Health Impacts of Industrial Wind Projects
A Public Health Presentation
September 10, 2019
Sponsor, Senator Robert Ortt

WIND TURBINE NOISE: A MAJOR NOISE PROBLEM

Robert W. Rand, ASA, INCE Member Emeritus
Rand Acoustics, LLC
Brunswick, Maine

Experience:

- Professional career in acoustics since 1980
- Ten years industrial power noise control at Stone & Webster
- Member ASA, INCE: committed to public health and welfare
- Design based on “good acoustic neighbor” methodologies
- Acoustic Investigator, wind turbines 2009 to present
- Measured wind turbine noise and pulsations at homes
- Tested inside homes, staying overnight
    - Falmouth MA 2011, Shirley WI 2012
- Experienced adverse health effects as neighbors report
    - nausea, dizziness, headache, spatial disorientation
- Peer-reviewed publications (cited in Pubmed)
- Expert testimony: national, state, county, municipal

Resources: INCE Ethics

Canon 1. Hold paramount the safety, health and welfare of the public.

- *Ethics requirements are not "optional".*
- *Potentially confusing and hazardous when professional ethics are ignored by applicants.*

Resources: Design Basis

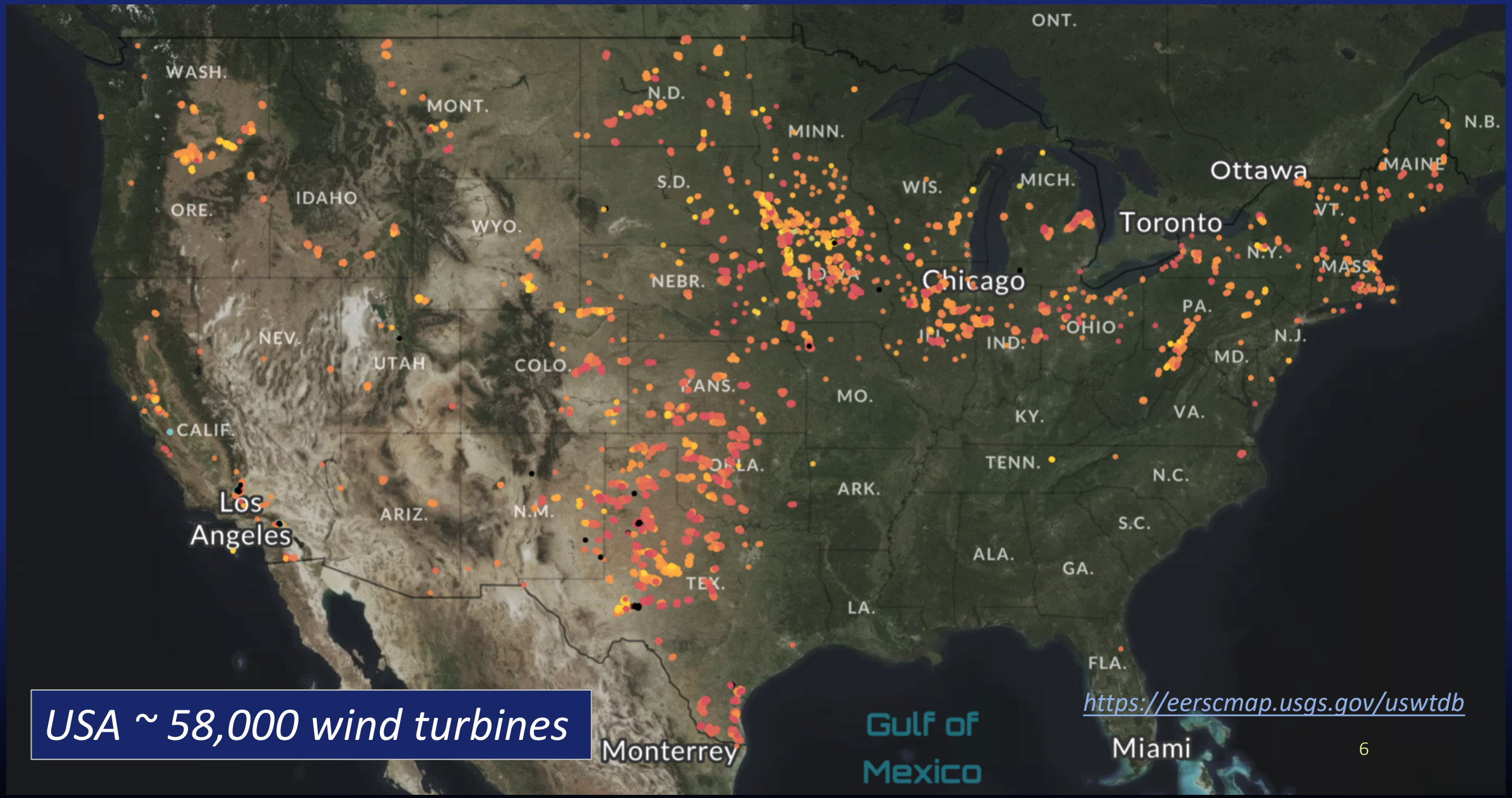
- Meet noise regulations with safety margin
- Hold paramount safety, health and welfare

Resources: Direct and acquired knowledge

- Professional experience
- WHO evidence for noise impacts on health
- ANSI consensus standards
- Noise and Health studies
- Neighbor reports, listening, testing in homes

We're dealing with a major noise problem.

- Wind turbines are sited mostly in quiet rural areas.
- Wind turbines are promoted as pollution-free.
- Most people think wind turbines are silent.
- Neighbors living near wind turbines in rural areas report adverse noise impacts; sleep disturbance, sickness.
- Regulators assess noise *levels*, ignoring noise *impacts*.
- Meters don't measure noise impacts.



USA ~ 58,000 wind turbines

https://eerscmap.usgs.gov/uswtdb


MOSTLY QUIET RURAL SITING
Bancroft
Minden
Midland
Perth
Cornwall
Newport
Plattsburgh
Brockville
Barrie
Vermont
Saint Johnsbury
Kingston
VERMONT
Watertown
Adirondack Mountains
Toronto
Lake Ontario
Oswego
Rutland
Hamilton
Claremont
New York
Rochester
Saratoga Springs
Sullivan
Utica
Batavia
Dunnville
Buffalo
Geneva
Brattleboro
NEW YORK
Albany
Ithaca
Oneonta
Jamestown
Olean
Elmira
Binghamton
Warren
Smethport
Meadville
Towanda
Fallsburg
Oil City
Saint Marys
Carbondale
CONNECTICUT
Connecticut
New London
Pennsylvania
PENNSYLVANIA
Wilkes-Barre
Bridgeport
Long Island Sound
Butler
Hazleton
State College
Indiana
Sunbury
New York
100 mi
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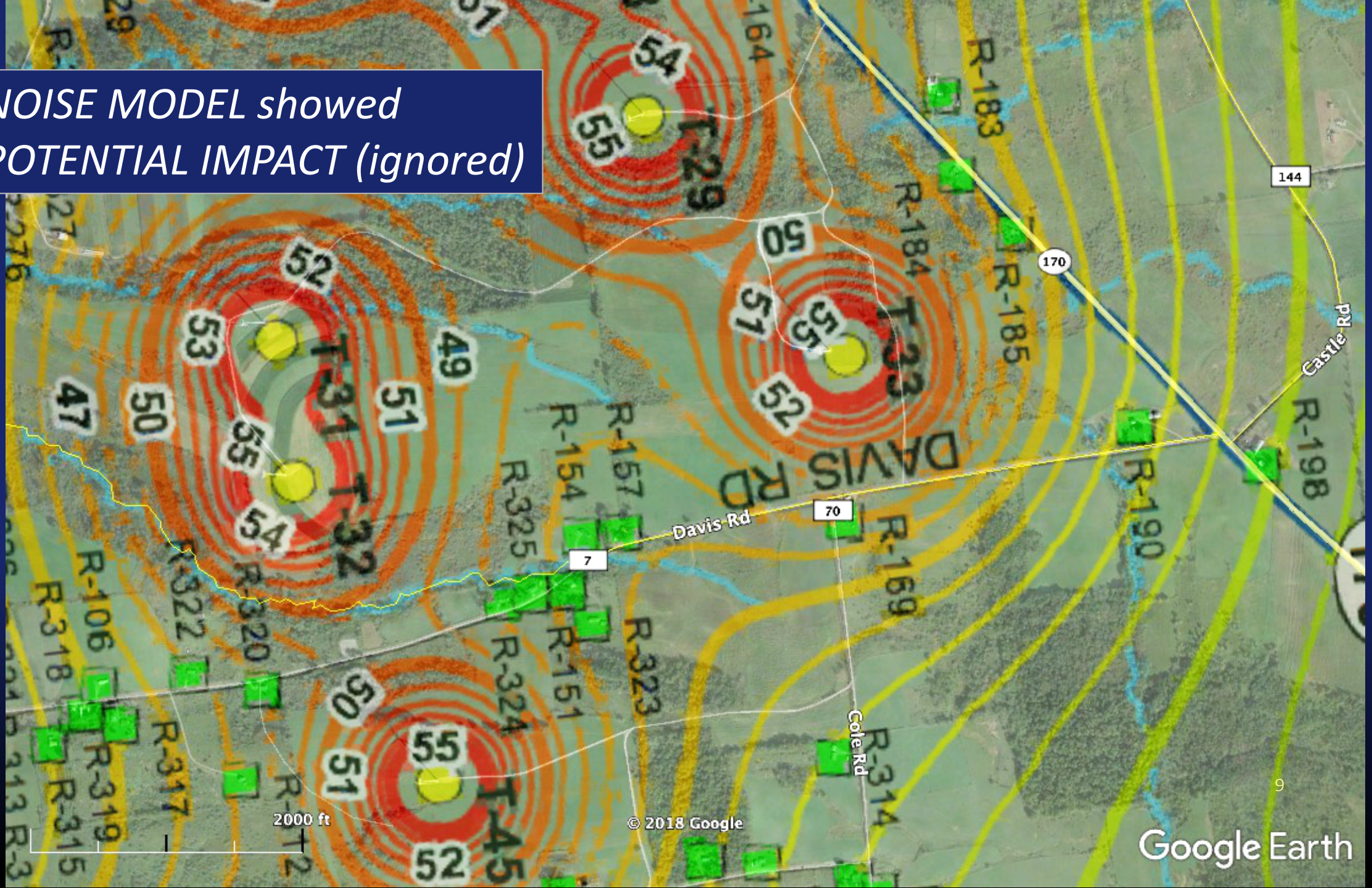
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth

QUIET RURAL NEW YORK


NOISE MODEL showed
POTENTIAL IMPACT (ignored)
T-29
T-31
T-32
T-33
T-45
R-183
R-184
R-185
R-198
R-190
R-169
R-154
R-157
R-325
R-151
R-323
R-324
R-320
R-322
R-106
R-318
R-319
R-315
R-317
R-314
DAVIS RD
Davis Rd
Cole Rd
Castle Rd
144
170
70
7
2000 ft
© 2018 Google
Google Earth

SITING CRITERIA

Most problems observed in wind turbine siting, including misleading marketing, regulations loosened (sometimes years) ahead of applications, "Good Neighbor" agreements, poor noise models, lack of noise impact assessments, unenforced noise regulations, noise complaints and legal action, stem from the primary design deficiency:

Distance has proved to be the only reliable noise control option available for wind turbines so far. In most places, there isn't enough distance to avoid impacts.

- Noise siting criteria are used to protect human safety, health and welfare and the environmental amenity as well as wildlife in protected areas.
- Noise-siting criteria include regulatory limits … when regulatory limits fail to protect the public, amenity, or natural and protected areas, criteria should be adjusted for protection.
- Systematic siting criteria were first formulated in the 1950s and expanded in the 1960s responding to noise impacts from transportation. EPA developed impact criteria in the 1970s.
- Regulatory limits typically employ the A-weighted sound level (dBA). A-weighting is unsuitable for low frequency sound (ANSI).

Community Response

Increase in Noise	Estimated Community Response
5 dB	Sporadic Complaints
10 dB	Widespread Complaints
15 dB	Threats of Community Action
20 dB	Vigorous Community Action

International Standards Organization, ISO/TC 43
New York: United Nations, November 1969.

- Background sound levels in rural areas are generally below 30 dBA at night, in the range of 20-25 dBA.
- Wind turbine facilities are often permitted with no design margin… usually with limits of 45, 50, 55 or 60 dBA in quiet rural areas… at the homes!
- Designing far louder than rural background sound levels guarantees complaints, appeals, or stronger reactions.
- When a facility produces complaints, appeals to stop the noise, and lawsuits, consultants and regulators have failed.

