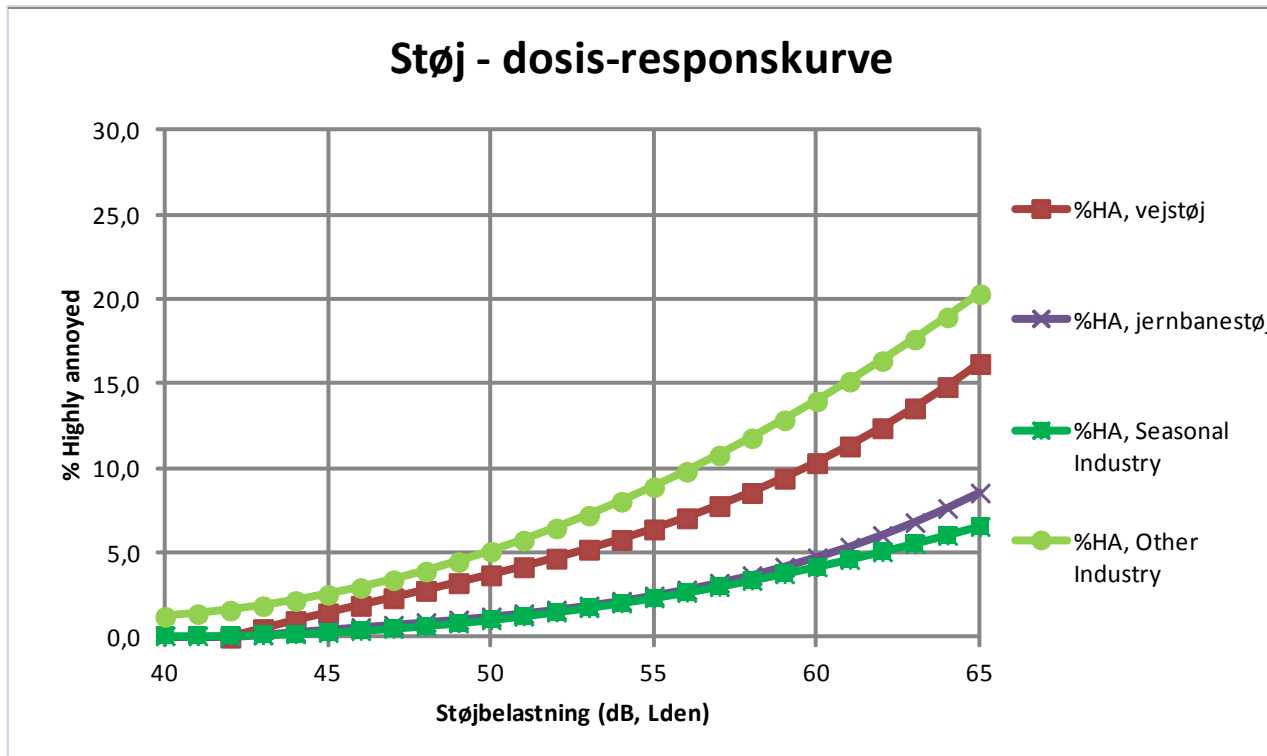


# Dosis/respons-kurver for vej-, tog-, industri- og vindmøllestøj

Hvor mange % af naboerne kan forventes at være "stærkt" generet ved en given støjbelastning?

1	"märker/hör inte"	Do not notice	
2	"märker, men störs inte"	Notice, but not annoyed	<b>Not annoyed</b>
3	"störs inte särskilt mycket"	Slightly annoyed	
4	"störs ganska mycket"	Rather annoyed	
5	"störs mycket"	Very annoyed	<b>Annoyed</b>



#### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
 Boligområder: 58dB Lden

#### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
 Boligområder: 64dB Lden

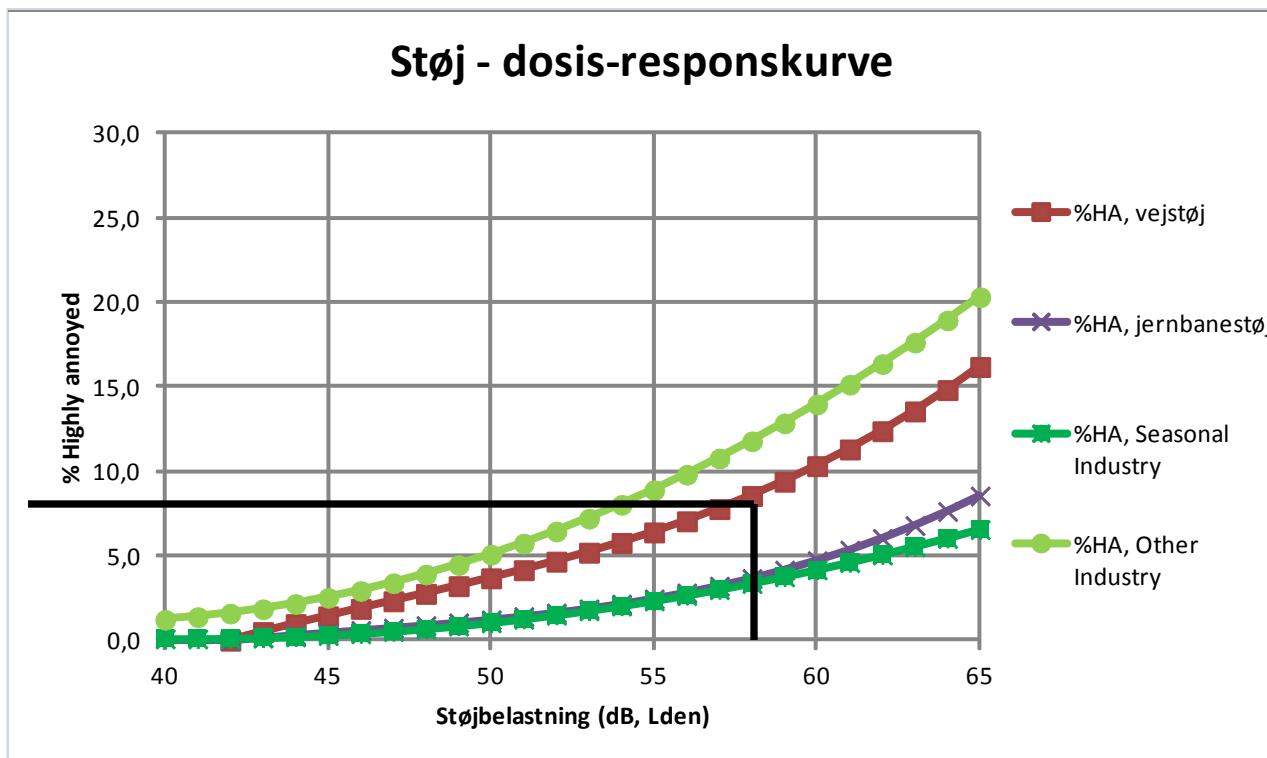
#### Vindmøllestøj:

Boliger i det åbne land: 44dBA (~49,7dB Lden)  
 Boligområder: 39dBA (~44,7dB Lden)

#### Industristøj:

Områder for blandet bolig- og erhvervsbebyggelse  
 55 / 45 / 40dBA (~52dB Lden)  
**Boligområder for åben og lav boligbebyggelse**  
 45 / 40 / 35 dBA (~44dB Lden)

## Støj - dosis-responskurve



Vejstøj: 8,6%

### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden

Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden

Boligområder: 64dB Lden

### Vindmøllestøj:

Boliger i det åbne land: 44dBA (~49,7dB Lden)

Boligområder: 39dBA (~44,7dB Lden)

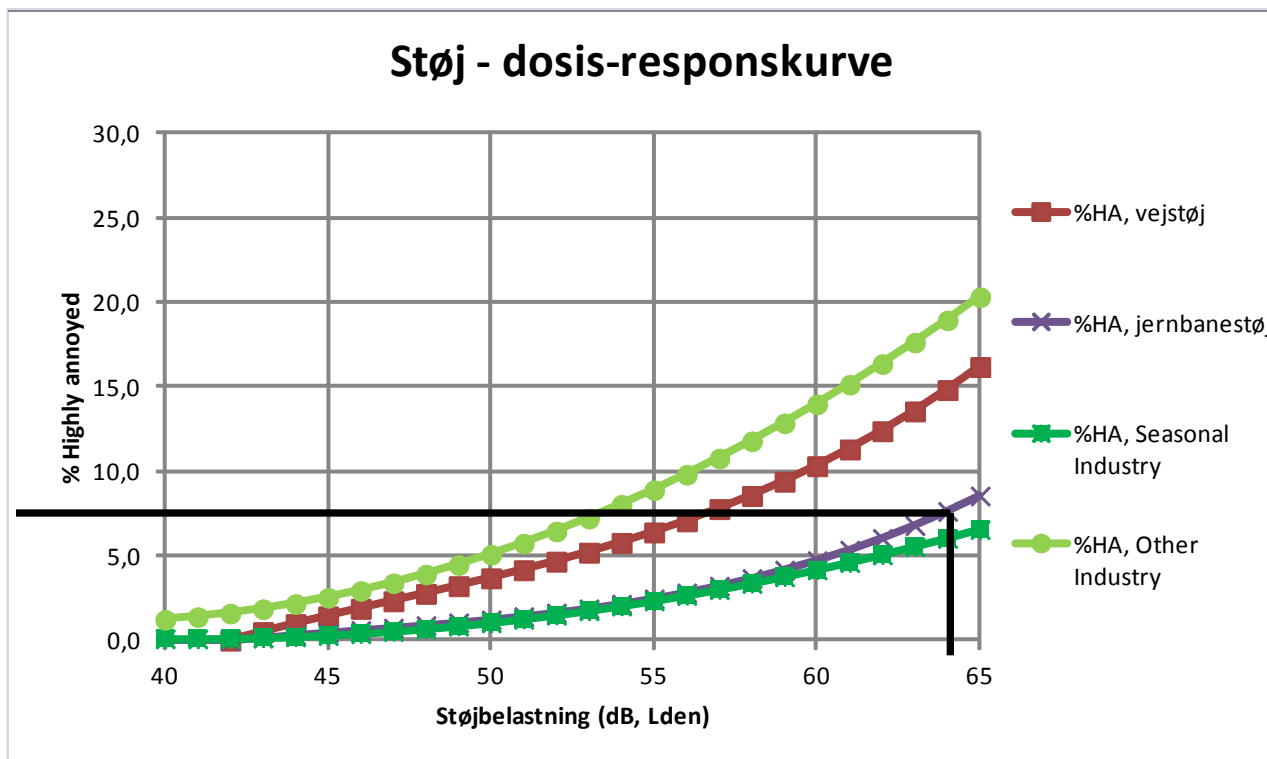
### Industristøj:

