

Wind Turbine Siting
Protection of Public Health & Safety

Christopher Ollson, PhD
Ollson Environmental Health Management

Robert McCunney, MD, MPH, MS
Brigham and Women's Hospital, Boston

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Dr. Ollson Qualifications

- Doctorate in Environmental Health Science
- Over 25 years in international environmental risk assessment and health consulting
- Owner of Ollson Environmental Health Sciences for the past 10 years
- Adjunct Professor University of Toronto
- 15 years of researching potential health impacts for those living in proximity to renewable energy and transmission lines
- Published 6 scientific peer reviewed papers on the topic.
- Testified before numerous county commissions, state hearings, and court cases as a qualified expert in the field
- Involved in over 25 GW of renewable energy projects across 26 States.
- Consultant of record for State of Vermont during wind siting rule making and appeared before Senate Committees in Kansas, North Dakota and Indiana

Dr. McCunney Qualifications

- Physician with specialty training in internal medicine and board certified in occupational and environmental medicine.
- Practicing physician in the Pulmonary Division of the Brigham and Women's Hospital (BWH) in Boston and a member of the Harvard Medical School faculty.
- Previously the Director of Environmental Medicine at the Massachusetts Institute of Technology (MIT).
- Past president of the American College of Occupational and Environmental Medicine (ACOEM),
- Expert panel that developed a 'white paper' entitled "Wind Turbine Sound and Health Effects: an expert panel review. (Colby et al, 2009)
- As a research scientist in Biological Engineering at MIT, was lead author of a critical review of the world's scientific literature regarding wind turbines and health. (McCunney et al, 2014)
- lead author of a publication related to potential health implications of living near wind turbines. (McCunney RJ et al. 2015)
- Have testified as an expert in numerous wind turbine hearings in US and Canada.

Establishing Wind Turbine Siting Guidelines

- There is no question that establishing wind siting guidelines can be a challenging undertaking.
- There is now >20 years and >150 peer-reviewed scientific and engineering research articles and government publication in this area.
- Emotions often run high during the process.
- Siting criteria for sound, shadow flicker and safety (blade failure, tower collapse, ice throw, fire) should be set based on experience, science and engineering principles.

Importance of Peer-Review Evidence

- The fundamental tenant of setting any environmental standards (soil quality, drinking water, air quality) is that they be based on the weight of peer-reviewed scientific and engineering evidence.

- The peer-review process is not perfect:
  - No single paper can provide the "smoking gun" answer to question at hand.
  - Many "pay to play journals" now exist. They are not of the same caliber or scientific rigor as those journals indexed in credible databases.
  - The primary database for source of credible scientific journals in this field is the National Library of Medicine – PubMed

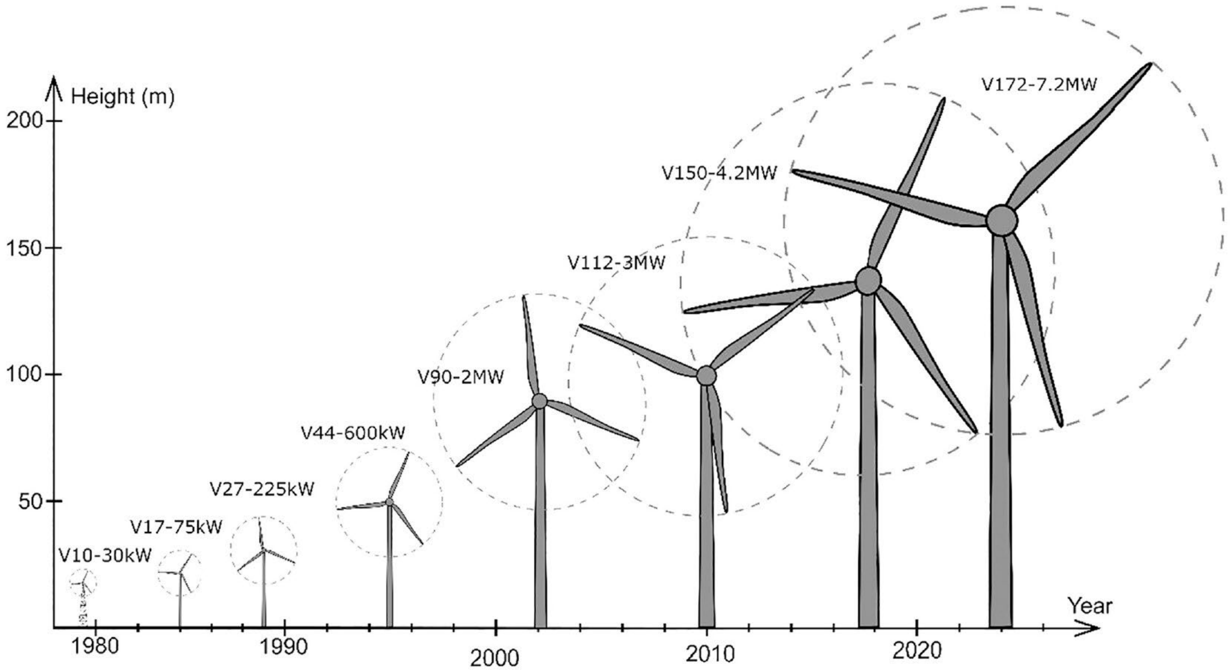
- There are also a number of government agency "white papers" that contain valuable information that isn't always peer-reviewed.

- Although a paper may be peer-reviewed it still needs to be scrutinized and considered against the weight of scientific evidence.

Weight of Cumulative Scientific Evidence

- Science is cumulative.
- Although a paper may have been published over a decade ago it will still contain valuable information.
  - In 2011, there were approximately 15 credible peer-reviewed wind publications. They were primarily from European academics that initiated the field of study. (Knopper and Ollson, 2011)
  - There was an explosion of research since 2015 from academics, consultants, and government research from around the globe (United States, Canada, Australian, United Kingdom and Europe.
  - There are now over 150 peer-reviewed credible scientific papers published in this field.
- During this time many State Utilities Commissions (e.g., North Dakota, South Dakota, Wisconsin, Minnesota, New York) held hearings for numerous wind projects and heard expert testimony from both sides. The findings of these commissions has also become important.