ANSI S12.9: Compatibility with Land Use

Criteria for "Compatibility" per ANSI S12.9:

Factor	**Day-Night Sound Level (DNL)**	***Day Sound Level:***	***Night Sound Level:***	***Average Level (Leq*):***
Part 5 Figure A.1 Residential Urban/suburban, Single Family Marginal Compatibility:	55	*55*	*45*	*49*
Adjust: 10 dB for quiet rural settings (Part 4 F.3.4.1):	-10	*-10*	*-10*	*-10*
Adjust: 5 dB for unfamiliar intrusive noise (Part 4 F.3.4.3):	-5	*-5*	*-5*	*-5*
Criteria for "Compatibility", dBA:	**40**	***40***	***30***	***34***

WHO Lnight,outside

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

"NOEL"

"LOAEL"

Table 3
Effects of different levels of night noise on the population's health

Outside to inside: windows open, -1 to -3 dBA; partially open, -6 dBA

Figure 2.
Photographs of Brouha Residence and Acentech OILR Sound Test Conditions (7/1/2014).

Loudspeaker and Residence

2nd Floor Bedroom – Partially Open Windows

Acentech to A. Kisicki, 9/25/15.

Why test outside-to-inside level reduction (OILR)?

- Wind industry models average (Leq) levels.
- Vermont permit included a 30 dBA indoors Leq, assumed a 15-dB level reduction. Wrong: windows open, -1 to -6 dB.
- Neighbors complained, appeals... house not livable.
- ***Testing yielded real limits for house LR assumptions.***

- OILR is also useful for assessing Lmax sleep impacts:

- WHO published Lmax thresholds for sleep impact.
- Wind industry has testified Lmax = Leq + ~6-11 dB.

WHO Lmax,indoors

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	EEG awakening	$L_{Amax,inside}$	35
	Motility, onset of motility	$L_{Amax,inside}$	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax,inside}$	35
Sleep quality	Waking up in the night and/or too early in the morning	$L_{Amax,inside}$	42
	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
	Increased average motility when sleeping	$L_{night,outside}$	42
Well-being	Self-reported sleep disturbance	$L_{night,outside}$	42
	Use of somnifacient drugs and sedatives	$L_{night,outside}$	40
Medical conditions	Environmental insomnia**	$L_{night,outside}$	42

Table 1
Summary of effects and threshold levels for effects where *sufficient* evidence is available

* *Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.*

***Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.*

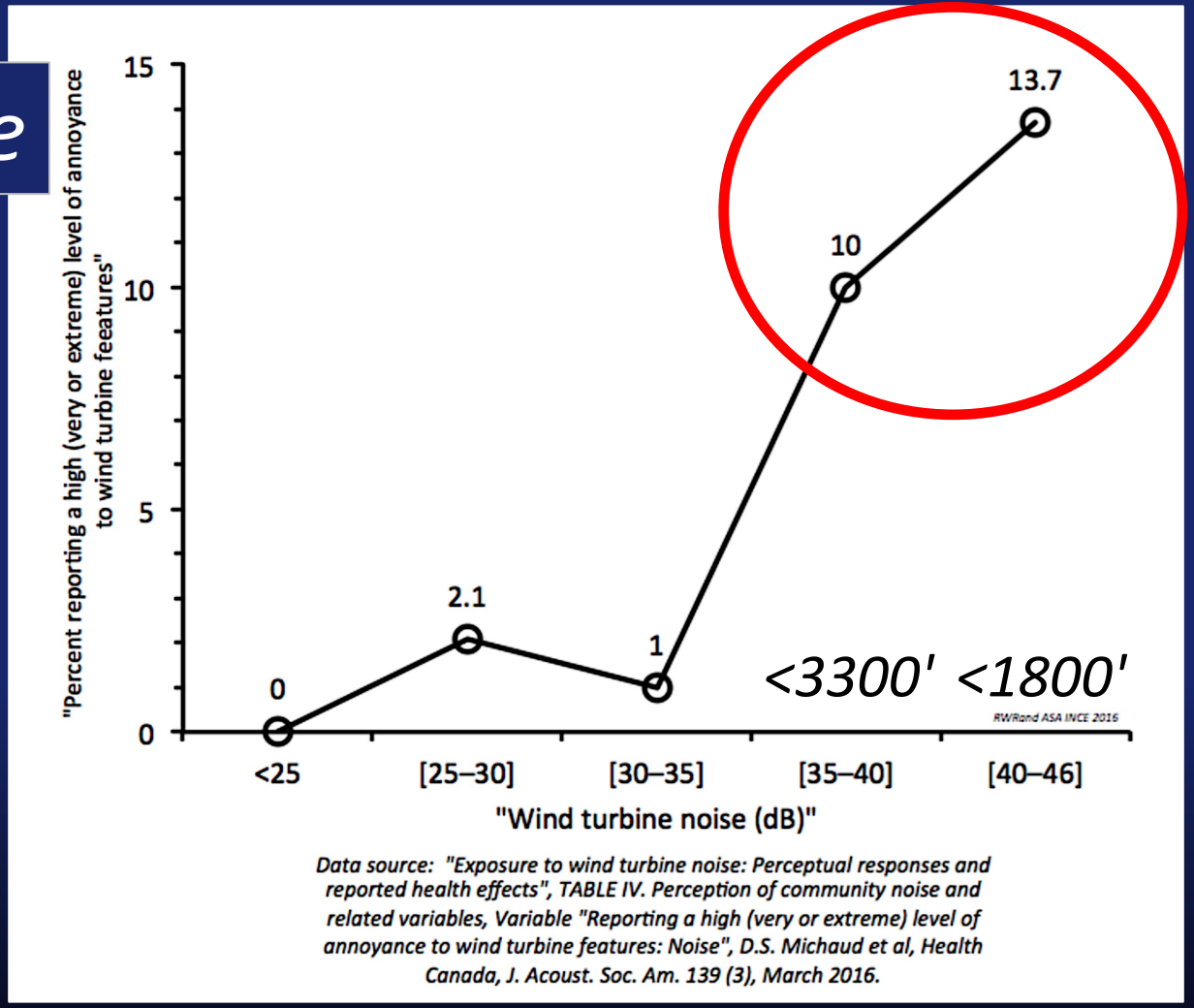
Annoyance

In 2008 Health Canada Study director David Michaud identified high annoyance due to intrusive noise as a measure of health impact:

"Defining high noise annoyance as an adverse health effect is certainly consistent with Health Canada's definition of what constitutes "health". ... "a change in %HAn can be used in environmental assessments as one of the measures of the magnitude of an adverse health effect caused by project related noise."

Health Canada

Annoyance



Data source: "Exposure to wind turbine noise: Perceptual responses and reported health effects", TABLE IV. Perception of community noise and related variables, Variable "Reporting a high (very or extreme) level of annoyance to wind turbine features: Noise", D.S. Michaud et al, Health Canada, J. Acoust. Soc. Am. 139 (3), March 2016.

Annoyance

Annoyance caused by noise:
"a high level of annoyance caused by environmental noise should be considered as one of the environmental health burdens."

WHO, 2011.

Annoyance

"A feeling of displeasure associated with any agent or condition known or believed by an individual or a group to be adversely affecting them" (Lindvall and Radford 1973; Koelega 1987). Any sound that is perceived as irritating or a nuisance (ANSI 1995).

WHO, 1999.

Nuisance: Over 40 dBA

JUDGMENT	Trial Court of Massachusetts The Superior Court
DOCKET NUMBER 1472CV00003	Scott W. Nickerson, Clerk of Court Barnstable County
CASE NAME Town of Falmouth vs. Falmouth Zoning Board of Appeals et al	COURT NAME & ADDRESS Barnstable County Superior Court 3195 Main Street Barnstable, MA 02630

This action came before the Court, Hon. Cornelius J Moriarty, II, presiding, and upon consideration thereof,

It is ORDERED and ADJUDGED:

1. that the decision of the Falmouth Zoning Board of Appeals be affirmed to the extent that the operation of Wind 1 and Wind 2 constitute a nuisance; and

2. that the Town of Falmouth cease and desist the operation of the wind turbines forthwith.

SITING CRITERIA
OUTDOORS NOISE LIMITS IN dBA

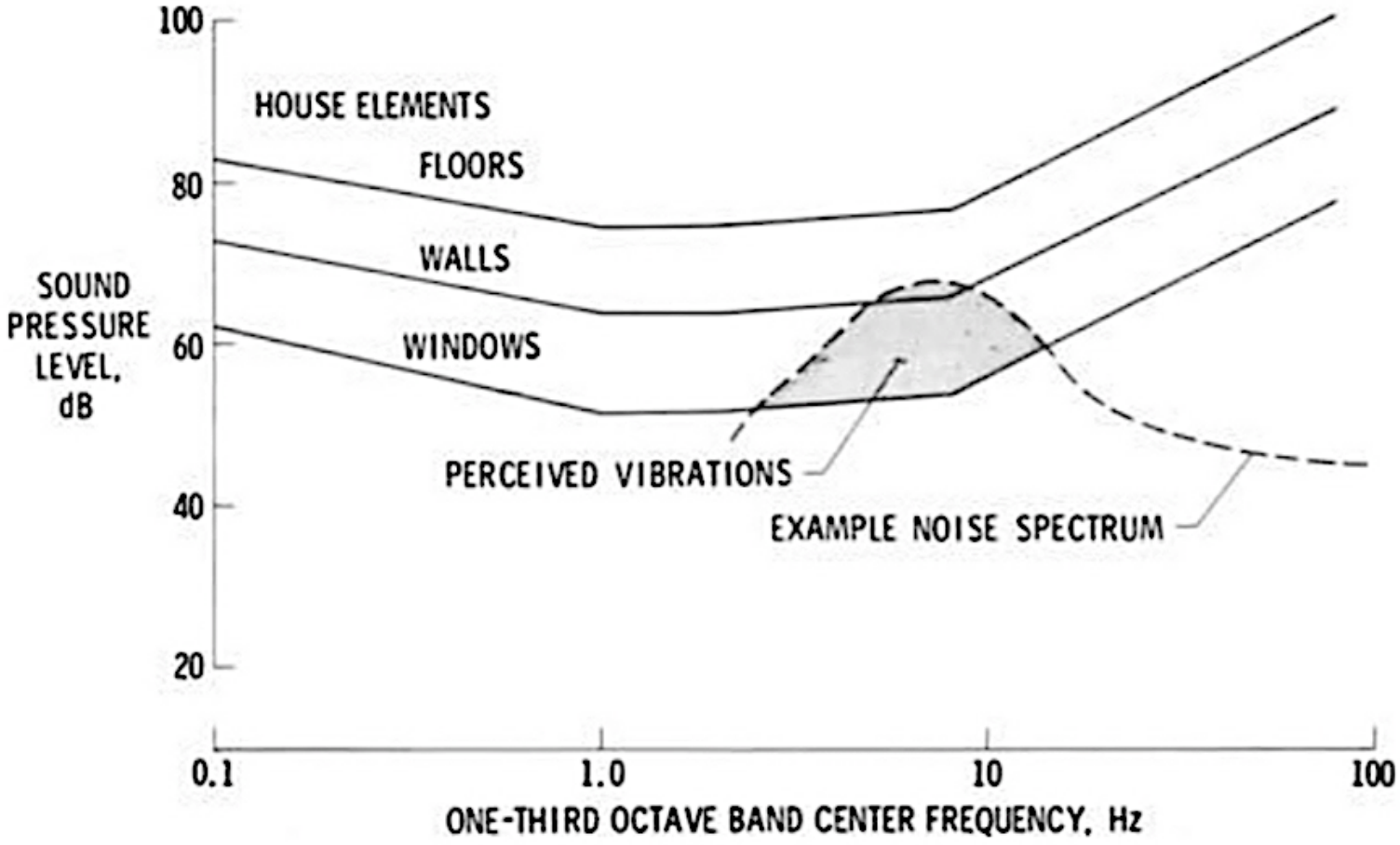
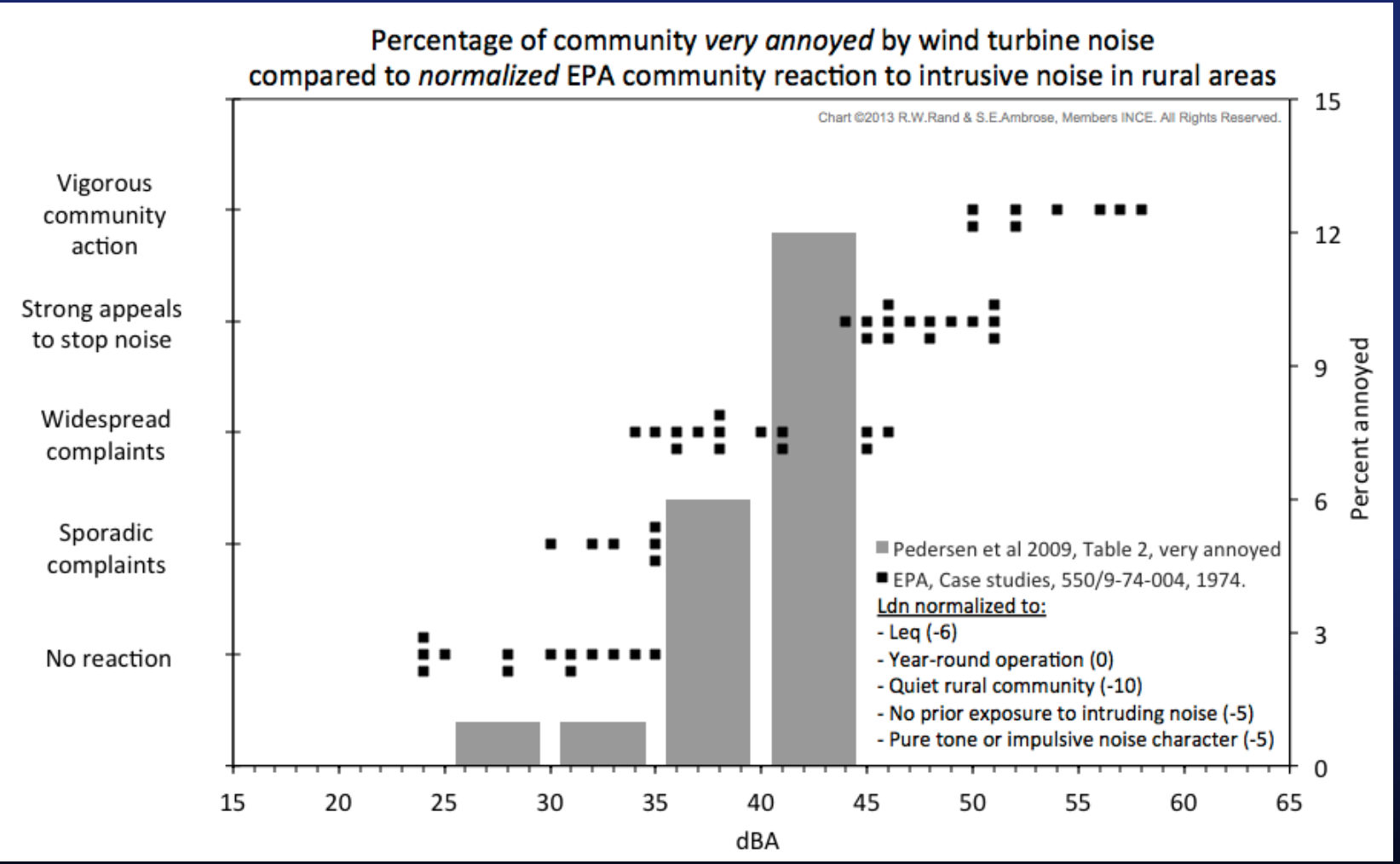


