Noise Assessment for Renewable Energy Development

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Noise

- What is noise?
- What are the effects of noise?
- How is it assessed?

- Noise from Wind Turbines

What is Noise?

- Sound "undesired by the recipient"

  Wilson Committee Report on the Problem of Noise, HMSO 1963

- Fluctuating Pressure in the Air
  - Loudness = size of pressure fluctuations

    →Measured in decibels (dB or dB(A))

  - Pitch = rate of pressure fluctuations

    →Measured in Hertz (Hz or kHz)

What's the dBs then, mate?

- Hearing Range
  - Threshold of Hearing 0 dB
  - Threshold of Pain 120 dB
- Perceptible Changes
  - 1 dB just perceptible
  - 3 dB clearly perceptible
  - 10 dB doubling of loudness
- Addition of Noise Sources
  - Doubling / Halving No. = +/- 3dB
  - Multiplying by 10 = +10 dB

And What's All This About Ultra-Infrasound?

- Frequency or 'Pitch' in Hertz (Hz)
- Range of Hearing
  - Ultra-Sound >20,000 Hz
  - Infra-Sound <20 Hz
- Frequency of Different Types of Sound
  - Low Frequency Sound 10 – 200 Hz
  - Middle 'C' 256 Hz
  - Concert 'A' 440 Hz
  - Consonants in speech (4 kHz)

Effects of Noise

(in descending order of noise level)

- Hearing Loss
- Interference with Speech
- Sleep Disturbance
- Annoyance (may cause secondary effects)

Noise Annoyance

Related to:

- Noise level
- Information it conveys
- Association or emotion it excites
- Other factors

How Do We Assess Noise?

- Fixed
  - Compare predicted noise with an absolute limit
    - →May vary according to noise source
    - →May vary according to location (urban, rural etc.)
- Comparative
  - Compare predicted noise with existing level
    - →Margin of allowed exeedence

Fixed or Comparative

- Road, Rail, Aircraft
  - Normally compared to fixed level.
- Industrial
  - Normally compared to existing (background) level.

Renewable Energy Developments

- Usually classed as ‘industrial’
  - Predicted noise level compared to background level relevant to operating period / conditions.
- Depends on location and type of noise
  - In rural areas comparison with background level may not be helpful.

