore University of Salford provides an example of a IWT Review which cites AWEA/CANWEA 2009 but omits disclosing the authors report "wind turbine syndrome" symptoms are the "… well-known stress effects of exposure to noise …". [19] (See Section 2.4 Happy to accept the symptoms)

University of Salford correctly identifies Minnesota Department of Health, 2009 as a "government review". However, the assertion that Minnesota Department of Health, 2009 concluded "that there are no direct health effects from WTs" is not supported by its contents. Minnesota Department of Health, 2009 states in its conclusion:

> "The most common complaint in various studies of wind turbine effects on people is annoyance or an impact on quality of life. Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside

> noise levels above 35 dB(A). It has been hypothesized that direct activation of the vestibular and autonomic nervous system may be responsible for less common complaints, but evidence is scant." [50]

3.2 They did not say that

It is not uncommon for IWT Reviews to inappropriately cite or misquote references to support statements. [62] The following example is provided to illustrate the importance of auditing citations contained in IWT Reviews.

The literature review *Health Effects and Wind Turbines: A Review of the Literature,* (Knopper and Ollson, 2011), contains the following statement:

> "A number of governmental health agencies agree that while noise from wind turbines is not loud enough to cause hearing impairment and are not causally related to adverse effects, wind turbines can be a source of annoyance for some people [1,30-34]." [18]

The authors of Knopper and Ollson (2011) cite six references to support this statement.

To verify if the cited references support the above Knopper and Ollson (2011) statement one needs to evaluate the individual references and assess if they meet the following four audit criteria:

1. Is the cited reference an official production of a governmental health agency?
2. Does the cited reference agree that noise from wind turbines is not loud enough to cause hearing impairment?
3. Does the cited reference agree noise from wind turbines is not causally related to adverse effects?
4. Does the cited reference agree wind turbines can be a source of annoyance?

A review of the six references cited in Knopper and Ollson (2011) support the conclusion that none of the six references cited appear to support the complete Knopper and Ollson (2011) sentence. For example, none of the six references appear to have concluded that wind turbines "… are not causally related to adverse effects… ". Two of the references cited do not appear to meet any of the four audit criteria. (See 7.3 Appendix 3 - Knopper and Ollson (2011) Audit Results)

IWT Reviews should not inappropriately cite or misquote references to support a statement or conclusions.

3.3 Understating health effects of IWT noise

Incorrectly interpreting and/or reporting data represents an error of commission.

Some IWT Reviews understate the health impacts of IWT noise. For example some IWT Reviews suggest the IWT annoyance or sleep disturbance occur only over a specific sound pressure level (i.e. above 40 dBA).

However IWT annoyance and/or sleep disturbance is documented at IWT noise levels below 40 dBA. [1,3,5,12]

A current Director of the Ontario Agency for Health Protection and Promotion acknowledged in a 2010 literature review that wind turbine noise annoyance and sleep disturbance are common between 30 and 45 dBA. [30]

However, Chief Medical Officer of Health (2010) reports:

> "The sound was annoying only to a small percentage of the exposed people; approximately four to ten per cent were very annoyed at sound levels between 35 and 45 dBA." [22]

The authors of Chief Medical Officer of Health (2010) appear to have misinterpreted and/or incorrectly reported the results from available studies on IWT noise annoyance. It appears the authors omitted respondents who were "rather" annoyed, and the respondents who reported annoyance when spending time outdoors at their dwelling.

Based on a peer-reviewed body of research IWT annoyance can be expected to be up to 28% at 45 dBA. [62] This is further supported by Health Canada Wind Turbine Noise Study Team Member, Sabine Janssen, who reports with a highest allowed immission level of 45 dB(A) it could be expected that "… less than 14% of the exposed population to be highly annoyed indoors by wind turbines and less than 29% to be highly annoyed outdoors." [64]

4.0 Jumping to conclusions

Some IWT Reviews provide a balanced assessment and attempt to draw reasonable scientific conclusions based on the totality of evidence. Other IWT Reviews present conclusions which are not supported by the references cited.

4.1 Conclusions that do not make sense

Colby et al (2009) acknowledges IWT sound may cause annoyance, stress and sleep disturbance and that "wind turbine syndrome" symptoms are the "… well-known stress effects of exposure to noise …". [19]

However, Colby et al (2009) states in its conclusion "Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effect in humans."