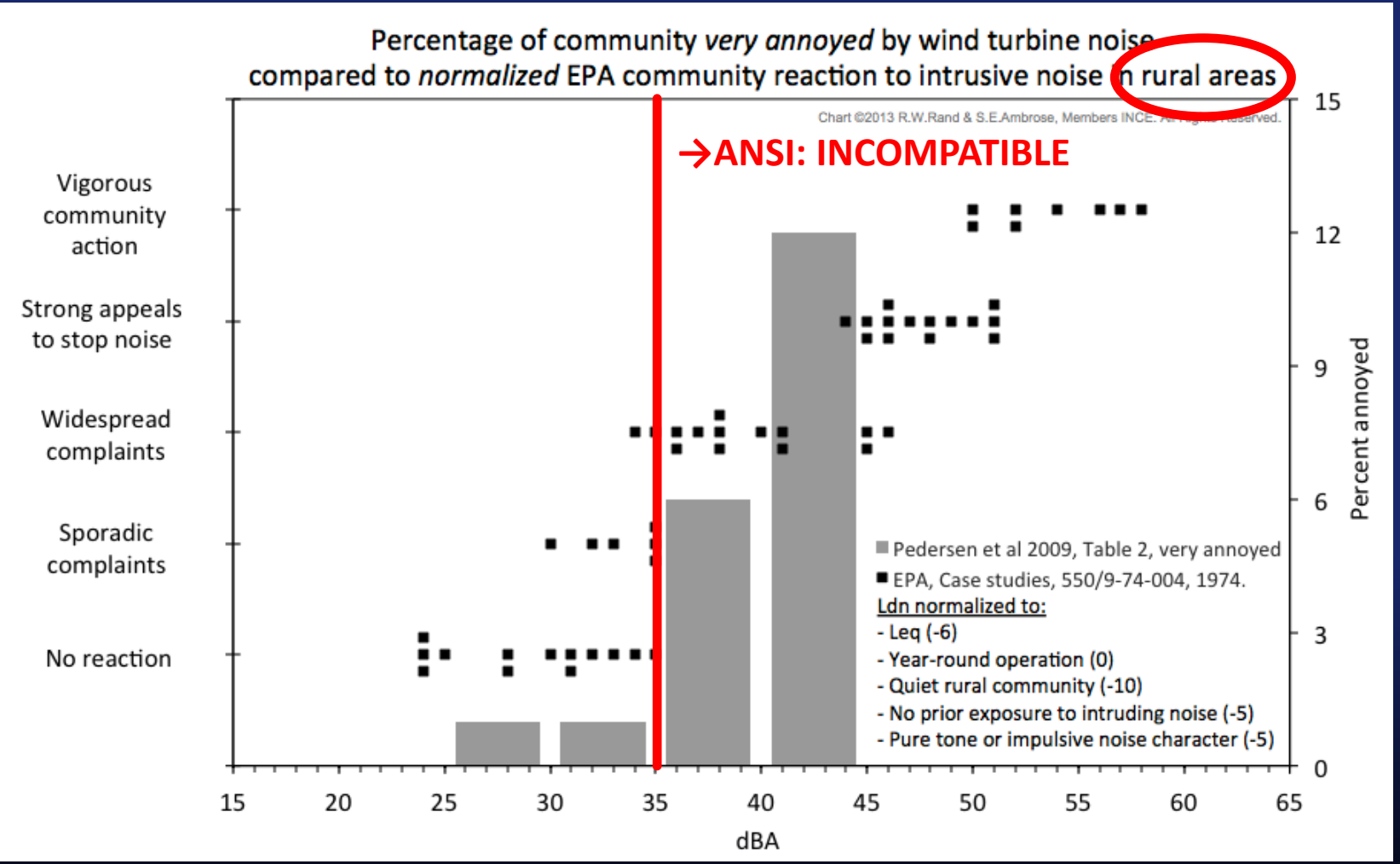
Figure 9—Sound pressure levels sufficient to cause perceptible vibrations of house structure elements over a range of frequencies

Hubbard 1982.

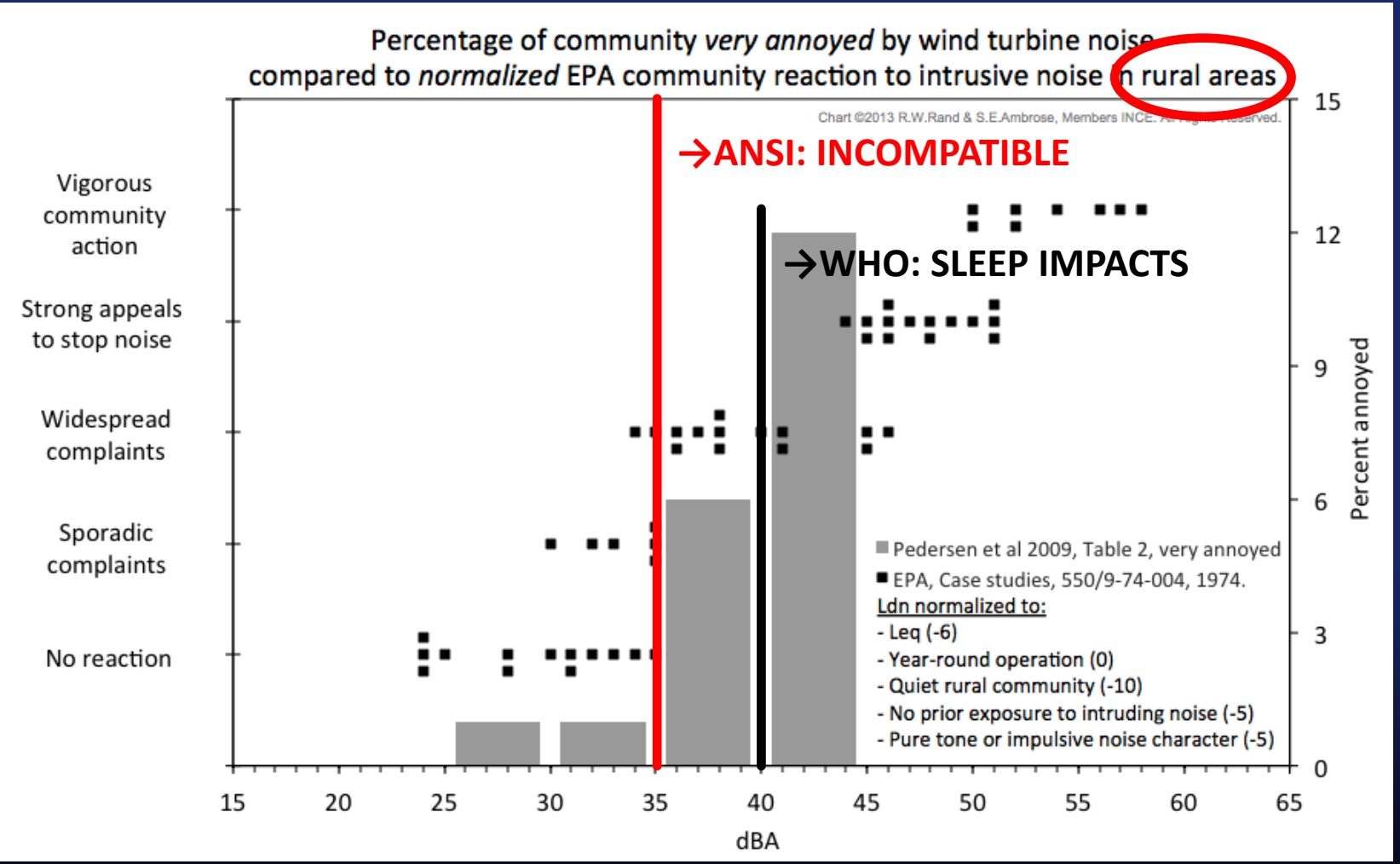
Noise Criteria Reference Chart for Rural Areas



Noise Criteria Reference Chart for Rural Areas



Noise Criteria Reference Chart for Rural Areas



DISCONNECT

Most people think

WIND TURBINES ARE SILENT

Most people think

WIND TURBINES = "CLEAN ENERGY"

Merica

PRNewsfoto/Budweiser.

Google clean energy Sign in

All News Images Maps Videos More Settings Tools SafeSearch

green energy | future | solar | cartoon | wind | infographic | renewable | nuclear


The most effective clean energy policy ...
vox.com


AES is Helping to Power Clean Energy ...
appliedenergysystems.com


provincial quotas for clean energy ...
chinadialogue.net

passed the most ambitious clean energy ...
ggwash.org


Clean Energy Goals Through Off-Site ...
renewableenergyworld.com


Switch to Renewable, 100% Clea...
cleanchoiceenergy.com

Tesla Providing Clean Energy To Pl...
cleantechnica.com


thenewdaily.com.au

Clean energy = wind turbines?


Communities Commit To 100% Clean Energy ...
nawindpower.com


large-scale renewable energy initiative
windpowerengineering.com

Clean energy patent market may offer ...
ipwatchdog.com


Republicans Can Embrace Clean Energy ...
aspeninstitute.org

No mention of noise… no stated plan to reduce noise pollution health impacts on communities, children or elderly.

"Environmental Justice" communities appear to exclude people living near wind turbines.

Wind Power

Wind is a powerful and plentiful resource that can provide energy without burning fossil fuel or emitting greenhouse gases.

Since ancient times, sailing vessels and windmills have been turning the energy of the wind into mechanical energy to push ships, pump water and grind grain. Today's advanced wind turbines convert wind energy directly into electricity, which can be moved instantaneously to where it is needed.

A single small wind turbine can generate enough clean electricity for local use. Connect several large turbines to an electric power grid and you have a wind farm -- a wind energy system generating significant amounts of pollution-free, renewable electric power to be used anywhere power lines reach.

Since 2009, New York has been a member of the "Gigawatt Club" with wind power generation capacity in excess of 1,000 MW. (Photo: Maple Ridge Wind Farm. Credit: Nat'l Renewable Energy Lab)

New York's Wind Power

Wind generation today. Today in New York, wind power makes a small but real contribution to meeting electric power needs.

- "..in the last six months following the Arkwright Wind Project, we have had a major increase in referrals of patients with idiopathic vestibular issues, syncope, migraines, seizures and strokes." Evan Davis, a registered nurse and new resident to the area.
- "I've got no problems with them. I wake up with them, I love them … it's a good thing for the community." Doug Fairbanks, chairman of the planning board for Arkwright when their project went in.