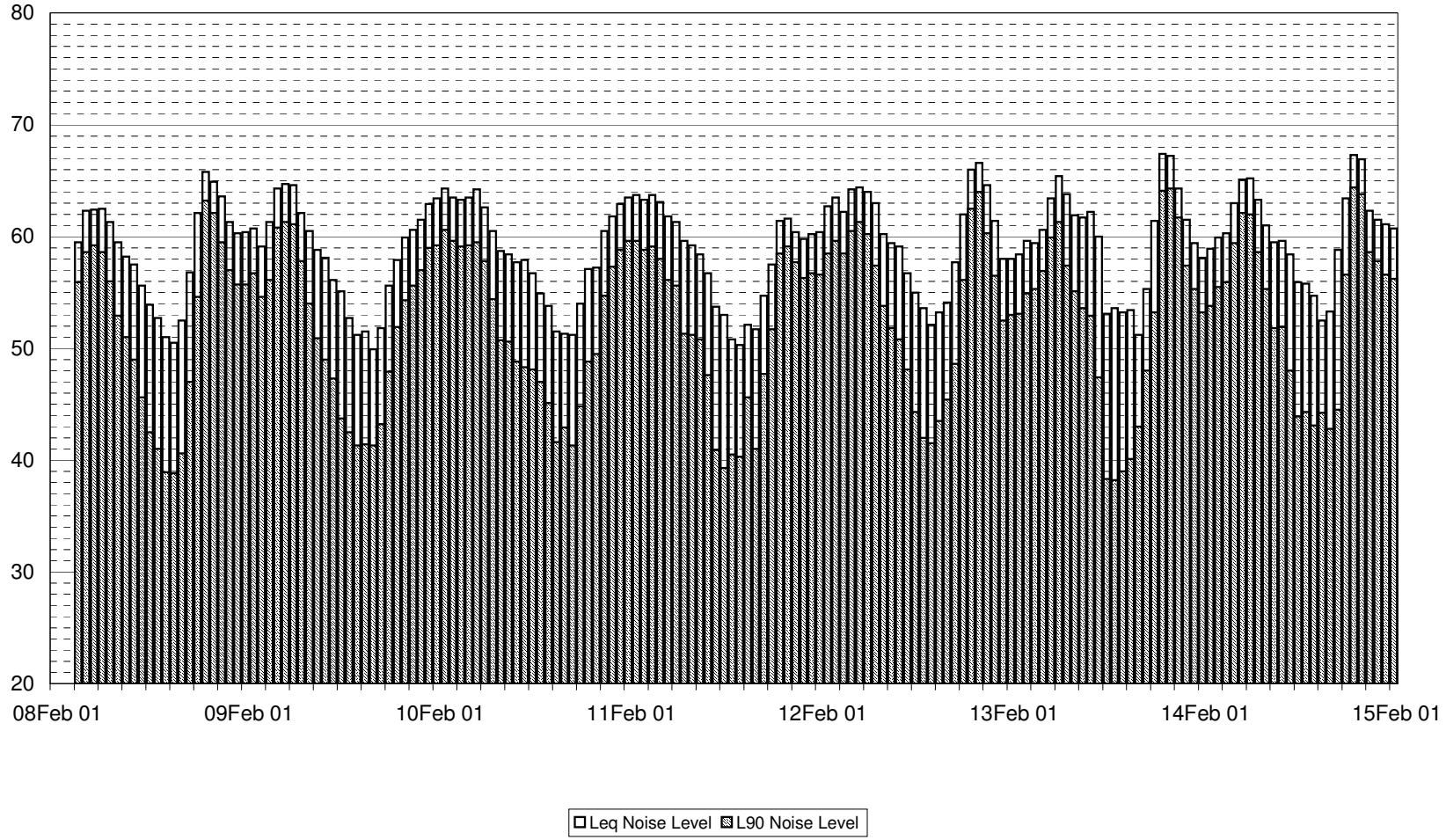
How Do We Quantify Noise Level?

- Sound Pressure Level (SPL)
  - Normally measured in A weighted decibels (dB(A)
- Different indices for different purposes
  - Source noise → dB L_{Aeq} (energy average)
  - Background noise → dB L_{A90} (level exceeded for 90% of the time)
  - Isolated events → dB L_{Amax} (maximum level)

Methodology (1)

- Measure existing noise
  - Attended monitoring
    - →Good detail but not statistically robust
  - Un-attended monitoring over a few days
    - →Less detail but more robust

Baseline Noise Data - Suburban Site



Methodology (2)