Wind Turbine Height has Increased



- Over the years wind turbines have increased in size.
- Typical tip height now ranges between 550 ft to 700 ft.
- However, sound output has typically remained the same or quieter than smaller turbines.
- Key is having a setback multiplier on total height of the wind turbine to features such as property lines, homes, roads, etc..

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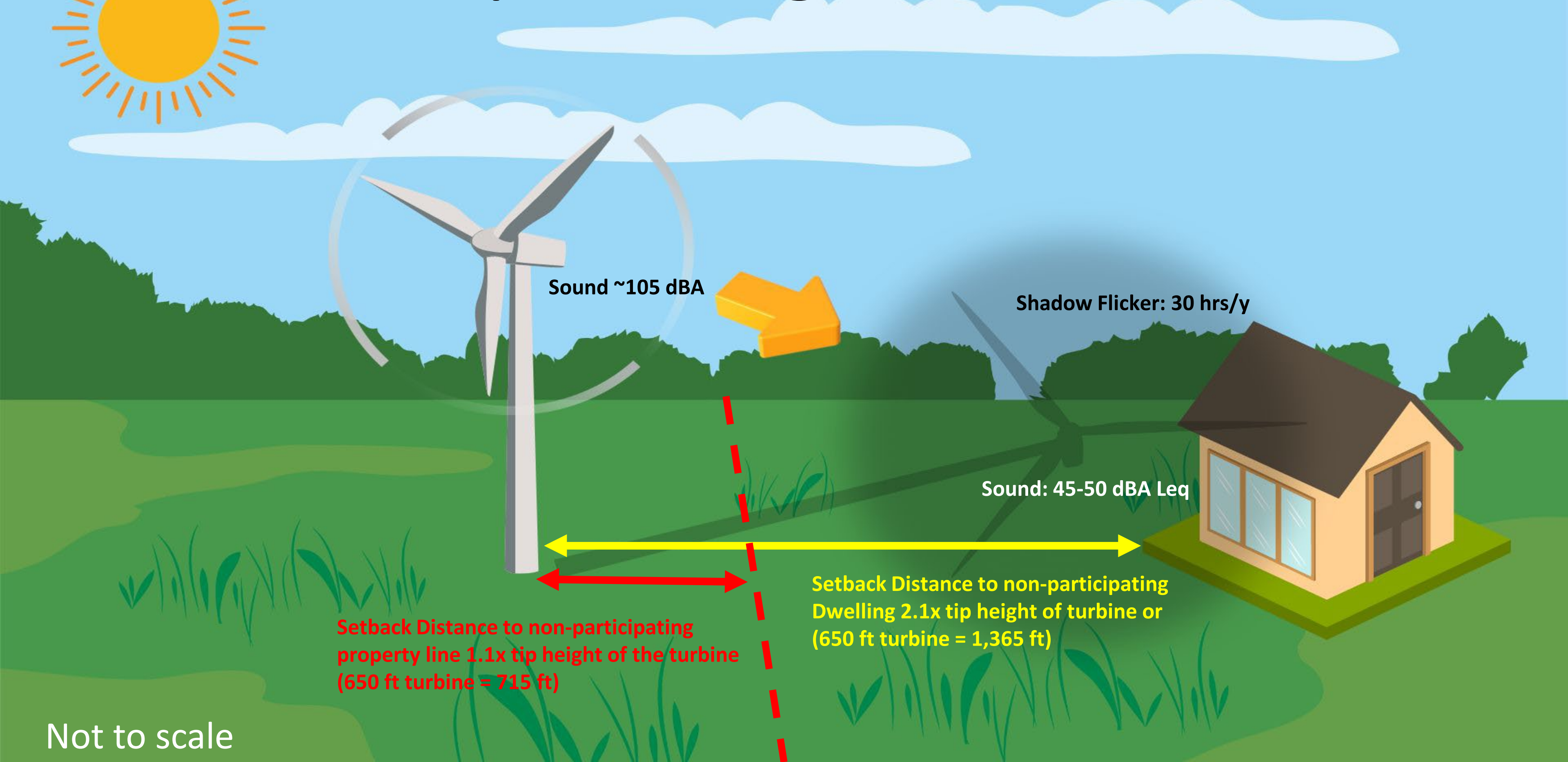
>75,000 Wind Turbines in United States
>1,800 Washington State
58 Turbines in Whitman County

Proper Siting Considerations



Health Concerns Often Raised

- Includes concerns around:
  - **Annoyance / Quality of Life**
  - Audible Noise
  - Low Frequency Noise
  - Infrasound
  - Shadow Flicker
  - Ice Throw
  - Blade or System Failure
  - Stray Voltage
  - Electromagnetic Fields (EMF)

acoustics

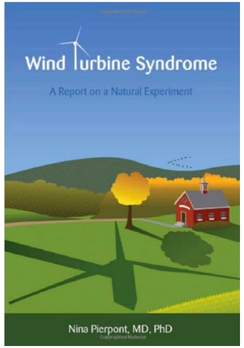
engineering

HEALTH

HEALTH CONSIDERATIONS

Where do the Question of Health Effects Come From – The Internet?

Wind Turbine Syndrome



VibroAcoustic Disease (VAD)

- These are self-published theories on wind turbines causing health impacts on people and livestock.
- They have not been accepted by the majority of scientists in the field, courts, or government agencies around the world.
- Public Utilities Commissions around the United States have reviewed this evidence for over a decade and found it not to be credible for purposes of developing siting guidelines.

Wind Turbine Sound Guidelines

- Sound levels of up to 45 - 50 dBA Leq at non-participating homes is common across the United States.