Områder for blandet bolig- og erhvervsbebyggelse  
55 / 45 / 40dBA (~52dB Lden)

**Boligområder for åben og lav boligbebyggelse**  
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## Støj - dosis-responskurve



Togstøj: 7,6%

### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
 Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
 Boligområder: 64dB Lden

### Vindmøllestøj:

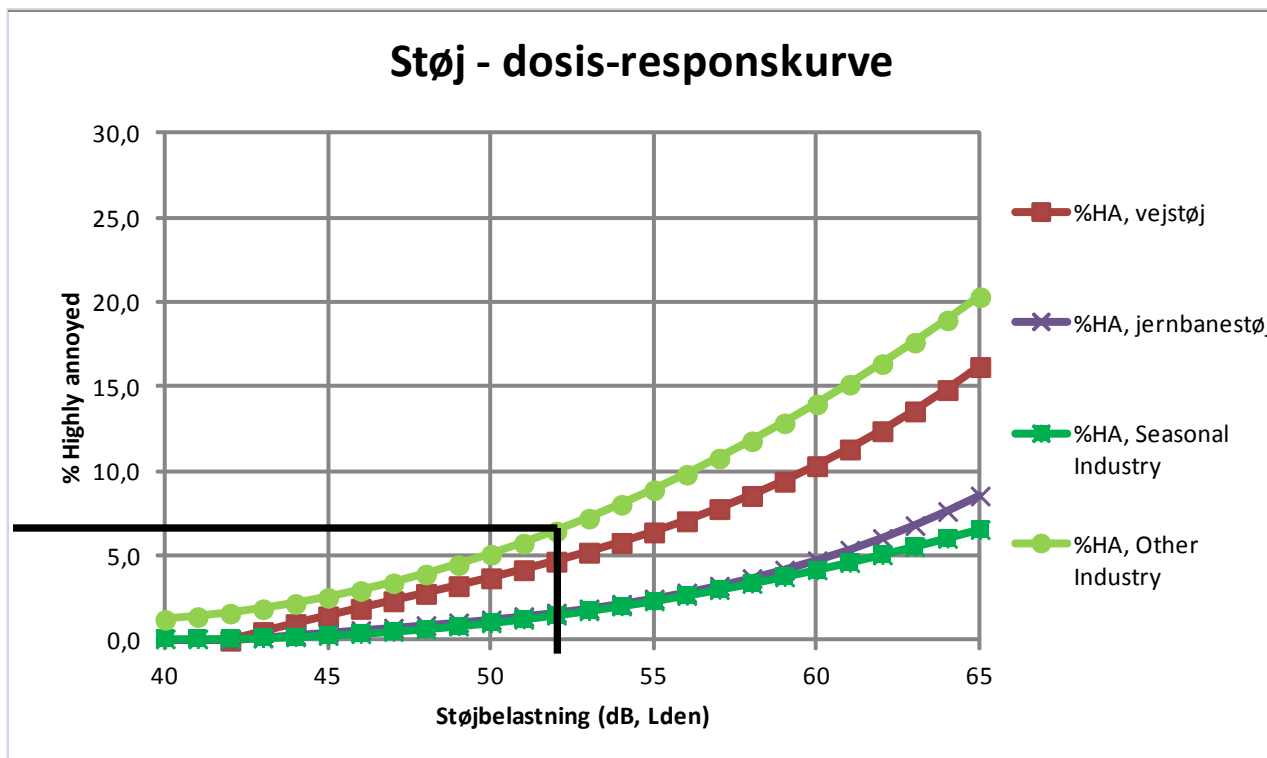
Boliger i det åbne land: 44dBA (~49,7dB Lden)  
 Boligområder: 39dBA (~44,7dB Lden)

### Industriestøj:

Områder for blandet bolig- og erhvervsbebyggelse  
 55 / 45 / 40dBA (~52dB Lden)  
**Boligområder for åben og lav boligbebyggelse**  
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## Støj - dosis-responskurve



Industri: 6,5%

### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden

Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden

Boligområder: 64dB Lden

### Vindmøllestøj:

Boliger i det åbne land: 44dBA (~49,7dB Lden)

Boligområder: 39dBA (~44,7dB Lden)

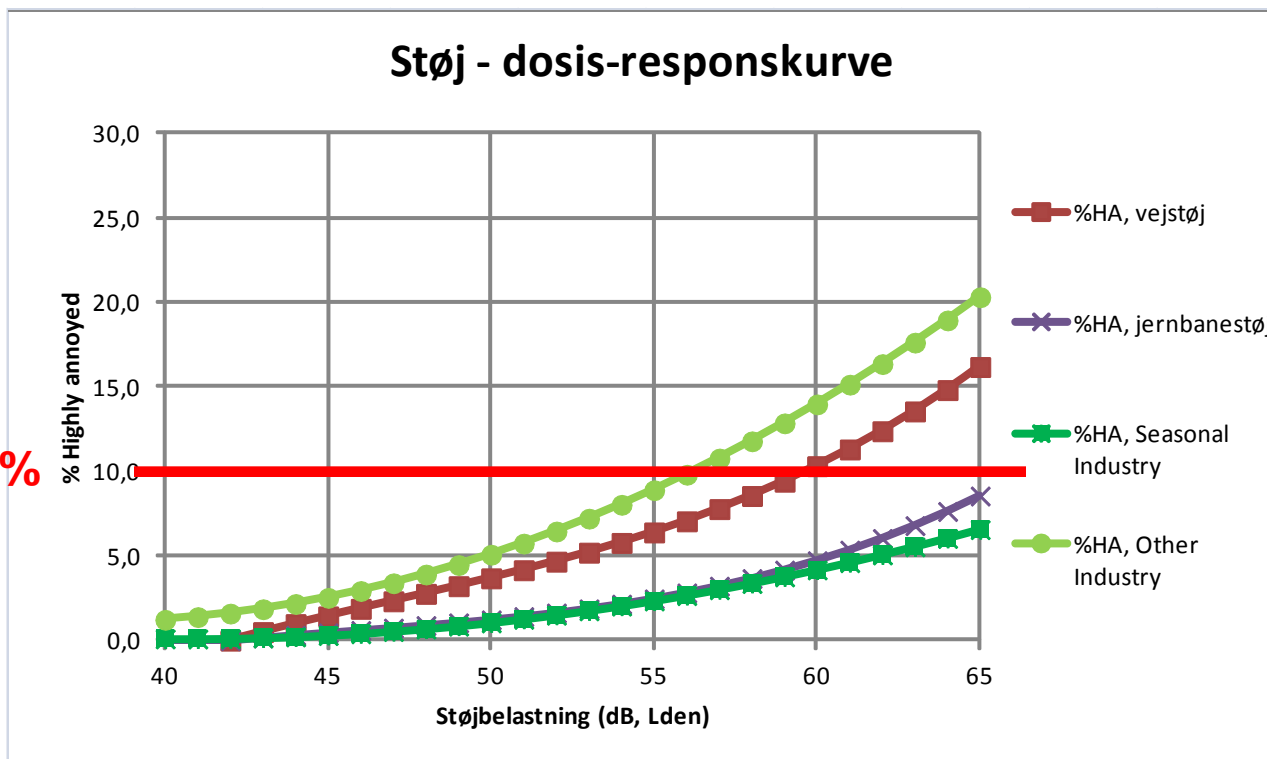
### Industristøj:

Områder for blandet bolig- og erhvervsbebyggelse  
55 / 45 / 40dBA (~52dB Lden)

**Boligområder for åben og lav boligbebyggelse**  
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## Støj - dosis-responskurve



Grænse: <10%

### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
 Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
 Boligområder: 64dB Lden

### Vindmøllestøj:

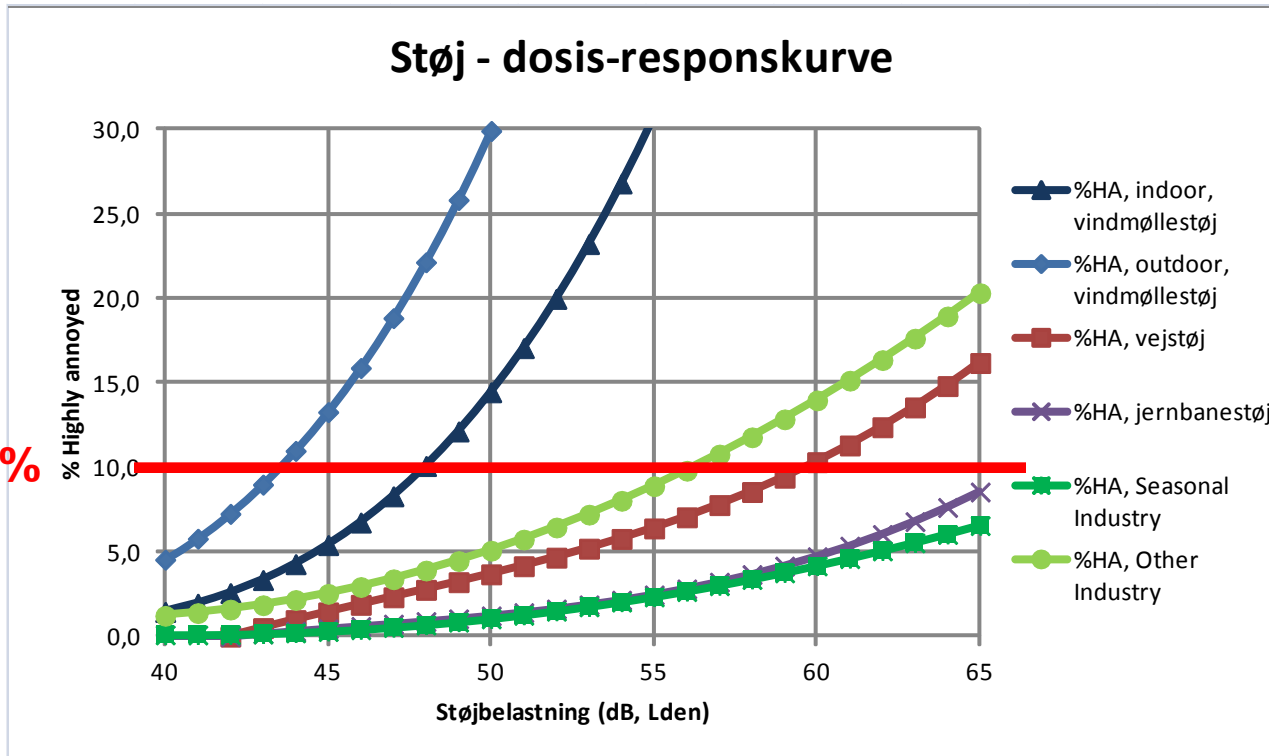
Boliger i det åbne land: 44dBA (~49,7dB Lden)  
 Boligområder: 39dBA (~44,7dB Lden)