- Predict new noise level
  - Source noise level
  - Propagation factors

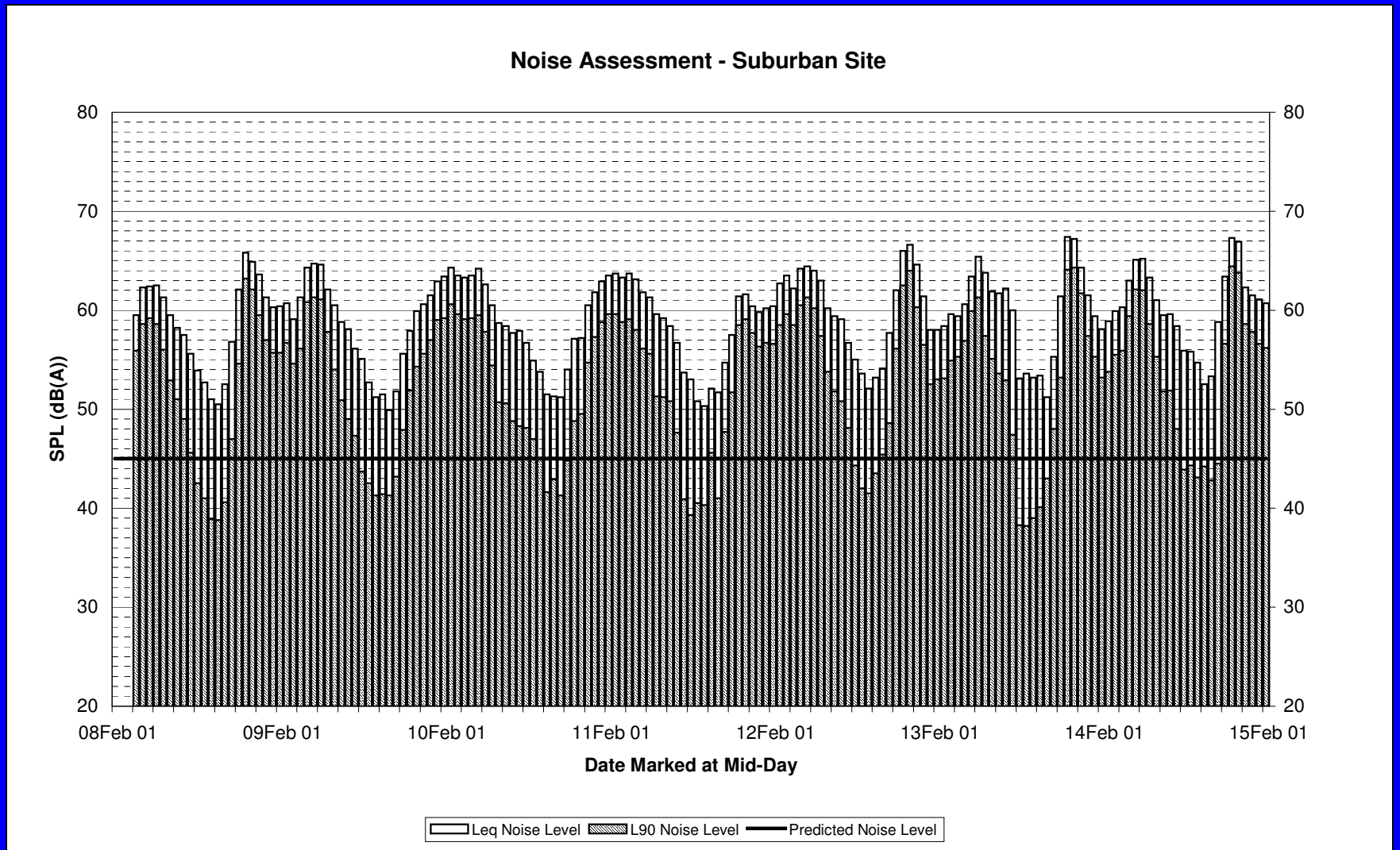
    →Directivity, atmospheric attenuation, ground absorption, screening etc.

Methodology (3)