- **Washington Administrative Code (WAC) 173-60 Maximum Environmental Noise Levels** ensures 50 dBA at non-participating homes.

- Preconstruction sound modeling predictions should follow the ANSI/ACP 111-1 (2022) is the universal standard for modeling sound from wind turbines.

- Lmax (maximum sound level) is not an appropriate metric for environmental noise standards.

- Leq (average) of 10 minutes or 1 hour consistent with the modeling methodology from standard would be the appropriate metric and time duration for the ordinance.

- You can require post construction sound monitoring to ensure compliance.

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Largest study ever undertaken around the world for people living near wind turbines.

The following were not found to be associated with wind turbine noise:

a. self-reported sleep (e.g., general disturbance, use of sleep medication, diagnosed sleep disorders);

b. self-reported illnesses (e.g., dizziness, tinnitus, prevalence of frequent migraines and headaches) and chronic health conditions (e.g., heart disease, high blood pressure and diabetes); and

c. self-reported perceived stress and quality of life.

The overall conclusion to emerge from the study findings is that the study found no evidence of an association between exposure to WTN and the prevalence of self-reported or measured health effects.

Health Canada findings are supported by more recent US, Australian and European Studies.

SLEEP DURATION/SLEEP QUALITY

Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep

David S. Michaud, PhD[1]; Katya Feder, PhD[1]; Stephen E. Keith, PhD[1]; Sonia A. Voicescu, MSc[1]; Leonora Marro, MSc[2]; John Than, MSc[2]; Mireille Guay, MSc[2]; Allison Denning, MES[3]; Brian J. Murray MD, FRCP(C)D, ABSM[4]; Shelly K. Weiss, MD, FRCPC[5]; Paul J. Villeneuve PhD[6]; Frits van den Berg, PhD[7]; Tara Bower, MSc[8]

Exposure to wind turbine noise: Perceptual responses and reported health effects

David S. Michaud,[a] Katya Feder, Stephen E. Keith, and Sonia A. Voicescu
Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer and Clinical Radiation Protection Bureau, 775 Brookfield Road, Ottawa, Ontario K1A 1C1, Canada

Personal and situational variables associated with wind turbine noise annoyance

David S. Michaud,[a] Stephen E. Keith, Katya Feder, and Sonia A. Voicescu
Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer and Clinical Radiation Protection Bureau, 775 Brookfield Road, Ottawa, Ontario K1A 1C1, Canada

Self-reported and measured stress related responses associated with exposure to wind turbine noise

David S. Michaud,[a] Katya Feder, Stephen E. Keith, and Sonia A. Voicescu
Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer and Clinical Radiation Protection Bureau, 775 Brookfield Road, Ottawa, Ontario K1A 1C1, Canada

Contents lists available at ScienceDirect
Environmental Research

An assessment of quality of life using the WHOQOL-BREF among participants living in the vicinity of wind turbines

Katya Feder[a], David S. Michaud[a,*], Stephen E. Keith[a], Sonia A. Voicescu[a], Leonora Marro[b], John Than[b], Mireille Guay[b], Allison Denning[c], Tara J. Bower[d], Eric Lavigne[e],

Estimating annoyance to calculated wind turbine shadow flicker is improved when variables associated with wind turbine noise exposure are considered

Sonia A. Voicescu, David S. Michaud,[a] and Katya Feder
Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer & Clinical Radiation Protection Bureau, 775 Brookfield Road, Ottawa, Ontario K1A 1C1, Canada

Over 20 peer-reviewed publications from the study

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J. Acoust. Soc. Am. 139 (3), March 2016

Exposure to wind turbine noise: Perceptual responses and reported health effects

David S. Michaud,[a)] Katya Feder, Stephen E. Keith, and Sonia A. Voicescu
Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer and Clinical Radiation Protection Bureau, 775 Brookfield Road, Ottawa, Ontario K1A 1C1, Canada

Health Canada 2016

TABLE V. Sample profile of health conditions.

