

**Critique of the Dr. King Report,
The Potential Health Impact of Wind Turbines
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Notes on the Eleven Peer-Reviewed Journal References

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The King Report used a total of 40 references to provide its conclusion that “the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects”. The most important of these 40 were the 11 that were published in peer-reviewed journals. Below are the entire abstracts from all 11 of these references. Where an online version was available there’s a link to it. I’ve studied all of them (except Braam, since I don’t read Danish, and Keith, which I so far haven’t been able to obtain) and have added my comments.

Remember as you read through this that King used these references to build her case that there were no health effects from wind turbines – a surprising result when not one of these references was any sort of a health study in the first place, and there are other studies that she omitted that do contain evidence of health issues.

The King report is available at <http://windfarmrealities.org/wfr-docs/king-health-opinion.pdf> .

My postings on the King Report are available at <http://windfarmrealities.org/?p=404> and at <http://windfarmrealities.org/?p=535> .

Guidelines on the Environmental Risk of Wind Turbines in the Netherlands Braam[2004]

[all I could find was this English summary of the Handbook that King referenced, which was published in 2005 in Dutch]

Abstract:

A structural failure of a wind turbine might lead to loss of blade (or parts of it) and thus cause a risk to nearby people and property. In the Netherlands, more densely populated areas are considered to achieve the target set by the Dutch government of implementing 1.500 MW wind power onshore. Because of the public opinion locations close to highways, railways, canals or existing industrial zones are preferred. This development brings about that the risk of wind turbines for the environment becomes more significant as more people might be present near a wind turbine for a longer period. To deal with risks of wind turbine in a rational manner, a handbook with procedures for the risk assessment of wind turbines has been drawn up in order of NOVEM (the Netherlands Agency for Energy and the Environment) [1]. This paper discusses the contents of the handbook and the status of the handbook in the legal framework.

My Comments

This English summary (6 pages) is all I could find, and is available at:

<http://windfarmrealities.org/wfr-docs/braam-guidelines-2004.pdf>. This Handbook contains failure statistics of wind turbines and thus is a valuable tool for risk analysis. The King Report has one short paragraph (section 2.3, page 7) on structural hazards and concludes on page 8 that the Ontario noise (550 meter) setbacks are more than sufficient. Unfortunately, the 550 applies just to residences. Other parts of a neighbor's land (precluding building on it?) and more importantly public roads and railways are subject to just a blade length + 10 meter setback, which is even shorter than the height of a turbine – and which have been known to “fall over”. Apparently Dr. King either didn't know this or didn't think it important. Either way, her conclusions about public safety are not consistent with Ontario's regulations.

Infrasound Emission from Wind Turbines Jakobsen (2005)

Abstract

A critical survey of all known published measurement results of infrasound from wind turbines has been made. The survey indicates that wind turbines of contemporary design with an upwind rotor generate very faint infrasound with a level far below the threshold of perception even at a rather short distance. From considerations on propagation and transmission of infrasound it is concluded that infrasound from such upwind turbines can be neglected when evaluating the environment effects of wind turbines. Turbines with downwind rotors produce 10 – 30 dB higher infrasound levels, and these may exceed relevant assessment criteria for dwellings in the immediate neighbourhood. When longer distances are considered, neither downwind nor upwind turbines are capable of violating assessment criteria for infrasound. This paper considers whether other aspects of the noise than the infrasound can explain the indicated adverse public reactions to large downwind turbines.

My Comments

This paper is widely used by the wind industry in their efforts to dismiss and health effects of wind turbines, and Dr. King has continued that tradition. Jakobsen surveyed 3 earlier papers in an attempt to see if the infrasound produced by wind turbines was either above Denmark's limits or created annoyance. It is available at <http://windfarmrealities.org/wfr-docs/jakobsen-low-freq-noise.pdf>. He didn't do any field studies at all, either to measure noise levels or to interview neighbors. Jakobsen is not a medical doctor and makes no claims to have any clinical experience or knowledge whatever.