### Industristøj:

Områder for blandet bolig- og erhvervsbebyggelse  
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## Støj - dosis-responskurve



Grænse: <10%

### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
 Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
 Boligområder: 64dB Lden

### Vindmøllestøj:

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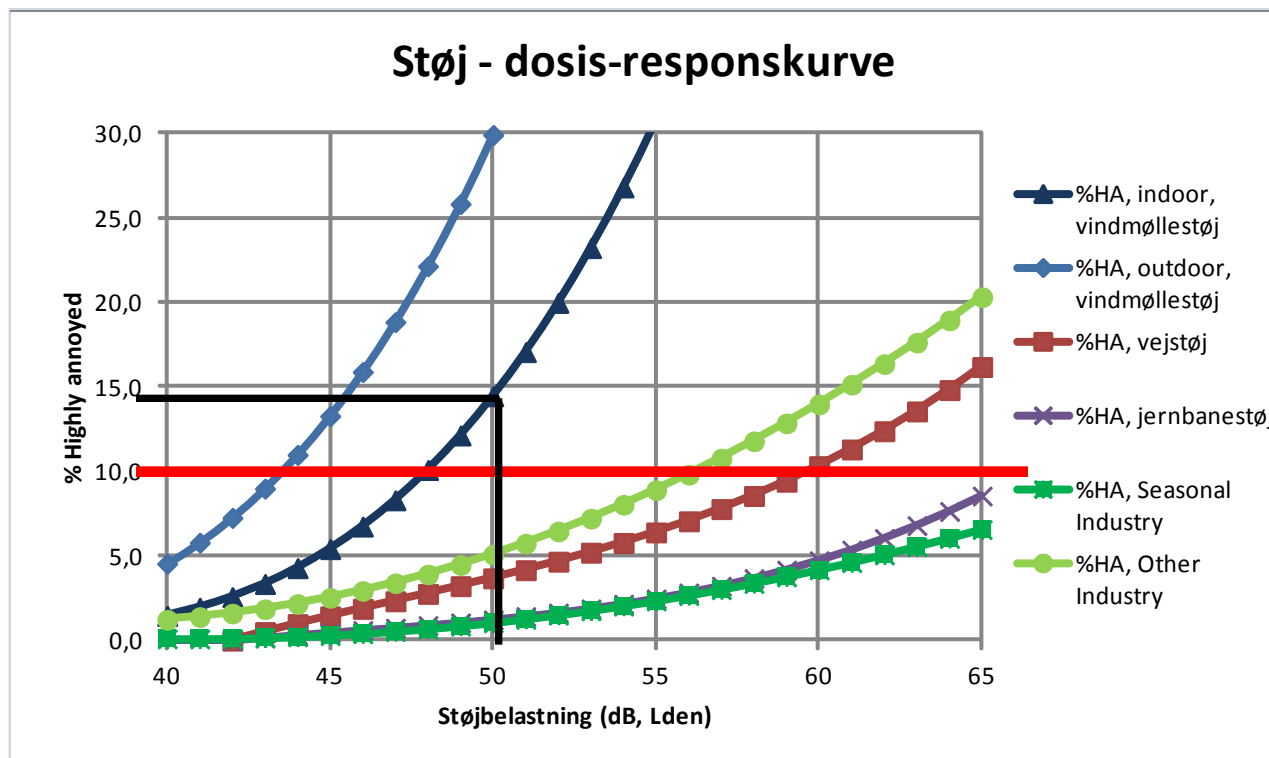
Områder for blandet bolig- og erhvervsbebyggelse  
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Vindmøller,  
Indoor:  
13,7%  
(ved 44dBA)



#### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
Boligområder: 58dB Lden

#### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
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Områder for blandet bolig- og erhvervsbebyggelse  
55 / 45 / 40dBA (~52dB Lden)

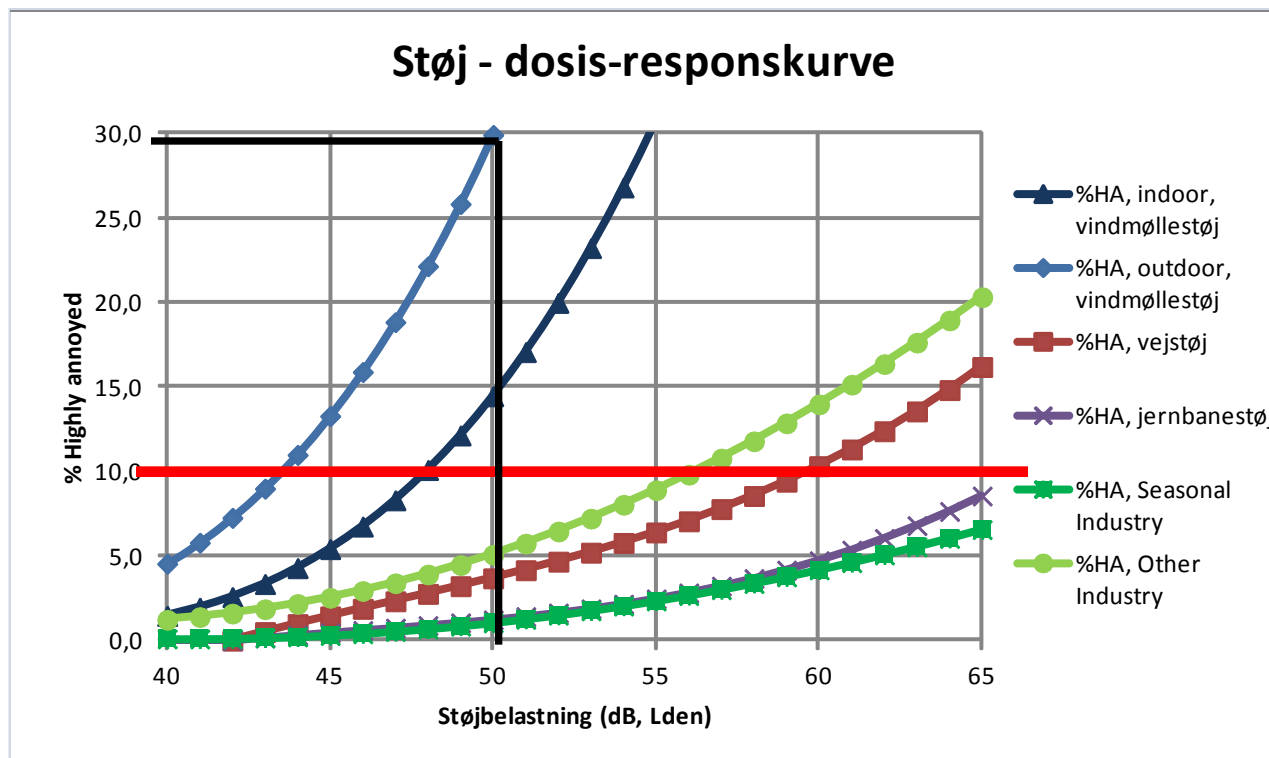
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Vindmøller,  
Outdoor:  
28,6%  
(ved 44dBA)



#### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
Boligområder: 58dB Lden

#### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
Boligområder: 64dB Lden

#### Vindmøllestøj:

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Boligområder: 39dBA (~44,7dB Lden)

#### Industristøj:

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# **A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources**

Sabine A. Janssen<sup>a)</sup> and Henk Vos

*Department of Urban Environment and Safety, Netherlands Organization for Applied Scientific Research,  
P.O. Box 49, 2600 AA Delft, The Netherlands*

Arno R. Eisses

*Department of Acoustics and Sonar, Netherlands Organization for Applied Scientific Research,  
P.O. Box 96864, 2509 JG The Hague, The Netherlands*

Eja Pedersen<sup>b)</sup>

*Ecology and Environmental Science, Halmstad University, P.O. Box 823, SE-301 18 Halmstad, Sweden*

(Received 4 November 2010; revised 17 June 2011; accepted 28 September 2011)

The proposed exposure-response relationships for annoyance by wind turbine noise are only based on three studies, and more studies are undeniably needed. Still, they may already serve as indicative for suitable regulations or for the evaluation of existing legislation. For example, regions with a highest allowed immission level of 45 dB(A) equivalent level [corresponding to  $L_{den}$  49.7 dB(A) in this study] such as Denmark could expect less than 14% of the exposed population to be highly annoyed indoors by wind turbines and less than 29% to be highly annoyed outdoors. However, it should be noted that situational factors, as well as possible cultural differences, may lead to considerable deviation from the curve in specific cases.

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Another choice was to base the comparison with other noise sources on indoor noise annoyance. This makes for a conservative comparison because almost all respondents reported a higher level of annoyance outdoors than indoors, and the exposure-response relationships for other noise sources are largely based on studies that did not distinguish between annoyance indoors and outdoors. Because wind turbines are usually situated in rural or mildly built-up areas, annoyance outdoors might play a more important role than is the case for other noise sources because the residents of these areas may spend a greater proportion of their time outdoors. In order to limit annoyance due to wind turbine noise, policy makers should take into consideration both the expected annoyance indoors and outdoors.