Variable *n* (%)	Wind turbine noise (dB) <25	[25–30)	[30–35)	[35–40)	[40–46]	Overall	CMH[a] *p*-value
n	84[b]	95[b]	304[b]	521[b]	234[b]	1238[b]	
Health worse vs last year [c]	17 (20.2)	12 (12.6)	46 (15.1)	90 (17.3)	51 (21.8)	216 (17.5)	0.1724
Migraines	18 (21.4)	24 (25.3)	56 (18.4)	134 (25.8)	57 (24.4)	289 (23.4)	0.2308
Dizziness	19 (22.6)	16 (16.8)	65 (21.4)	114 (21.9)	59 (25.2)	273 (22.1)	0.2575
Tinnitus	21 (25.0)	18 (18.9)	71 (23.4)	129 (24.8)	54 (23.2)	293 (23.7)	0.7352
Chronic pain	20 (23.8)	23 (24.2)	75 (24.8)	118 (22.6)	57 (24.5)	293 (23.7)	0.8999
Asthma	8 (9.5)	12 (12.6)	22 (7.2)	43 (8.3)	16 (6.8)	101 (8.2)	0.2436
Arthritis	23 (27.4)	38 (40.0)	98 (32.2)	175 (33.7)	68 (29.1)	402 (32.5)	0.6397
High blood pressure (BP)	24 (28.6)	36 (37.9)	81 (26.8)	166 (32.0)	65 (27.8)	372 (30.2)	0.7385
Medication for high BP	26 (31.3)	34 (35.8)	84 (27.6)	163 (31.3)	63 (27.0)	370 (29.9)	0.4250
Family history of high BP	44 (52.4)	49 (53.8)	132 (45.5)	254 (50.6)	121 (53.8)	600 (50.3)	0.6015
Chronic bronchitis/emphysema/COPD	3 (3.6)	10 (10.8)	17 (5.6)	27 (5.2)	14 (6.0)	71 (5.7)	0.7676
Diabetes	7 (8.3)	8 (8.4)	33 (10.9)	46 (8.8)	19 (8.2)	113 (9.1)	0.6890
Heart disease	8 (9.5)	7 (7.4)	31 (10.2)	32 (6.1)	17 (7.3)	95 (7.7)	0.2110
Highly sleep disturbed[d]	13 (15.7)	11 (11.6)	41 (13.5)	75 (14.5)	24 (10.3)	164 (13.3)	0.4300
Diagnosed sleep disorder	13 (15.5)	10 (10.5)	27 (8.9)	44 (8.4)	25 (10.7)	119 (9.6)	0.3102
Sleep medication	16 (19.0)	18 (18.9)	39 (12.8)	46 (8.8)	29 (12.4)	148 (12.0)	0.0083
Restless leg syndrome	7 (8.3)	16 (16.8)	37 (12.2)	81 (15.5)	33 (14.1)	174 (14.1)	
Restless leg syndrome (ON)	4 (6.7)	15 (17.4)	27 (11.0)	78 (17.3)	28 (16.5)	152 (15.0)	0.0629[e]
Restless leg syndrome (PEI)	3 (12.5)	1 (11.1)	10 (16.9)	3 (4.2)	5 (7.8)	22 (9.7)	0.1628[e]
Medication anxiety or depression	11 (13.1)	14 (14.7)	35 (11.5)	59 (11.3)	23 (9.8)	142 (11.5)	0.2470
QoL past month[f]							
Poor	9 (10.8)	3 (3.2)	21 (6.9)	29 (5.6)	20 (8.6)	82 (6.6)	0.9814
Good	74 (89.2)	92 (96.8)	283 (93.1)	492 (94.4)	213 (91.4)	1154 (93.4)	
Satisfaction with health[f]							
Dissatisfied	13 (15.5)	13 (13.7)	49 (16.1)	66 (12.7)	36 (15.4)	177 (14.3)	0.7262
Satisfied	71 (84.5)	82 (86.3)	255 (83.9)	455 (87.3)	198 (84.6)	1061 (85.7)	

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Health Canada 2021

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Sleep Research Society®
SLEEPJ, 2021, 1–12

doi: 10.1093/sleep/zsab070
Advance Access Publication Date: 26 March 2021
Original Article

Sleep actigraphy time-synchronized with wind turbine output

David S. Michaud[1,*], Stephen E. Keith[1], Mireille Guay[2], Sonia Voicescu[3], Allison Denning[1] and James P. McNamee[1]

[1]Health Canada, Environmental and Radiation Health Sciences Directorate, Consumer & Clinical Radiation Protection Bureau, Ottawa, ON, Canada, [2]Health Canada, Population Studies Division, Biostatistics Section, Ottawa, ON, Canada and [3]University of Victoria, School of Environmental Studies, Victoria, BC, Canada

Overall results showed that wind turbine SPL below 45 dBA was not associated with any consequential changes in actigraphy-measured sleep.

Australia 2022

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Sleep Research Society®

SLEEPJ, 2022, 1–11

https://doi.org/10.1093/sleep/zsab283
Advance Access Publication Date: 12 December 2021
Original Article

The effect of wind turbine noise on polysomnographically measured and self-reported sleep latency in wind turbine noise naïve participants

Tessa Liebich[1,2,*], Leon Lack[2], Gorica Micic[2], Kristy Hansen[3], Branko Zajamšek[2], Claire Dunbar[1,2], Bastien Lechat[2], Hannah Scott[2], Nicole Lovato[2], Felix Decup[3], Duc Phuc Nguyen[3] and Peter Catcheside[2]

[1]College of Education, Psychology and Social Work, Flinders University, Adelaide, Australia, [2]Flinders Health and Medical Research Institute for Sleep, Adelaide Institute for Sleep Health, College of Medicine and Public Health, Flinders University, Adelaide, Australia and [3]College of Science and Engineering, Flinders University, Adelaide, Australia

Results: Linear mixed model analysis revealed no differences in objective or subjective sleep latency between the WTN versus control nights.

Netherlands 2021

International Journal of *Environmental Research and Public Health*

MDPI

Review

Health Effects Related to Wind Turbine Sound: An Update

Irene van Kamp [1,*] and Frits van den Berg [2]

[1] National Institute for Public Health and the Environment, 3721 MA Bilthoven, The Netherlands
[2] Mundonovo Sound Research, 9953 PH Baflo, The Netherlands; frits@mundonovo.nl

Int. J. Environ. Res. Public Health **2021**, *18*, 9133. https://doi.org/10.3390/ijerph18179133 https://www.mdpi.com/journal/ijerph

We can conclude that a clear association with wind turbine related sound levels cannot be confirmed.

United States 2019

J. Acoust. Soc. Am. **146** (2), August 2019 0001-4966/2019/146(2)/1124/18/$30.00

Wind turbine audibility and noise annoyance in a national U.S. survey: Individual perception and influencing factors

T. Ryan Haac,[a] Kenneth Kaliski, and Matthew Landis
RSG, 55 Railroad Row, White River Junction, Vermont 05001, USA

Ben Hoen and Joseph Rand
Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, California 94720, USA

Jeremy Firestone
College of Earth, Ocean, and Environment, University of Delaware, Newark, Delaware 19716, USA

Debi Elliott
Survey Research Lab, Portland State University, Portland, Oregon 97207, USA

Gundula Hübner[b] and Johannes Pohl[b]
Institute of Psychology, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany

The results suggest that wind turbine noise annoyance is mostly an expression of personal experience and visual perceptions rather than an objective response to wind turbine sound level.