In spite of substantial and recognized inconsistencies among the 3 papers, he concluded that upwind turbines produced infrasound that was *far below relevant assessment criteria, including the limit of perception*. Jakobsen quickly dismisses the possibility of vibration/rattling (section 5.1) and indoor levels being higher than outdoor levels (section 4.3), both of which have been widely reported in defiance of his dismissals. The one sentence the wind industry has seized upon in any number of reports, parsing it to include all health issues, is: *Such low infrasound levels are unimportant for the evaluation of the environmental effects of wind turbines*.

In her report King uses Jakobsen as a reference for the point that *a small increase in sound level at low frequency can result in a large increase in perceived loudness*. What any of this has to do with any health issues is unclear.

A proposal for evaluating the potential health effects of wind turbine noise for projects under the Canadian Environmental Assessment Act

Keith, Michaud (2008)

Abstract

The Canadian Environmental Assessment Act (CEAA) requires certain projects with federal government triggers to undergo an environmental assessment before receiving federal government approval. On request under CEAA, Health Canada provides advice on the health effects of noise to responsible authorities for wind turbine projects. The advice that Health Canada provides on the health effects of noise is generally based only on well-accepted scientific evidence for a link between noise exposure and health. For quiet rural areas, in which annoyance reactions towards intruding noise may be augmented, this paper proposes noise mitigation if predicted wind turbine noise levels exceed 45 dBA at noise sensitive receptors. In this proposal, a cautious approach is adopted by using predicted noise levels that are evaluated at the wind speed that produces the highest wind turbine noise, and background noise is evaluated in calm winds. This accounts for sheltering by obstructions. Wind speed gradient effects related to stable atmospheric conditions are also accounted for with this approach. The proposal is based on predicted project-noise related changes in long-term high annoyance, rattle and sleep disturbance. Noise mitigation for wind turbine construction noise is proposed based on potential for expectation of complaints.

My Comments

This paper contains a regulatory proposal at the federal level. I have not yet been able to find this report, either online or in hard copy. Since it was written by industry players I doubt it contains anything of interest for our purposes.

The one project I know of that triggered the federal CEAA was Wolfe Island. I've studied Wolfe in detail, and even though the CEAA might have been triggered, Ottawa deferred to Ontario's process, effectively providing no environmental oversight at all. I've documented the details at <http://amherstislandwindinfo.com/wolfebirds.htm>. The results were predictable as the post-construction studies there have shown: <http://windfarmrealities.org/?p=358>. Aside from the lack of any health-related information in this paper, it is disingenuous to use a regulatory proposal to build your case when your employer will do everything in its power to circumvent that regulation.

In any event, this report has nothing to do with health issues – simply assuming that if the noise level is below 45dBA there are none. It was not used in the body of Dr. King's report.

Infrasound From Wind Turbines – Fact, Fiction or Deception Leventhall (2006)

Abstract

Infrasound is discussed in terms of what it actually is, how the media has dealt with it and what those with limited knowledge say about it. The perception of infrasound occurs at levels higher than the levels produced by wind turbines and there is now agreement amongst acousticians that infrasound from wind turbines is not a problem. Statements on infrasound from objectors are considered and it is shown how these may have caused avoidable distress to residents near wind turbines and also diverted attention from the main noise source, which is the repeating sound of the blades interacting with the tower. This is the noise which requires attention, both to reduce it and to develop optimum assessment methods.

My Comments

This paper is widely used by the wind industry in their efforts to dismiss any health effects of wind turbines, and Dr. King has continued that tradition – using it 4 times. However its main point has nothing whatever to do with health. Leventhall is convinced that the term “infrasound” (which Leventhall thinks occupies *a special position in the nation psyche*) has been misused in an effort to make wind turbines scarier than they should be, when it is audible noise we should be concerned with. The article is available at <http://windfarmrealities.org/wfr-docs/leventhall-canacoustics.pdf> . The one sentence the wind industry uses, parsing it to include all health effects, is: *Infrasound from wind turbines is below the audible threshold and of no consequence.*

For this paper Leventhall didn't go into the field at all, took no measurements, interviewed no neighbors, looked at no medical records. Leventhall is not a medical doctor and makes no claims to have any clinical experience or knowledge whatever. What any of this has to do with any health issues is unclear.

For a nice summary of this article's deficiencies, go to <http://www.algonquinadventures.com/waywardwind/misreps.htm> .