In March 2011, Dr. Leventhall testified under oath [65] that the Colby et al. (2009) statement would be more clearly worded by adding the words, "direct physiopathological effects" that is, sound from wind turbines does not pose a risk of hearing loss or any other direct physiopathological effect in humans. This addition of the words "direct physiopathological" is an important distinction which alters the fundamental meaning of one of the literature review's main conclusions.

National Health and Medical Research Council (2010) repeat the error by citing verbatim the Colby et al. (2009) conclusion "Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effects in humans." National Health and Medical Research Council (2010) fails to challenge the accuracy of the conclusion. [31]

On June 7, 2011 Dr. Geoff Leventhall presented to the National Health and Medical Research Council at a "Scientific Forum" on "Wind Farms and Humans Health". [66] Dr. Geoff Leventhall's slides state:

> "Effects of wind turbine noise on health are mediated through annoyance from audible noise … Wind Turbine Syndrome is the result of stress from annoyance by audible noise from wind turbines …". [48]

Literature reviews should fully disclose unwanted sound (noise) from IWTs can cause annoyance and/or sleep disturbance and/or stress related health impacts and/or reduced quality of life.

4.2 The jury is still out

A number of IWT Reviews contain conclusive statements that inaudible IWT low frequency noise and infrasound is not a health issue. However in the absence of definitive research there is not sufficient evidence to exclude inaudible IWT low frequency noise and infrasound as plausible causes of annoyance and/or other health effects.

There remains debate about the impact of IWT sound from these low frequencies. However, "…there is an increasing body of evidence suggesting that infrasound and low frequency noise have physiological effects on the ear." [53]

"Low-frequency noise may also produce vibrations and rattles as secondary effects." [24] "People who are exposed to wind turbine noise inside buildings experience a much different acoustic environment than do those outside….They may actually be more disturbed by the noise inside their homes than they would be outside. … One of the common ways that a person might sense the noise-induced excitation of a house is through structural vibrations. This mode of observation is particularly significant at low frequencies, below the threshold of normal hearing." [67]

Low-frequency noise produced by Ontario IWT projects has been found to be inaudible outside the home but audible inside and "…quite annoying to the occupants." [68] IWT low-frequency noise has resulted in reported annoyance, "sleep deprivation" and "uninhabitable" living conditions. [68] To escape the noise, some Ontarians report resorting to sleeping in vehicles, tents, trailers, basements lined with mattresses, garages, and at relatives or friends' homes. [13]

A 2012 cooperative measurement survey and analysis of low-frequency and infrasound at an IWT project in Brown County, Wisconsin states:

> "The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry. It should be addressed beyond the present practice of showing that wind turbine levels are magnitudes below the threshold of hearing at low frequencies." [69]

IWT Reviews should disclose that it is plausible inaudible IWT low frequency noise and/or infrasound could adversely affect humans.

4.3 Misinterpreting the data

Some IWT Reviews suggest that the attitude of the respondent is causally related to annoyance and/or other health effects.

Referring to noise in general Suter (1991) states:

> "…community annoyance is positively correlated with noise exposure level, other variables also appear to be important, such as ambient noise level, time of day and year, location, and socioeconomic status. None of these other variables, however, is as powerful as the attitude of the residents surveyed. This is a good example of the fact that the human being is not a black box, where the effect is a simple consequence of the input." [36]

In studies where adverse health effects have been documented some researchers have commented that the IWTs were initially welcomed into the communities for their perceived economic [12] and/or environmental [8] benefits. "The reported adverse impacts were unexpected." [13]

Some IWT Reviews speculate on the influence of non acoustical factors such visual and economic impacts on annoyance and/or other adverse effects.

However, Pedersen et al. (2009) states:

> "Annoyance with wind turbine noise is related to a negative attitude toward the source and to noise sensitivity; in that respect it is similar to reactions to noise from other sources." [5]

van den Berg et al. (2008) reports:

> "A free sight from the dwelling to one or more of the wind turbines also gives free way for the sound. In these cases the immission levels at the dwelling of the respondent were in accordance with the calculated levels, and not less due to hindrance of the sound propagation. When the sight of the wind farm is blocked, than the sound may be (partly) blocked too, leading to lower sound levels. This may explain the lower levels of annoyance. However, the enhanced probability for annoyance if the wind turbines were visible could also be due to a multimodal effect; the rotating blades of a wind turbine attracting the sight could increase the awareness of the sound and hence also the possibility of noise annoyance." [43]
>
> "It is difficult to separate the visual from the acoustic impact, because they are so closely related: when turbines are closer and bigger they are usually better audible. However, when wind turbines are less visible they are less easily noticed by their sound and cause less annoyance." [43]

