

**First International Symposium on Adverse Health Effects from Wind Turbines  
The Global Wind Industry and Adverse Health Effects: Loss of Social Justice?  
Picton, Prince Edward County, Ontario, Canada  
October 29-31, 2010**

**Session III  
Cause and Effect**

Abstract and bio on slide 2 is reproduced from the Symposium Program

**First International Symposium on Adverse Health Effects from Wind Turbines  
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**Dr. Christopher Hanning, B.Sc., MB, BS, MRCS, LRCP, FRCA, MD**

**THE TORMENT OF SLEEP DISTURBANCE**

**Abstract:** The most common complaint of those exposed to industrial wind turbine noise (WTN) is sleep disturbance. Many of the other symptoms, fatigue, headache, nausea, memory problems and tiredness are probably secondary to sleep disturbance. Sleep is by the brain and for the brain. It's principal purpose seems to be the consolidation of memory. Loss of sleep, in the short term, causes daytime sleepiness, fatigue, problems with memory and thought processes and, in the longer term an increased risk of obesity, diabetes, high blood pressure and heart disease. There is now a large body of evidence proving beyond any reasonable doubt that sleep is disturbed and health impaired by wind turbines at distances up to 2km, at noise levels claimed to be safe by the industry.

**Bio:** Dr. Hanning is Honorary Consultant in Sleep Disorders Medicine to the University Hospitals of Leicester NHS Trust, UK. He retired in September 2007 as Consultant in Sleep Disorders Medicine. After initial training in anaesthesia, he developed an interest in Sleep Medicine. He founded and ran the Leicester Sleep Disorders Service, one of the longest standing and largest services in the UK. He was a founder member and President of the British Sleep Society. His expertise in this field has been accepted by the civil, criminal and family courts. He chairs the Advisory panel of the SOMNIA study, a major project investigating sleep quality in the elderly, and sits on Advisory panels for several companies with interests in sleep medicine.

# Wind Turbine Noise and Sleep:

## The Torment of Sleep Disturbance

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BSc MRCS LRCP MB BS FRCA MD  
Emeritus Consultant in Sleep Medicine  
University Hospitals of Leicester NHS Trust