Environment International 132 (2019) 105090

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

United States 2019

Monitoring annoyance and stress effects of wind turbines on nearby residents: A comparison of U.S. and European samples

Gundula Hübner[a,b], Johannes Pohl[a,b,*], Ben Hoen[c], Jeremy Firestone[d], Joseph Rand[c], Debi Elliott[e], Ryan Haac[f]

[a] Institute of Psychology, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany
[b] Department of Psychology, MSH Medical School Hamburg, University of Applied Science and Medical University, Hamburg, Germany
[c] Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[d] College of Earth, Ocean, and Environment, University of Delaware, Newark, DE, USA
[e] Regional Research Institute for Human Services (RRI), Portland State University, Portland, OR, USA
[f] Resource Systems Group Inc., White River Junction, VT, USA

- Objective indicators, such as the distance from the nearest turbine and sound pressure level modeled for each respondent, **were not** found to be correlated to noise annoyance.
- In all cases the annoyance levels were comparable to the levels associated with traffic noise.
- Our findings provide evidence that WT annoyance and related stress effects are not a widespread problem.

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Sleep Research Society®

SLEEP, 2024, 47, 1–8
https://doi.org/10.1093/sleep/zsad286
Advance access publication 6 November 2023
Perspective

Perspective

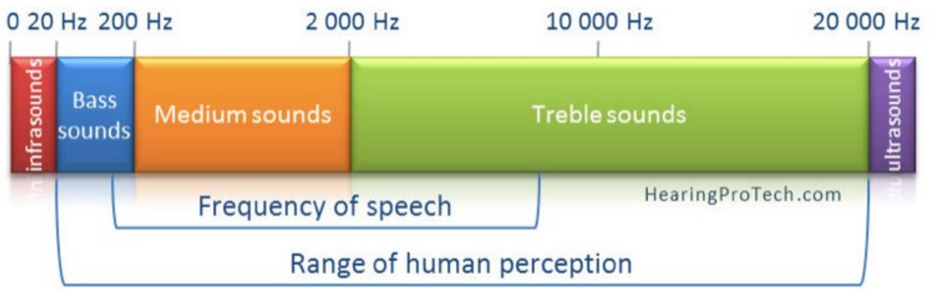
Noise-induced sleep disruption from wind turbines: scientific updates and acoustical standards

Jeffrey M. Ellenbogen[1,*], Colleen B. Kellam[2] and Michael Hankard[3]

United States 2024

- Examining scientific literature combined with biological plausibility and principles of acoustics, we conclude that modern wind turbines do not pose a risk to sleep when developed with reasonable restrictions.
- Though the upper limit is not established, noise from wind turbines measured outside the residence, up to 46 dBA (or modeled up to 49 dBA using the new standard [ANSI/ACP 111-1]), poses no risk to human sleep.
- Not at this audible range, nor its associated infrasound or low-frequency noise levels.

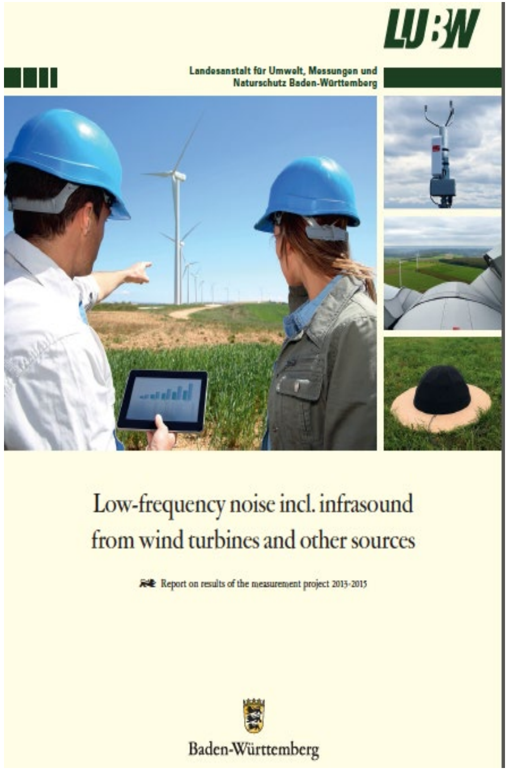
WHAT IS LOW FREQUENCY NOISE AND INFRASOUND

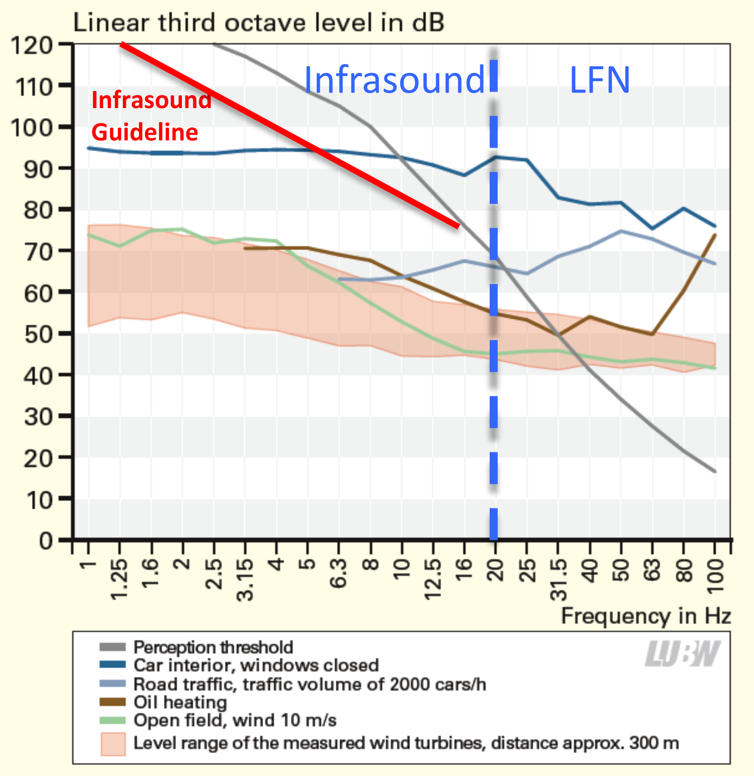


Scale of sound frequencies

Numerous studies confirm that infrasound and low frequency noise emitted from wind turbines is well below a level that would impact health or sleep.