Planning?

Jo Ward, Jo Ward | Evening Observer | Sep 6, 2019
https://www.observertoday.com/news/page-one/2019/09/dissension-in-the-air-villenova-hears-pros-cons-of-turbines/

WIND TURBINE NOISE

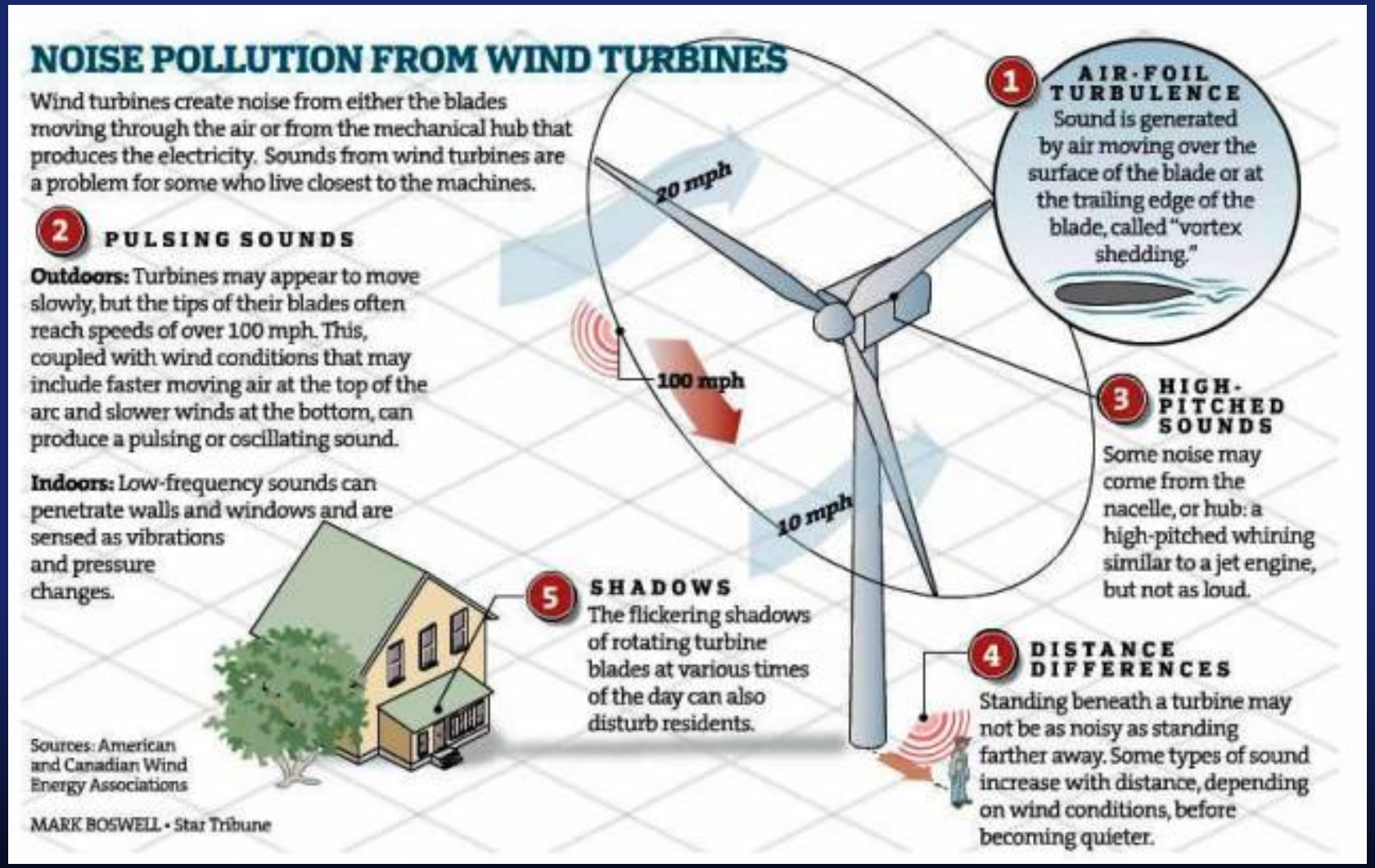
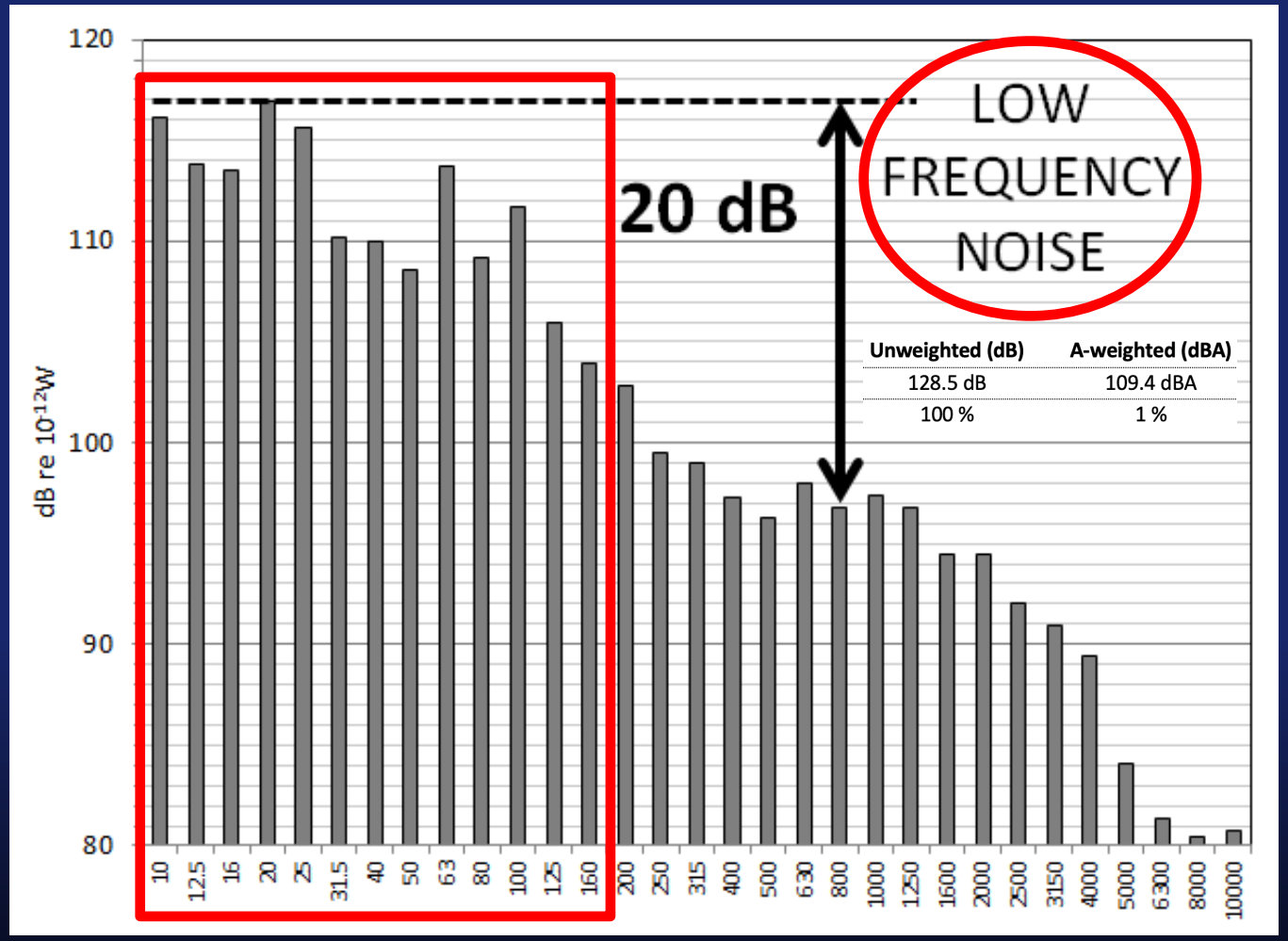

NOISE POLLUTION FROM WIND TURBINES
Wind turbines create noise from either the blades moving through the air or from the mechanical hub that produces the electricity. Sounds from wind turbines are a problem for some who live closest to the machines.
2 PULSING SOUNDS
Outdoors: Turbines may appear to move slowly, but the tips of their blades often reach speeds of over 100 mph. This, coupled with wind conditions that may include faster moving air at the top of the arc and slower winds at the bottom, can produce a pulsing or oscillating sound.
Indoors: Low-frequency sounds can penetrate walls and windows and are sensed as vibrations and pressure changes.
20 mph
100 mph
10 mph
1 AIR-FOIL TURBULENCE
Sound is generated by air moving over the surface of the blade or at the trailing edge of the blade, called "vortex shedding."
3 HIGH-PITCHED SOUNDS
Some noise may come from the nacelle, or hub: a high-pitched whining similar to a jet engine, but not as loud.
4 DISTANCE DIFFERENCES
Standing beneath a turbine may not be as noisy as standing farther away. Some types of sound increase with distance, depending on wind conditions, before becoming quieter.
5 SHADOWS
The flickering shadows of rotating turbine blades at various times of the day can also disturb residents.
Sources: American and Canadian Wind Energy Associations
MARK BOSWELL • Star Tribune

Figure 3.12 Noise emission from a large wind turbine in the rotor plane, measured by microphone arrays at 1D upstream of the turbine. As seen, the noise is mostly produced at the outer part of the blade during its descent.

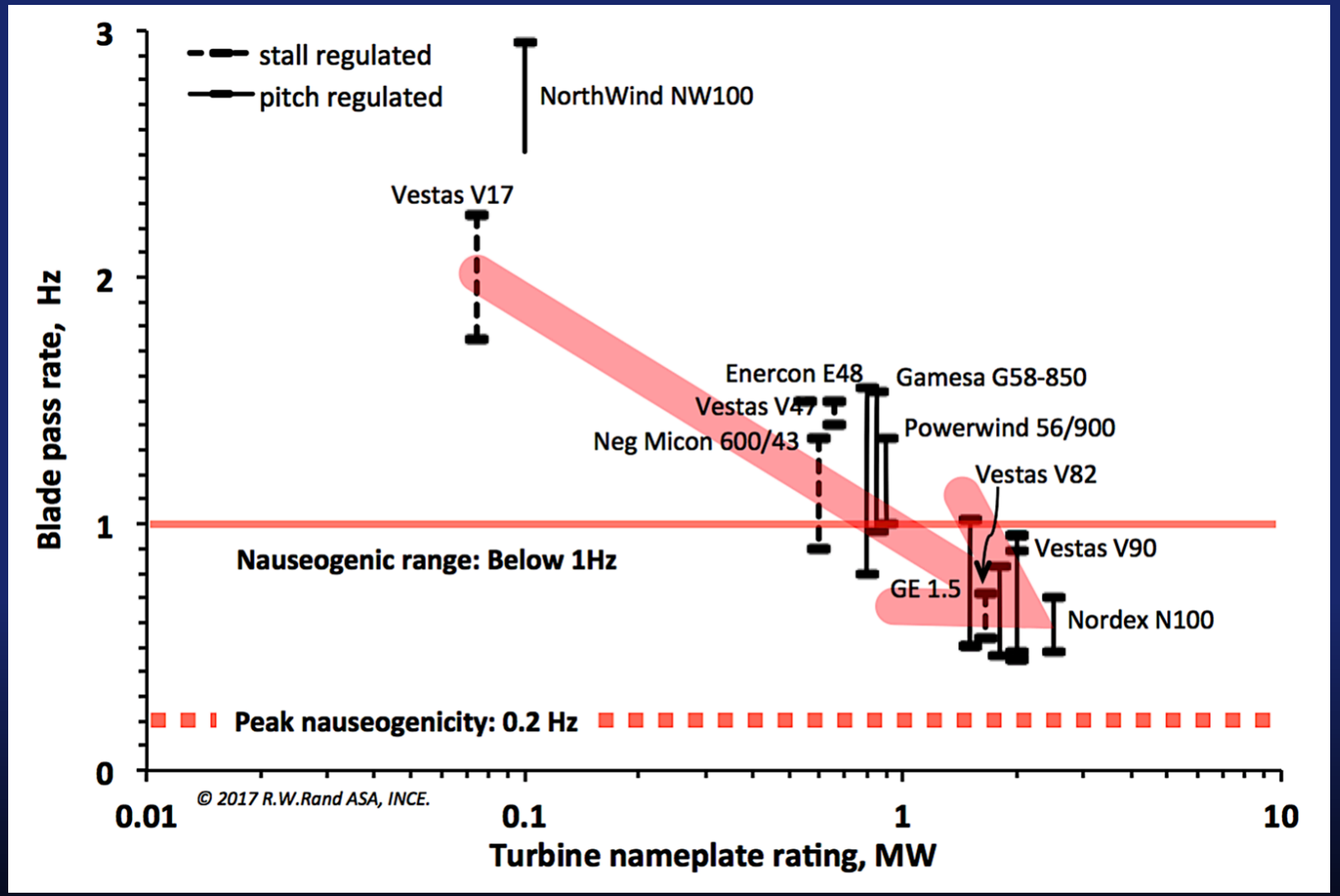
-- Nima Sedaghatizadeh, Thesis School of Mech. Eng, Adelaide, AU, 2019.