- Comparison with baseline
  - Including any mitigating factors

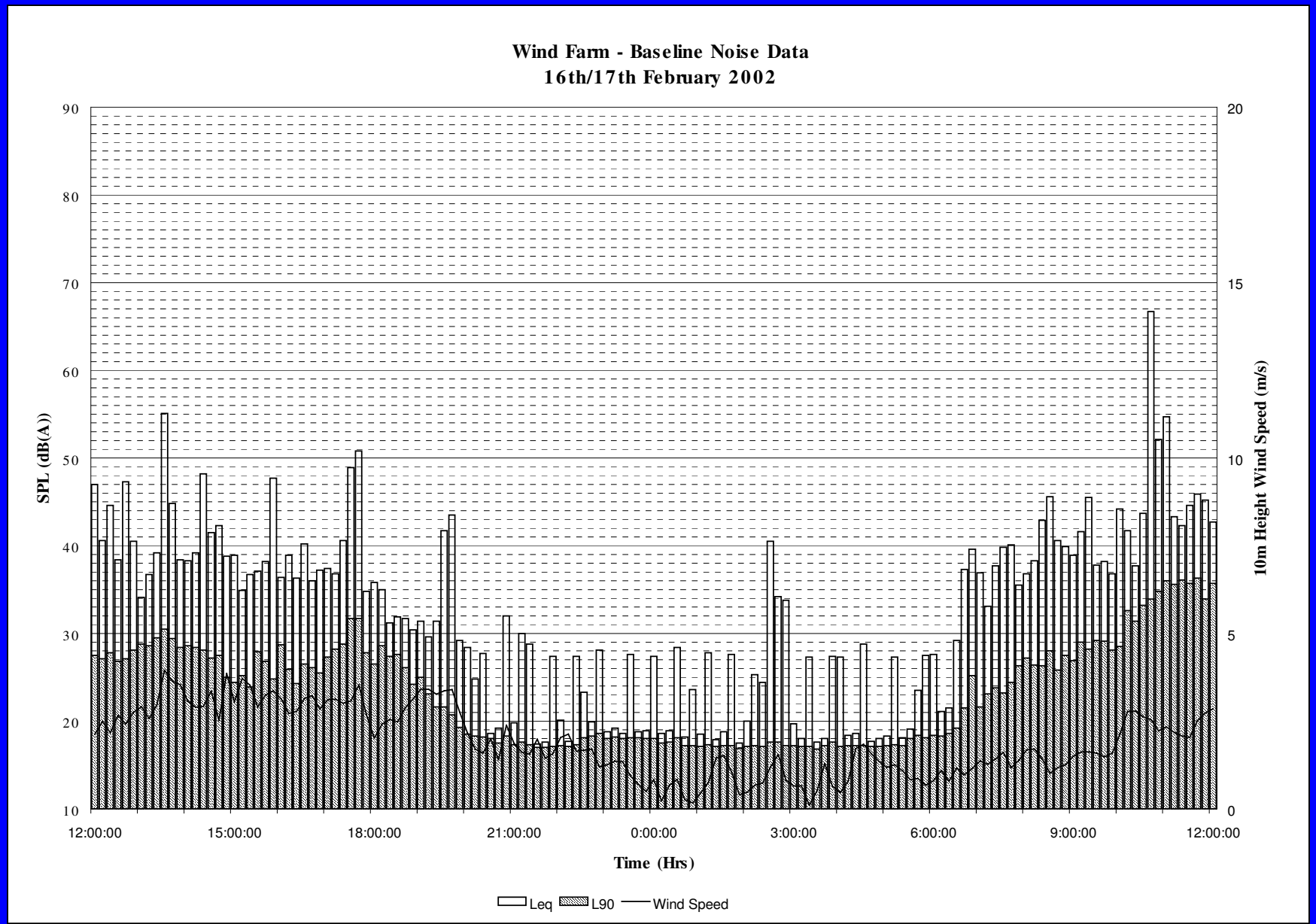
- *Penalties for:
  - Tonal content in the noise.
  - Impulsive content in the noise.
  - Noise which is ‘irregular enough to attract attention’.