# Names will be taken!



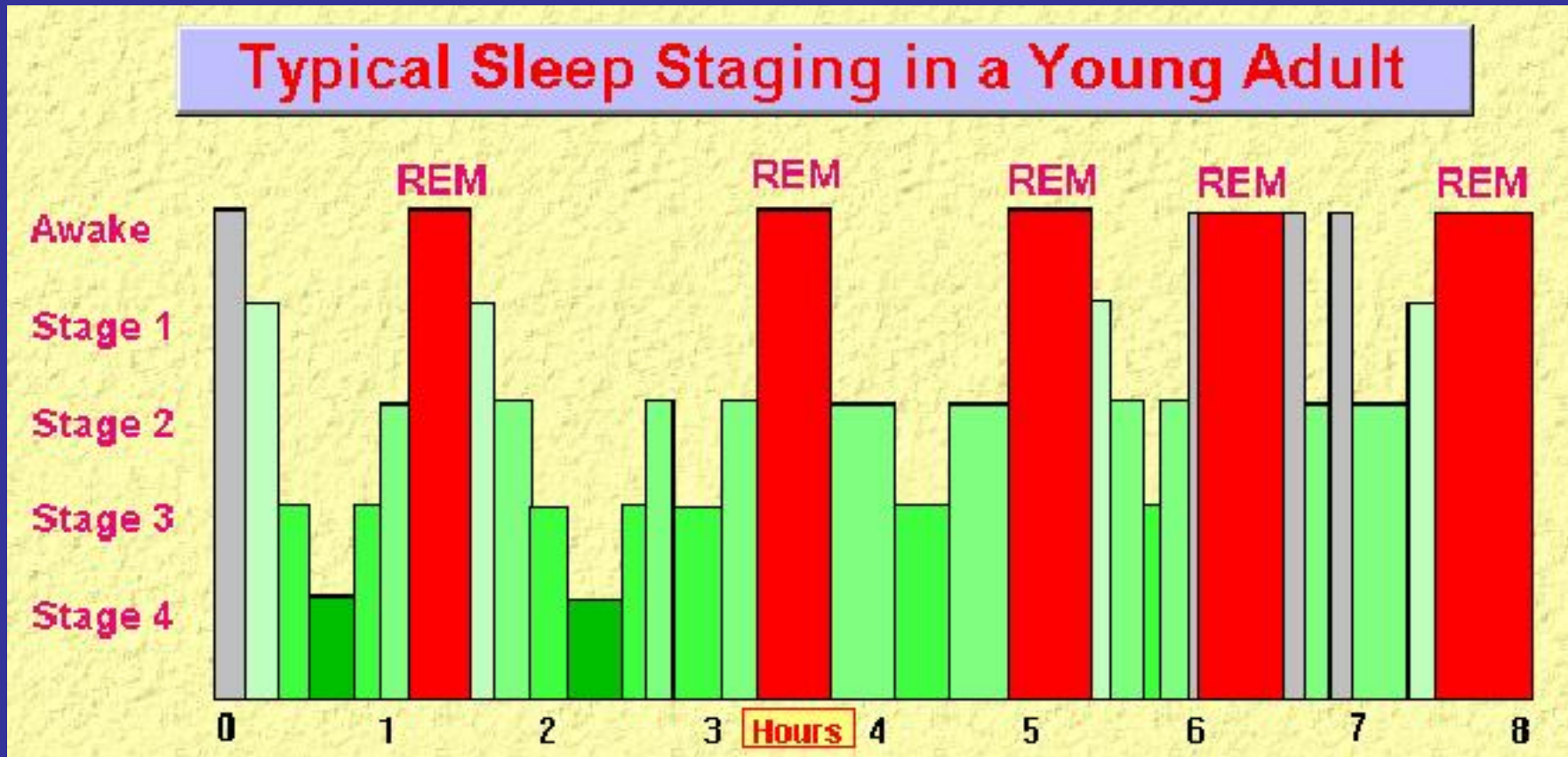
# Wind turbine noise and sleep

- Four Questions
  - How does noise affect sleep and health?
  - Why does WTN affect sleep so much?
  - How far away should they be?
  - What do we need to do next?

# How does noise affect sleep?

- Sleep is essential for human health
  - Adequate duration
  - Adequate quality
- Inadequate sleep leads to:
  - Sleepiness
  - Poor concentration and memory
  - Fatigue, weariness
  - Increased risk of heart disease, obesity, diabetes etc

# How does noise affect sleep?



# How does noise affect sleep?

- Sleep can be disturbed by:
  - Internal disturbances
    - Snoring and breath holding
    - Leg fidgets
    - Pain
    - Coughing etc., etc.
  - External disturbances
    - Noise (partner, traffic, machinery, aircraft, trains, teenagers, drunks, wind turbines etc., etc.)
    - Light
    - Touch



# How does noise affect sleep?

- Stops you getting to sleep
  - Anger, frustration, loss of control, invasion of home, torment
- Stops you getting back to sleep
  - Everybody wakes during the night
  - Remember wakening if more than 30secs
  - Older people – more and longer
- Arousals

# How does noise affect sleep?

- Arousals
  - Brief shift from deep sleep to light sleep
  - Lower sound levels than awakening (<30dBA)
  - Not recalled
  - Accompanied by short  $\acute{e}$  in blood pressure
  - Elderly more spontaneous arousals
  - Some people aroused more easily

# How does noise affect sleep?

- Arousals
  - Arousals more likely than awakenings
  - Fragment sleep
  - Unrefreshing sleep, fatigue etc., etc.
  - é risk high blood pressure
  - Subject only knows sleep is unrefreshing not why! That's the torment

# How does noise affect sleep?

- WTN “research” looks at remembered awakenings
- Awakenings are the tip of the iceberg
- Arousals are far more likely than remembered awakenings

