

# Windturbinegeluid & gezondheid

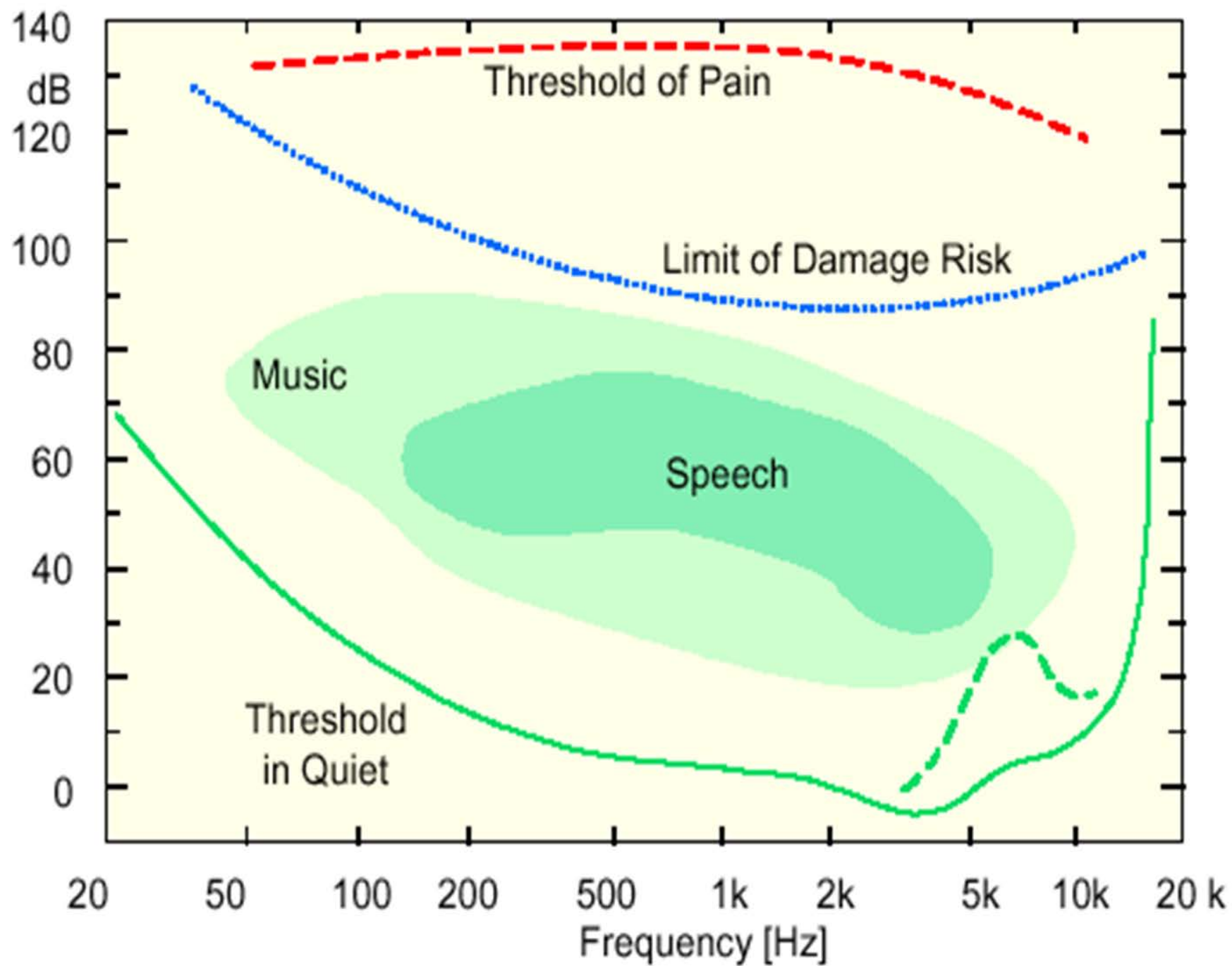
**Windturbines in Dinkelland (Denekamp)**

**Gemeenteraadscommissievergadering Windbeleid**

**12 december 2023**

**Dr.ir. Jan A.P.M. de Laat, klinisch-fysicus - audioloog**

Sound Pressure Level



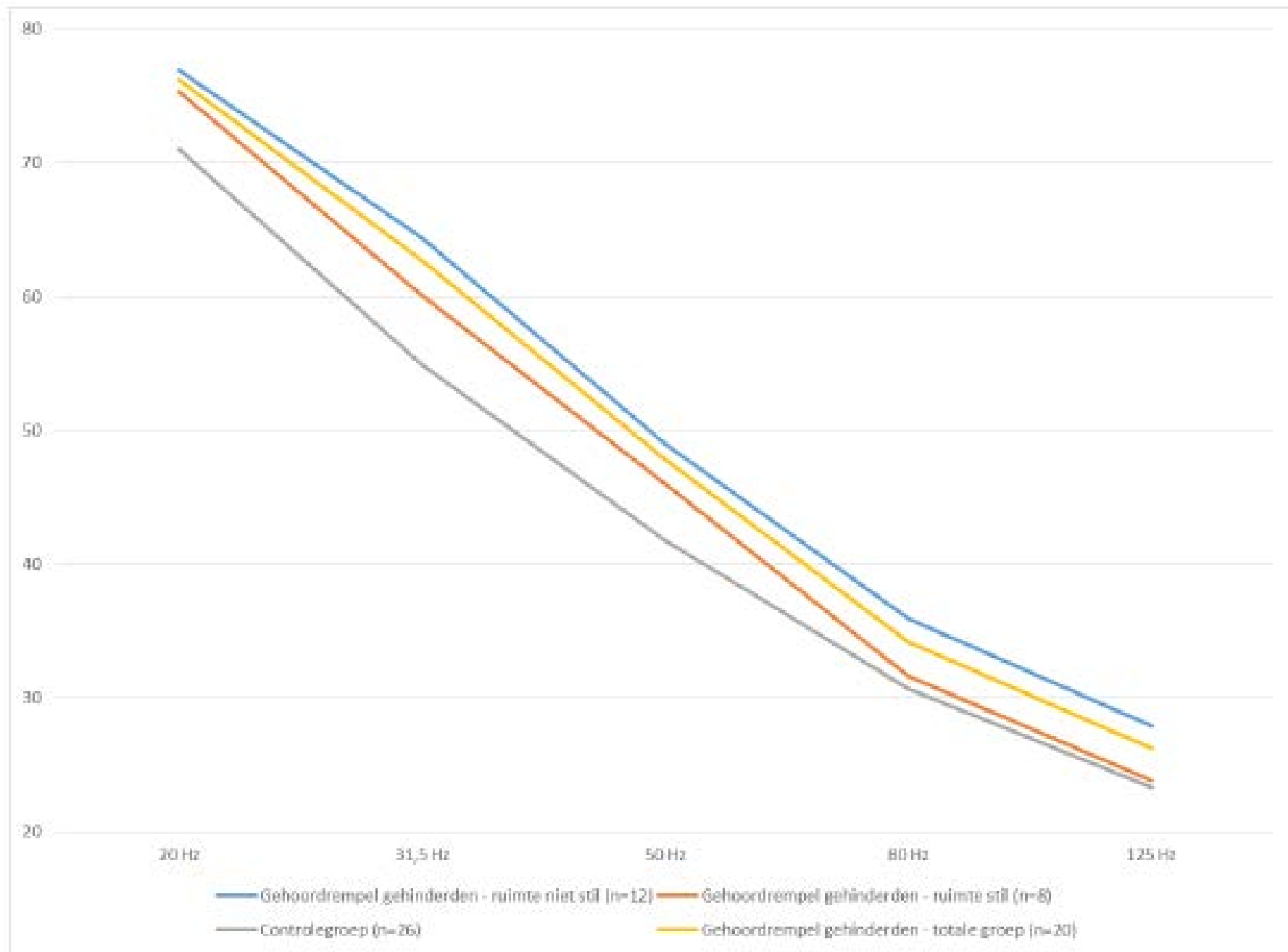
## Hebben mensen die hinder hebben van laag frequent geluid een lagere gehoordrempel voor lage tonen?