Pederson et al. (2009) reports those: "…who benefit economically from wind turbines have a significantly decreased risk of annoyance, despite exposure to similar sound levels." [5]

The study reported on in Pederson et al. (2009) is "Project WINDFARM Perception: Visual and Acoustic Impact of Wind Turbine Farms on Residents". van den Berg et al. (2008) reports:

> "Respondents that benefit will more usually have control: most or all of them have taken part in the decision to put up the turbines and they can stop them if they want. One respondent remarked that if a turbine close by caused too much noise for him or his neighbour, he stopped the turbine." [43]

Excerpts from sample Canadian IWT hosting agreements indicate individuals who benefit financially from wind energy projects typically agree to noise and/or other adverse effects:

> "… in consideration of the Rent paid by the Lessee to the Lessor. … the parties hereto covenant and agree … Lessor grants and transfers to Lessee a non-exclusive License for audio, visual, view, light, flicker, noise, shadow, vibration, air turbulence, wake, electromagnetic, electrical and radio interference, and any other effects attributable to the Wind Power Facilities or activity located on the Leased Lands or on adjacent properties ("Effect License")." [70]
>
> "The Rent, in respect of the Specified Locations…represent compensation in full for…nuisance, noise, signal interference,…, casting of shadows and other inconveniences or damage…incurred by Lessor from the acts or omissions of Lessee." [71]

Financial compensation paid to participating property owners represents, in part, compensation for effects attributable to the IWT facility. Conversely financial compensation is not typically provided to non participating property owners in proximity to IWTs. Non participating property owners in proximity to IWTs are not typically compensated for the burdens of nuisance, noise, signal interference, casting of shadows and other inconveniences or damage resulting from the IWT project.

Despite any attitudinal associations found van den Berg et al. (2008) reports:

> "In this survey sound was the most annoying aspect of wind turbines." [43]

Referring to wind turbines van den Berg et al. (2008) reports

> "Other factors, such as attitude, are more ambiguous; we do not know if the attitude has an influence on annoyance or if annoyance leads to a negative attitude. The statistical tests can only show whether there is a relationship between attitude and annoyance, not which one is the cause and which one the effect." [43]

5.0 Discussion

"Literature reviews can be useful tools for summarizing existing literature related to a particular topic. In order to be considered reliable a literature review must be complete, accurate, and objective." [62]

By employing standard audit procedures some IWT Reviews can be shown to contain errors of omission and/or commission. The existence of errors should be a concern not only for the authors but also readers who rely on IWT Reviews to inform health protection.

"Authors have an inherent responsibility to ensure that they accurately reflect the contents of references cited. Literature reviews which inappropriately cite or misquote references should be viewed with caution." [62]

An audit checklist (See 7.4 Appendix 4 – Literature review audit checklist) can be a useful tool to assist in determining the completeness, accuracy, and objectivity of IWT Reviews.

Due to space limitations this paper does not provide an exhaustive list of issues identified. The examples presented in this paper are provided for illustrative purposes only.

Common failures identified in IWT Reviews include, but are not limited to:

- failure to apply the definition of health established in the WHO Constitution which is accepted by 194 WHO member states;
- failure to fully disclose health effects which act via the indirect causal pathway of noise;
- failure to disclose IWT noise is perceived to be more annoying than other sources of equally loud sound;
- failure to fully disclose the serious health risk that noise induced annoyance can represent;
- failure to accurately disclose the expected prevalence of IWT health effects;
- failure to disclose a non-trivial percentage of exposed individuals are expect to be highly annoyed at typical IWT sound pressure levels;
- failure to fully disclose the IWT noise characteristics which are plausible causes of annoyance and/or other adverse effects;
- failure to provide conclusions which are supported by the references cited;
- providing inaccurate and/or misleading information;

- inappropriate citation or misquoting of references;
- failure to cite high quality references i.e. peer reviewed journal articles; and
- use of low quality references i.e. industry fact sheets, internet blog posting.