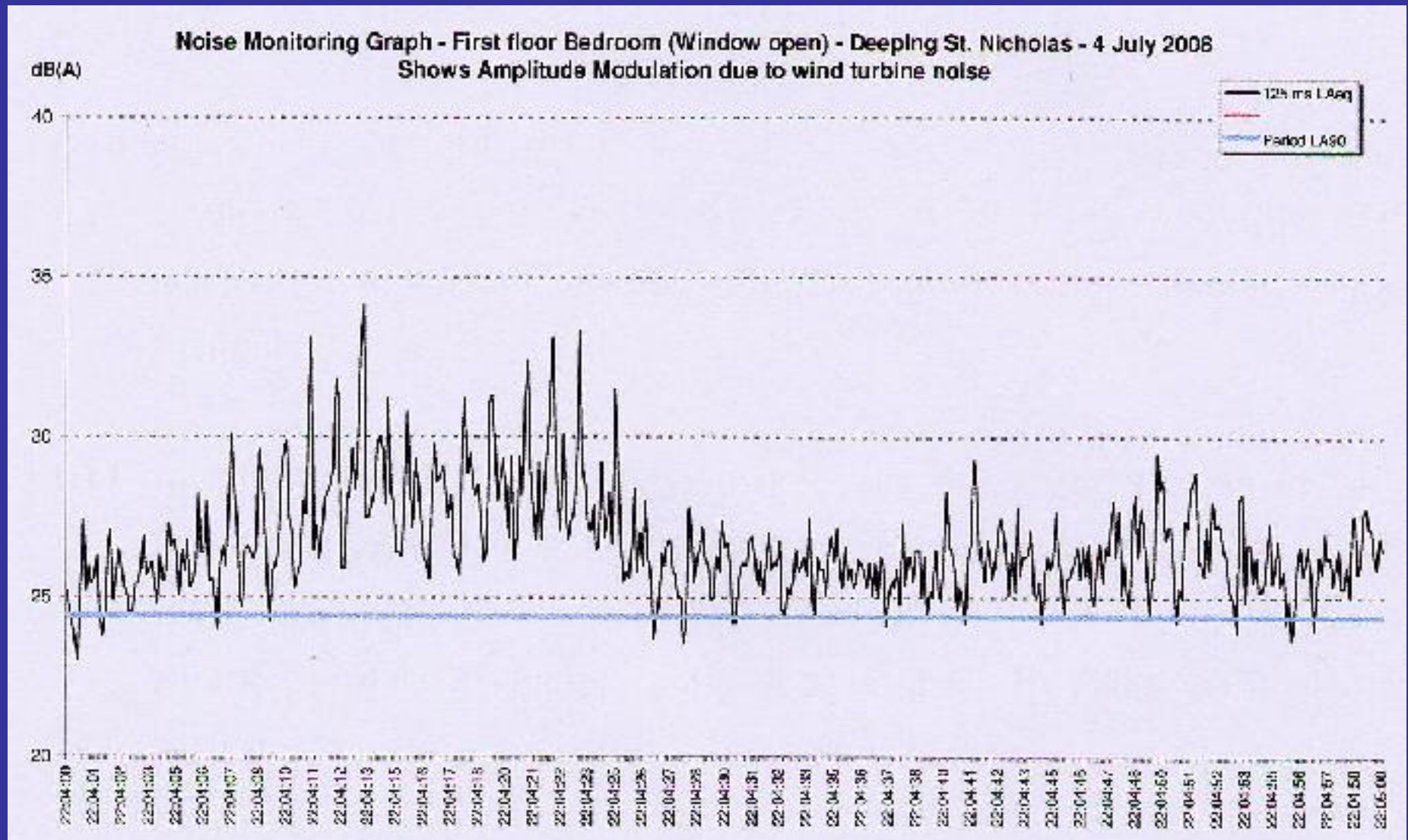
# Why does WTN affect sleep so much?

- Noise character
- Frequency spectrum
- Diurnal variation

# Why does WTN affect sleep so much?

- Noise character
  - Swishing, thumping, pulsing (impulsive) noise
  - Varies, especially if two or more turbines
  - “In your face noise”
  - Fire alarm type of noise
  - Not masked by background noise (traffic, wind noise)

# Why does WTN affect sleep so much?



# Why does WTN affect sleep so much?

- Excess Amplitude Modulation
  - Thumping, pulsing (impulsive) noise
  - Turbine interaction
  - More likely with big turbines
  - More likely with wind shear





# Why does WTN affect sleep so much?

- Frequency spectrum
  - Low Frequency Noise
    - Travels further
    - Penetrates buildings
    - Threatening
    - ? Disturbs sleep more easily