Note: Noise above 200 Hz.

Wind Turbines Emit Low Frequency Noise (LFN)



Vestas V112 3MW Sound Power Level, manufacturers test.


stall regulated
pitch regulated
NorthWind NW100
Vestas V17
Enercon E48
Gamesa G58-850
Vestas V47
Powerwind 56/900
Neg Micon 600/43
Vestas V82
Vestas V90
GE 1.5
Nordex N100
Nauseogenic range: Below 1Hz
Peak nauseogenicity: 0.2 Hz
© 2017 R.W.Rand ASA, INCE.
Blade pass rate, Hz
Turbine nameplate rating, MW
0
1
2
3
0.01
0.1
1
10

Wind Turbine Noise Generation

via Computational Fluid Dynamics (CFD) Modeling:

"… the underlying mechanism associated with the perceived noise in the far-field of the turbine blades is amplitude modulation due to partial stall on the blades or interaction of the blades with incoming turbulent structures"

-- Nima Sedaghatizadeh, Thesis School of Mech. Eng, Adelaide, AU, 2019.

Wind Turbine Noise Characteristic:

Two main features of the aerodynamic noise are noticeable:
a) “swish” which has broadband content and directed towards the leading edge, generated primarily due to turbulent boundary layer interaction with the trailing edge of the turbine airfoil;
b) “thumping” at the blade pass frequency which travels a few kilometres and is known to have the most annoying effect on people (Waye and Öhrström, 2002, Leventhall, 2006, Bolin et al., 2011, Pedersen et al., 2009, Oerlemans and Schepers, 2009)."

-- Nima Sedaghatizadeh, Thesis School of Mech. Eng, Adelaide, AU, 2019.

WIND TURBINE NOISE IMPACTS

Wind Turbines Disturb Sleep.

"Sixteen per cent of surveyed respondents who lived where calculated outdoor turbine noise exposures exceeded 35 dBA ... reported disturbed sleep."

[NOTE: Turbines 150-600kw size, not 1.5+MW.]

-Pedersen E, Persson Waye K. Perception and annoyance due to wind turbine noise—a dose-response relationship. J Acoust Soc Am 2004;116:3460-70.

Wind Turbines Cause Noise Complaints.

"Shortly after wind turbines began to be erected close to housing, complaints emerged of adverse effects on health. Sleep disturbance was the main complaint."

--Drs. C. Hanning and A. Evans, British Medical Journal, 2012.

Nocebo? NO.

"Such reports have been dismissed as being subjective and anecdotal, but experts contend that the quantity, consistency, and ubiquity of the complaints constitute epidemiological evidence of a strong link between wind turbine noise, ill health, and disruption of sleep.

--Drs. C. Hanning and A. Evans, British Medical Journal, 2012.

Nocebo discredited by research.

"Hair of badgers living <1 km of a wind farm had a 264% higher cortisol level than badgers >10 km from a wind farm. This demonstrates that affected badgers suffer from enhanced hypothalamo-pituitary-adrenal activity and are physiologically stressed."

--Journal of Wildlife Diseases, 52(3), 2016.

Wind Turbines Cause Harm If Too Close.

"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."

Ontario Case 10-121/10-122, Feb 2011
Erickson v. Director, Ministry of the Environment
Environmental Review Tribunal, Decision, p 207.

WIND TURBINE NOISE STUDIES

Falmouth, MA 2011:

Bulletin of Science, Technology & Society
http://bst.sagepub.com/

Wind Turbine Acoustic Investigation : Infrasound and Low-Frequency Noise—A Case Study

Stephen E. Ambrose, Robert W. Rand and Carmen M. E. Krogh

Bulletin of Science Technology & Society 2012 32: 128 originally published online 17 August 2012
DOI: 10.1177/0270467612455734

The online version of this article can be found at:
http://bst.sagepub.com/content/32/2/128

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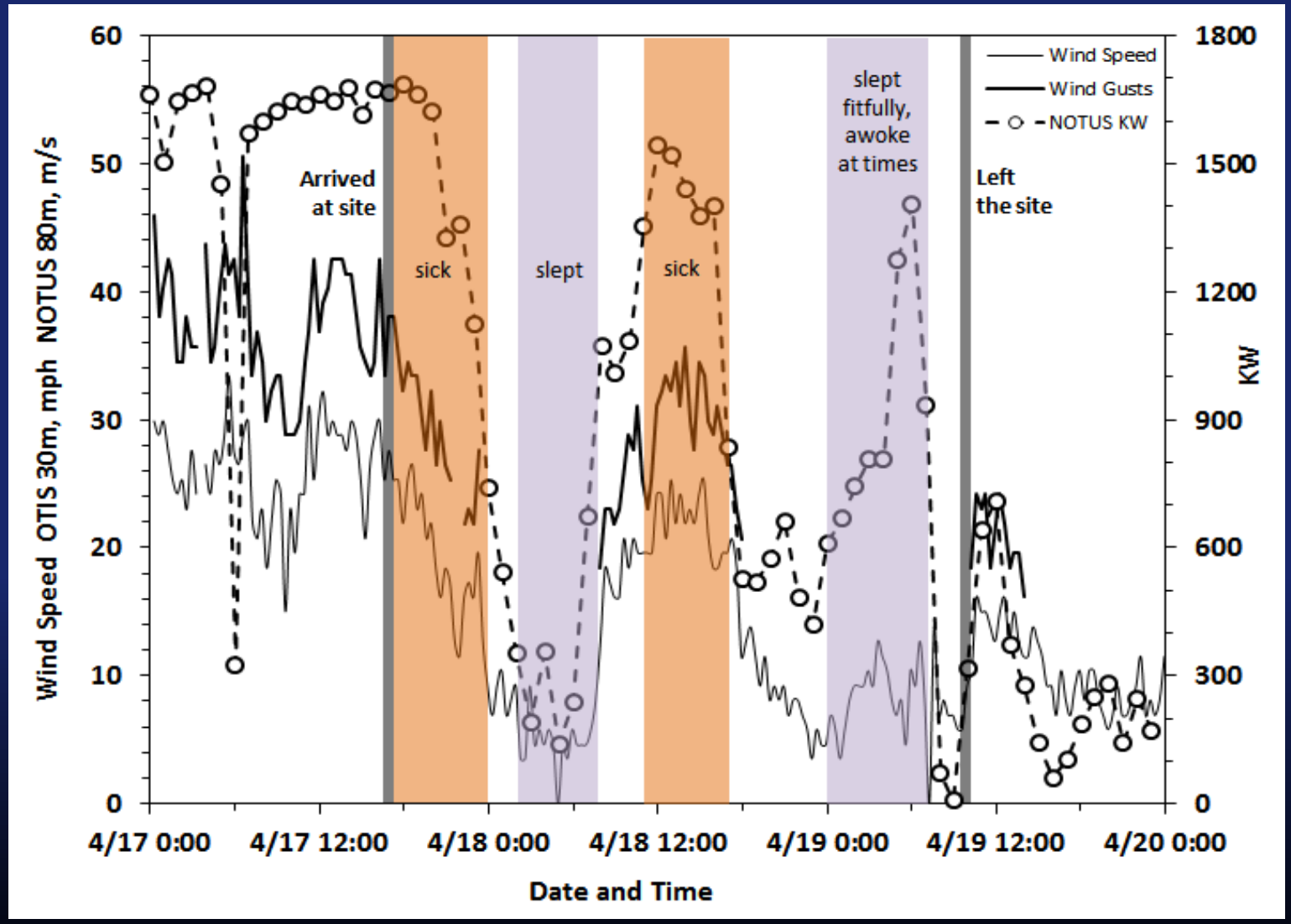
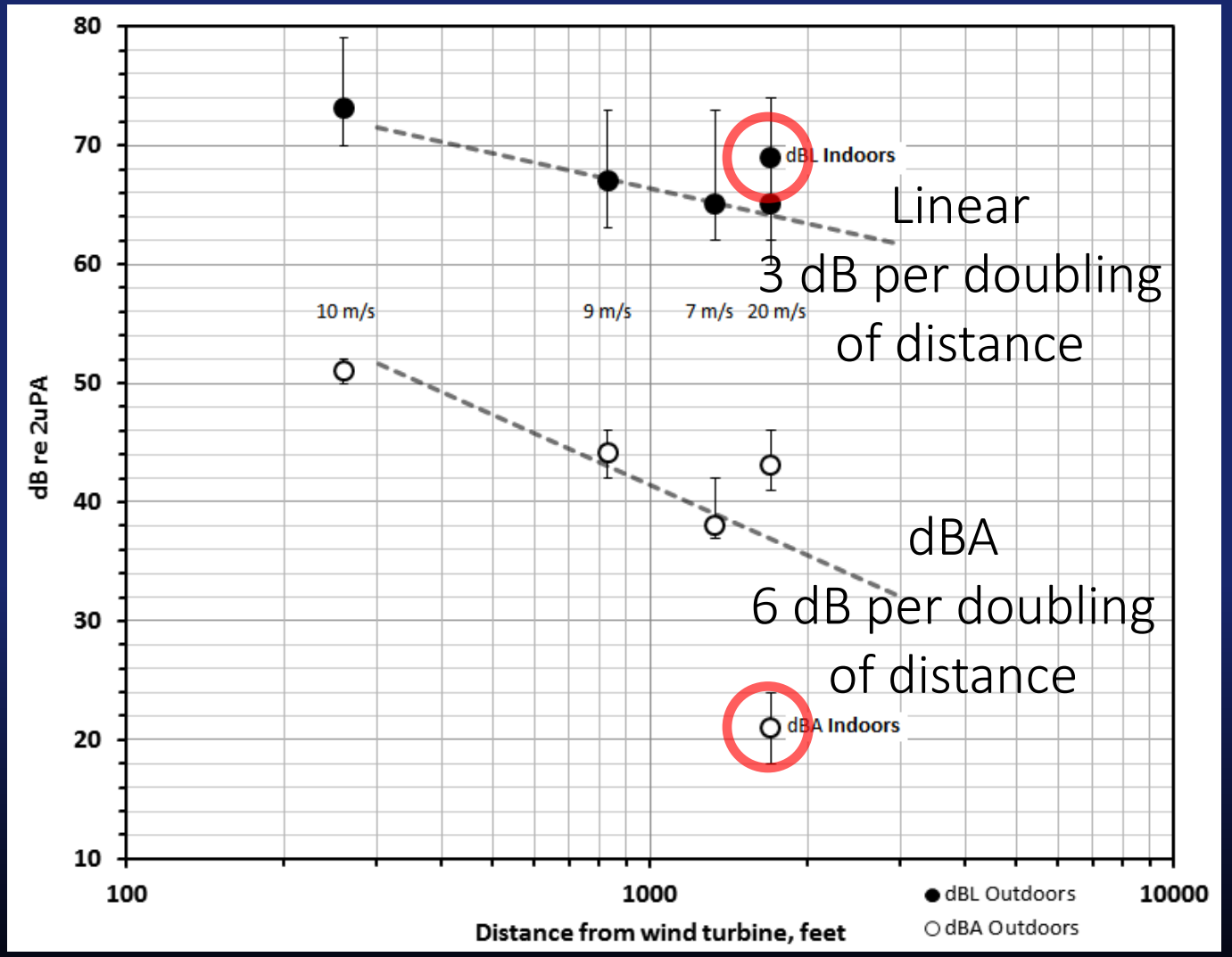
On behalf of:
National Association for Science, Technology & Society