Een onderzoek naar overgevoeligheid voor lage tonen.



L. Groenewold, GGD Noord Oost Gelderland  
S. Schoevaars-Lops, GGD Gelderland-Midden  
F. Aarts, GGD Gelderland-Zuid  
J. de Laat, Leids Universitair Medisch Centrum

22 december 2016



**Figuur 2: Gemiddelde gehoordrempel per groep in dB per aangeboden frequentie.**

RAPID COMMUNICATIONS



## A new method with an explant culture of the utricle for assessing the influence of exposure to low-frequency noise on the vestibule

Nobutaka Ohgami<sup>a,b</sup>, Tingchao He<sup>a,b</sup>, Reina Oshino-Negishi<sup>a,b</sup>, Yishuo Gu<sup>a,b</sup>, Xiang Li<sup>a</sup>, and Masashi Kato<sup>a,b</sup>

<sup>a</sup>Department of Occupational and Environmental Health, Nagoya University Graduate School of Medicine, Nagoya, Japan; <sup>b</sup>Voluntary Body for International Health Care in Universities, Nagoya, Japan

<https://nos.nl/op3/artikel/2196081-een-aanval-met-onhoorbaar-geluid-hoe-werkt-dat>

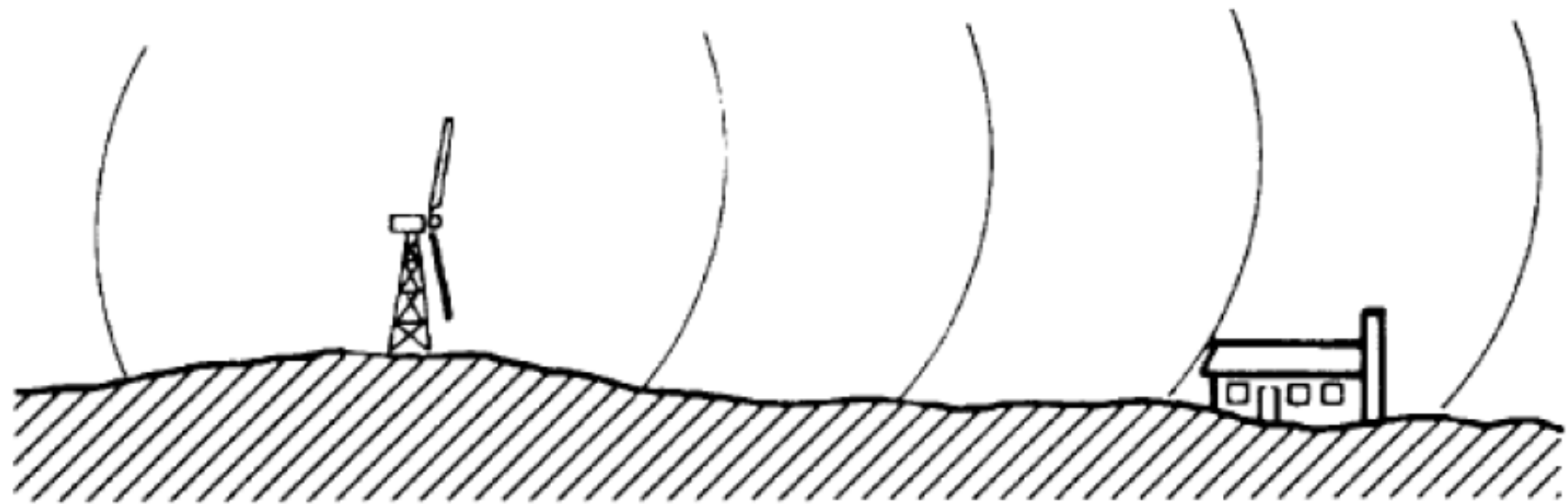


## Windturbinegeluid op steeds grotere afstand



Voorbeeld orgelpijp, 32' , 20 Hz, <https://www.sydneyorgan.com/STH64.mp3>

<https://freesound.org/people/soundslikewillem/sounds/176235/>



Noise sources

- Aerodynamic
- Mechanical

Propagation paths

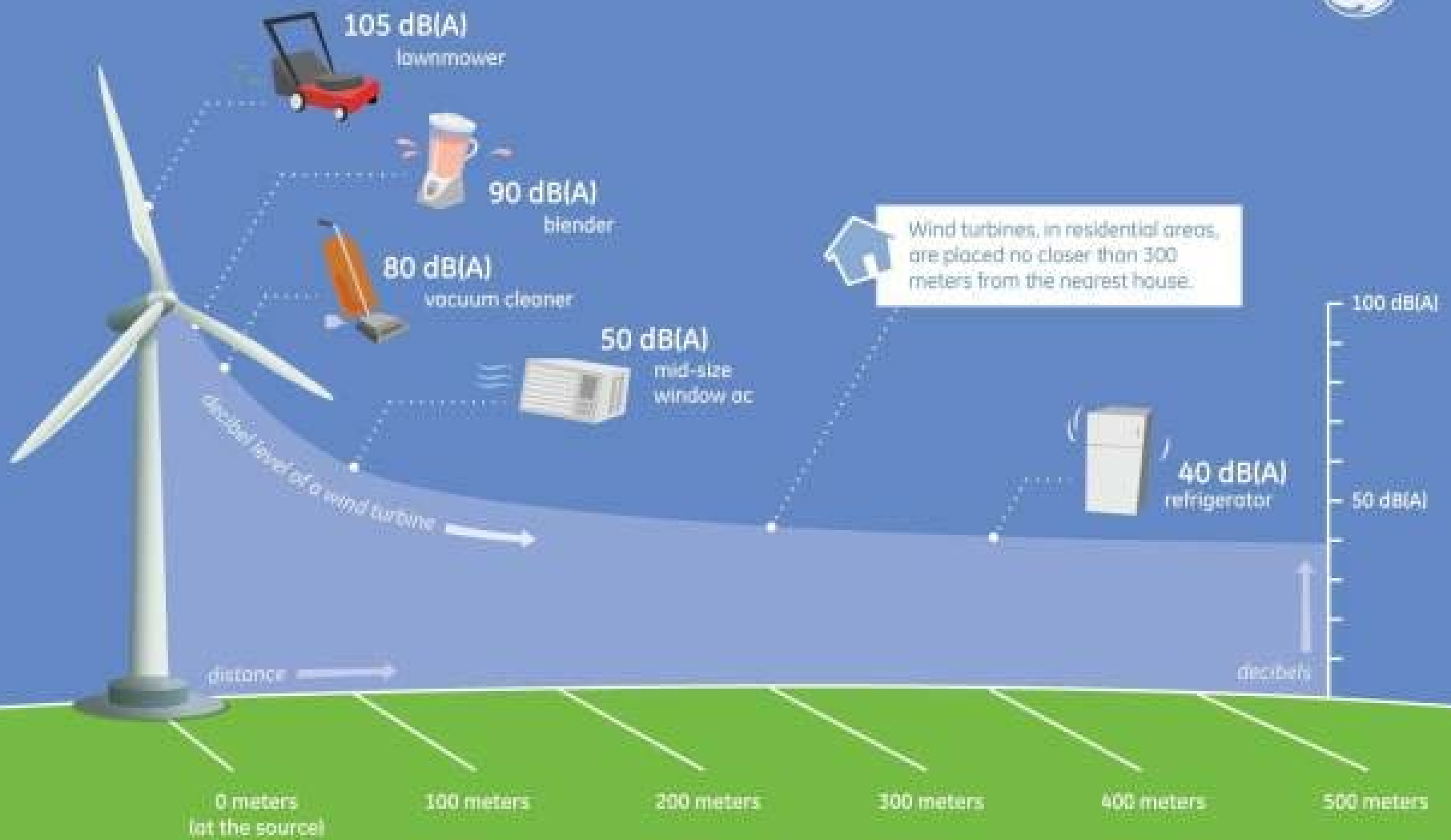
- Distance
- Wind gradients
- Absorption
- Terrain

Receivers

- Ambient noise
- Indoor/outdoor exposure
- Building vibrations



# How Loud Is A Wind Turbine?



# Eigen onderzoek, artikelen

Eind augustus 2021 is 'n artikel in MT-Integraal geplaatst:

<https://mtintegraal.nl/artikelen/1169/hinderlijk-geluid-van-windturbines>.

Eind oktober 2021 'n andere versie in het KNO-tijdschrift:

[https://ntvkno.nl/article\\_ft.php?a=2817&d=2165&i=309](https://ntvkno.nl/article_ft.php?a=2817&d=2165&i=309).

En, begin december 2021, 'n weer iets andere (uitgebreidere) versie in het NTVG:

<https://www.ntvg.nl/artikelen/geluid-van-industriële-windturbines>.

Sinds 2021 zijn we bezig met 'n Systematic Review (ruim 300 artikelen), die nog steeds onderhevig is aan veel nationaal en internationaal commentaar.

Newcastle-Ottawa quality scale (NOS)

Minimal Clinically Important Differences (MCID)

Grading of Recommendations Assessment, Development and Evaluation (GRADE, health outcomes)

Pittsburgh Sleep Quality Index (PSQI)

Epworth Sleepiness Scale (ESS)

Insomnia Severity Index (ISI) scores

Auteurs: Sylvia van Manen, Louw Feenstra, Wilco Alteveer, Ronald Maas, ....., Jan de Laat

**Table 2a**  
Main characteristics of studies investigating the association between wind turbine noise, sleep and quality of life.