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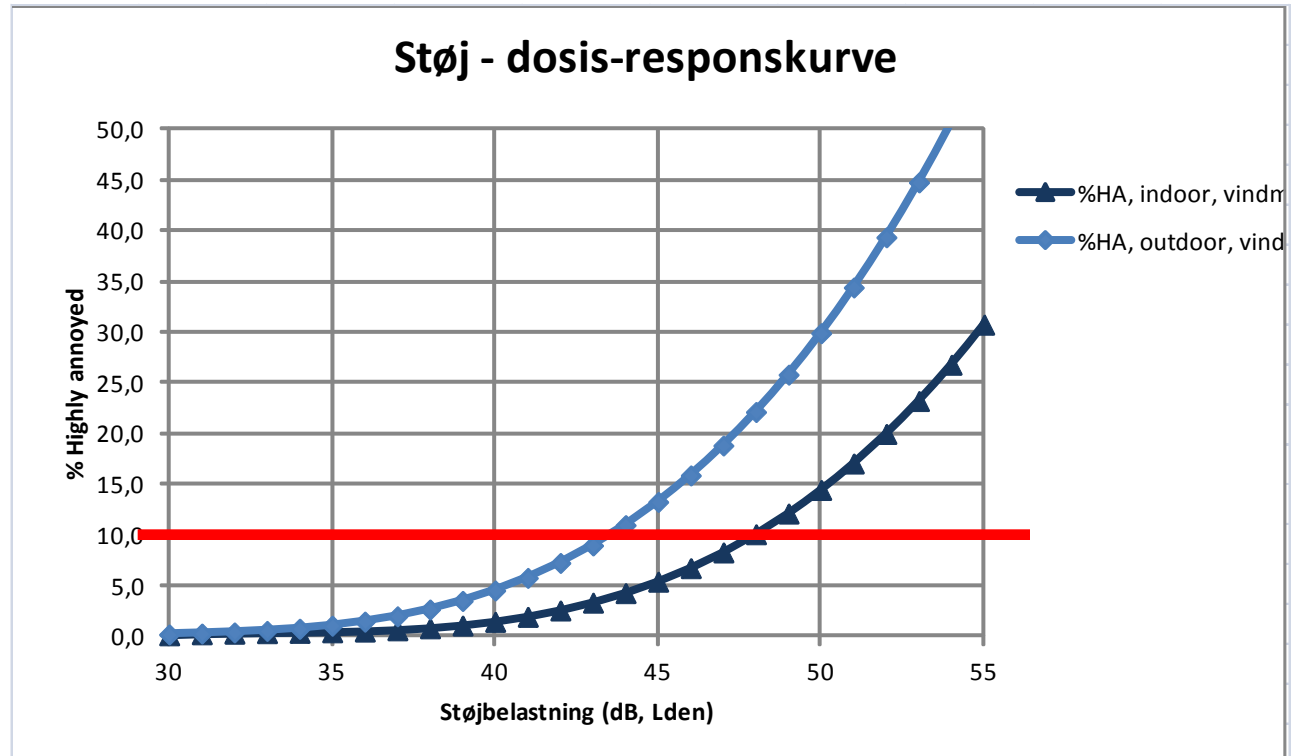
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## Støj - dosis-responskurve



### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
 Boligområder: 58dB Lden

### Jernbanestøj:

Rekreative områder i det åbne land: 59dB Lden  
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### Industristøj:

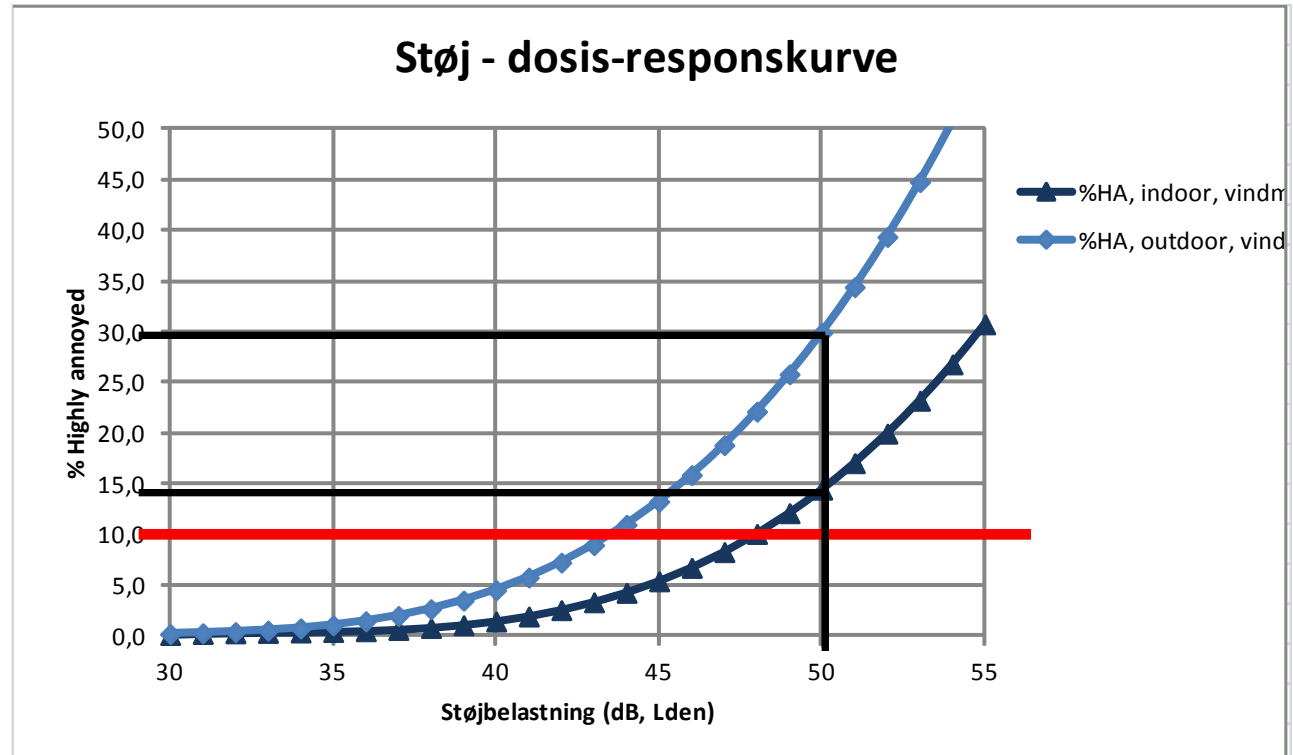
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## Støj - dosis-responskurve



### Vindmøller

#### % Meget generede:

Indendørs: 13,7%

Udendørs: 28,6%

(ved 44dBA)

#### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden

Boligområder: 58dB Lden

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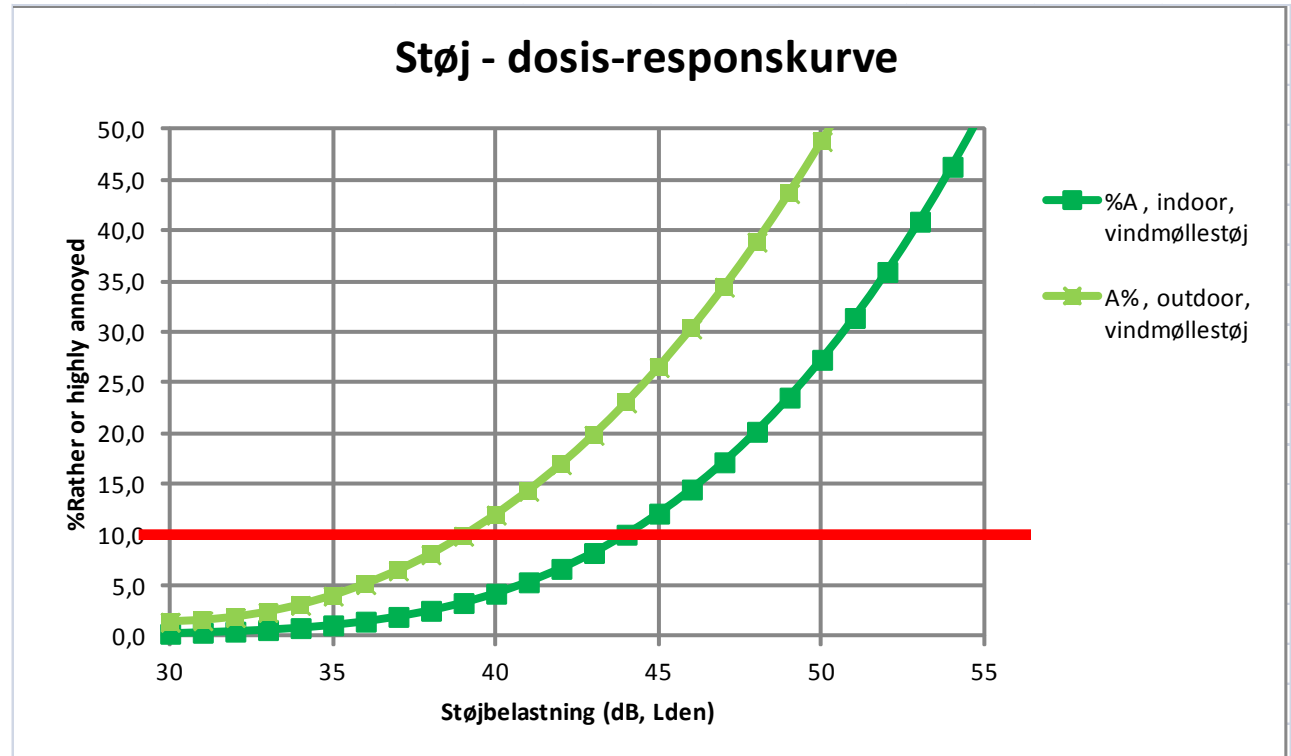
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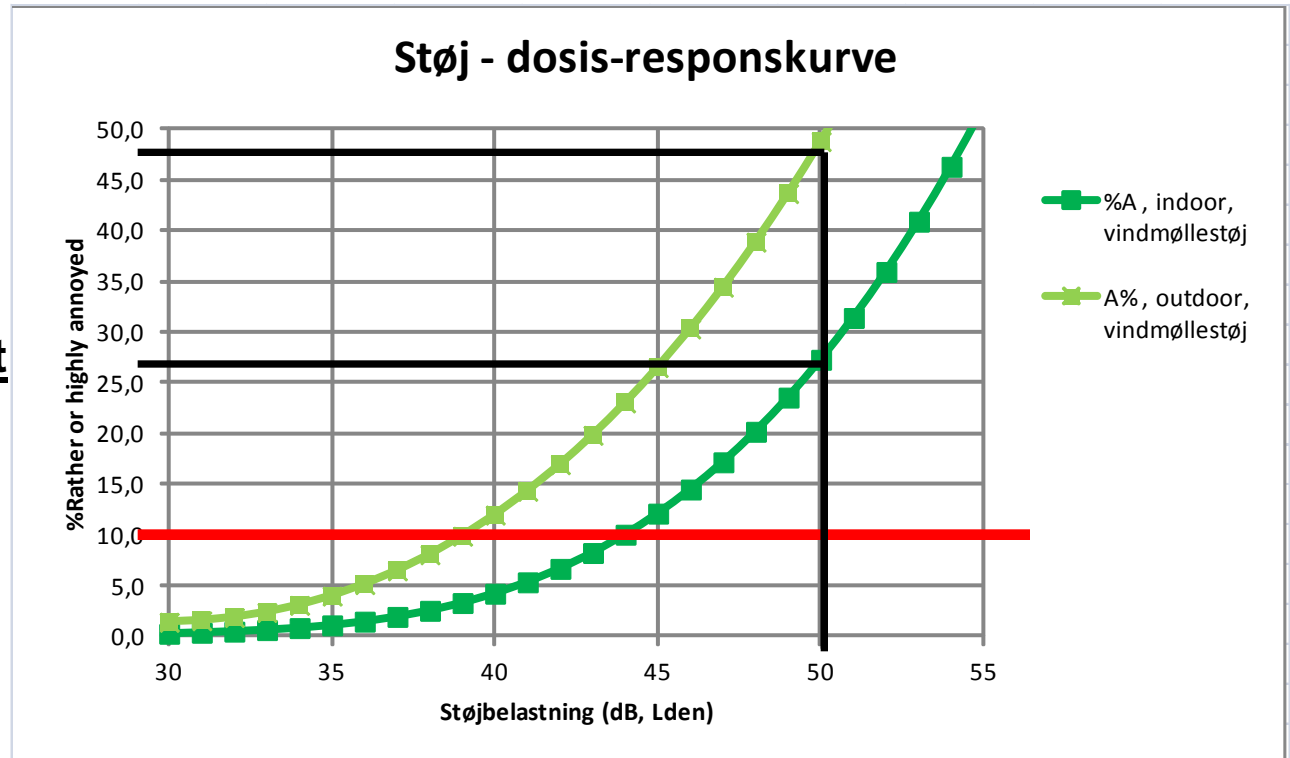
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## Vindmøller % Ganske eller meget generede:

