Wind Turbines and Human Health: The Weight of Scientific Evidence

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Intrinsik Environmental Sciences, Inc. Mississauga, ON, Canada

State of Vermont Public Service Board Workshop, Tuesday July 29, 2014
Intrinsik’s Renewable Energy Health Team

- Environmental Health Scientists
  - 4 Ph.D.; 1 Ph.D. Candidate; 1 MD; 1 MPH

- Work with developers and regulators
  - human health experts (public forums, legal support)

- Academics
  - Published in the field (5 articles; 1 being submitted)
Health effects and wind turbines: A review of the literature

Loren D Knopper¹* and Christopher A Ollson²

Viewed >30,000 times
Ranks 9th most viewed 2013
Ranks 10th all time
Cited >40 times
Human Health and Wind Turbines

• Public attitude is generally overwhelmingly in favor of wind energy (Upham et al., 2009)
  – But does not always translate into local acceptance of projects

• Those opposed point to a number of issues concerning wind turbines

• Human health is commonly raised
  – a proportion of people that live near wind turbines self-report health effects they attribute to turbines
Human Health and Wind Turbines

• Self-reported symptoms generally included:
  – annoyance, sleep disturbance, tiredness, headache, tinnitus, irritability, nausea, lack of concentration

• This collection of effects is commonly called “Wind Turbine Syndrome” (Pierpont, 2009)

• The reason for the self-reported health effects is highly debated
Human Health – The Debate

Health effects related to wind turbine operation*

– Audible noise
– Low frequency noise
– Infrasound
– Shadow flicker

*often regardless of regulated setbacks

Health effects related to subjective issues**

– Attitude
– Visual cue
– Stress
– Expectations
– Economics

**based on proper noise setbacks
Human Health – The Debate

• Environmental noise above certain levels is a factor in a number of human health issues
  – e.g., hearing, sleep, myocardial infarction, annoyance

• Noise from wind turbines can be annoying to some and associated with sleep disturbance
  – especially when found at levels greater than 40 dB(A)
  – WHO (EU) night noise guideline

• Proper siting of wind turbines is key!
  – Even when noise limits are enforced it is possible that a segment of the population may remain annoyed (or report other health impacts)
# Human Health – The Debate

## Health effects related to wind turbine operation
- Fewer than 20 articles
- Vast majority published in one journal (B. Sci. Technol. Soc.)
- Authored by (e.g.,): Ambrose, Bronzaft, Hanning, Krough, McMurtry, Nissenbaum, Phillips, Salt, Shepherd, Thorne

## Health effects related to subjective issues
- Closer to 45 articles
- Published in a variety of journals
- Various authors (e.g.,): Bakker, Chapman, Crichton, Deignan, Janssen, Knopper, Ollson, O’Neal, Pedersen, Persson Waye, Turnbull, Taylor, Whitfield Aslund........
- Authors from wide and diverse affiliations
- Note: some supportive based on noise measurements
Weight of Scientific Evidence from ~60 Peer-Reviewed Articles

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level
Wind turbine noise, annoyance and self-reported health and well-being in different living environments

Eja Pedersen, Kerstin Persson Waye

Figure 1  Proportion of respondents who noticed sound from wind turbines outside their dwelling, in relation to A-weighted sound pressure levels in 2.5-dB intervals. Vertical bars indicate 95% confidence intervals; n, the total number of respondents in each interval.
Weight of Scientific Evidence

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level

2. A proportion of people that notice sound from wind turbines find it annoying
A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources

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\textbf{J. Acoust. Soc. Am. 130 (6), December 2011}

\begin{figure}
\centering
\begin{subfigure}{0.5\textwidth}
\centering
\includegraphics[width=\textwidth]{fig1_left}
\caption{(Color online) The exposure-response relationships between $L_{den}$ and the percentage of residents annoyed ($\%A$) and highly annoyed ($\%HA$) indoors (left) and outdoors (right).}
\end{subfigure}\hfill
\begin{subfigure}{0.5\textwidth}
\centering
\includegraphics[width=\textwidth]{fig1_right}
\end{subfigure}
\end{figure}
Wind turbine noise, annoyance and self-reported health and well-being in different living environments

Eja Pedersen, Kerstin Persson Waye

Figure 1. Proportion of respondents who noticed sound from wind turbines outside their dwelling, in relation to A-weighted sound pressure levels in 2.5-dB intervals. Vertical bars indicate 95% confidence intervals; n, the total number of respondents in each interval.

Figure 2. Proportion of respondents who were annoyed by sound from wind turbines outside their dwelling, in relation to A-weighted sound pressure levels in 2.5-dB intervals. Vertical bars indicate 95% confidence intervals; n, the total number of respondents in each interval.
Weight of Scientific Evidence

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level

2. A proportion of people that notice sound from wind turbines find it annoying

3. Noise-related annoyance from turbines can be within the range of existing levels of community noise related annoyance
Impact of Wind Turbine Noise in The Netherlands
Verheijen, E., Jabben, J., Schreurs, E., Smith, K.B

• “The percentage of severely annoyed at 45 dB [Lden] is rated at 5.2% for wind turbine noise, which is well below 10% that corresponds to the existing road and railway traffic noise limits”.