6.0 Conclusions

IWT noise can harm humans if placed too close to residents. Some individuals living in the environs of IWTs experience negative health effects including annoyance and/or sleep disturbance and/or stress related health impacts and/or reduced quality of life. At typical IWT sound pressure levels a non-trivial percentage of exposed individuals are expected to be adversely affected.

Authors of literature reviews have a responsibility to fully disclose the health risks of an exposure. It is paramount the information presented is complete, accurate, and objective.

A number of IWT Reviews have been commissioned by various organizations to report on the health impacts of IWTs. Using standard audit procedures it can be concluded that while some IWT Reviews provide a balanced assessment others are found to contain errors of omission and/or commission. IWT Reviews containing errors can misinform the placement of IWTs thereby resulting in harm to the physical, mental and social well-being of humans.

The audit findings presented in this paper support the conclusion a rigorous audit should be conducted before IWT Reviews are relied upon to make informed decisions. IWT Reviews which contain errors of omission and/or errors of commission should not be relied on to make informed decisions.

7.0 Appendices

7.1 Appendix 1 – Chief Medical Officer of Health – Indirect causal link

The following excerpts are from government documents obtained in a freedom of information request related to the Chief Medical Officer of Health *The Potential Health Impact of Wind Turbines (2010).*

The May 11, 2010 draft version of the "*WIND TURBINES Q & A*" (see excerpt below) contains a track changes comment that studies support a causal link between wind turbine noise and adverse health effects, and states "Should add 'direct'…"

Information and Privacy Commissioner of Ontario
Commissaire à l'information et à la protection de la vie privée de l'Ontario

WIND TURBINES
Qs & As

1. What scientific evidence is available on the potential health impacts of wind turbines?

A few case studies and cross-sectional studies in people living near wind turbines were published in the literature. The scientific evidence available to date, however, does not demonstrate any causal link between wind turbine noise and any adverse health effects.

Comment [r1]: Should add 'direct' as the studies would support a link through 'annoyance'

The May 19, 2010 version of the "*WIND TURBINES Q & A*" was changed to add the word "direct". (see excerpt below)

Appendix B

WIND TURBINES
Qs & As

1. What scientific evidence is available on the potential health impacts of wind turbines?

A few case studies and cross-sectional studies in people living near wind turbines were published in the literature. The scientific evidence available to date, however, does not demonstrate any direct causal link between wind turbine noise and any adverse health effects.

However these and other acknowledgements, contained in the May 11 and 19, 2010 versions of the "*WIND TURBINES Q & A*", are not disclosed in CMOH "*The Potential Health Impact of Wind Turbines (2010)* ".

7.2 Appendix 2 – Chief Medical Officer of Health – Fess up or delete

The following excerpts are from government documents obtained in a freedom of information request related to the Chief Medical Officer of Health *The Potential Health Impact of Wind Turbines (2010).*

The May 11, 2010 draft version of the *"WIND TURBINES Q & A"*, contain a track changes comment which directs the authors to "fess up" to the annoyance link.

9. Your research refers to "some people living near wind turbines reporting symptoms such as dizziness, headaches and sleep disturbance." If not attributable to the effect of wind turbines, what do you think is causing these health conditions?

Although some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, available scientific evidence does not demonstrate a causal link to wind turbine noise. As many factors can trigger these non-specific symptoms, people should consult with their physician about possible causes.

Comment [r8]: This answer isn't credible. Either 'fess up to the annoyance link or delete.

In an apparent effort to "fess up" the May 19, 2010 version of the "*WIND TURBINES Q & A*" was altered to include the word "direct" and acknowledge the potential for annoyance to result in symptoms such as dizziness, headache and sleep disturbance.

9. Your research refers to "some people living near wind turbines reporting symptoms such as dizziness, headaches and sleep disturbance." If not attributable to the effect of wind turbines, what do you think is causing these health conditions?

Although some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, available scientific evidence does not demonstrate a direct causal link to wind turbine noise. It is possible that these symptoms are a result of annoyance with the noise.

However these and other acknowledgements, contained in the May 11 and 19, 2010 versions of the "*WIND TURBINES Q & A*" are not disclosed in the Chief Medical Officer of Health "*The Potential Health Impact of Wind Turbines (2010)*".