Indendørs: 26,1%  
Udendørs: 47,2%  
(ved 44dBA)



#### Vejstøj:

Rekreative områder i det åbne land: 53dB Lden  
Boligområder: 58dB Lden

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# Vindmøllestøj & helbred

- Der er ikke udført lægevidenskabelige studier, der kan afvise evt. negative helbredseffekter af kronisk af eksponering af vindmøllestøj
- Vindmøllestøj fra store vindmøller (>0.5MW) er i epidemiologisk sammenhæng en "ny" støjkilde.

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## Health Canada Announces Wind Turbine Noise and Health Study

**UPDATE - July 18, 2012:** In recognition of the potential difficulty over the summer holiday period of certain interested Canadians in providing input before August 8, 2012, submissions will be accepted until September 7, 2012.

**July 10, 2012**

**For immediate release**

**OTTAWA** - Health Canada, in collaboration with Statistics Canada, will conduct a research study that will explore the relationship between wind turbine noise and health effects reported by, and objectively measured in, people living near wind power developments.

"This study is in response to questions from residents living near wind farms about possible health effects of low frequency noise generated by wind turbines," said the Honourable Leona Aglukkaq, Minister of Health. "As always, our Government is putting the health and safety of Canadians first and this study will do just that by painting a more complete picture of the potential health impacts of wind turbine noise."

Health Canada is aware of health-related complaints from individuals living in close proximity to wind turbine establishments. The study is being designed with support from external experts, specializing in areas including noise, health assessment, clinical medicine and epidemiology.

The study results are expected to be published in 2014.

# Vindmøllestøj & helbred

  
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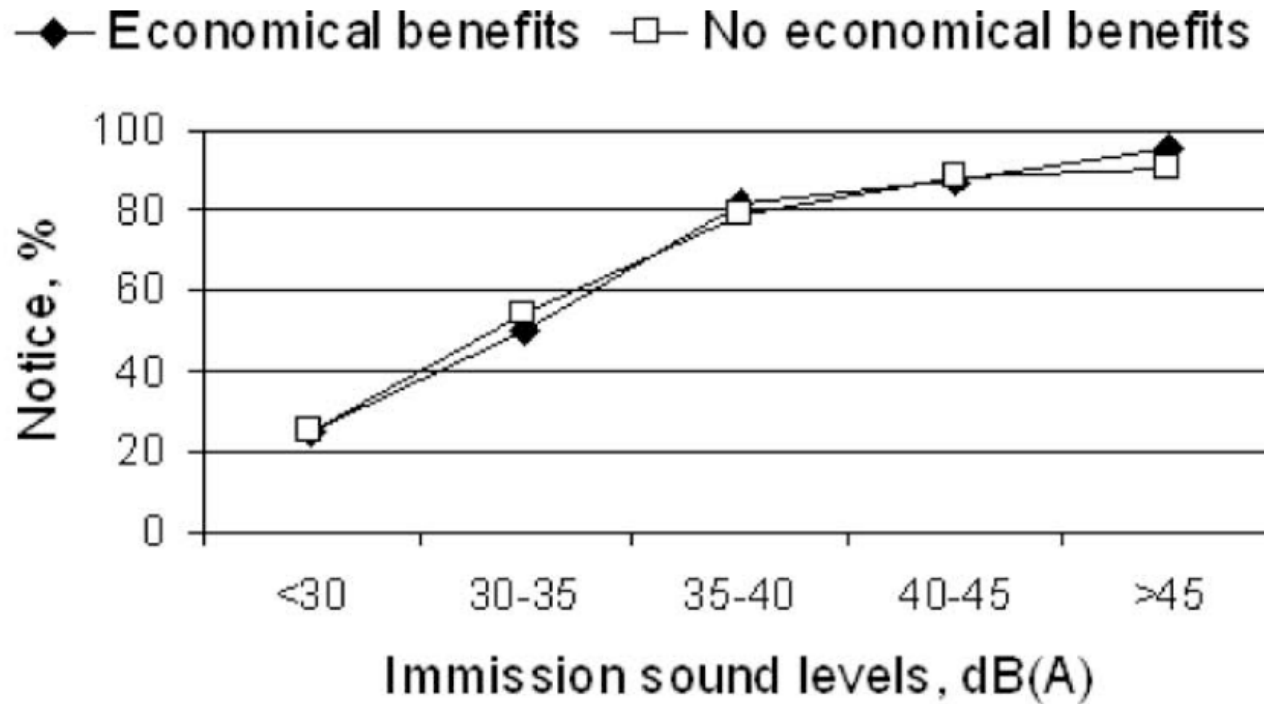
# Vindmøllestøj & helbred

Study	MW	Country	# Subjects	% annoyed, >40dBA
DELTA - 1994	<0.15	Denmark	200	13%
SWE - 00	0,6	Sweden, Rural	351	44%
SWE - 05	0,6	Sweden, Suburban	754	15%
NL - 07	>0,5	Holland, mixed*	725	25%

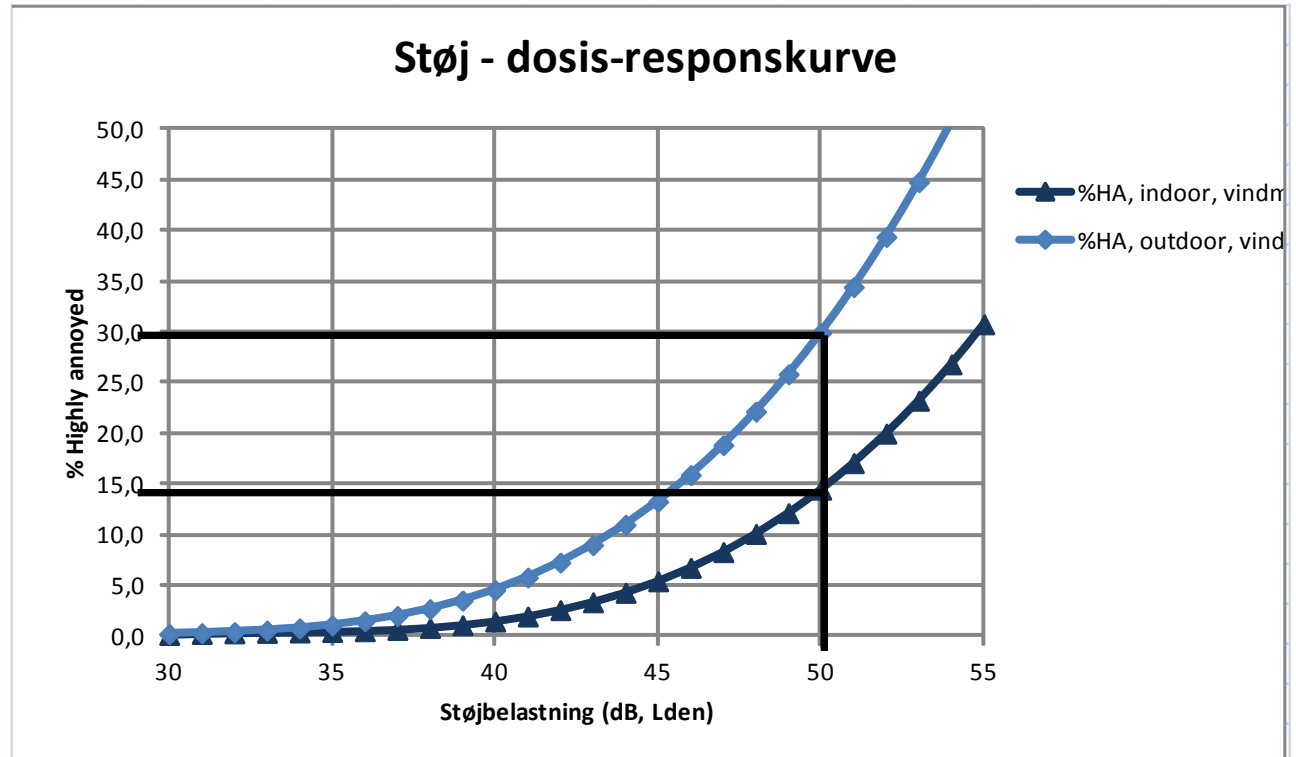
1	"märker/hör inte"	Do not notice	
2	"märker, men störs inte"	Notice, but not annoyed	<b>Not annoyed</b>
3	"störs inte särskilt mycket"	Slightly annoyed	
4	"störs ganska mycket"	Rather annoyed	
5	"störs mycket"	Very annoyed	<b>Annoyed</b>