Living in the Vicinity of Wind Turbines – A Grounded Theory Study **Pedersen, Hallberg, Waye (2007)**

Abstract

Little is known of wind turbines' impact on people living in their vicinity. The aim of this study was to gain a deeper understanding of how people perceive and are affected by wind turbines in their living environment. In-depth interviews with 15 informants, strategically chosen to form a heterogeneous group, were analyzed using the constant comparative method of grounded theory. The informants were to different extents affected by the swishing noise, flickering light, and constant movement of the turbines' rotor blades. Some informants perceived the exposures as *outside their territory* while others perceived them as *intrusion into privacy*; a divergence partly determined by the informants' *personal values about the living environment*. The feeling of intrusion was associated with feeling *a lack of control, subjected to injustice, a lack of influence, and not being believed*. Informants used various coping strategies, such as rebuilding their houses or complaining, but mainly tried to ignore exposures from the wind turbines. The findings can help us to better understand the severe reactions wind turbines sometimes evoke and contribute to the knowledge base used when planning for new wind farms.

My Comments

I was unable to obtain this study online, but did get a hard copy from my friendly library. It is not used in the body of Dr. King's report. In it Dr. Pedersen went into the field and personally interviewed 15 neighbors, identified from earlier studies. Her goal was to try to understand why the reactions to wind turbines were so strong, given the relatively low amount of noise they produce. *The base of that fear [of the neighbors about wind turbines] is not easily understood, as the audible and visual levels from wind turbines are low compared to those known to generate annoyance with other sources, such as road traffic.* Dr. Pedersen has authored a number of papers that try to reconcile the low level of turbine noise with the relatively high level of complaints and this was one of those papers.

In any event, in this study there were no questions on health issues, no exams, no records looked at. How this paper contributed to Dr. King's conclusions is not clear.

The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines

Pedersen, Larsman (2008)

Abstract

Wind turbines are highly visible objects and the response to wind turbine noise is possibly influenced by visual factors. In this study, visibility of the noise source, visual attitude and vertical visual angle (VVA) in different landscapes were explored. Data from two cross-sectional field studies carried out among people living near wind turbines ($n=1095$) were used for structural equation modelling. A proposed model of the influence of visual attitude on noise annoyance, also comprising the influence of noise level and general attitude, was tested among respondents who could see vs. respondents who could not see wind turbines from their homes, living in flat vs. hilly/rocky terrain, and living in built-up vs. rural areas. Visual attitude towards the noise source was associated with noise annoyance to different degrees in different situations. A negative visual attitude, more than multi-modal effects between auditory and visual stimulation, enhanced the risk for noise annoyance and possibly also prevented psychophysiological restoration possibilities. Aesthetic evaluations of the noise source should be taken into account when exploring response to environmental noise.

My Comments

I couldn't find this study online, so I obtained it in hardcopy and read through it. This paper is a follow-up to the 2005 Swedish survey of 754 neighbors (the 2nd of 3 studies as discussed below), and was a further exploration of the idea that either visually-related attitudes and/or general attitudes towards turbines along with the noise influenced the perception of annoyance. The visual aspects seemed to affect their level of annoyance while their general attitude did not. Health issues were not studied or discussed at all. Dr. King did not reference this paper in her report. How this paper contributed to Dr. King's conclusions is not clear.

Wind turbines—low level noise sources interfering with restoration? Pedersen, Waye (2008)

Abstract

Wind turbines generate a low level noise and would thus not be expected to cause annoyance and disturb rest. In a society where people are being exposed to an increasing noise load, moderate and low level noise sources may also be perceived as annoying and hence inhibit restoration. This article presents an analysis of two socio-acoustic studies of wind turbine noise with the emphasis on perception, annoyance and consequences for restoration. It is hypothesized that low and moderate stressors such as wind turbine noise could have an impact on health. The risk seems to be higher if restoration is, or is perceived to be, impaired and also for certain groups of individuals. The observations warrant further studies.

My Comments

This and the next 3 references, which discuss the results of 3 studies in Europe, seem to form the backbone of Dr. King's research. The first two studies were done by Pedersen and Waye in Sweden in 2000 and 2005 and are covered in their 2004 and 2007 papers below. The third study was led by van den Berg in the Netherlands in 2007 and is summarized in Pedersen 2009 below. Dr. King mentions them in the Overview, section 2.1 and again in section 2.2.