Study ID	Study location & site topography	Number of participants	SPLs & distance from WTGs	Power & number of WTGs	Outcomes	Tools used to measure outcomes
Bakker et al. (2012)	1. Rural area (with no major road within 500 m from the closest wind turbine) 2. Rural area with a major road within 500 m from the closest wind turbine 3. More densely populated built up area Flat terrain	725	21–54 dB (average: 35 dB) 0–2.5 km	≥500 kW (0.5 MW); 1846	Annoyance, sleep disturbance, psychological stress	Annoyance: 5-point ordinal scale & 2 Likert scales. Sleep disturbance: Frequency
Krogh et al. (2011)	5 WTG areas with anecdotal reports of adverse health effects	109	0.35–2.4 km	1.65 MW; 5 WTG project areas	Sleep disturbance	WindVOiCe Survey Questionnaire
Magari et al. (2014)	1. Rural area 2. 5 receptor locations within wind turbine park; two locations outside the park as comparator	62	0.4–4 km	1.5 MW; 84	Annoyance, health effects	Validated general questionnaire
Nissenbaum et al. (2012)	2 rural areas – ‘low-lying, tree-covered island.’ Flat terrain	79	32–57 dB 0.4–6.6 km	1.5 MW; 31	Sleep quality, mental health	Sleep disturbance: PSQI & ESS QOL: (SF-36v2)
Pawlaczyk-Łuszczynska et al. (2014)	1. 3 populated areas in Central & Northwest Poland 2 Flat terrain 3. Mainly agricultural, but railroads and/or roads also present	156	30–50 dB 0.24–2.5 km	0.15, 1.5 & 2 MW; total number of wind turbines 108	Annoyance, mental health	Annoyance: 5-point ordinal scale Sleep and QOL: GHQ
Pedersen and Persson Waye (2004)	5 wind turbine areas; flat terrain	351	<30 to >40 dB 0.15–1.2 km	14 WTGs: 600–650 kW; 2 WTGs: 150 & 500 kW	Noise perception, annoyance, sleep disturbance	Validated general questionnaire: Annoyance: unipolar annoyance scale Sleep disturbance: presence or absence
Pedersen and Persson Waye (2007)	7 wind turbine areas; different landscapes in terrain and urbanisation (flat and ‘complex’-rocky or altitude); suburban and rural	754	31.4–38.2 dB (mean: 33.4). 0.6–1 km (mean: 0.78 km)	> 500 kW; 478	Perception, annoyance, sleep quality, quality of life	Validated general questionnaire Annoyance: unipolar annoyance scale Sleep disturbance: presence or absence
Shepherd et al. (2011)	2 semi-rural coastal areas differentiated by their proximity to wind turbines; hilly terrain	197	20–50 dB <2 to 8 km	2300 kW; 66	Annoyance, sleep disturbance, quality of life (health)	Questionnaire with subcomponents: Annoyance: 7-item scale Sleep: 7-item scale QOL: HRQOL

Abbreviations: SPLs: sound pressure levels; WTGs: wind turbine generators; dB: decibels; km: kilometres; kW: kilowatts; MW: megawatts; PSQI: Pittsburgh Sleep Quality Index; ESS: Epworth Sleepiness Scale; QOL: quality of life; GHQ: general health questionnaire; HRQOL: health-related quality of life.

# Wind Turbine Syndrome

A REPORT ON A NATURAL EXPERIMENT

.....  
Nina Pierpont, M.D., Ph.D.

Health worse vs last year<sup>c</sup>

Migraines

Dizziness

Tinnitus

Chronic pain

Asthma

Arthritis

High blood pressure (BP)

Medication for high BP

Family history of high BP

Chronic bronchitis/emphysema/COPD

Diabetes

Heart disease

Highly sleep disturbed<sup>d</sup>

Diagnosed sleep disorder

Sleep medication

Restless leg syndrome

Restless leg syndrome (ON)

Restless leg syndrome (PEI)

Medication anxiety or depression

QoL past month<sup>f</sup>

Poor

Good

Satisfaction with health<sup>f</sup>

Dissatisfied

Satisfied

## INFRASOUND AND LOW FREQUENCY NOISE GUIDELINES: ANTIQUATED AND IRRELEVANT FOR PROTECTING POPULATIONS

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# scientific reports



OPEN

## A longitudinal, randomized experimental pilot study to investigate the effects of airborne infrasound on human mental health, cognition, and brain structure

L. Ascone<sup>1✉</sup>, C. Kling<sup>3</sup>, J. Wiczorek<sup>3</sup>, C. Koch<sup>3</sup> & S. Kühn<sup>1,2</sup>

## Research

### Long-Term Exposure to Wind Turbine Noise and Risk for Myocardial Infarction and Stroke: A Nationwide Cohort Study

*Aslak Harbo Poulsen,<sup>1</sup> Ole Raaschou-Nielsen,<sup>1,3</sup> Alfredo Peña,<sup>2</sup> Andrea N. Hahmann,<sup>2</sup> Rikke Baastrup Nordsborg,<sup>1</sup> Matthias Ketzel,<sup>3,5</sup> Jørgen Brandt,<sup>3</sup> and Mette Sørensen<sup>1,4</sup>*

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**BACKGROUND:** Noise from wind turbines (WTs) is reported as more annoying than traffic noise at similar levels, raising concerns as to whether WT noise (WTN) increases risk for cardiovascular disease, as observed for traffic noise.







Acoustics Australia (2020) 48:181–197

<https://doi.org/10.1007/s40857-020-00192-4>

REVIEW PAPER

## A Review of the Potential Impacts of Wind Turbine Noise in the Australian Context

John Laurence Davy<sup>1,2</sup>  · Kym Burgemeister<sup>3</sup>  · David Hillman<sup>4</sup>  · Simon Carlile<sup>5,6</sup> 

Received: 9 September 2020

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DOI: 10.1111/jsr.13228

REVIEW PAPER



## A systematic review and meta-analysis of wind turbine noise effects on sleep using validated objective and subjective sleep assessments








Tessa Liebich<sup>1,2</sup>  | Leon Lack<sup>1</sup>  | Kristy Hansen<sup>3</sup>  | Branko Zajamšek<sup>1</sup>  |  
Nicole Lovato<sup>1</sup>  | Peter Catchside<sup>1</sup>  | Gorica Micic<sup>1</sup> 