- SWE-00: Perception and annoyance due to wind turbine noise—a dose–response relationship, *J. Acoust. Soc. Am.*, Vol. 116, No. 6, December 2004
- SWE-05: Wind turbine noise, annoyance and self-reported health and well-being in different living environments, *Occup Environ Med* 2007;64:480–486
- NL-07: Response to noise from modern wind farms in The Netherlands, *J. Acoust. Soc. Am.* 126, 2, August 2009
- SAMLET: Health aspects associated with wind turbine noise—Results from three field studies, *Noise Control Eng. J.* 59 (1), Jan-Feb 2011
- SAMLET: A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources, *J. Acoust. Soc. Am.* 130 (6), December 2011
- SAMLET: Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress; *Science of the Total Environment*, March (2012)

# Vindmøllestøj & helbred



# Vindmøllestøj & helbred



## % Highly annoyed:

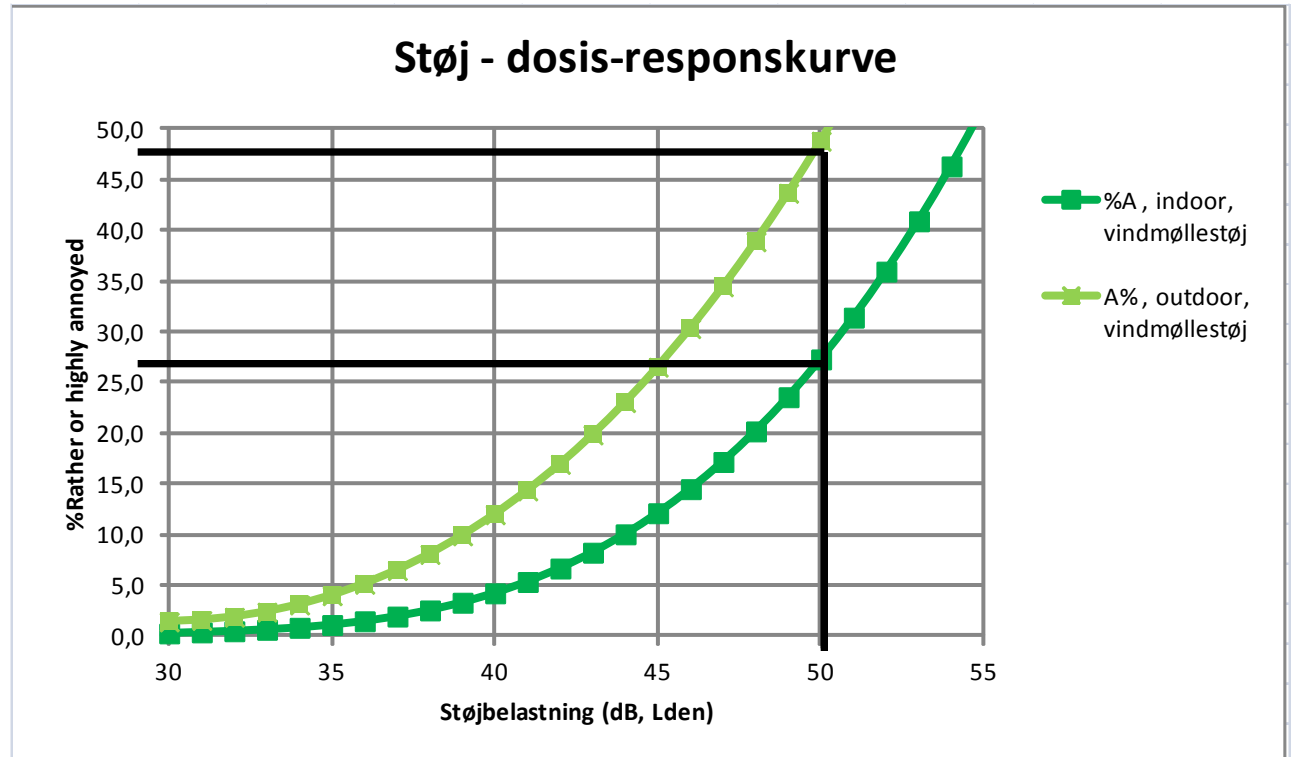
Indendørs: 13,7%

Udendørs: 28,6%

(ved 44dBA)



# Vindmøllestøj & helbred



## % Annoyed:

Indendørs: 26,1%

Udendørs: 47,2%

(ved 44dBA)

# Vindmøllestøj & helbred

## **Health aspects associated with wind turbine noise—Results from three field studies (Eja Pedersen, 2011)**

**“...annoyance could also be viewed as a measurable indicator of enhanced risk for chronic imbalance in the physiological stress system”**

*Table 2—Association between annoyance outdoors due to wind turbine noise (independent, continuous variable) and variables measuring response and/or effect (dependent, binary variable) tested with logistic regression. Statistically significant associations in bold numbers.*

Symptoms	SWE-00 <sup>a</sup> N <sup>c</sup> =319–333	SWE-05 <sup>a</sup> N <sup>c</sup> =720–744	NL-07 <sup>b</sup> N <sup>c</sup> =658–672
Sleep interruption	<b>2.26 (1.76–2.90)</b>	<b>1.71 (1.35–2.17)</b>	<b>1.78 (1.49–2.14)</b>
Chronic disease	0.90 (0.71–1.08)	0.90 (0.74–1.26)	0.98 (0.81–1.19)
Diabetes	0.69 (0.37–1.31)	0.71 (0.40–1.28)	<b>1.70 (1.14–2.56)</b>
High blood pressure	0.82 (0.55–1.22)	1.10 (0.84–1.45)	0.86 (0.64–1.17)
Cardiovascular disease	1.07 (0.58–1.98)	1.00 (0.64–1.55)	0.95 (0.65–1.38)
Tinnitus	1.55 (0.95–2.53)	0.88 (0.60–0.98)	0.82 (0.45–1.48)
Impaired hearing	1.03 (0.96–1.19)	0.78 (0.51–1.21)	1.13 (0.76–1.67)
Headache	<b>1.24 (1.01–1.51)</b>	1.04 (0.86–1.26)	<b>1.25 (1.04–1.50)</b>
Undue tiredness	<b>1.22 (1.00–1.49)</b>	1.12 (0.93–1.35)	1.10 (0.93–1.31)
Tense and stressed	<b>1.25 (1.00–1.56)</b>	<b>1.22 (1.00–1.50)</b>	<b>1.27 (1.07–1.50)</b>
Irritable	<b>1.36 (1.10–1.69)</b>	<b>1.22 (1.00–1.49)</b>	<b>1.27 (1.07–1.50)</b>

<sup>a</sup>Adjusted for age, sex, and A-weighted sound pressure levels.

<sup>b</sup>Adjusted for age, sex, A-weighted sound pressure levels, and economic benefits.

<sup>c</sup>Range of number of respondents in the analyses. Differences in number of respondents are due to missing cases, that is, the respondents not answering single questions in the questionnaire.

# Vindmøllestøj & helbred

***Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress***  
(R.H. Bakker, E. Pedersen b, G.P. van den Berg, 2012)

## Major conclusions:

“...People living in the vicinity of wind turbines are at **risk of being annoyed by the noise, an adverse effect in itself.**”

“...Noise annoyance in turn could lead to **sleep disturbance and psychological distress.**”

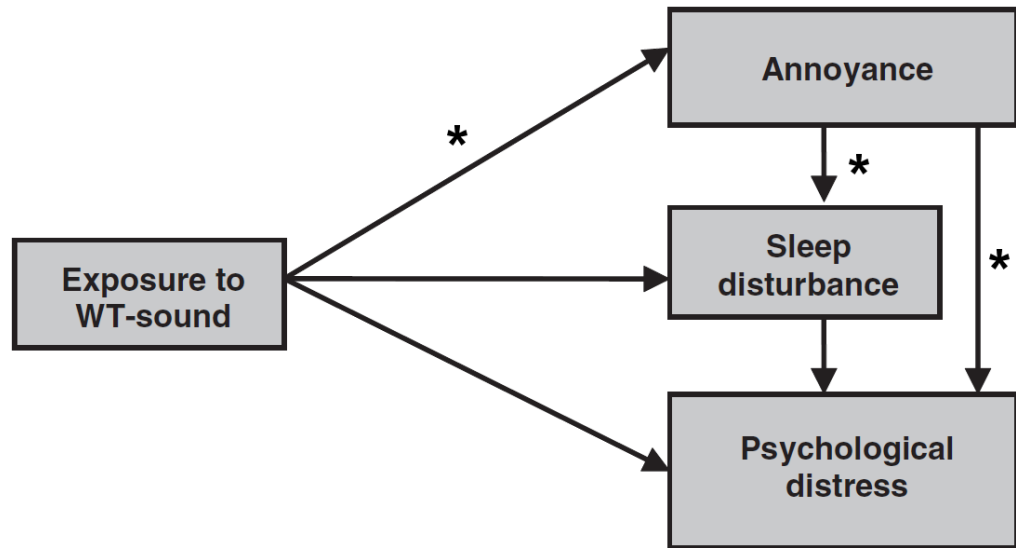


Fig. 1. Model of possible associations between sound exposure, annoyance, sleep disturbance and psychological distress.

