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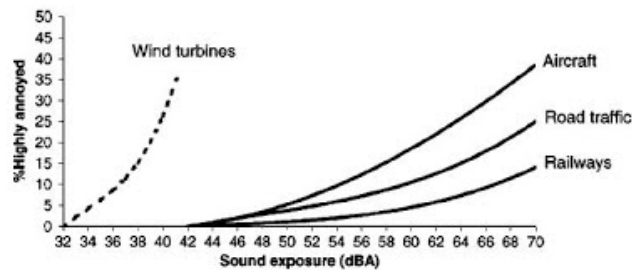
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## Annoyance and Wind Turbines

*"Annoyance with wind turbine noise was associated with psychological distress, stress, difficulties to fall asleep and sleep interruption."* [1]

Peer reviewed scientific articles based on studies of European wind turbine facilities have concluded that wind turbine noise is more annoying than equally loud noise sources such as airport and traffic noise. [2], [3], [4], [5] Annoyance is predominately attributed to the unique sound characteristics of wind turbine noise. Plausible causes include wind turbine amplitude modulation, audible low frequency noise, temporal variability, and lack of night time abatement. Shadow flicker and other visual impacts may also contribute to high annoyance levels.



Sound exposure is for wind turbines calculated A-weighted  $L_{eq}$  for a hypothetical time period and for transportation DNL.

**Source Pedersen, E. and K. Persson Waye. 2004. Perception and annoyance due to wind turbine noise: A dose-response relationship, Journal of the Acoustical Society of America 116: 3460-3470.**

"The sound level associated with wind turbines at common residential setbacks ... may lead to annoyance and sleep disturbance." [6] and evidence demonstrates "Annoyance and sleep disruption are common when sound levels are 30 to 45 dBA." [7]

The American Wind Energy Association and Canadian Wind Energy Association sponsored literature review entitled "Wind Turbine Sound and Health Effects" acknowledges wind turbine noise, including low frequency noise, may cause annoyance, stress and sleep disturbance and as a result people may experience adverse physiological and psychological symptoms.

[8]

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This wind industry sponsored literature review acknowledges the reported symptoms can be caused by wind turbine noise and states these "...symptoms are not new and have been published previously in the context of "annoyance" to environmental sounds .... The following symptoms are based on the experience of noise sufferers extending over a number of years: distraction, dizziness, eye strain, fatigue, feeling vibration, headache, insomnia, muscle spasm, nausea, nose bleeds, palpitations, pressure in the ears or head, skin burns, stress, and tension...." [\[9\]](#)

The symptoms listed in the wind industry literature review are consistent with international research and media reports documenting subjects exposed to wind turbines who are reporting adverse health effects. [\[10\]](#), [\[11\]](#), [\[12\]](#), [\[13\]](#), [\[14\]](#)

The health impact of annoyance must not be underestimated.

A coauthor of the wind industry sponsored "Wind Turbine Sound and Health Effects", W. David Colby, M.D., reinforced this position regarding wind turbine induced annoyance by stating

"We're not denying that there are people annoyed and that maybe some of them are getting stressed out enough about being annoyed that they're getting sick." [\[15\]](#)

Geoff Leventhall, another coauthor of the wind industry sponsored "Wind Turbine Sound and Health Effects", reportedly elaborated:

"... there was no doubt people living near the turbines suffered a range of symptoms, including abnormal heart beats, sleep disturbance, headaches, tinnitus, nausea, visual blurring, panic attacks and general irritability....it's ruining their lives – and it's genuine..." [\[16\]](#)

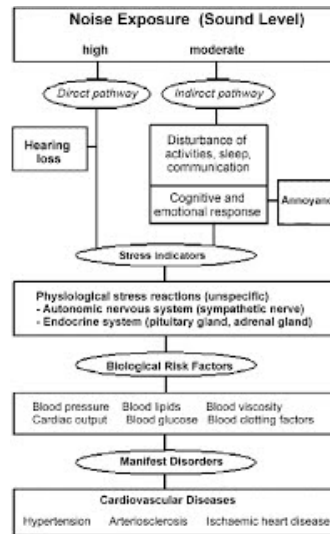
The word annoyance may mean different things to different people however in clinical terms annoyance is acknowledged to be a risk to human health.

Peer reviewed articles and other references acknowledge annoyance to be an adverse health effect.[\[17\]](#),[\[18\]](#), [\[19\]](#), [\[20\]](#)

Regarding noise induced annoyance the US Environmental Protection Agency states "... "annoyance" can have major consequences, primarily to one's overall health." [\[21\]](#)

A World Health Organization study "...confirmed, on an epidemiological level, an increased health risk from chronic noise annoyance." [\[22\]](#)

Noise induced annoyance contributes to stress, [\[23\]](#) sleep disturbance [\[24\]](#) and an increased risk of regulation diseases. [\[25\]](#)



**Noise effects reaction scheme Source: Babisch, 2002. from World Health Organization, Night Noise Guidelines for Europe, 2009**

Annoyance may adversely affect physiological health. Research indicates that for “chronically strong annoyance a causal chain exists between the three steps health – strong annoyance – increased morbidity.” [26]

The subjective experience of noise stress can, through central nervous processes, lead to an inadequate neuro-endocrine reaction and finally to regulation diseases. [27]

“Adults who indicated chronically severe annoyance by neighbourhood noise were found to have an increased health risk for the cardiovascular system and the movement apparatus, as well as an increased risk of depression and migraine...With children the effects of noise-induced annoyance from traffic, as well as neighbourhood noise, are evident in the respiratory system.” [28] Peer reviewed studies have consistently concluded that wind turbine noise is more annoying than equally loud traffic noise. [29], [30], [31], [32]

To protect against adverse health effects noise level limits “...should be based on annoyance responses to noise.” [33]

“Dose-response relations for different types of traffic noise (air, road and railway) clearly demonstrate that these noises can cause different annoyance effects at equal LAeq,24h values.” [34] Currently there is no health based generalized dose-response relationship developed to avoid possible adverse health effects from wind turbine noise exposure. [35]

“The need for guidelines for maximum exposure to wind turbine noise is urgent.” [36]

Wind turbine visual effects such as shadow flicker may also cause visually induced adverse health effects such as annoyance and/or stress. [37], [38], [39], [40], [41], [42], [43], [44]

## Conclusions

Based on the best available science the following conclusions can be made

- The main conclusion of peer reviewed scientific studies state noise from wind turbines is more annoying than noise from most other sources at comparable sound levels. This annoyance is predominately attributed to the unique sound characteristics of wind turbine noise.
- Noise induced annoyance is an adverse health effect which can result in stress, sleep disturbance and an increased risk of regulation diseases.
- Possible symptoms of wind turbine noise induced annoyance include distraction, dizziness, eye strain, fatigue, feeling vibration, headache, insomnia, muscle spasm, nausea, nose bleeds, palpitations, pressure in the ears or head, skin burns, stress, and tension. These symptoms are consistent with international research and media reports documenting subjects exposed to wind turbines who are reporting adverse health effects.
- The audible sound from wind turbines, at the levels experienced at typical receptor distances is expected to result in an unacceptable percentage of persons being highly annoyed.
- Exposure to wind turbines may also visually induce adverse health effects. It is acknowledged wind turbine shadow flicker may cause annoyance and/or stress.
- Wind turbines must be sited to protect humans from the adverse health effect of visually induced annoyance as well as noise induced annoyance.

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