This particular paper is a follow-up discussion of the Pedersen, Waye 2004 and 2007 papers and is available at: <http://windfarmrealities.org/wfr-docs/pedersen-waye-2008.pdf>. This paper presented a new hypothesis, that maybe the level of annoyance being reported was affected by the neighbors no longer regarding their homes as a place of restoration. It offered no new research or any conclusions; rather it framed a new line for potential new studies. Health issues were not studied or discussed at all.

Wind turbine noise, annoyance and self-reported health and well-being in different living environments

Pedersen, Waye (2007)

Abstract

Objectives: To evaluate the prevalence of perception and annoyance due to wind turbine noise among people living near the turbines, and to study relations between noise and perception/annoyance, with focus on differences between living environments.

Methods: A cross-sectional study was carried out in seven areas in Sweden across dissimilar terrain and different degrees of urbanisation. A postal questionnaire regarding living conditions including response to wind turbine noise was completed by 754 subjects. Outdoor A-weighted sound pressure levels (SPLs) were calculated for each respondent. Perception and annoyance due to wind turbine noise in relation to SPLs was analysed with regard to dissimilarities between the areas.

Results: The odds of perceiving wind turbine noise increased with increasing SPL (OR 1.3; 95% CI 1.25 to 1.40). The odds of being annoyed by wind turbine noise also increased with increasing SPLs (OR 1.1; 95% CI 1.01 to 1.25). Perception and annoyance were associated with terrain and urbanisation: (1) a rural area increased the risk of perception and annoyance in comparison with a suburban area; and (2) in a rural setting, complex ground (hilly or rocky terrain) increased the risk compared with flat ground. Annoyance was associated with both objective and subjective factors of wind turbine visibility, and was further associated with lowered sleep quality and negative emotions.

Conclusion: There is a need to take the unique environment into account when planning a new wind farm so that adverse health effects are avoided. The influence of area-related factors should also be considered in future community noise research.

My Comments

All I could find online was an earlier report, available at <http://windfarmrealities.org/wfr-docs/pedersen-different-2006.pdf>. It covers the same 2005 Swedish study - the 2nd of the 3 main studies that Dr. King referenced. There were 765 respondents and the main thrust of the study was to more closely examine the effects of different living environments on annoyance, as the 1st study in 2000 was done in flat terrain.

I obtained the quite different referenced report in hard copy. One part of the questionnaire asked about general health and well-being. No relation to the noise levels was found, except for sleep disruption. That was as far as their analysis went – no physical exams were made, no detailed questions were asked, no medical records checked, no follow-up of any kind. Perhaps this is where Dr. King concluded there's no health effects, but it is very thin gruel, convincing only to someone who was determined to be convinced.

In the 7 areas there were a total of 28 turbines with a combined capacity of 14MW, with 3 of the sites having just 1 turbine. Compared to current Ontario projects, this is trivially small. No wonder the percentages of those who were annoyed were quite low, from 6% at 35dBA up to 15% at 40 – and it's these number King quotes, conveniently omitting the higher numbers from the other two studies.

Response to noise from modern wind farms in The Netherlands

Pedersen, van den Berg (2009)

Abstract

The increasing number and size of wind farms call for more data on human response to wind turbine noise, so that a generalized dose-response relationship can be modeled and possible adverse health effects avoided. This paper reports the results of a 2005 field study in The Netherlands with 725 respondents. A dose-response relationship between calculated A-weighted sound pressure levels and reported perception and annoyance was found. Wind turbine noise was more annoying than transportation noise or industrial noise at comparable levels, possibly due to specific sound properties such as a “swishing” quality, temporal variability, and lack of nighttime abatement. High turbine visibility enhances negative response, and having wind turbines visible from the dwelling significantly increased the risk of annoyance. Annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study further demonstrates that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, despite exposure to similar sound levels. Response to wind turbine noise was similar to that found in Sweden so the dose-response relationship should be generalizable.