Table 1 Low-frequency noise criterion curves

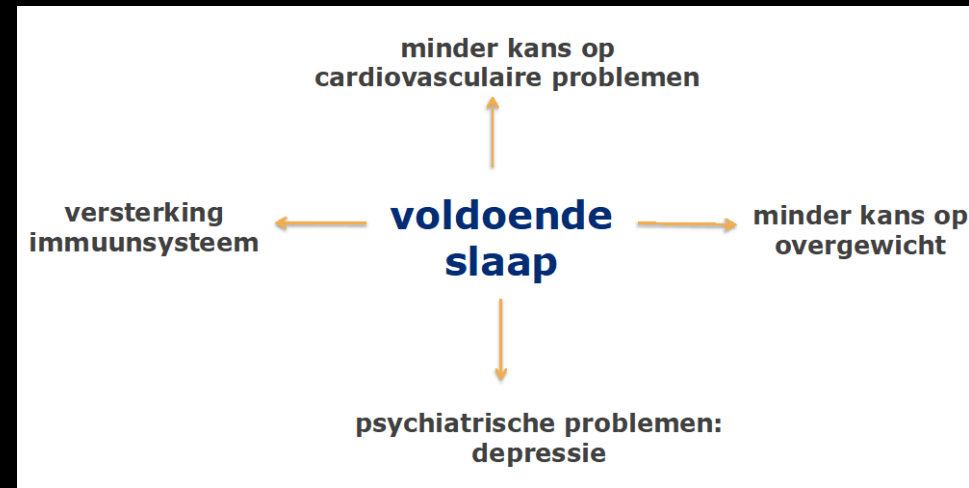
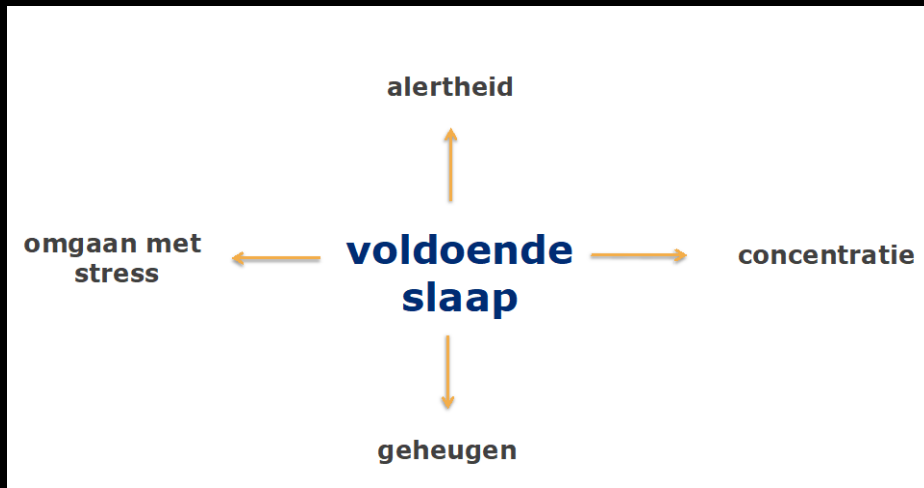
Frequency Hz	Poland 10 dB(A) contour	Germany DIN 45680 dB	Netherlands NSG dB	Denmark Night 20 dB(A) contour	Sweden dB	UK DEFRA dB	ISO 226 dB
8		103					
10	80.4	95		90.4		92	
12.5	83.4	87		93.4		87	
16	66.7	79		76.7		87	
20	60.5	71	74	70.5		74	74.3
25	54.7	63	64	64.7		64	65
31.5	49.3	55.5	55	59.4	56	56	56.3
40	44.6	48	46	54.6	49	49	48.4
50	40.2	40.5	39	50.2	43	43	41.7
63	36.2	33.5	33	46.2	41.5	42	35.5
80	32.5	28	27	42.5	40	40	29.8
100	29.1	23.5	22	39.1	38	38	25.1
125	26.1			36.1	36	36	20.7

## Conclusies

- a) vooral slaapstoornissen (en het lange termijn effect t.a.v. kinderen)
- b) meer onderzoek nodig t.a.v. de grotere turbines, > 5 MW, infrasoona