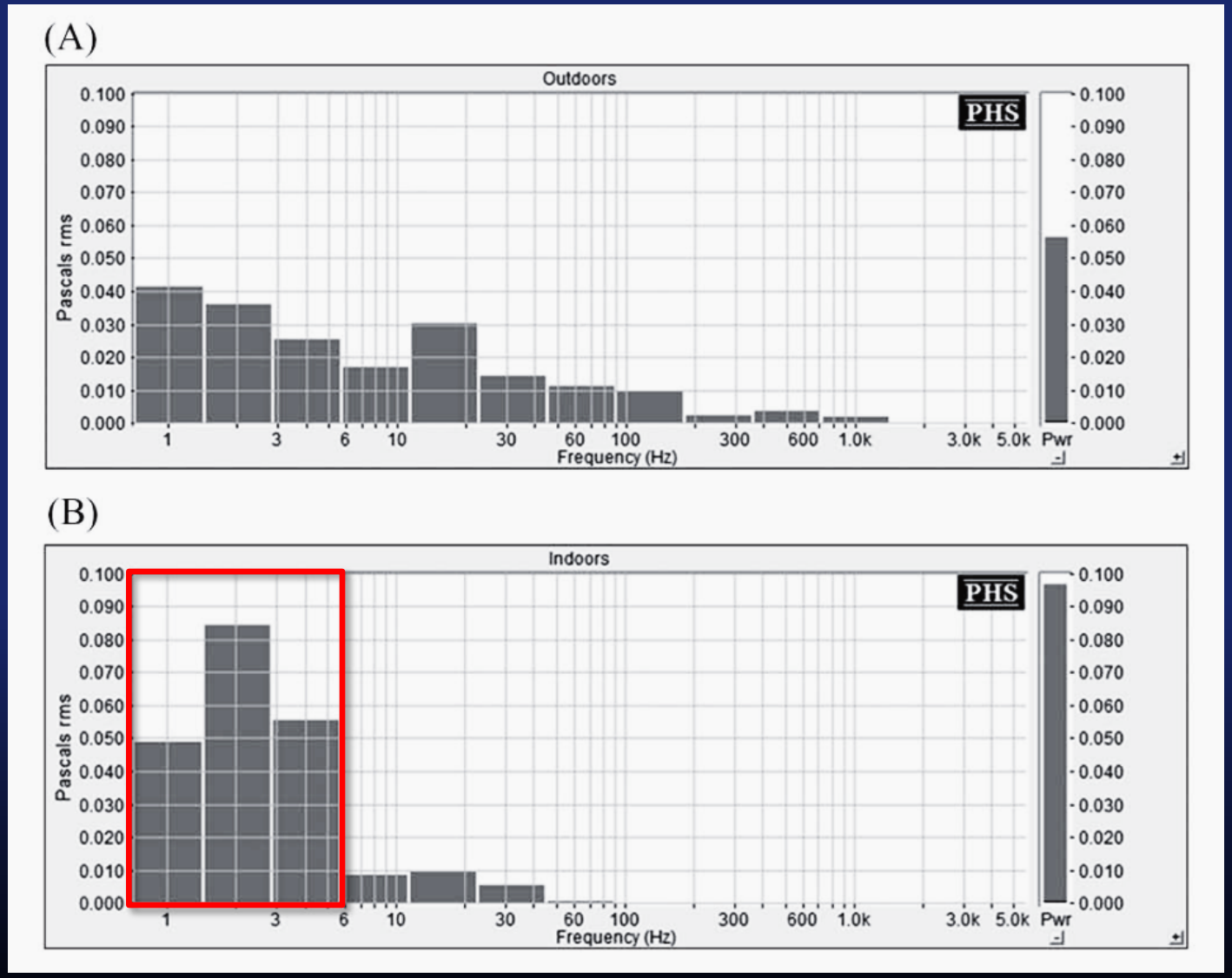
Health Impacts, Falmouth, Ma 4/11, 520 m (1700 ft)



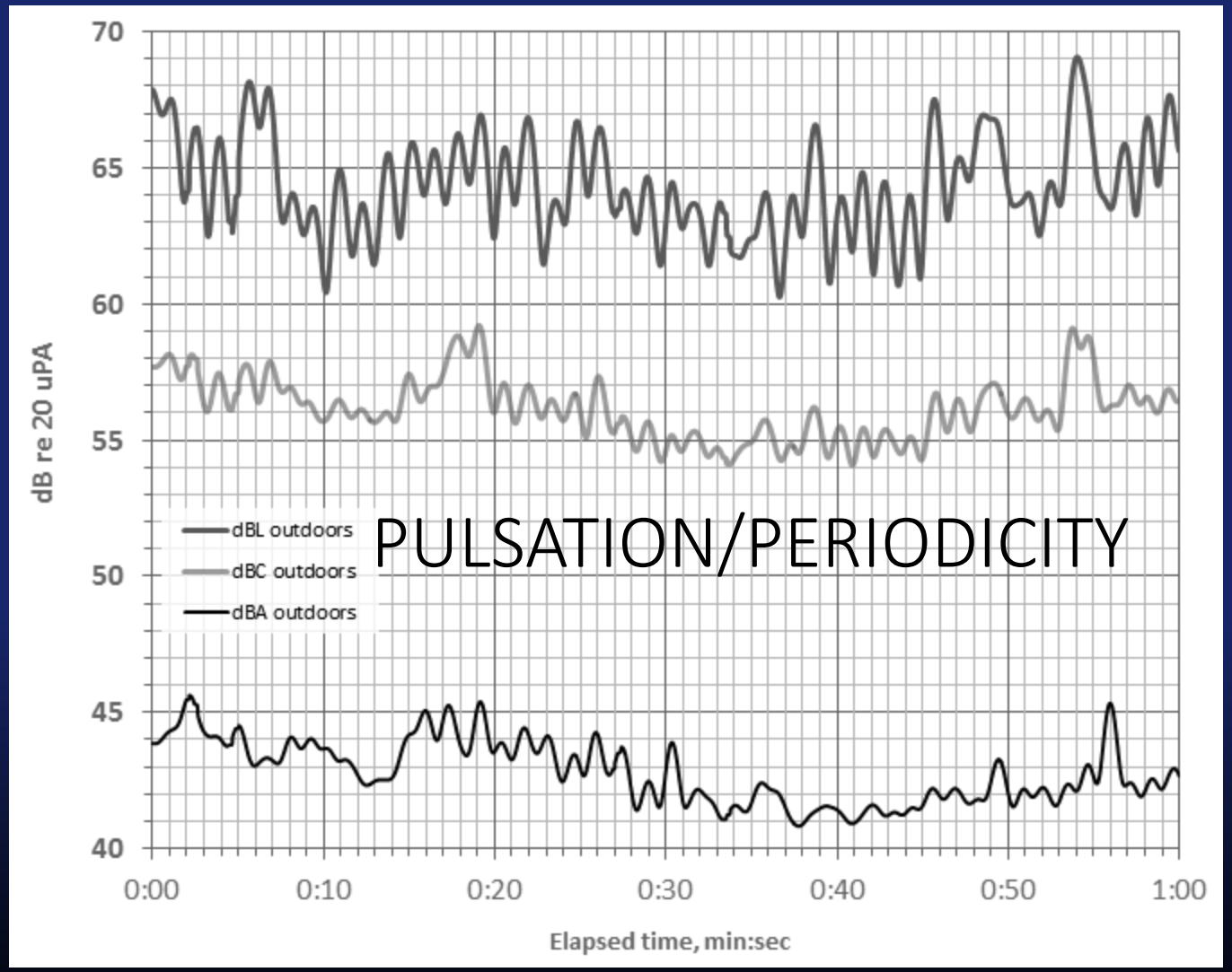
Low Frequency Noise Dominates



Stronger indoors, pressure pulsations.



Pulsations at 0.7 Hz. Time series: linear, dBC and dBA.



Spacial Disorientation (similar to jet pilot reports after repeated hard maneuvering)

Rob Rand: “I went outside hoping to feel better. I looked straight at a tree with my eyes, and my brain said the tree was about 20 to 30 degrees elevated and about 20 to 30 degrees to the right. Then I tried to focus on a bush looking straight at it, and again my brain said the bush was off to the right and elevated at about the same angle as before; and the same for the house. For everything I looked at, immediately my brain would say it was elevated and off to the right.” Steve Ambrose had exactly the same experience, only not the same angles.

Schomer et al, J. Acoust. Soc. Am., Vol. 137, No. 3, March 2015

Falmouth, MA 2011:

Findings: The vestibular system appears to be stimulated by responding to these pressure pulsations rather than by motion or disease, especially at low ambient sound levels. Dose response appears involved, due to time onset.
Planning: It is especially important to include a margin of safety sufficient to prevent inaudible low-frequency wind turbine noise from being detected by the human vestibular system.

Shirley, WI 2012:

Report Number 122412-1
Issued: December 24, 2012
Revised:

A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin

Prepared Cooperatively By:

Channel Islands Acoustics, Camarillo, CA
Principal: Dr. Bruce Walker

Hessler Associates, Inc., Haymarket, VA
Principals: George F. and David M. Hessler

Rand Acoustics, Brunswick, ME
Principal: Robert Rand

Schomer and Associates, Inc., Champaign, IL
Principal: Dr. Paul Schomer

Residents report being intensely affected
despite inaudibility
and to be aware of turbine operation
when the turbines are not visible.

Walker, 2012.

Shirley Study 2012 Team Summary:

The critical questions are what physical effects do these low frequencies have on residents and what LFN limits, if any, should be imposed on wind turbine projects. The reported response at residence R2 by the wife and their child was extremely adverse while the husband suffered no ill effects whatsoever, illustrating the complexity of the issue. The family moved far away for a solution.

A most interesting study in 1986 by the Navy reveals that physical vibration of pilots in flight simulators induced motion sickness when the vibration frequency was in the range of 0.05 to 0.9 Hz with the maximum (worst) effect being at about 0.2 Hz, not too far from the blade passing frequency of future large wind turbines. If one makes the leap from physical vibration of the body to physical vibration of the media the body is in, it suggests adverse response to wind turbines is an acceleration or vibration problem in the very low frequency region.

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.

Shirley Study 2012 Rand Conclusions:

A nauseogenic factor is present. Naval, aviation and other research has established human sensitivity to motion producing nausea. While mechanism for motion sickness is not well understood, "theories all describe the cause of motion sickness via the same proposition: that the vestibular apparatus within the inner ear provides the brain with information about self motion that does not match the sensations of motion generated by visual or kinesthetic (proprioceptive) systems, or what is expected from previous experience". The range of motion nauseogenicity has been measured at 0.1 to 0.7 Hz and with a maximum nauseogenic potential at 0.2 Hz [5][6] (see Figure 1). The Nordex N100 has a rotational rate of 0.16 to 0.25 Hz and a nominal blade passage rate of 0.5 to 0.7 Hz (three times the rotational rate). A hypothesis is suggested based on the limited, preliminary research correlating acceleration and nauseogenicity: ***Nauseogenicity is present at Shirley due to acceleration on inner ear from modulated, impulsive acoustic pressure at rotation and/or blade passage rates.***

A theory to explain some physiological effects of the infrasonic emissions at some wind farm sites: Schomer 2015

Most residents do not hear the wind-turbine sound; noise annoyance is not an issue. The issue is physiological responses that result from the very low frequency infrasound and that appears to trigger motion sickness mainly in some of those who are susceptible to it. These results suggest a relation between wind turbines and motion sickness symptoms in what appears to be a small fraction of those exposed.
(Note: perhaps 5-10 percent of the population).

Schomer et al, J. Acoust. Soc. Am., Vol. 137, No. 3, March 2015

INTRUSIVE LOW FREQUENCY NOISE: A PROBLEM KNOWN FOR DECADES

Low frequency noise:
Sick Building Syndrome, 1970s.

Sick Building Syndrome: Acoustic Aspects

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Abstract

Low-frequency noise, centred around a frequency of about 7 Hz, was found to occur in several office rooms investigated. Symptoms resulting from exposure to infrasound can include fatigue, headache, nausea, concentration difficul ties, disorientation, seasickness, digestive disorders, cough, vision problems and dizziness, that is, symptoms typical of the sick building syndrome. Many of the occupants exhibited such symptoms. It is shown that the low-frequency component of ventilation noise is often being amplified in the tightly sealed rooms. Repeated or long-term exposure to such amplified infrasound may be triggering an allergic-type response in individuals.

Intrusive noise penetrates homes, disturbing. (Hubbard 1982).