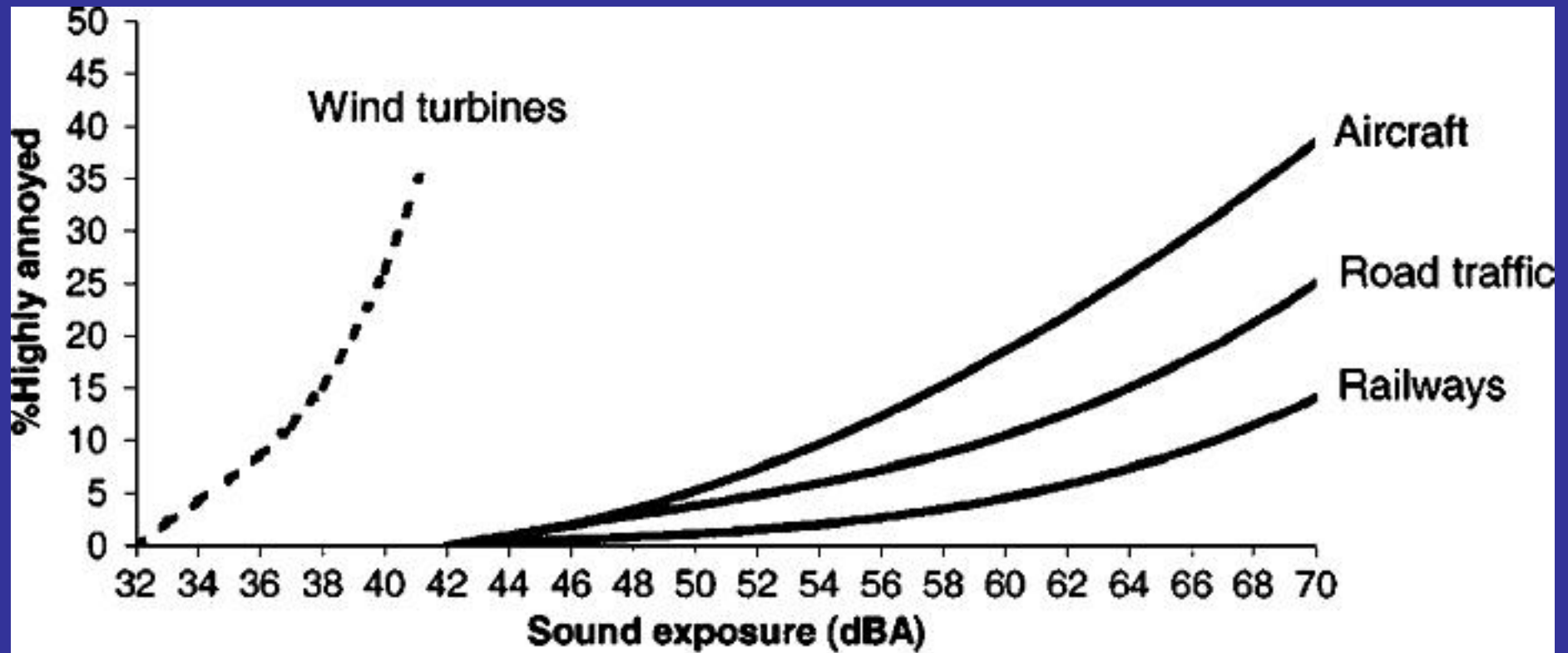
# Why does WTN affect sleep so much?

- Diurnal variation
  - Louder at night
    - Atmospheric stability (wind shear)
    - Thermal inversion
  - Reduced background noise

# Why does WTN affect sleep so much?

- How annoying are they?
  - Worse than traffic
  - Worse than aircraft
  - Worse than almost every industrial sound
  - Only beaten by:
    - The teenager next door's boom box
    - A railway shunting yard