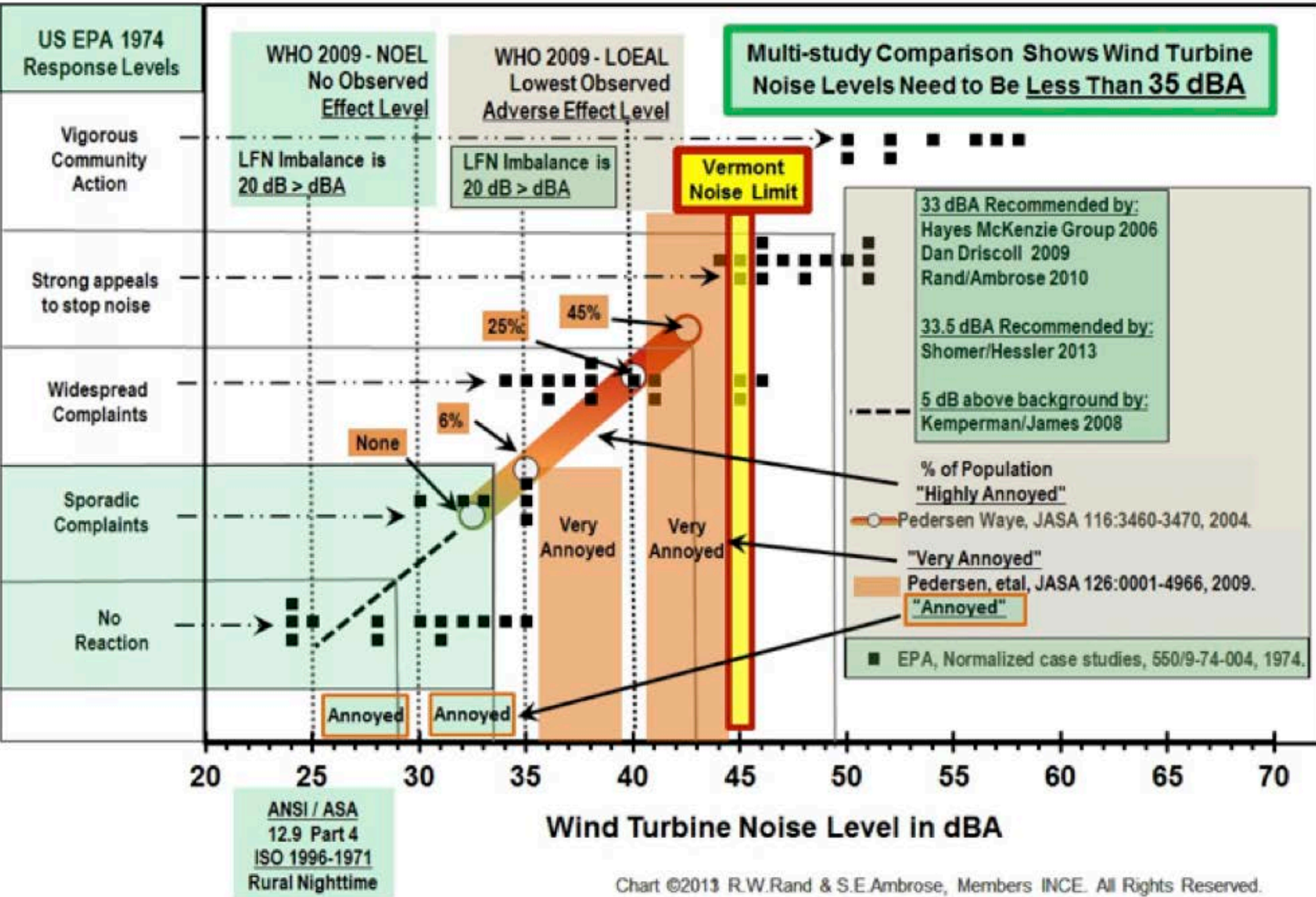


## (Laagfrequent) Geluid



Winni Hofman, UvA

# Predicted Community Reaction for Wind Turbine Noise