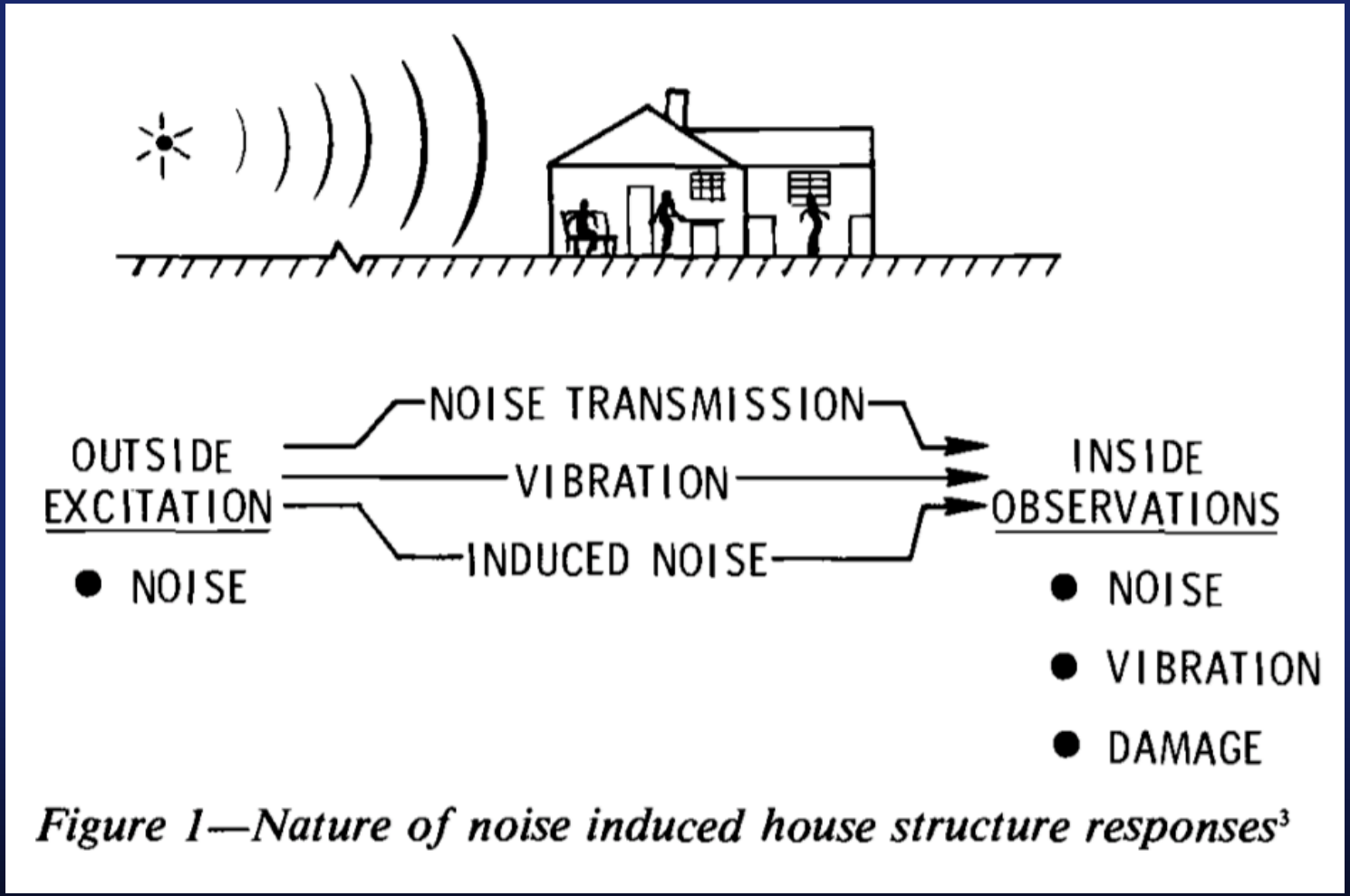


Figure 1—Nature of noise induced house structure responses[3]

Low frequency noise adverse well below the “hearing threshold”.

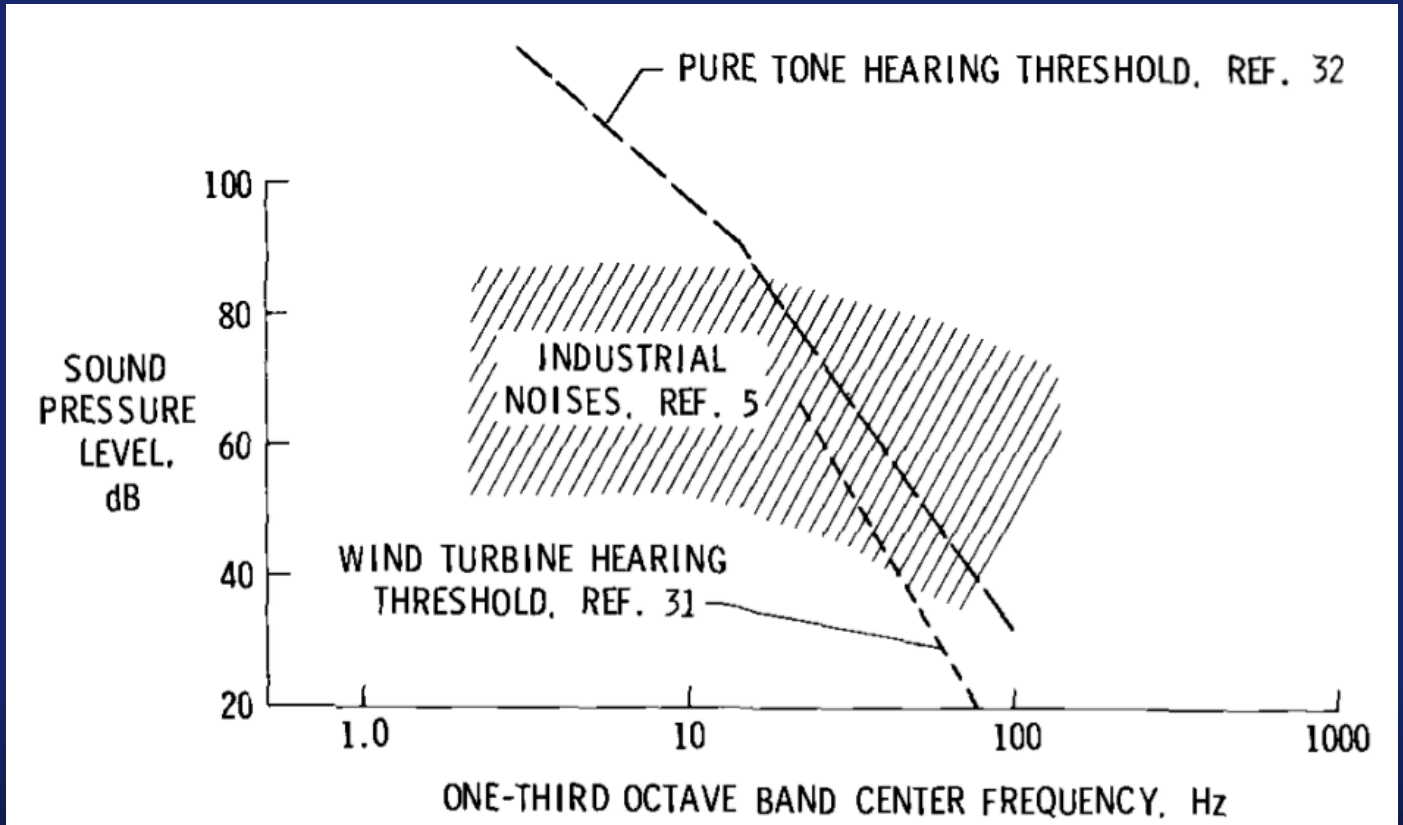
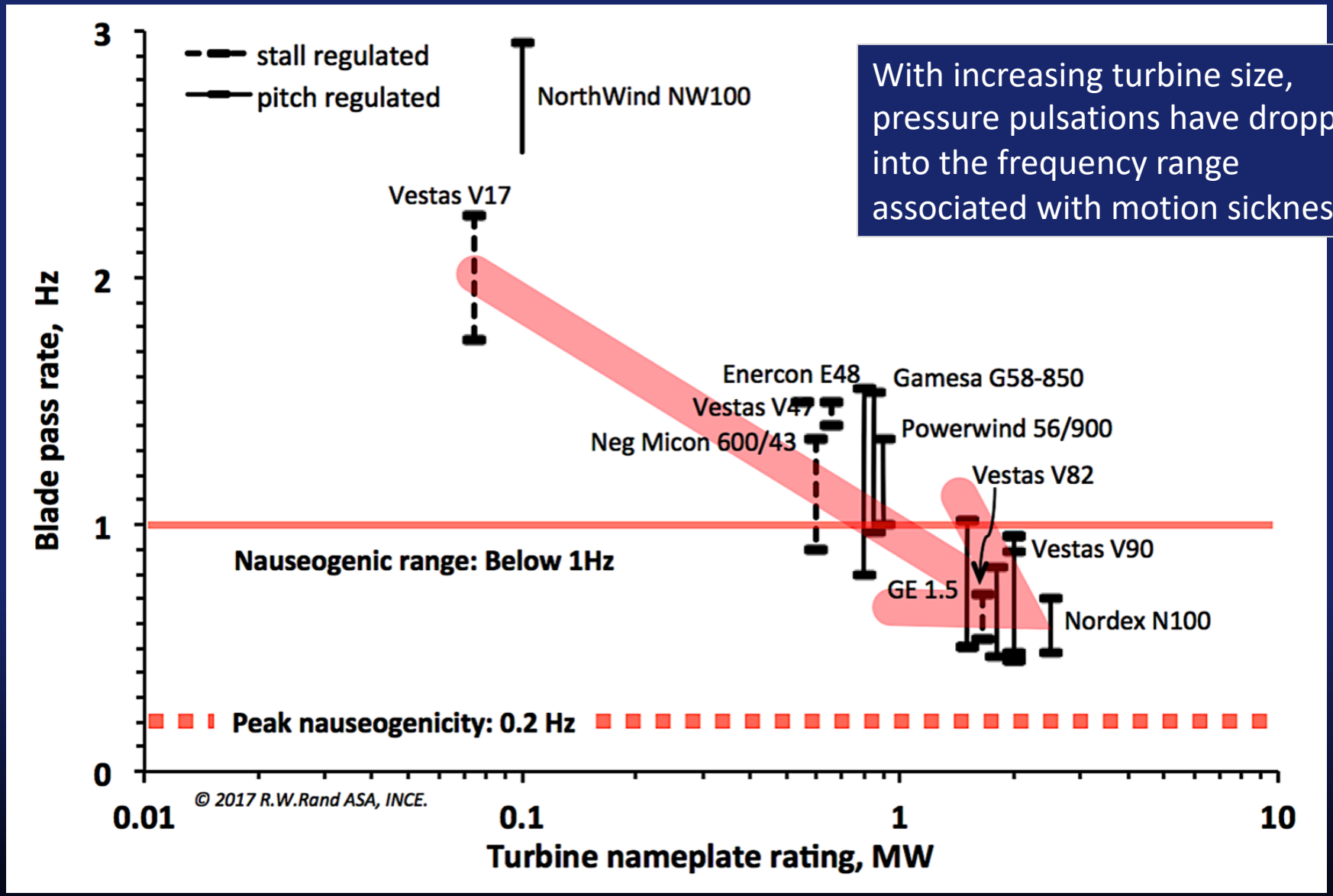


Figure 12—Range of low frequency inside noise levels which caused adverse reactions by occupants

Hubbard 1982.



With increasing turbine size, pressure pulsations have dropped into the frequency range associated with motion sickness.

Motion sickness and low frequency oscillations:

ISO 9996: Mechanical vibration and shock - Disturbance to human activity and performance - Classification

(Quoting from equivalent open standard IS 14979:2001)

"Motion sickness (popularly named airsickness, seasickness and so on, according to context) is a commonly experienced and sometimes severe but reversible (i.e. physiological) disorder specifically associated with exposure to actual or perceived oscillatory motion in the frequency range 0,1 Hz to 1 Hz. One or more of a constellation of symptoms (with or without frank vomiting) may afflict the sufferer."

"There is evidence that infrasound has a physiological effect on the ear. Until this effect is fully understood, it is impossible to conclude that wind turbine noise does not cause any of the symptoms described."

J Laryngol Otol. 2013 Mar;127(3):222-6.
doi: 10.1017/S0022215112002964.

Department of ENT Head and Neck Surgery
Glan Clwyd Hospital, Rhyl, Wales, UK
https://www.ncbi.nlm.nih.gov/pubmed/23331380

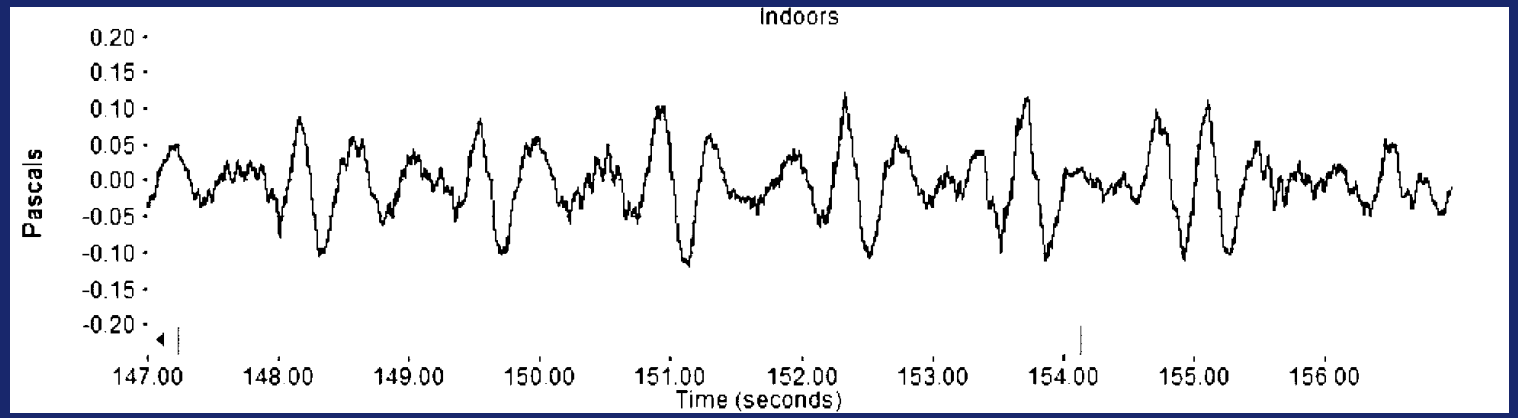
”..infrasound near the hearing threshold may induce changes of neural activity across several brain regions, some of which are known to be involved in auditory processing, while others are regarded as key players in emotional and autonomic control. These findings thus allow us to speculate on how continuous exposure to (sub-)liminal IS could exert a pathogenic influence on the organism.”