* Similar findings reported in Canada and UK
Weight of Scientific Evidence

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level.

2. A proportion of people that notice sound from wind turbines find it annoying.

3. Noise-related annoyance can be within the range of existing levels of community noise related annoyance.

4. Annoyance is not only related to wind turbine noise but also to subjective factors like attitude, visual cue, stress and expectations.
Perception and annoyance due to wind turbine noise—a dose–response relationship
Eja Pedersen and Kerstin Persson Waye
J. Acoust. Soc. Am. 116 (6), December 2004

Can Expectations Produce Symptoms From Infrasound Associated With Wind Turbines?
Fiona Crichton, George Dodd, Gian Schmid, Greg Gamble, and Keith J. Petrie
University of Auckland

Health Psychol. 2013 Nov 25. [Epub ahead of print]
The Power of Positive and Negative Expectations to Influence Reported Symptoms and Mood During Exposure to Wind Farm Sound.
Crichton F, Dodd G, Schmid G, Gamble G, Cundy T, Petrie KJ.

The Effects of Vision-Related Aspects on Noise Perception of Wind Turbines in Quiet Areas
Luigi Maffei, Tina Iachini, Massimiliano Masullo, Francesco Aletta, Francesco Sorrentino, Vincenzo Paolo Senese and Francesco Ruotolo
Int. J. Environ. Res. Public Health 2013, 10

The Pattern of Complaints about Australian Wind Farms Does Not Match the Establishment and Distribution of Turbines: Support for the Psychogenic, ‘Communicated Disease’ Hypothesis
Simon Chapman, Alexis St. George, Karen Waller, Vince Cakic
Sydney School of Public Health, University of Sydney, New South Wales, Australia
Weight of Scientific Evidence

1. People tend to notice sound from wind turbines almost linearly with increasing sound pressure level

2. A proportion of people that notice sound from wind turbines find it annoying

3. Noise-related annoyance can be within the range of existing levels of community noise related annoyance

4. Annoyance is not only related to wind turbine noise but also to subjective factors like attitude, visual cue, stress and expectations

5. People who economically benefit from wind turbines have significantly decreased levels of annoyance compared to individuals that received no economic benefit
Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress

R.H. Bakker a,* , E. Pedersen b, G.P. van den Berg c, R.E. Stewart d, W. Lok a,1, J. Bouma e

Table 4
Response to indoor wind turbine sound among economically benefitting and non-benefitting respondents.

<table>
<thead>
<tr>
<th>Response</th>
<th>Do not notice</th>
<th>Notice, not annoyed</th>
<th>Slightly annoyed</th>
<th>Rather annoyed</th>
<th>Very annoyed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>No economical benefit</td>
<td>394</td>
<td>68</td>
<td>98</td>
<td>17</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>Economical benefit</td>
<td>53</td>
<td>54</td>
<td>39</td>
<td>39</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 7
Sound sources of sleep disturbance in rural and urban area types, only respondents who did not benefit economically from wind turbines.

<table>
<thead>
<tr>
<th>Sound source of sleep disturbance</th>
<th>Rural</th>
<th>Urban</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Not disturbed</td>
<td>196</td>
<td>69.8</td>
<td>288</td>
</tr>
<tr>
<td>Disturbed by people/ animals</td>
<td>33</td>
<td>11.7</td>
<td>64</td>
</tr>
<tr>
<td>Disturbed by traffic/mechanical sounds</td>
<td>35</td>
<td>12.5</td>
<td>75</td>
</tr>
<tr>
<td>Disturbed by wind turbines</td>
<td>17</td>
<td>6.0</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>281</td>
<td>100</td>
<td>444</td>
</tr>
</tbody>
</table>
Weight of Scientific Evidence

• Based on the findings and scientific merit of the available studies, the weight of evidence suggests that when sited properly, wind turbines are not related to adverse health effects

• Government findings
  – National Health and Medical Research Council in Australia, 2010
  – Chief Medical Officer of Health (ON), May 2010
  – MassDEP and MDPH, 2012
  – Oregon Health Authority, 2013
  – National Health and Medical Research Council in Australia, 2014
Intrinsik’s Health Based Siting Recommendations — Knopper et al. 2014

1. Setbacks should be sound-based rather than distance-based alone.

2. Preference should be given to sound emissions of ≤40 dBA (outside, not including ambient) for non-participating individuals.

3. Post construction monitoring should be common place to ensure actual sound levels are within required noise limits.

4. If sound emissions from wind projects in the 40-45 dB(A) range for non-participating individuals, we suggest community consultation and community support.
5. Setbacks of >45 dB(A) (wind turbine noise only; not including ambient noise) for non-participating individuals directly outside a dwelling are not supported due to possible direct effects from audibility and possible levels of annoyance above background.

6. When ambient noise is taken into account, wind turbine noise can be >45 dB(A), but a combined wind turbine-ambient noise should not exceed >55 dB(A) for non-participating and participating individuals due to possible annoyance, sleep and cardiovascular effects.
Thank you

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