German Wind Turbine Infrasound Study (2016)





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frontiers in
PUBLIC HEALTH

ORIGINAL RESEARCH ARTICLE
published: 24 February 2015
doi: 10.3389/fpubh.2015.00031

Health-based audible noise guidelines account for infrasound and low-frequency noise produced by wind turbines

Robert G. Berger[1], Payam Ashtiani[2], Christopher A. Ollson[3], Melissa Whitfield Aslund[3], Lindsay C. McCallum[3,4], Geoff Leventhall[5] and Loren D. Knopper[3]*

[1] Intrinsik Health Sciences Inc., Mississauga, ON, Canada
[2] Aercoustics Engineering Limited, Mississauga, ON, Canada
[3] Intrinsik Environmental Sciences Inc., Mississauga, ON, Canada
[4] Department of Physical and Environmental Sciences, University of Toronto, Toronto, ON, Canada
[5] H.G. Leventhall – Consultancy, Surrey, UK

Canada
2016

Over-all, the data from this and other studies suggest that health-based audible noise wind turbine siting standards (i.e., WAC 173-60 standard) provide an effective means to evaluate, monitor, and protect potential receptors from audible noise as well as Infrasound and Low Frequency Noise.

Appropriate Wind Turbine Sound Guidelines

Sound Standard 45 to 50 dBA Leq at non-participating residences and occupied community buildings will ensure the protection of residents' public health, safety and welfare.

Shadow Flicker

- Shadow flicker is an indoor phenomena only.
- Shadow flicker does not induce seizures (Smedley and Harding research from the UK).
  - Wind turbines quite simply don't rotate fast enough.
- Shadow flicker is not a health concern and has not been shown to cause disorientation, nausea, headaches or any other health impacts.
- Zero hours of shadow flicker at a home is not needed to protect public health.

No more than 30 hours a year of actual shadow flicker ensures a reduction of annoyance in neighbors and is almost the universal standard across the US.

Energy Research & Social Science 87 (2022) 102471

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Check for updates

United States 2022

In the shadow of wind energy: Predicting community exposure and annoyance to wind turbine shadow flicker in the United States

Ryan Haac [a], Ryan Darlow [b], Ken Kaliski [a], Joseph Rand [c], Ben Hoen [c,*]

[a] RSG, 55 Railroad Row, White River Junction, VT 05001, USA
[b] Vermont Environmental Research Associates, Inc., 30 Foundry Street, Waterbury, VT 05676, USA
[c] Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA

Conversely, SF annoyance was not significantly correlated with SF exposure. Rather, SF annoyance is primarily a subjective response to wind turbine aesthetics, annoyance to other anthropogenic sounds, level of education, and age of the respondent.

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McCallum *et al. Environmental Health* 2014, **13**:9
http://www.ehjournal.net/content/13/1/9

ENVIRONMENTAL HEALTH

RESEARCH **Open Access**

Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern?

Lindsay C McCallum[1,2], Melissa L Whitfield Aslund[2], Loren D Knopper[2], Glenn M Ferguson[2] and Christopher A Ollson[2*]

Canada 2014

- Study measuring EMF surrounding wind turbines and a 500 kV high voltage transmission line.
- Magnetic field levels in the vicinity of wind turbines were lower than those produced by common household electrical devices and were well below health-based regulatory guidelines.
- Measurements of magnetic fields taken below the 500 kV transmission line decreased rapidly with distance and were well below background levels at people's homes.

Health Conclusion

- There has been 20 years of research on living in proximity to wind turbines and potential affects on people's health.
  - There are now over 150 research studies published in the field and no clear or consistent association between wind turbine noise and any reported disease or other indicator of harm to human health.
- Low-frequency sound and infrasound sound are emitted by wind turbines.
  - The levels of infrasound from wind turbines at homes will be well below audibility thresholds.
  - Components of wind turbine sound, including infrasound and low frequency sound, have not been shown to present unique health risks to people living near wind turbines.
- Annoyance associated with living near wind turbines is a complex phenomenon related to personal factors.
  - Noise from turbines plays a minor role in comparison with other factors in leading people to report annoyance in the context of wind turbines.
  - Annoyance is not a health effect
- Shadow flicker is not a risk to health, including for photo epileptic seizures

Robert J. McCunney, MD, MPH, MS
Occupational and Environmental Medicine
Brigham and Women's Hospital, Boston

PHYSICAL SAFETY CONSIDERATIONS

State Level Siting

Setbacks	North Dakota	Wisconsin	Illinois	Michigan	New York	South Dakota (State and County Generally)
Neighboring Non- Participating Property Line	1.1x tip height	1.1x tip height	1.1x tip height	1.1x tip height	1.1x tip height	1.1x tip height
Neighboring Non- Participating Home	3x tip height	Lower of 1,250 feet or 3.1x tip height	2.1x tip height	2.1x tip height	2x tip height	1,500 ft or 2- 3x tip height
Incorporated Municipalities	Typically 1 mile	N/A	Typically 1 mile	N/A	Typically 1 mile	1 mile
Interstate, Roads, and Highways	Typically 1.1x the tip height	1.1x tip height	1.1x tip height	1.1x tip height	Typically 1.1x tip height	1.1x tip height
State Park	N/A	N/A	2.1x tip height	N/A	N/A	1 mile

- Typical setback to a non-participating residence is 2 total height
- 1.1x to total turbine height to non-participating property lines

Risk Assessment of Ice Throw (Norway 2017)

Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Understanding and acknowledging the ice throw hazard - consequences for regulatory frameworks, risk perception and risk communication

To cite this article: R. E. Bredesen *et al* 2017 *J. Phys.: Conf. Ser.* **926** 012001