# Vindmøllestøj & helbred

## Tværsnitsstudier (SV00,SV05,NL07):

- Vindmøllestøj er forbundet med et markant højere niveau af "*annoyance*" ved gældende støjgrænser, end det er tilfældet for trafikstøj og industristøj
- "*Annoyance*" er forbundet med hovedpine, stress, irritabilitet og søvnforstyrrelser
- "*Annoyance*" er en indikator for kronisk fysiologisk stress
- "*Annoyance*" er en "*adverse health effect*" (WHO 1999, community noise)

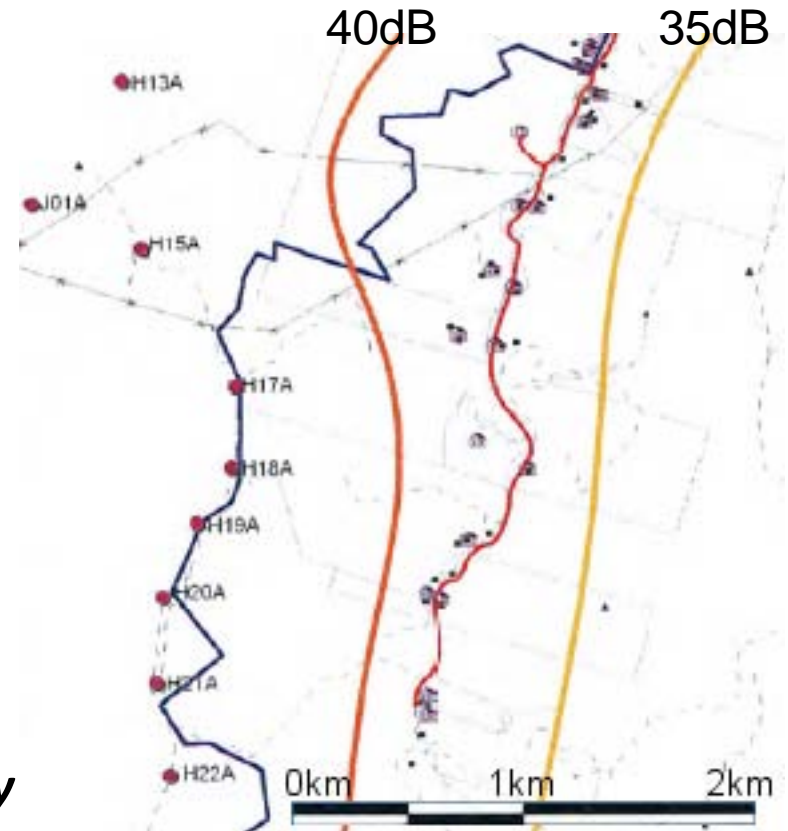
# Vindmøllestøj & helbred

**Wind turbine noise and health-related quality of life of nearby residents: a cross-sectional study in New Zealand.**

*Daniel Shepherd, School of Public Health, Auckland University of Technology*

**DESIGN:** Maskeret spørgeskemaundersøgelse (HRQoL). Eksponeret gruppe (39 naboer, <2km), matchet kontrolgruppe (154 personer, >8km fra vindmøller).

**RESULTATER:** *“...residents living within 2km of a turbine installation reporting lower overall quality of life, physical quality of life, and environmental quality of life. Those exposed to turbine noise also reported significantly lower sleep quality.”*




Uddrag af kort tilsendt af Daniel Shepherd

*Der er matchet for køn, alder, uddannelsesniveau, jobstatus, støjfølsomhed og comorbiditet.*

Hjem


## DASAM's hørings svar på Vindmølle bekendtgørelsen

 [DASAM referat af møde "Effekter på mennesket ved at bo tæt på vindmøller", 13. december 2011](#)

 [Hørings svar vedrørende revision af bekendtgørelse om støj fra vindmøller](#)

 [Præsentation Christian Buhl](#)

 [Præsentation Jørgen Jakobsen](#)

 [Præsentation Christian Sejer Pedersen: Noise from large wind turbines \(with focus on low frequencies\)](#)

▶ Menu

- ▶ Om arbejds- og miljømedicin.
- ▶ Årsmøder
- ▶ Referater

▶ Kalender

**UEMS Occupational Medicine, Section meeting**  
13. April 2012 kl. 00:00  
Hvor: Innsbruck, Austria

[Hele kalenderen ses her.](#)

## Dansk Selskab for Arbejds- og Miljømedicin

---

Høringsvar vedrørende revision af bekendtgørelse om støj fra vindmøller - sagsnummer: 5114-00048.

DASAM mener imidlertid, at bekendtgørelsen ikke i tilstrækkeligt omfang beskytter mod sundhedsrisici ved støjgenerne, og foreslår derfor:

- De generelle støjgrænser bør sænkes fra 39dB(A) til 35 dB(A)
- Der anbefales også at 35dB bruges som GV i støjsvage områder på landet – i dag vurderes de typisk under 44 dB GV.

## Dansk Selskab for Arbejds- og Miljømedicin

---

Høringsvar vedrørende revision af bekendtgørelse om støj fra vindmøller - sagsnummer: 5114-00048.

”...Vi vurderer, at med de nuværende GV’er for støj fra vindmøller vil et **uacceptabelt antal borgere** indenfor den afstand fra vindmøller som bekendtgørelsen regulerer **være generet eller kraftigt generet af støjen.**”





# Støj & helbred

## Forklaringsmodel:

### Støj-påvirkning

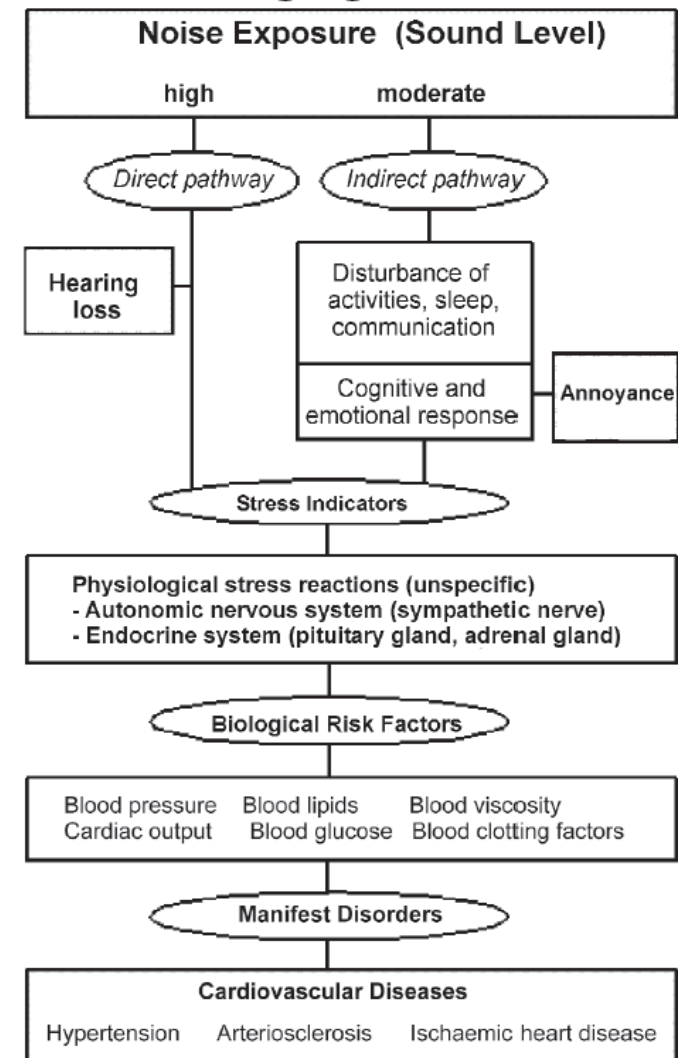
→ Kropslig + Psykologisk stress-reaktion

→ Øget risiko for udvikling af sygdom

### Annoyance:

Værdifuld indikator for stress-reaktion og overtrådt individuel tærskelværdi

## The Noise/Stress Concept Wolfgang Babisch



# Støj & helbred

Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease

W Babisch, H Ising, J E J Gallacher

**Aims:** Traffic noise is a psychosocial stressor. Epidemiological studies suggest chronic noise stress to be a risk factor for cardiovascular disorders.

**Methods:** In a prospective cohort study, the association between annoyance and disturbances due to road traffic noise and the incidence of ischaemic heart disease (IHD) was studied in 3950 middle aged men.

## Main messages

- Noise annoyance due to exposure to road traffic may be a risk factor for the incidence of ischaemic heart disease. The prevalence of pre-existing chronic diseases modifies this association.

## Policy implications

- Chronic environmental noise stress increases the risk of ischaemic heart disease.

**Table 5** Model adjusted odds ratios of IHD incidence for different traffic noise exposed groups of subjects (odds ratio, 95% CI)

Exposure variable	Noise exposure category			
	1	2	3	4
Traffic noise level (dB(A))	51-55	56-60	61-65	66-70
Traffic noise level				
-PD	1.00	0.78 (0.42 to 1.47)	0.97 (0.55 to 1.72)	1.03 (0.55 to 1.94)
Annoyance/disturbances	Never	Seldom	Sometimes	Often + always
Annoyance				
-PD	1.00	0.70 (0.44 to 1.12)	1.05 (0.67 to 1.65)	2.45 (1.13 to 5.31)
Relaxation				
-PD	1.00	0.94 (0.62 to 1.44)	0.75 (0.41 to 1.36)	2.61 (1.14 to 6.01)
Nervous or tense				
-PD	1.00	1.01 (0.63 to 1.61)	0.98 (0.53 to 1.82)	3.00 (1.12 to 8.02)
Falling asleep				
-PD	1.00	1.02 (0.65 to 1.60)	0.76 (0.40 to 1.42)	1.70 (0.70 to 4.17)
Waking up				
-PD	1.00	1.42 (0.94 to 2.15)	1.15 (0.71 to 1.86)	2.06 (0.93 to 4.56)

Results are given for the total sample (n = 3950) and the stratified subsamples of subjects with (n = 1519) and without (n = 2431) pre-existing diseases (PD).

+PD, -PD: subjects with and without pre-existing disease.

\*Adjusted for room orientation and window opening habits.