Weichenberger M., et al, Department of Psychiatry and Psychotherapy, Charité-Universitätsmedizin Berlin, Berlin, Germany. Physikalisch-Technische Bundesanstalt (PTB), Braunschweig and Berlin, Germany. University Clinic Hamburg-Eppendorf, Clinic and Policlinic for Psychiatry and Psychotherapy, Hamburg,Germany

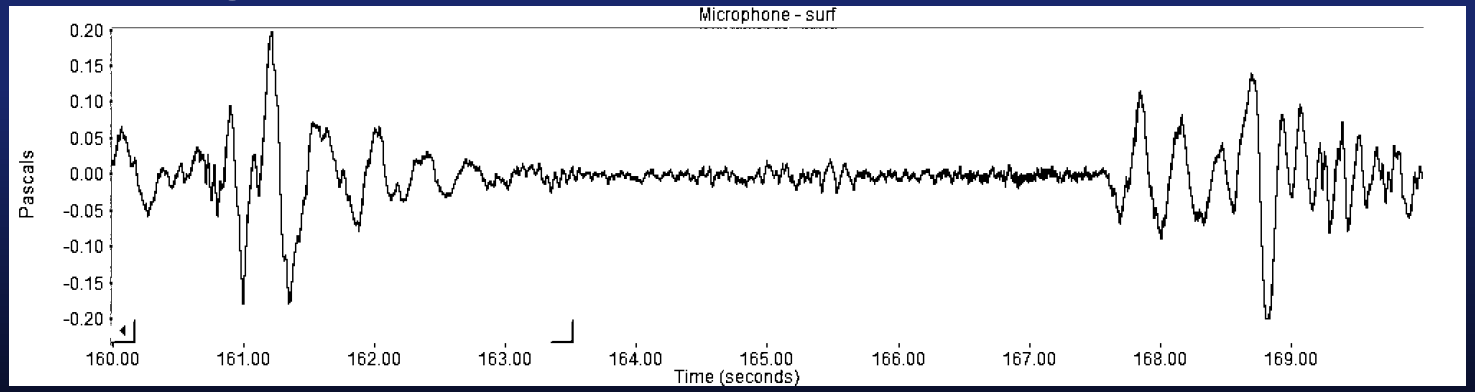
PLoS One 2017 Apr 12. doi: 10.1371/journal.pone.0174420
https://www.ncbi.nlm.nih.gov/pubmed/28403175

Field Tests: Wind turbine and surf pulsations

1.65MW Wind turbine 525m, indoors, 4/2011. SICK, DIZZY, NAUSEOUS.



Strong surf 30m, indoors, 10/2012. HEALTHY, SLEPT WELL.



Noise complaints indoors

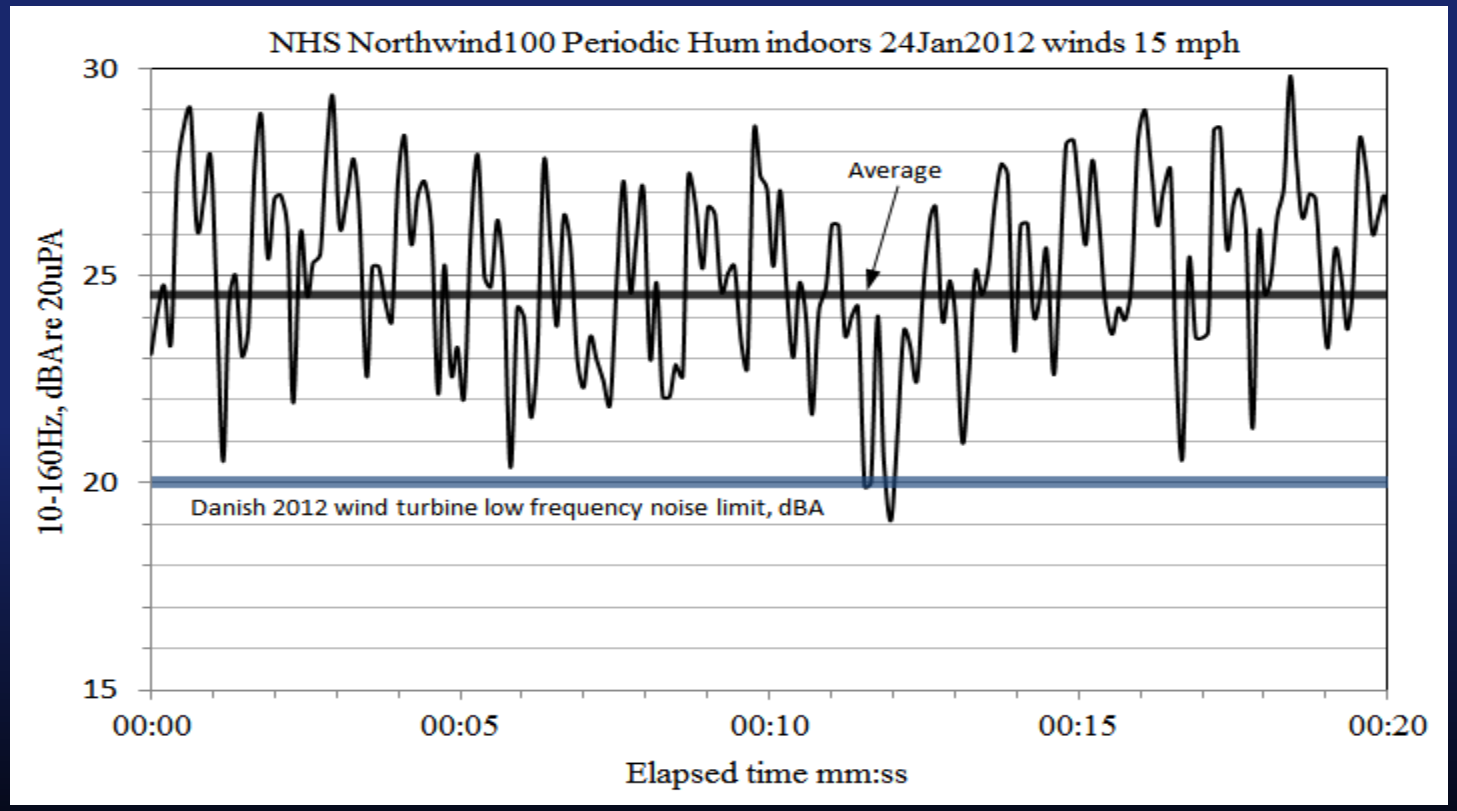
Usually noise complaints are for indoors impacts.
Usually for low-frequency noise (LFN).
Usually for pulsatile or repeating peak noise.

DISCONNECT WITH REGULATORY AUTHORITY:
A-weighting is not representative for LFN (ANSI).
Regulation limits outdoors, impacts indoors = Lawsuits.

Evaluate with linear, un-averaged, attended
LFN intrusive noise standard, Danish Lpa,LF (10-160 Hz)

Nantucket: 100kw IWT, re Danish 20 dBA,lf standard. LFN pulsations clearly visible.

LFN INDOORS: APPEALS TO STOP THE NOISE



Low frequency noise induced annoyance:

"Those exposed may adopt protective strategies, such as sleeping in their garage if the noise is less disturbing there. Or they may sleep elsewhere, returning to their own homes only during the day."

Leventhall HG. Low frequency noise and annoyance.
Noise Health [serial online]
2004 [cited 2009 Dec 31];6:59-72. Available from:
http://www.noiseandhealth.org/text.asp?2004/6/23/59/31663

Wind Turbine Noise Control Options

Unlike all other power plant technologies, which have numerous noise control options:
The only reliable noise control option for wind turbines is **DISTANCE**.

Reality: NOISE POLLUTION isn't "CLEAN".

Reality: Wind turbines are NOISY

When too close to neighbors: NOISE POLLUTION.

2000 meters (6560 feet) – Politician.. demands failed.

Simon Ramsay. *Photo: Rob Gunstone*

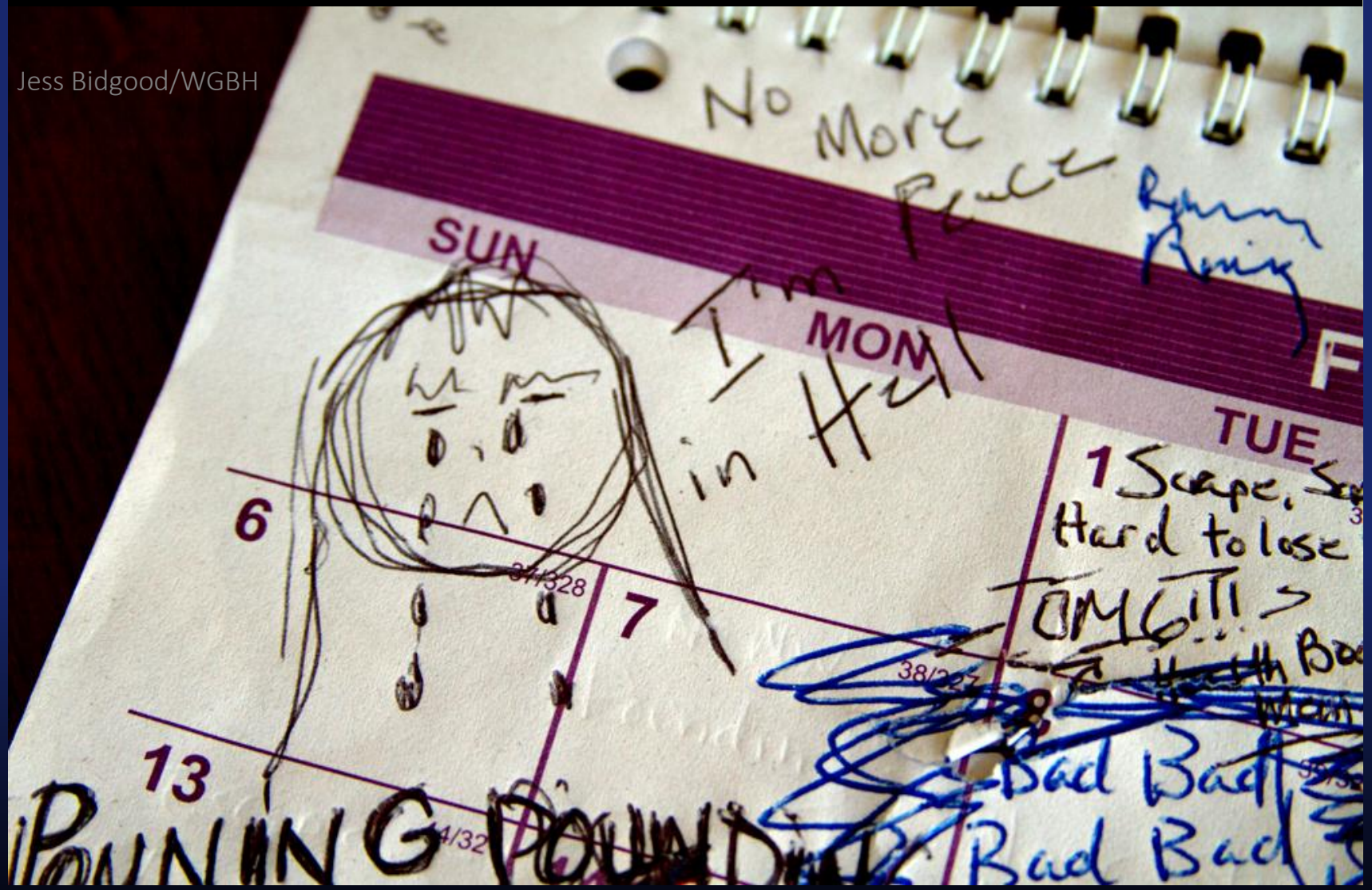
IN THE NEWS…

In the mid-2000s Australian Upper house MP Simon Ramsay was a vocal champion of wind energy and obtained permits for turbines on a parcel of his own land, … His recent activism has included campaigning *against* turbines for which he previously held permits. He sought a string of concessions, including that the company ***scrap all turbines within two kilometres of his home.***

theage.com.au, 2/12

http://www.theage.com.au/environment/energy-smart/mp-pressured-wind-farm-developer-20120221-1tlwc.html

430 meters (1410 feet) – Neighbor.. appeals ignored.



THANK YOU FOR LISTENING.

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