My Comments

This is the *WINDFARMperception* study and is the 3rd of 3 main studies that make up the backbone of Dr. King’s references. It was led by van den Berg in the Netherlands in 2007. Three reports came out of it:

- (1) Pedersen’s summary (6 pages) which is referenced above and is available at <http://windfarmrealities.org/wfr-docs/pedersen-response-netherlands-2009.pdf> and
- (2) van den Berg’s summary (3 pages) which is available at <http://windfarmrealities.org/wfr-docs/vandenberg-umcg-2008-summ.pdf> and
- (3) van den Berg’s full report (99 pages) which is available at <http://windfarmrealities.org/wfr-docs/vandenberg-umcg-2008-full.pdf>.

Dr. King didn’t reference the full study in the body of her paper, but she did include it in the “Grey Literature” section so I assume she has read it. Like the Swedish studies (and some of the same researchers worked on both) this study primarily measured annoyance and had a handful of general health-related questions in their questionnaire. And like the Swedish studies, they found no evidence of health issues, except for sleep disturbance. At least there were a few larger turbines by this time (358 gt 1.0MW vs. 698 lt 1.0MW), but no projects as large as what is found in Ontario. This study had a common failing with the Swedish studies in that the noise levels were modeled in a simple isotropic fashion.

One result that has received much notice in the industry is that those who had an economic interest in the turbines were almost never annoyed by them. Another result is that those with a negative opinion of the turbines had a higher level of annoyance. The implications are that the levels of annoyance have little to do with the noise itself, that maybe jealousy and dislike of all things new may be the bigger culprits. While these implications are convenient for the wind industry, an actual reading of the

paper reveals that van den Berg had more plausible explanations. Why are the participants not annoyed? It may be because some unknown number (potentially all) of them can turn the turbines off when they get too loud. Why the negative opinion? Maybe the cause and effect are reversed, with the turbines causing the negative opinions, not the industry's preferred other way around. For whatever reason van den Berg doesn't further investigate either of these.

Still, van den Berg is a competent and intelligent researcher and although he didn't (to my mind) make enough of an effort to avoid having his work misused by the wind industry, he did leave a few interesting tidbits. One of those was a summary of the annoyance levels discovered by the three studies, eliminating the participants. Here's the chart:

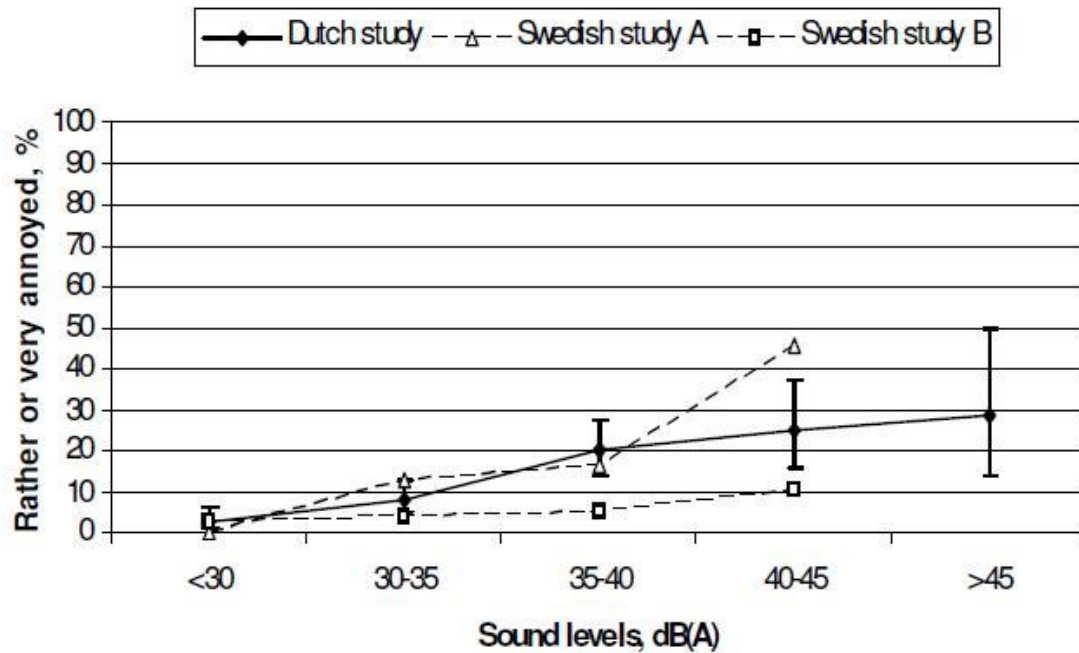


Figure G.2. Annoyance with wind turbine sound; comparisons between the Dutch study (only respondents that did not benefit economically) and the Swedish studies A and B (with 95% CI for the Dutch study).