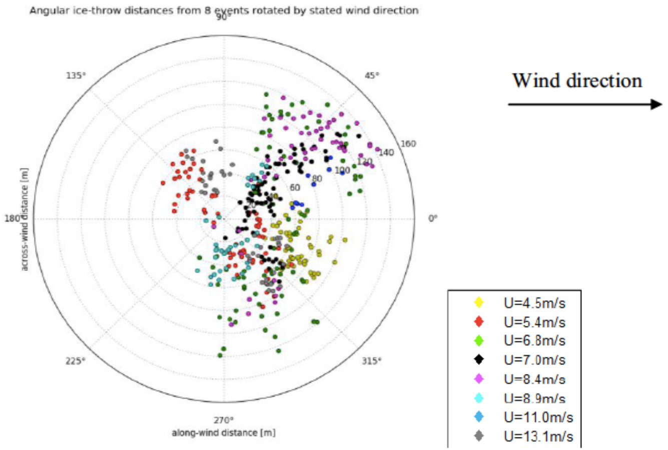
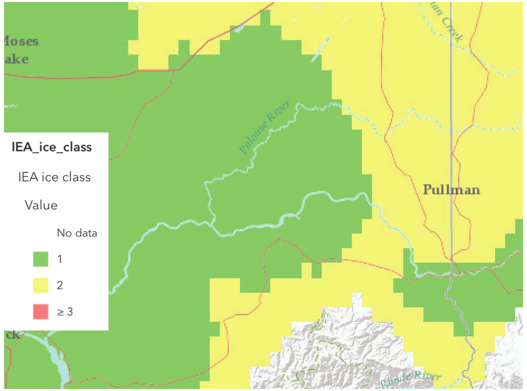


Figure 6. 417 ice pieces from the IceThrower database for the considered V90 turbine with a tipheight of 140 m. The location of all ice pieces are rotated by the given wind direction for each given case. Events are listed A-H by colored markers for increasing wind velocities.



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Blade Fragment Throw

HSE
Health and Safety Executive

Study and development of a methodology for the estimation of the risk and harm to persons from wind turbines

Prepared by **MMI Engineering Ltd**
for the Health and Safety Executive 2013

RR968
Research Report

Source of Fatality	*Annual Risk*	*Assumptions*
Wind turbine - Direct impact by blade/fragment	10^{-9}	At 2x hub height from wind turbine
Wind turbine - Indirect impact by blade/fragment	10^{-8}	At 2x hub height from wind turbine
Cancer	2.58×10^{-3}	Averaged over population. England & Wales 1999
Lightning	5.35×10^{-8}	England & Wales 1995-1999
Mining Industry	1.09×10^{-4}	GB 1996-2001
Construction Industry	5.88×10^{-5}	GB 1996-2001
Agriculture	5.81×10^{-5}	GB 1996-2001
Service Industry	3.00×10^{-6}	GB 1996-2001
Fairground Rides	4.79×10^{-9}	Assumes 4x rides per annum. UK 1996-2000
Road Accidents (all forms)	5.95×10^{-5}	UK 1999
Rail Travel Accidents (per passenger journeys)	2.32×10^{-8}	Fatality per passenger journeys GB 1996-1997
Rail Travel Accidents (annual risk - commuter)	1.05×10^{-5}	Annual risk of fatality: 2 daily journeys, 45 weeks per year
Aircraft Accident (per passenger journeys)	8.00×10^{-9}	Fatality per passenger journeys UK 1991-2000
Aircraft Accident (annual risk – holidaymaker)	1.60×10^{-8}	Annual risk of fatality: 2 flights

Wind Energy

WILEY

RESEARCH ARTICLE OPEN ACCESS

United States 2025

Simulation Analysis and Safety Risk Assessment of a Wind Turbine Blade Failure Event

Jonathan Rogers[1] | Christopher Ollson[2]

[1]Georgia Institute of Technology, Atlanta, Georgia, USA | [2]Ollson Environmental Health Management, Toronto, Ontario, Canada

- Case study of an actual wind turbine blade failure event caused by a lightning strike in the midwestern United States. The nature of the debris field is described, along with measurements of example blade fragments collected from the site.
- Ballistic impact models are used to determine whether any fragments thrown beyond 1.1 times the turbine tip height could have caused injury to a person.

This ballistic analysis shows that debris that traveled beyond 1.1 times the tip height had relatively low kinetic energy and would be extremely unlikely to cause injury to a person.

Claims vs. Facts

Microplastics and BPA in Wind Turbine Blades

CLAIM: Wind turbine blades are emitting large amounts of bisphenol A (BPA) and microplastics into their surrounding environments.

FACT: **Wind turbine blades contain only microscopic traces of residual BPA and therefore do not account for large, or any, emissions of BPA or microplastics to the environment.**

CLAIM: Erosion caused by rain releases BPA and microplastics from wind turbine blades into the environment.

FACT: **Wind turbine blades' protective coatings are non-toxic and contain negligible amounts of BPA, and the blades are specifically designed to have high resistance to weathering.**

Wind turbines do not shed fiberglass during operations. There is no evidence that operating wind turbines impact agricultural soils.

Tower Fire

Wind Turbine Fire

- Very rare with typically <10 turbine fires a year in US
- Caused by mechanical failure or excessive lightning strike
- Fire Protection Systems – minimize fire risk through design
- Fire Suppression Systems – optional and rarely employed
- Development of a strong emergency response plan in cooperation with local fire districts is key
- Training with the fire fighters before operations commences will occur
- No specialized equipment needed
- Fire fighters asked to set a perimeter, let the turbine burn itself out, and only put out any ground spot fires that may occur

Tower Collapse

- Towers collapse within turbine height
- Will remain on participating landowners' property

Setback distances of 1.1x to non-participating property lines and 2.1x to non-participating homes (1,320 ft) are key to protection of public safety.