in Quiet Areas



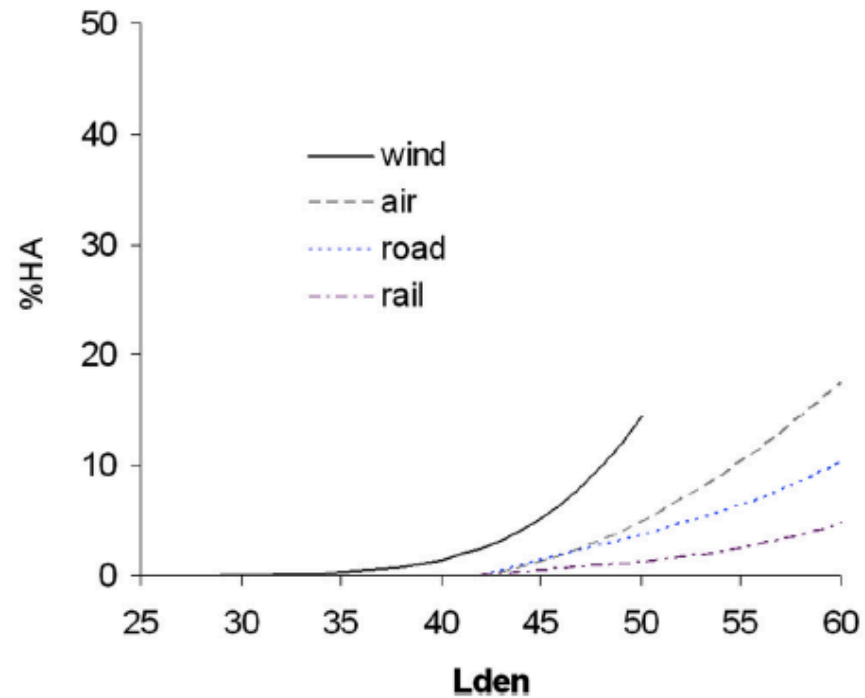
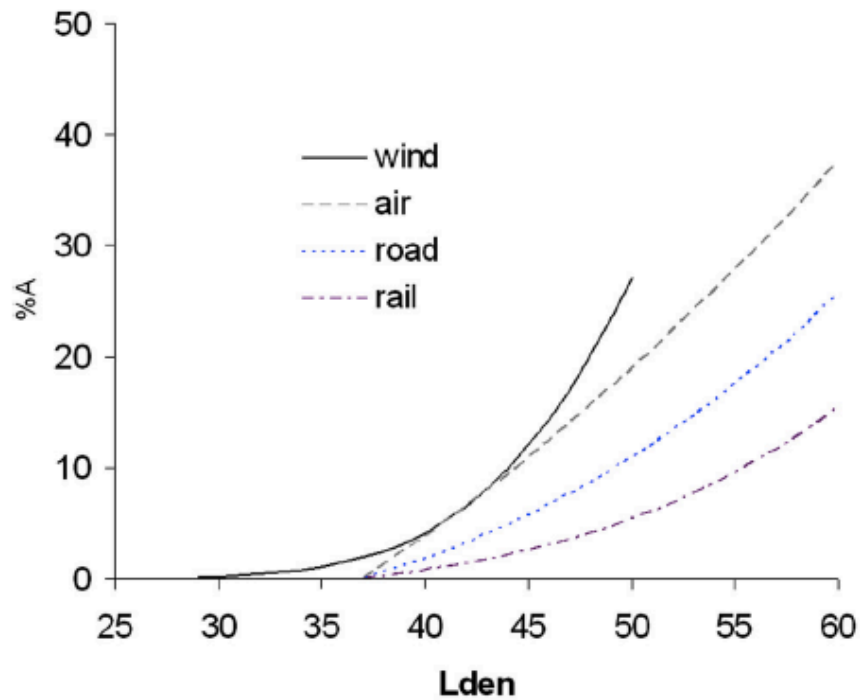
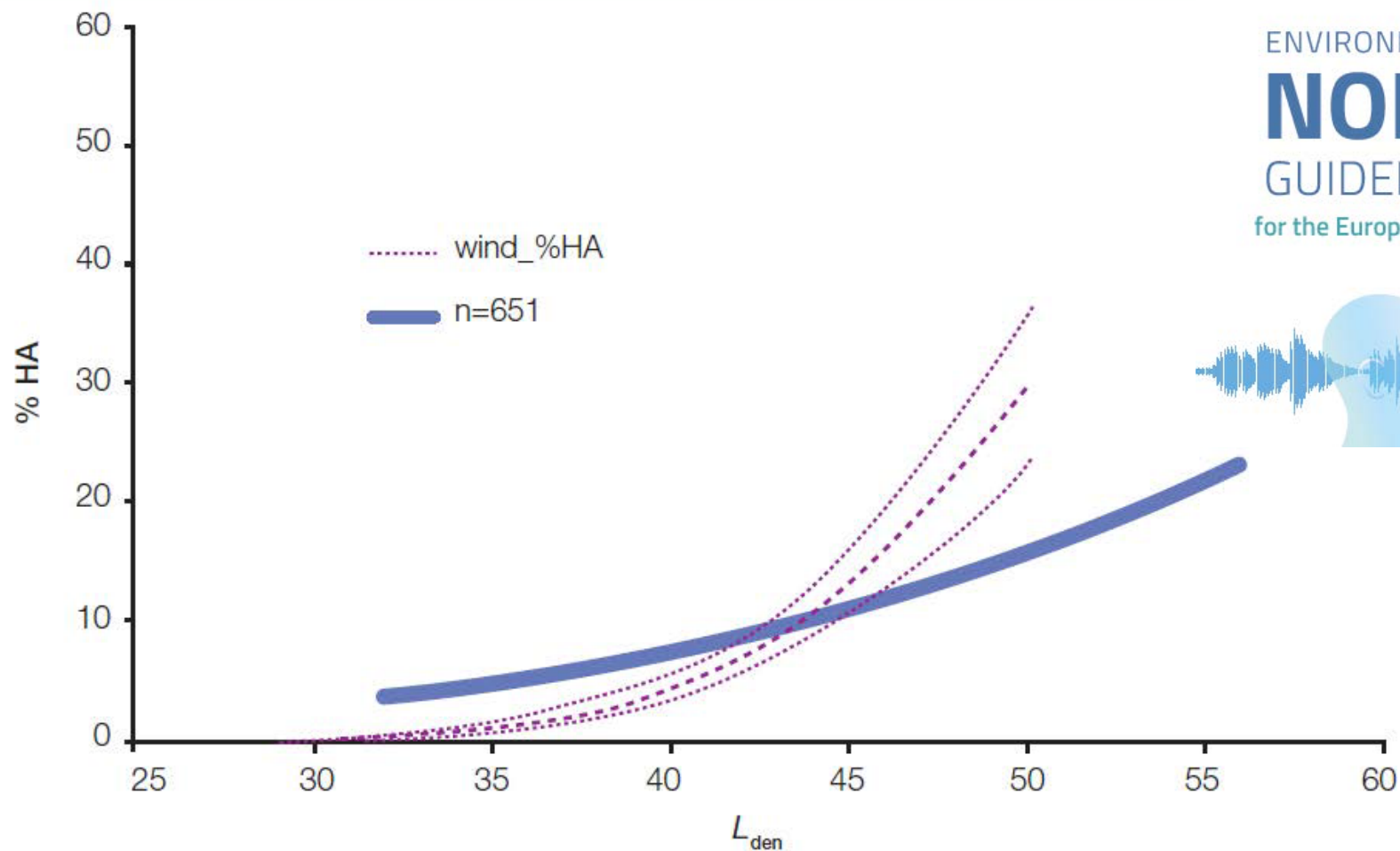