In the King Report it was stated that “approximately 4 to 10 per cent were very annoyed at sound levels between 35 and 45 dBA”. That certainly is parsed pretty carefully, isn't it? The chart above tells the real story.

Perception and annoyance due to wind turbine noise—a dose–response relationship

Pedersen, Wayne (2004)

Abstract

Installed global wind power increased by 26% during 2003, with U.S and Europe accounting for 90% of the cumulative capacity. Little is known about wind turbines' impact on people living in their vicinity. The aims of this study were to evaluate the prevalence of annoyance due to wind turbine noise and to study dose–response relationships. Interrelationships between noise annoyance and sound characteristics, as well as the influence of subjective variables such as attitude and noise sensitivity, were also assessed. A cross-sectional study was performed in Sweden in 2000. Responses were obtained through questionnaires ($n = 351$; response rate 68.4%), and doses were calculated as A-weighted sound pressure levels for each respondent. A statistically significant dose–response relationship was found, showing higher proportion of people reporting perception and annoyance than expected from the present dose–response relationships for transportation noise. The unexpected high proportion of annoyance could be due to visual interference, influencing noise annoyance, as well as the presence of intrusive sound characteristics. The respondents' attitude to the visual impact of wind turbines on the landscape scenery was found to influence noise annoyance.

My Comments

This paper discussed the 1st of the 3 major studies that Dr. King references. It was done in Sweden in 2000. Questionnaires were sent out to 531 neighbors who were presumed to be subjected to wind turbine noise above 30dBA. 351 of them responded, and their answers constitute the backbone of the study. The study is available at: <http://windfarmrealities.org/wfr-docs/pedersen-waye-2003.pdf> .

The 5 areas covered by this study had a total of 16 turbines, with a combined capacity of about 8MW. In Ontario projects it isn't uncommon for one home to have that much capacity within earshot. One recognized weakness was that the noise levels were never measured, but were modeled instead.

Two figures from this study should be noted. First, there were 128 respondents with exposures above 35dBA. Of these, 29 (23%) reported being either “rather annoyed” or “very annoyed”. Second, of that same population 20 (16%) reported sleep disturbances from the wind turbines.

There were several general questions on health topics, but no trends were statistically significant (and given the small numbers a finding of significance would be really noteworthy) and there was no further discussion about them. The questions themselves were not even included in the appendix with the other questions. One other notable result of this study was that wind turbine noise is much more annoying than other types of industrial noise. This was a study of annoyance, not health.

Effects of the wind profile at night on wind turbine sound van den Berg (2004)

Abstract

Since the start of the operation of a 30 MW, 17 turbine wind park, residents living 500 m and more from the park have reacted strongly to the noise; residents up to 1900 m distance expressed annoyance. To assess actual sound immission, long term measurements (a total of over 400 night hours in 4 months) have been performed at 400 and 1500 m from the park. In the original sound assessment a fixed relation between wind speed at reference height (10 m) and hub height (98 m) had been used. However, measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference wind speed in daytime. Moreover, especially at high rotational speeds the turbines produce a ‘thumping’, impulsive sound, increasing annoyance further. It is concluded that prediction of noise immission at night from (tall) wind turbines is underestimated when measurement data are used (implicitly) assuming a wind profile valid in daytime.

My Comments

http://windfarmrealities.org/wfr-docs/vandenberg_windnoise.pdf . This paper is not referenced in the body of the King report. It was this paper that revealed the problems with allowing higher levels of noise from the turbines in windier conditions. This “masking” provision assumed that the wind at ground level would make enough noise to mask the noise from the turbines, thus allowing the turbines to be placed closer to homes. Van den Berg showed that especially at night the atmosphere becomes more stable, allowing wind speeds at the hub to be much greater than at the ground, so the turbines produce a lot of noise with no masking. This paper led indirectly to Ontario coming out with the 2008 Interpretation, which redid their noise regulations to better reflect the reality.

None of this has anything to do with health. Why this reference was included in the King report is unclear.