# Why does WTN affect sleep so much?



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

# How big a setback?

## 1. Calculate “safe” external noise

Theoretical assumptions

Industry response

Dose-response relationship

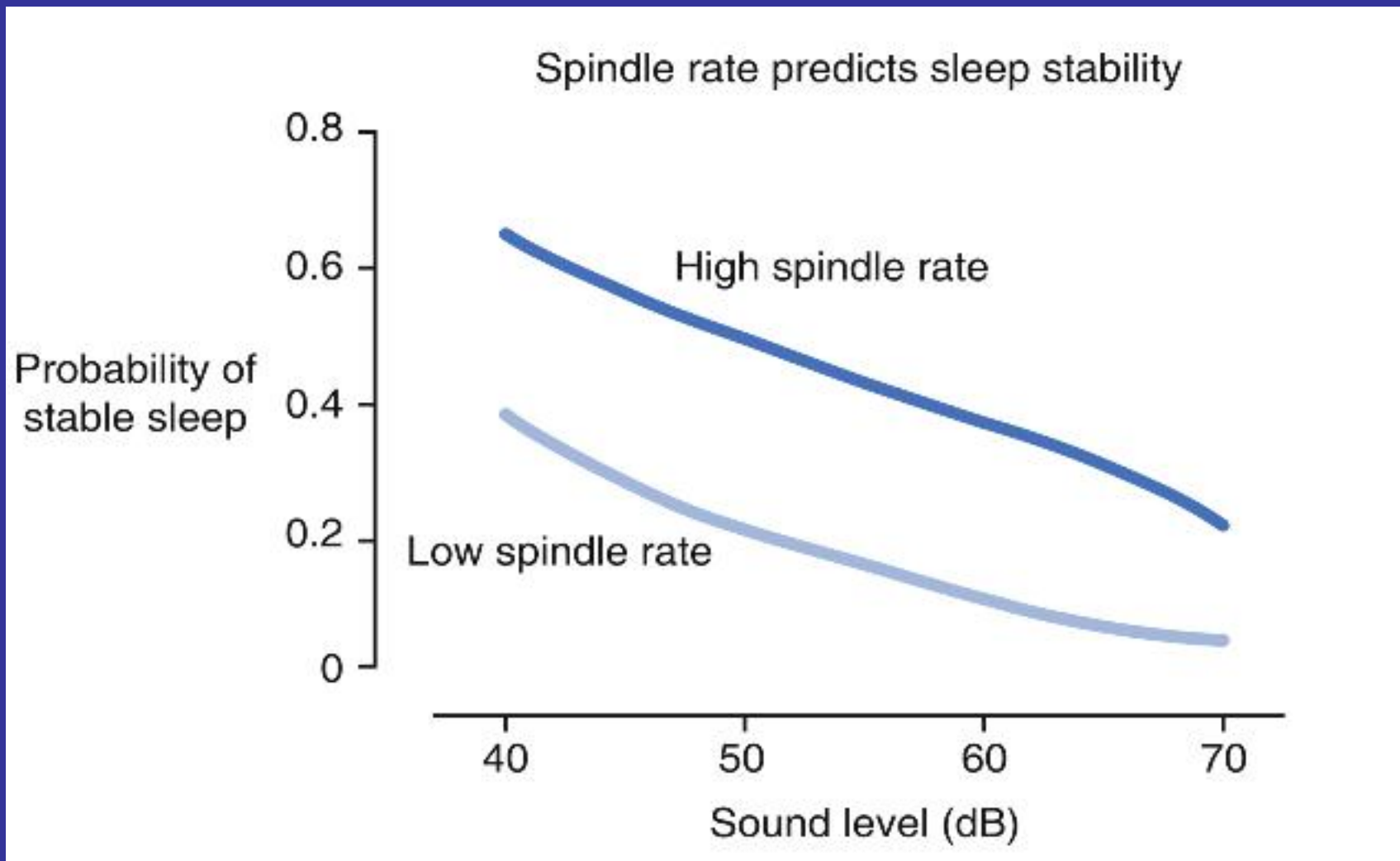
Scientific response

## 2. Calculate “safe” setback distance

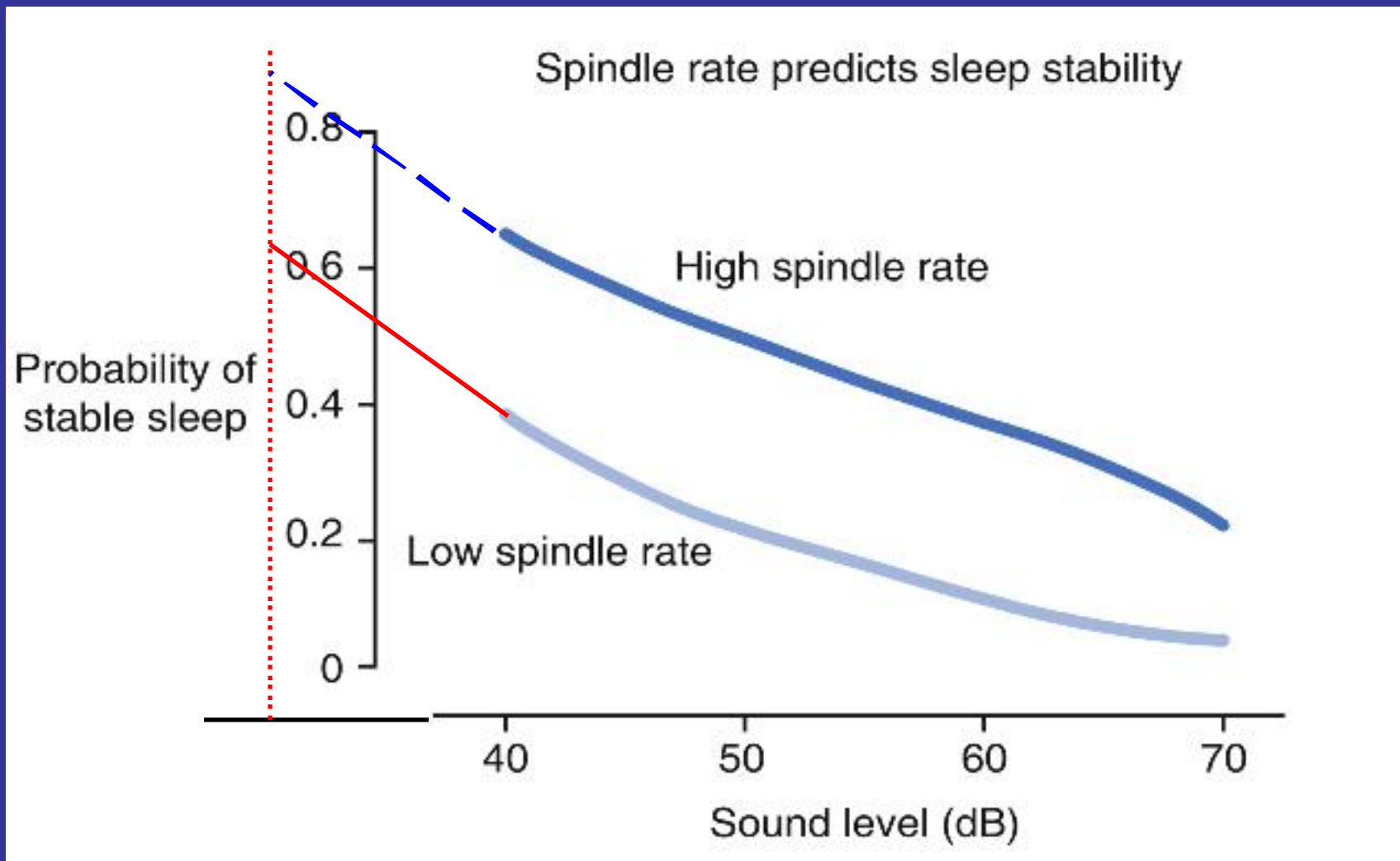
What is “safe”?

Which windfarms do you survey?

# Dose-response relationship



# Dose-response relationship



# How big a setback?

- Present “guidance”
  - Outdated assumptions on noise effects
  - Ignoring modern research
  - Inappropriate averaging of sound
  - Inappropriate assumptions on background masking
  - Exclusion of low frequency contribution
  - No involvement of appropriate experts



# How big a setback?

- Too much evidence to review today, see my updated paper at [www.windvigilance.com](http://www.windvigilance.com)
- At least 1.5km, probably 2km.
- External noise level  $<35\text{dB } L_{A90}$

# What do we need to do next?

- Encourage or force governments to use properly determined dose-response relationships in determining truly safe setback distances.
- In the meantime, apply the precautionary principle.

# What do we do next?

- Choose a Dose-response relationship
  - External noise v “Annoyance”
  - External noise v “Sleep Disturbance”
    - Reported awakenings
    - Measured arousals
    - **Measured outcome** (PSQI, ESS, BFI)
- RIVM (Dutch Environmental Health)
- External noise <35dBA ( $L_{DEN}$  40dB)

# Questions?