7.3 Appendix 3 - Knopper and Ollson (2011) Audit Results

Reference Cited in Knopper and Ollson (2011)	1. Is the cited reference an official production of a governmental health agency?	2. Does the cited reference agree that noise from wind turbines is not loud enough to cause hearing impairment?	3. Does the cited reference agree noise from wind turbines is not causally related to adverse effects?	4. Does the cited reference agree wind turbines can be a source of annoyance?
1. World Health Organization (WHO): (2004)	**No** [i] [ii] [iii] [iv]	**No** [v]	**No** [vi]	**No**
30. Leventhall G, Benton S, Robertson (2008)	**No** [vii]	**No**	**No**	**No**
31. Chatham-Kent Public Health Unit: (2008)	**Yes**	**(Indirectly)** [viii]	**No** [ix]	**(Indirectly)** [x]
32. Minnesota Department of Health (2009)	**Yes**	**No** [xi]	**No** [xii]	**Yes**
33. Chief Medical Officer of Health (2010)	**Yes**	**Yes**	**No** [xiii] [xiv]	**Yes**
34. National Health and Medical Research Council: (2010)	**Yes**	**(Indirectly)** [xv]	**No** [xvi] [xvii]	**Yes**

Audit notes

[i] Note: In an email dated July 17, 2012 Dr. Knopper confirmed the version of Fourth Ministerial Conference on Environment and Health. Energy, Sustainable Development and Health cited in Knopper and Ollson (2011).
[ii] The WHO (2004) version cited in Knopper and Ollson (2011) is an "UNEDITED DRAFT"
[iii] Note: a search of the WHO website "Library and Information Network" did not return a document EUR/04/5046267/BD/8, dated 3 June 2004, entitled: "Energy, sustainable development and health" [July 14, 2012] http://dosei.who.int/uhtbin/cgisirsi/Jl3dREVj55/72610010/5/0
[iv] Note: inquiries to confirm if document number EUR/04/5046267/BD/8, dated 3 June 2004, entitled: "Energy, sustainable development and health" is an official WHO document have been made. As of the date of this paper the WHO have not confirmed that it is an official WHO document, Email from WHO July 23 2012.
[v] WHO (2004) does not provide conclusions regarding hearing impairment, causal relationship to reported adverse effects, or annoyance caused by wind turbine noise.
[vi] WHO (2004) states: "Wind energy can, however, have some potential burdens on amenity through visual intrusion or/and noise." "Most wind farms are considered to have very low impacts, and these are caused mostly at the local scale – noise pollution may be a problem if turbines are situated close to centres of population."
[vii] Leventhall et al., 2008 does not appear to be an official production of a governmental health agency nor does it appear to have commented on wind turbines. Wind turbines are not mentioned in the reference.
[viii] Chatham-Kent Public Health Unit (2008) does not appear to specifically comment on "hearing impairment".
[ix] Chatham-Kent Public Health Unit (2008) does not state noise from wind turbines "is not causally related to adverse effects".
[x] Chatham-Kent Public Health Unit (2008) does not specifically state wind turbines can be a source of annoyance for some people.
[xi] Minnesota Department of Health (2009) does not appear to specifically comment on "hearing impairment".
[xii] Minnesota Department of Health (2009) states "Most available evidence suggests that reported health effects are related to audible low frequency noise."
[xiii] Chief Medical Officer of Health (2010) does not state noise from wind turbines "is not causally related to adverse effects". CMOH (2010) focuses on direct causal links. In 2011 the lead author acknowledged under oath Chief Medical Officer of Health (2010) looked only at direct links to human health. At a public information session on wind turbines Dr. Christopher Ollson acknowledged Chief Medical Officer of Health (2010) "… didn't look at indirect effects …"
[xiv] A May 19, 2010 Chief Medical Officer of Health information sheet states: "It is possible that these symptoms are a result of annoyance with the noise."
[xv] NHMRC (2010) does not appear to specifically comment on "hearing impairment".
[xvi] NHMRC (2010) focuses on direct causal links and does not state noise from wind turbines "is not causally related to adverse effects".
[xvii] In 2012 when asked if the NHMRC is prepared to say that there are no health problems from the wind turbines the Chief Executive Officer of NHMRC, Professor Anderson, stated "…we have never been prepared to say that because it is very hard to rule things out …".