GE Renewable Energy

- Original -

Technical Documentation
Wind Turbine Generator Systems
All Onshore Turbine Types

General Description

Setback Considerations for Wind Turbine Siting

imagination at work

Setback Distance from center of turbine tower	Objects of concern within the setback distance

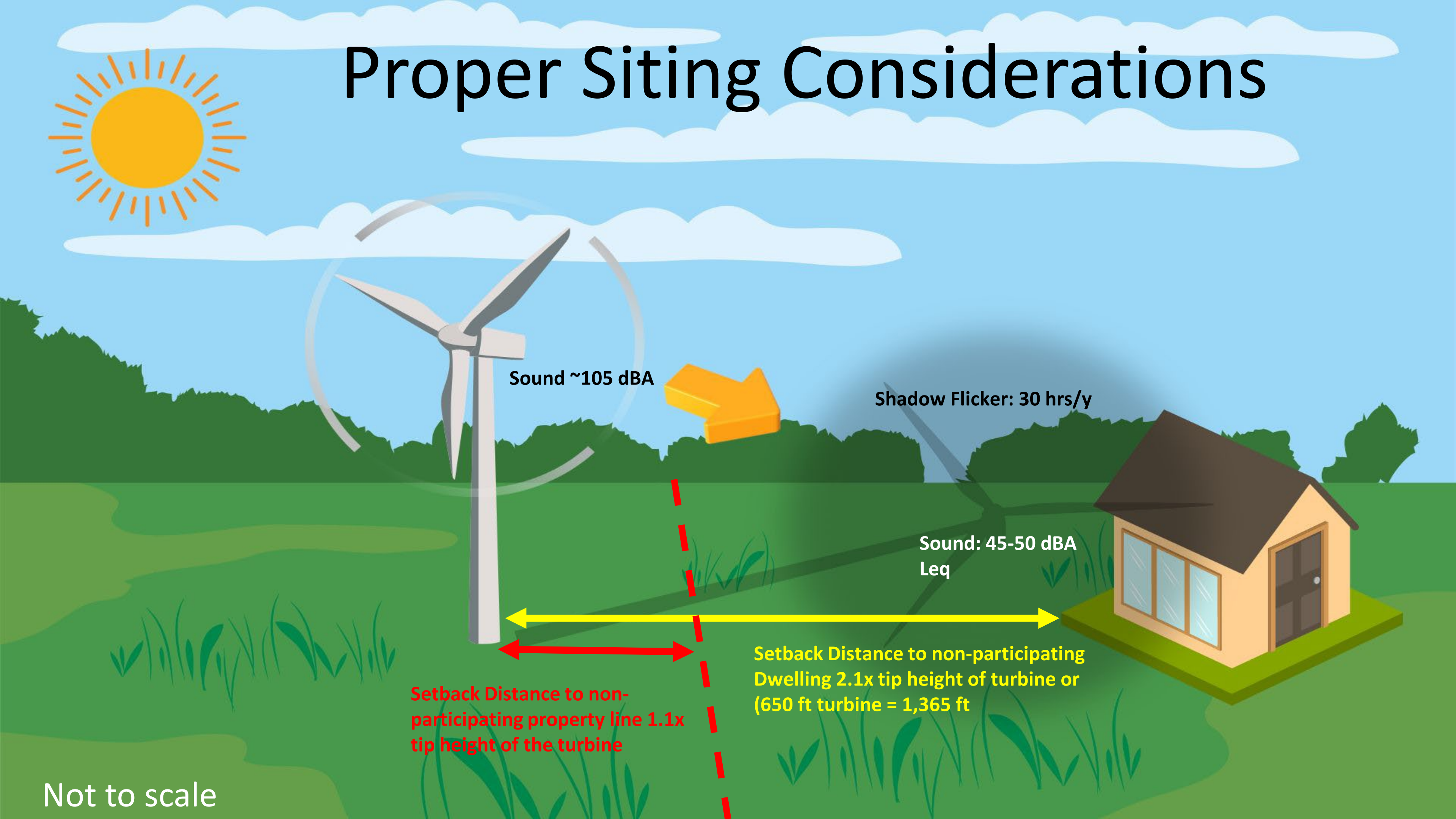
All turbine sites (blade failure/ice throw):
1.1 x tip height[1], with a minimum setback distance of 170 meters
	- Public use areas
	- Residences
	- Office buildings
	- Public buildings
	- Parking lots
	- Public roads
	  - Moderately or heavily traveled roads if icing is likely
	  - Heavily traveled multi-lane freeways and motorways if icing is not likely
	- Passenger railroads

All turbine sites (tower collapse): 1.1 x tip height[1]	- Public use areas - Residences - Office buildings - Public buildings - Parking lots - Heavily traveled multi-lane freeways and motorways - Sensitive above ground services[2]
All turbine sites (rotor sweep/falling objects): 1.1 x blade length[3]	- Property not owned by wind farm participants[4] - Buildings - Non-building structures - Public and private roads - Railroads - Sensitive above ground services

Environmental Health Management

State of Wind Turbine Research and Health Effects

- 20 years of research in the field
- Over 150 peer-reviewed research papers published in the field
- Findings support:
  - Sound levels of up to 50 dBA at non-participating homes
  - Shadow flicker <30 hours a year
  - Setbacks 1.1x tip height to roads, property lines, transmission lines, etc.. for protection on ice throw, blade failure and tower collapse
  - Setbacks 2x tip height to non-participating homes (based primarily on achieving sound limits)


Proper Siting Considerations
Sound ~105 dBA
Shadow Flicker: 30 hrs/y
Sound: 45-50 dBA Leq
Setback Distance to non-participating property line 1.1x tip height of the turbine
Setback Distance to non-participating Dwelling 2.1x tip height of turbine or (650 ft turbine = 1,365 ft
Not to scale

Overall Siting Conclusion

Based on two decades of scientific health research from around the world properly sited wind projects do not have a detrimental effect on public health, safety, and welfare of local residents.

Christopher Ollson, PhD
Ollson Environmental Health Management

Robert J. McCunney, MD, MPH, MS
Occupational and Environmental Medicine
Brigham and Women's Hospital, Boston

OLLSON
Environmental Health Management