# Støj & helbred

*“... **Health** is a state of **complete physical, mental and social well-being** and not merely the absence of disease or infirmity.”  
(WHO, 1948)”*

*“...**annoyance** could also be viewed as a measurable **indicator** of enhanced risk for **chronic imbalance** in the physiological **stress system**; an imbalance that **could lead to more severe states, such as high blood pressure, and if prolonged, to cardiovascular diseases.**” (Eja Pedersen, 2011)*

*“A large body of evidence now exists to suggest that **wind turbines disturb sleep and impair health** at distances and external noise levels that are permitted in most jurisdictions, including the United Kingdom.” (C. Hanning, BMJ 2012)*

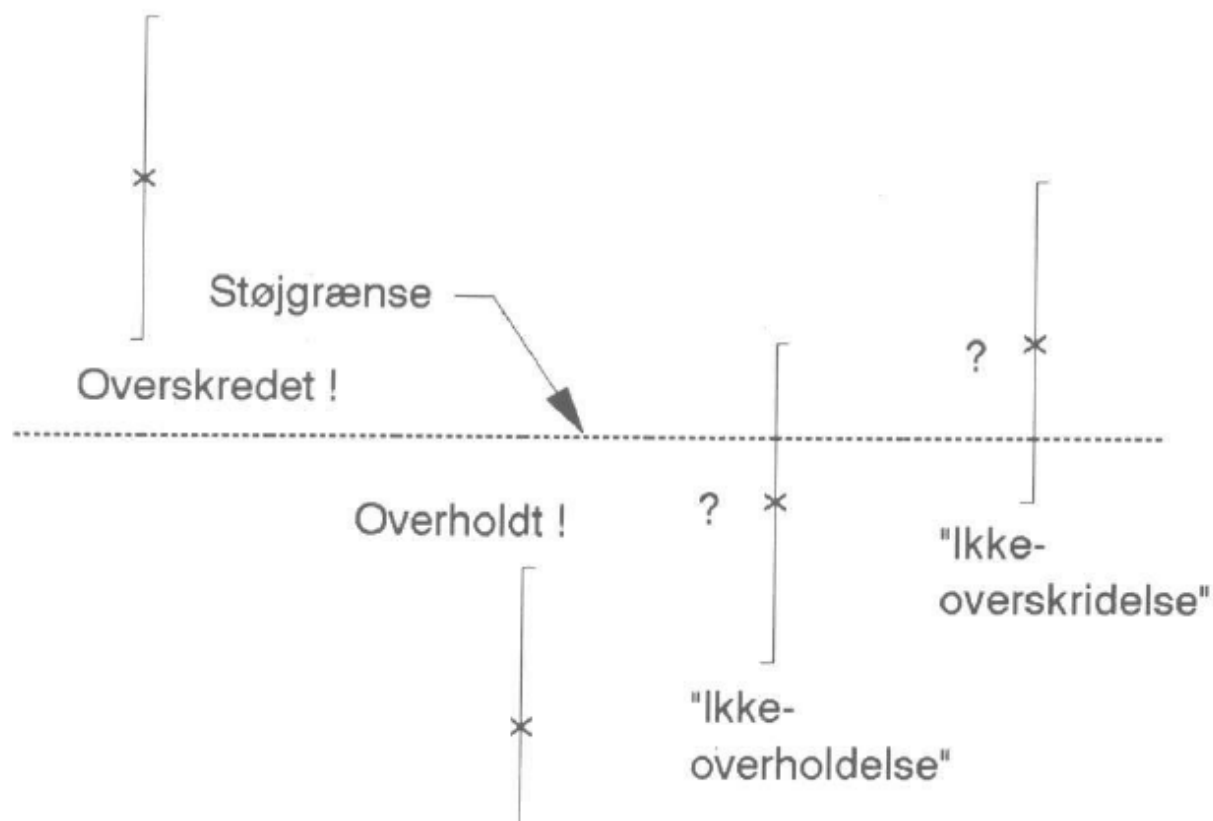
*“...Annoyance due to wind turbine noise should in the future be avoided by applying **proper regulations** for shortest allowable distance between wind turbines and dwellings in the surroundings.”  
(Eja Pedersen, 2011)*



# Vindmøllebekendtgørelse

- Ændret generel grænseværdi til 35dB v/ 8m/s jf. DASAMs høringssvar (gældende for alle boliger/beboelsesejend.)
- Indførelsen af IEC TS 61400-14, således at det anvendte "kilde støjs-tal" med 95% sikkerhed er korrekt
- Tage højde for usikkerhedsintervallet ved projektering, således at beregningerne med 95% sikkerhed kan overholdes
- Indførelsen af støjisolationsstal, der dækker 90-95% af de danske huse frem for blot 66% => mere valid beregning af indendørs lavfrekvent støj

# Vindmøllebekendtgørelse



Miljøstyrelsens, orientering nr.16  
(Om støj-usikkerheder)

# Vindmøllebekendtgørelse

17. november 1994

Miljøministerens besvarelse af spørgsmål nr. 12 (alm. del - bilag 17) stillet af Folketingets Miljø- og Planlægningsudvalg

## Spørgsmål :

Vil ministeren redegøre for ministeriets initiativer for at tilse, at amterne lever op til deres ansvar for at sikre, at borgere i boligområder ikke forstyrres af støj op over 40 dB(A) fra vindmøller ?

## Svar:

Jeg har ikke gennem de henvendelser, der indkommer til ministeriet vedrørende vindmøller, indtrykket af, at amterne forsummer deres tilsynspligt. Klager over amtsafgørelser i forbindelse med vindmøller er ret beskedne i antal.

Amterne skal ikke gribe ind overfor møllestøj, før overskridelsen af den gældende støjgrænse er mere end 2-3 dB (A), idet man da først med sikkerhed ved, at der sker en overskridelse. Det skyldes måleusikkerhed.

Tilsvarende skal amterne sikre sig ved en mølleansøgning, at det forventede støjbidrag fra møllen ved nærmeste nabo er 2-3 dB (A) under den gældende støjgrænse, idet man da først med sikkerhed ved, at der ikke sker en overskridelse.



# Vindmøllebekendtgørelse

## IEC TS 61400-14:

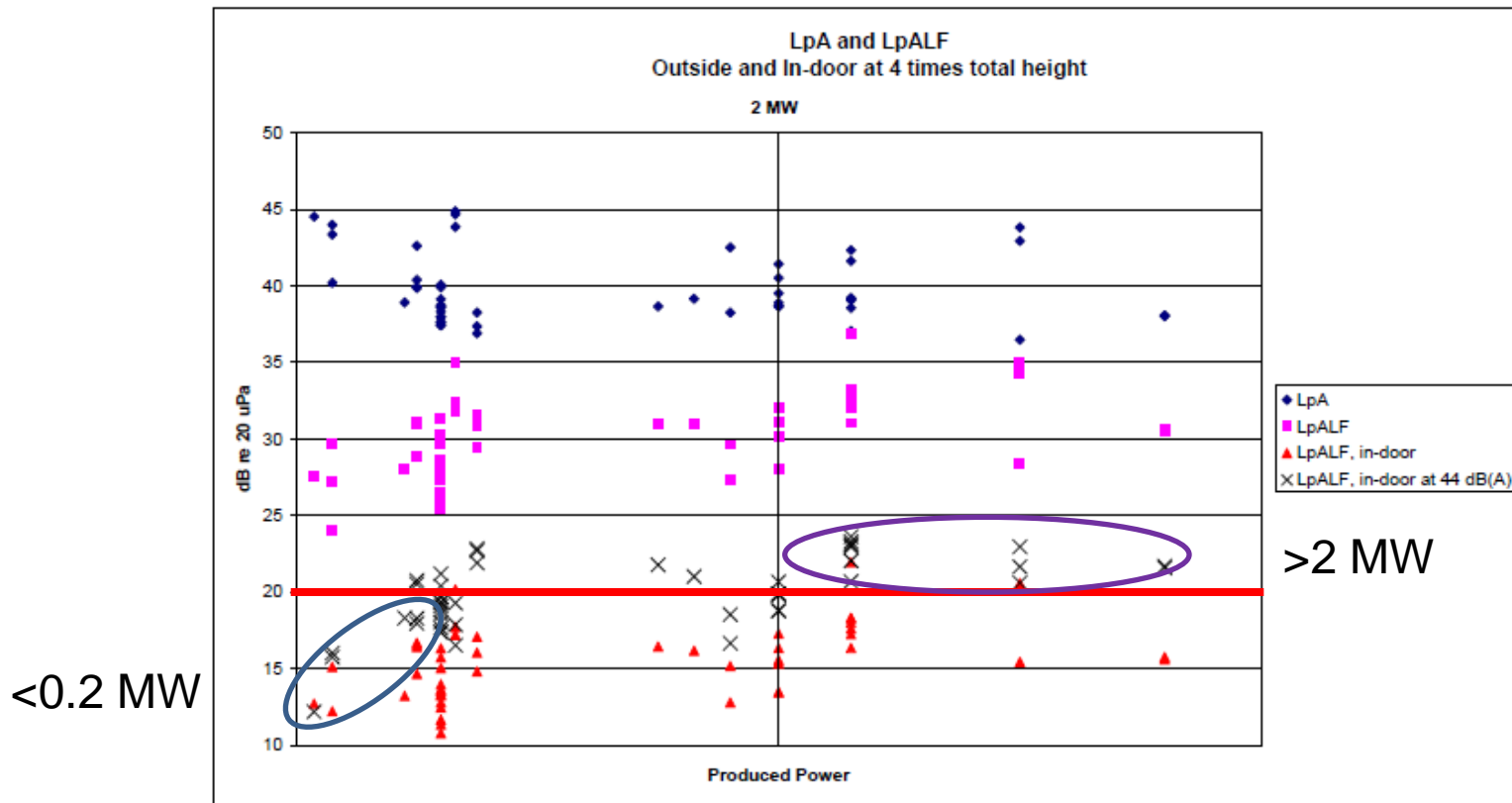
*” Information on the apparent sound power level and tonality of wind turbines is needed by planners, manufacturers and authorities . At present, wind turbine noise specifications tend to be based on measurement results from a single turbine of a particular make and model, and these are then taken to be representative of these turbines as a whole. Clearly, this is unlikely to be the case, as there will be individual variation between different turbines .”*

*“The declaration will increase the reliability of wind farm planning and facilitate the comparison of apparent sound power levels and tonality values of different types of wind turbines.”*

# Vindmøllebekendtgørelse

Beregninger 2008, Delta:

Some results (4 times total height)



Dansk Vindkraftkonference 22.-23. maj 2008