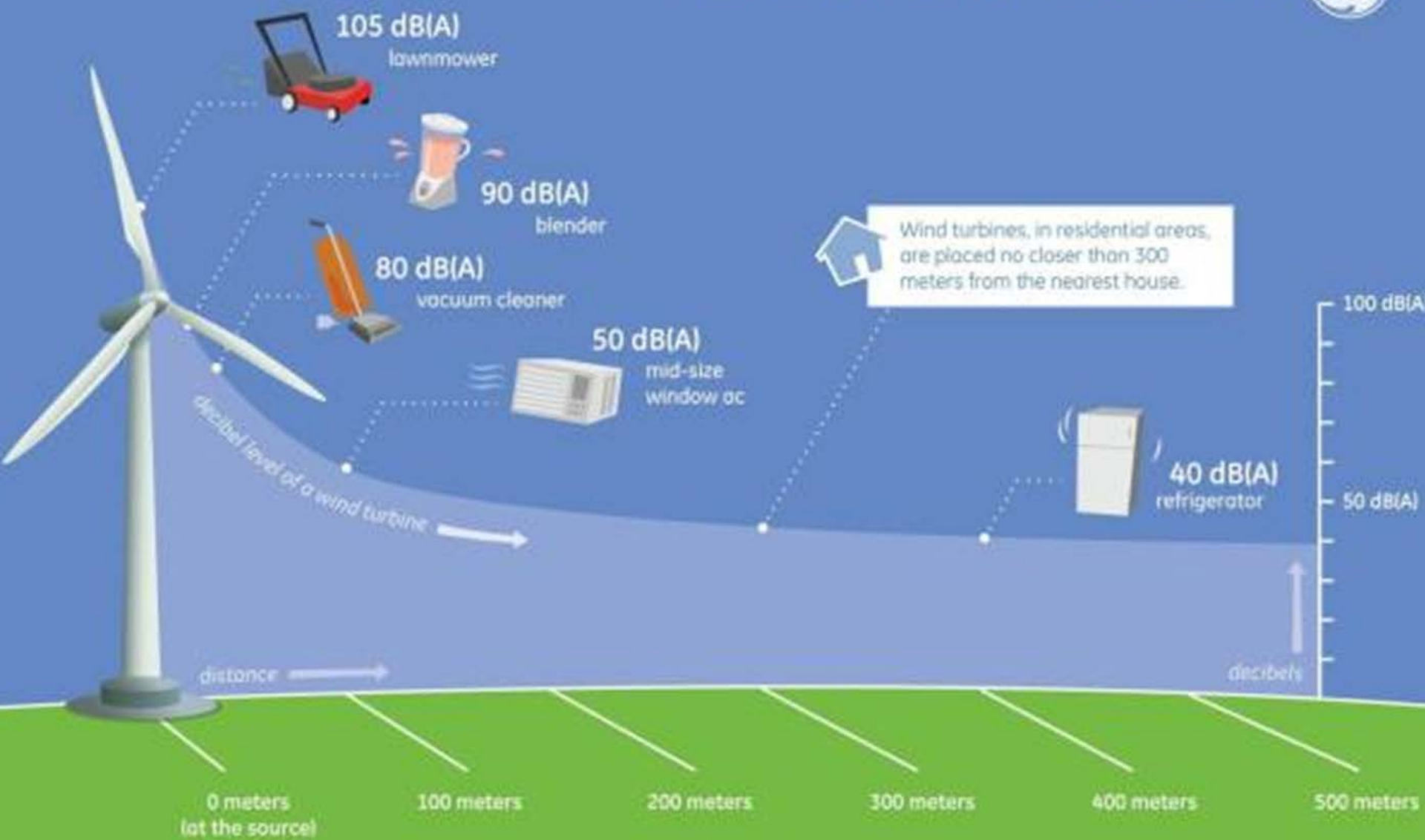
FIG. 3. (Color online) Comparison of the percentage of residents annoyed (%A) or highly annoyed (%HA) indoors due to wind turbine noise (wind) and due to transportation noise (air, road and rail).

Fig. 16. Overlay of the two wind turbine annoyance graphs



Notes: Overlay of the two wind turbine outdoor annoyance graphs adapted from Janssen et al. (2011, red) and Kuwano et al. (2014, blue). The Kuwano et al. curve is based on  $L_{dn}$ ; no correction for  $L_{den}$  has been applied.<sup>18</sup> For further details on the studies included in the figure please refer to the systematic review on environmental noise and annoyance (Guski et al., 2017).