7.4 Appendix 4 – Literature review audit checklist

	Industrial Wind Turbine (IWT) Health Effects Literature Review Audit checklist	**Audit impact**
1.	Does the IWT Review conclude IWTs can harm humans if placed too close to residents?	Yes = + No = -
2.	When the authors are from a member state of the WHO does the IWT Review disclose health is: “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”? (Note: Australia, Canada, New Zealand, the United Kingdom and the United States of America are among the 194 WHO member states listed and by definition accept the WHO constitution.)	Yes = + No = -
3.	When the authors are from a member state of the WHO does the IWT Review disclose “The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.”?	Yes = + No = -
4.	Does the IWT Review apply an acceptable definition of health when the authors are not from a member state of the WHO?	Yes = + No = -
5.	Does the IWT Review fully evaluate both direct and indirect health effects?	Yes = + No = -
6.	Does the IWT Review identify the plausible causes of IWT health effects? i.e. unwanted sound (noise), visual impacts (shadow flicker), stray voltage and social economic impacts	Yes = + No = -
7.	Does the IWT Review disclose noise can seriously harm human health?	Yes = + No = -
8.	Does the IWT Review disclose the main health risks of noise? i.e. pain and hearing fatigue; hearing impairment including tinnitus; annoyance; interferences with social behaviour (aggressiveness, protest and helplessness); interference with speech communication; sleep disturbance and all its consequences on a long and short term basis; cardiovascular effects; hormonal responses (stress hormones) and their possible consequences on human metabolism (nutrition) and immune system; performance at work and school.	Yes = + No = -
9.	Does the IWT Review disclose IWTs produce sound which is perceived by humans to be more annoying than transportation noise or industrial noise at comparable sound pressure levels?	Yes = + No = -
10.	Does the IWT Review acknowledge annoyance to IWT noise starts at dBA sound pressure levels in the low 30’s and rises sharply at 35 dBA?	Yes = + No = -
11.	Does the IWT Review disclose annoyance is a health effect?	Yes = + No = -
12.	Does the IWT Review disclose annoyance can result in serious harm to human health?	Yes = + No = -
13.	Does the IWT Review disclose symptoms associated with noise annoyance include stress, sleep disturbance, headaches, difficulty concentrating, irritability, fatigue, dizziness or vertigo, tinnitus, anxiety, heart ailments, and palpitation?	Yes = + No = -

14.	Does the IWT Review disclose IWT Review authors, retained by two wind energy trade associations, report "Wind Turbine Syndrome" symptoms are the well-know stress effects of noise?	Yes = + No = -
15.	Does the IWT Review accurately disclose the expected prevalence of IWT health effects?	Yes = + No = -
16.	Does the IWT Review disclose that Health Canada propose IWT noise criteria which are predicted to result in an increase in percentage highly annoyed?	Yes = + No = -
17.	Does the IWT Review disclose that CanWEA member, HGC Engineering, concluded "The audible sound from wind turbines, at the levels experienced at typical receptor distances in Ontario, is nonetheless expected to result in a nontrivial percentage of persons being highly annoyed. As with sounds from many sources, research has shown that annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts in some persons."	Yes = + No = -
18.	Does the IWT Review disclose a non-trivial percentage of individuals exposed to wind turbine can be expect to be adversely affected (i.e. highly annoyed)?	Yes = + No = -
19.	Does the review accurately and appropriately cite the contents of references?	Yes = + No = -
20.	Does the IWT Review refrain from citing and relying on low quality references? i.e. internet blog postings, industry produced fact sheets,	Yes = + No = -
21.	Does the IWT Review disclose WHO noise guidelines are not designed for IWT noise?	Yes = + No = -
22.	Does the IWT Review disclose noise does not need to be considered loud to cause harm to human health?	Yes = + No = -
23.	Does the IWT Review disclose IWT sound characteristics which are identified as plausible causes for annoyance and/or other health effects? i.e. amplitude modulation (swooshing); audible low-frequency noise; infrasound; tonal noise, impulse noise; and night time noise.	Yes = + No = -
24.	Does the IWT Review disclose that modern IWTs routinely produce audible low frequency noise?	Yes = + No = -
25.	Does the IWT Review disclose that modern IWTs routinely produce audible amplitude modulation?	Yes = + No = -
26.	Does the IWT Review disclose that it is plausible inaudible IWT low frequency noise and/or infrasound could adversely affect humans?	Yes = + No = -
27.	Does the IWT Review fully disclose accurate IWT noise limits and regulations?	Yes = + No = -

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