# How Loud Is A Wind Turbine?





# Was das Windkraft-Gesetz aus Bayern bedeutet

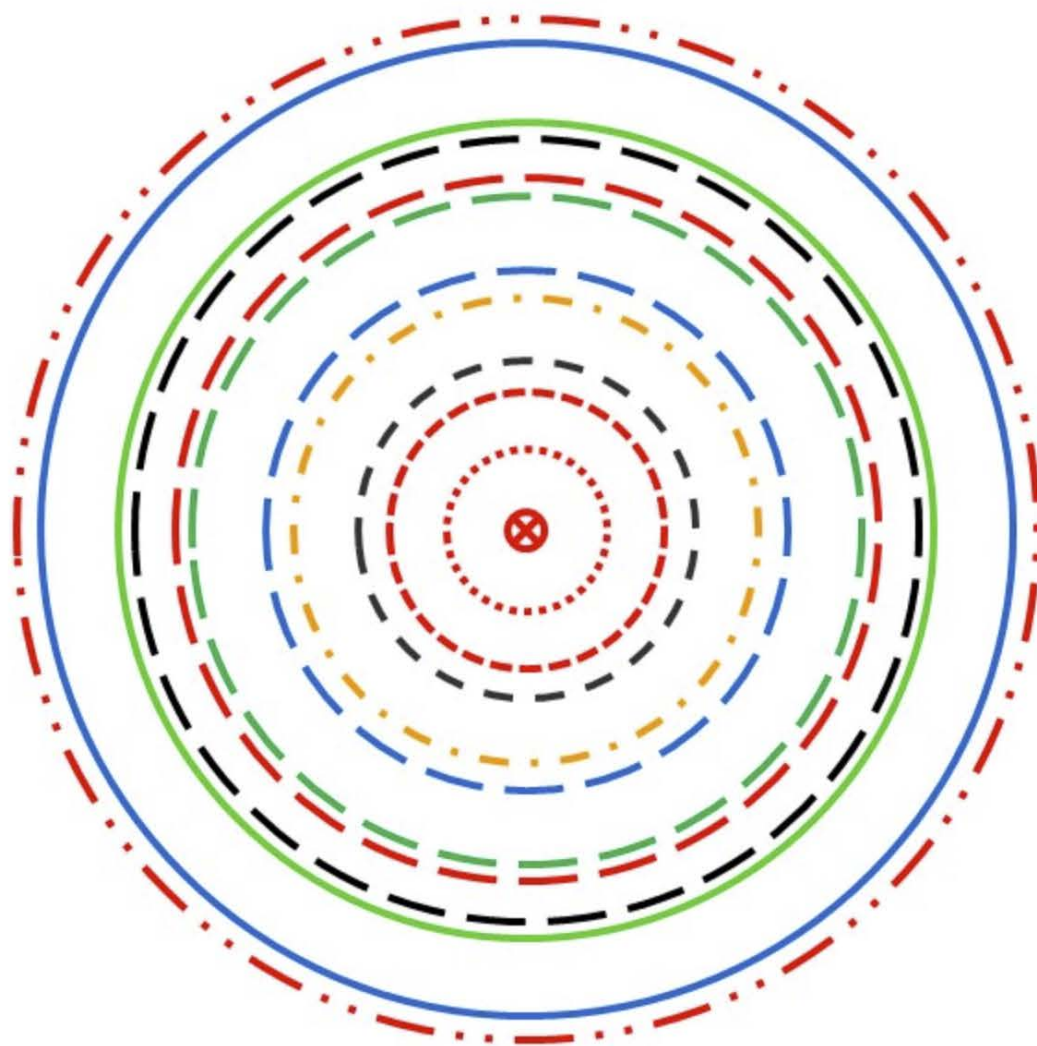
Seit 2014 gilt in Bayern die sogenannte 10-H-Regel.

Demnach muss der Abstand eines Windrads von Wohnungen mindestens zehn Mal so weit sein wie die Anlage hoch ist.

Bei einem 200 Meter hohen Windrad – das ist heutzutage Standard – wären das 2.000 Meter.

Alle Windräder, die nicht bis dahin geplant und genehmigt waren, müssen diese neue Abstandsregelung berücksichtigen.

# Afstanden volgens geluidsnorm voor de nacht voor V150-4.0MW, ashoogte 155 m



- Denemarken
- Frankrijk Zweden
- Duitsland
- Vlaanderen
- Wallonië
- Tsjechië Finland Itale Luxemburg
- Ierland
- Noorwegen
- Liechtenstein Letland Portugal Zwitserland
- Nederland zonder mitigatie
- Nederland met mitigatie



## SAMENVATTING

- a) Langdurige blootstelling aan laagfrequent geluid van bijv. windturbines kan gezondheidsklachten veroorzaken omdat overgevoeligheid voor geluid tussen 10 en 50 Hz gemakkelijk kan optreden (kleine hoorspan).
- b) Die overgevoeligheid betreft niet alleen het “horen” maar ook het evenwichtsorgaan (duizeligheid, misselijkheid, hoofdpijn).
- c) Bij windturbines spelen nogal wat factoren een rol: a) aerodynamica, b) mechaniek, c) afmetingen, d) afstanden, e) wind, f) bodemgesteldheid, g) omgevingsgeluiden, h) trillingsoverdracht
- d) Ook op grote afstand kunnen laagfrequente trillingen “doordringen”.
- e) Overige gemelde gezondheidsklachten, behalve slaapstoornissen, duizeligheid, misselijkheid en hoofdpijn, zijn: oorsuizen, concentratieverlies, hoge bloeddruk en hartslag, bronchitis, rusteloosheid, angst, depressie, m.n. als indirecte gevolgen van bijv. slaapgebrek.
- f) Slaapstoornissen komen 't meest voor, mogelijk leidend tot ontwikkelingsstoornissen bij kinderen, wat nog onvoldoende onderzocht is, evenals de infrasone component (grote turbines).
- g) De nachtelijke norm zou o.i. moeten liggen bij 35 dB(A) en niet hoger vanwege het percentage gehinderden.
- h) Ook de WHO neigt er langzamerhand toe om het acceptabele percentage gehinderden op 5% te bepalen i.p.v. het huidige percentage van 9% (WHO guidelines 2018).
- i) Dit leidt tot ons advies om niet langer lastig te handhaven geluidsnormen te hanteren, maar 'n relatieve afstandsnorm: veilige afstand is 10 x masthoogte van turbines, overeenkomend met de regels in Denemarken, Duitsland, en .....

# Windturbinegeluid & gezondheid

**Dank voor uw aandacht!**

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