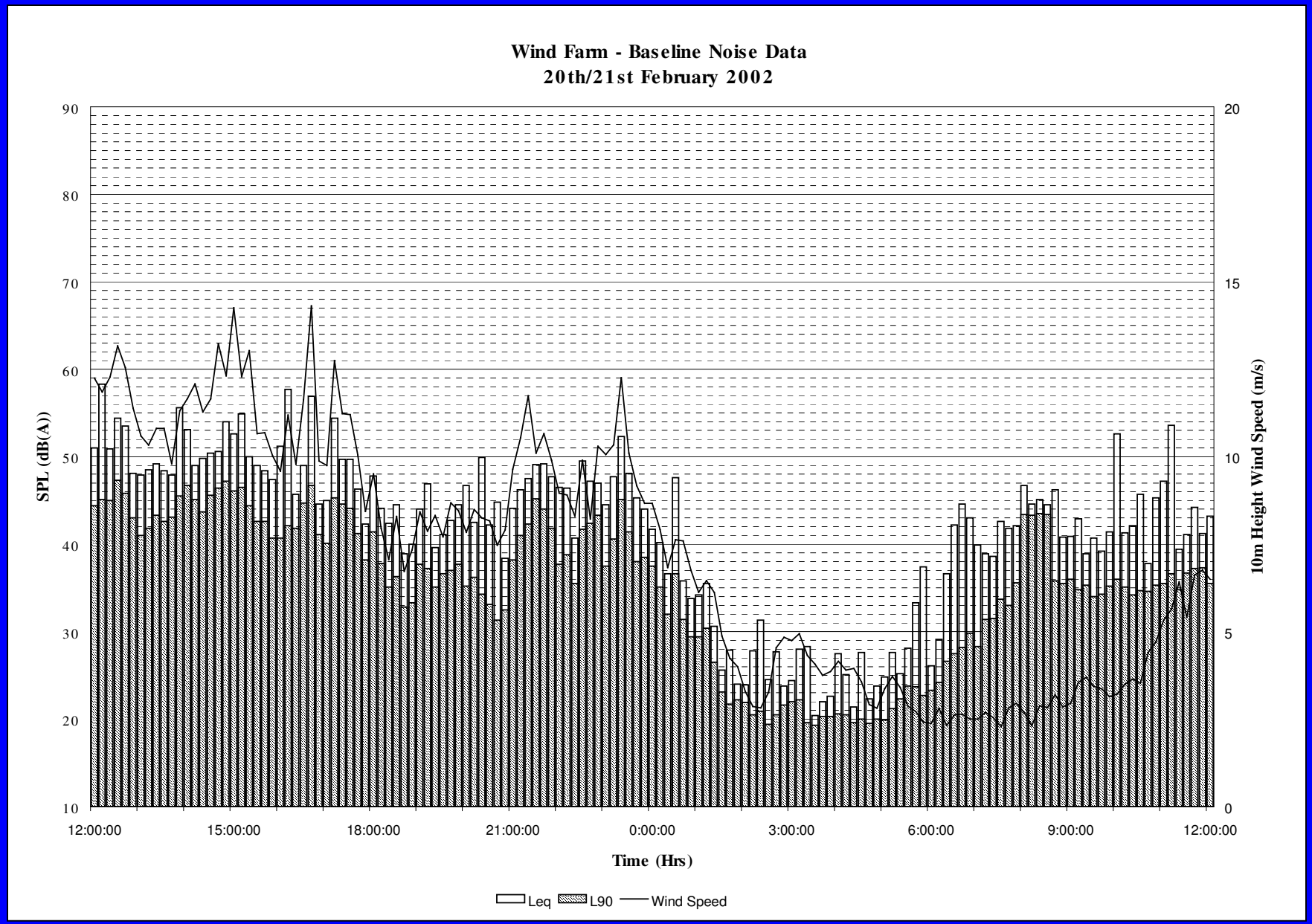
British Standard BS4142
Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas


Noise Assessment - Suburban Site
SPL (dB(A))
80
70
60
50
40
30
20
08Feb 01
09Feb 01
10Feb 01
11Feb 01
12Feb 01
13Feb 01
14Feb 01
15Feb 01
Date Marked at Mid-Day
Leq Noise Level
L90 Noise Level
Predicted Noise Level

Noise from Wind Turbines

- Low level noise source but quiet locations
- Noise sources
  - aerodynamic → broadband noise
  - mechanical → tonal noise
- Variation in b/g level with wind speed
- Variation in source level with wind speed


Wind Farm - Baseline Noise Data
16th/17th February 2002
SPL (dB(A))
10m Height Wind Speed (m/s)
Time (Hrs)
90
80
70
60
50
40
30
20
10
20
15
10
5
0
12:00:00
15:00:00
18:00:00
21:00:00
0:00:00
3:00:00
6:00:00
9:00:00
12:00:00
Leq
L90
Wind Speed


Wind Farm - Baseline Noise Data
20th/21st February 2002
SPL (dB(A))
10m Height Wind Speed (m/s)
Time (Hrs)
90
80
70
60
50
40
30
20
10
20
15
10
5
0
12:00:00
15:00:00
18:00:00
21:00:00
0:00:00
3:00:00
6:00:00
9:00:00
12:00:00
Leq
L90
Wind Speed

Assessment of Wind Turbine Noise

- Planning Policy Statement (PPS)22

  Renewable Energy

- *ETSU-R-97*

  The Assessment & Rating of Noise from Wind Farms

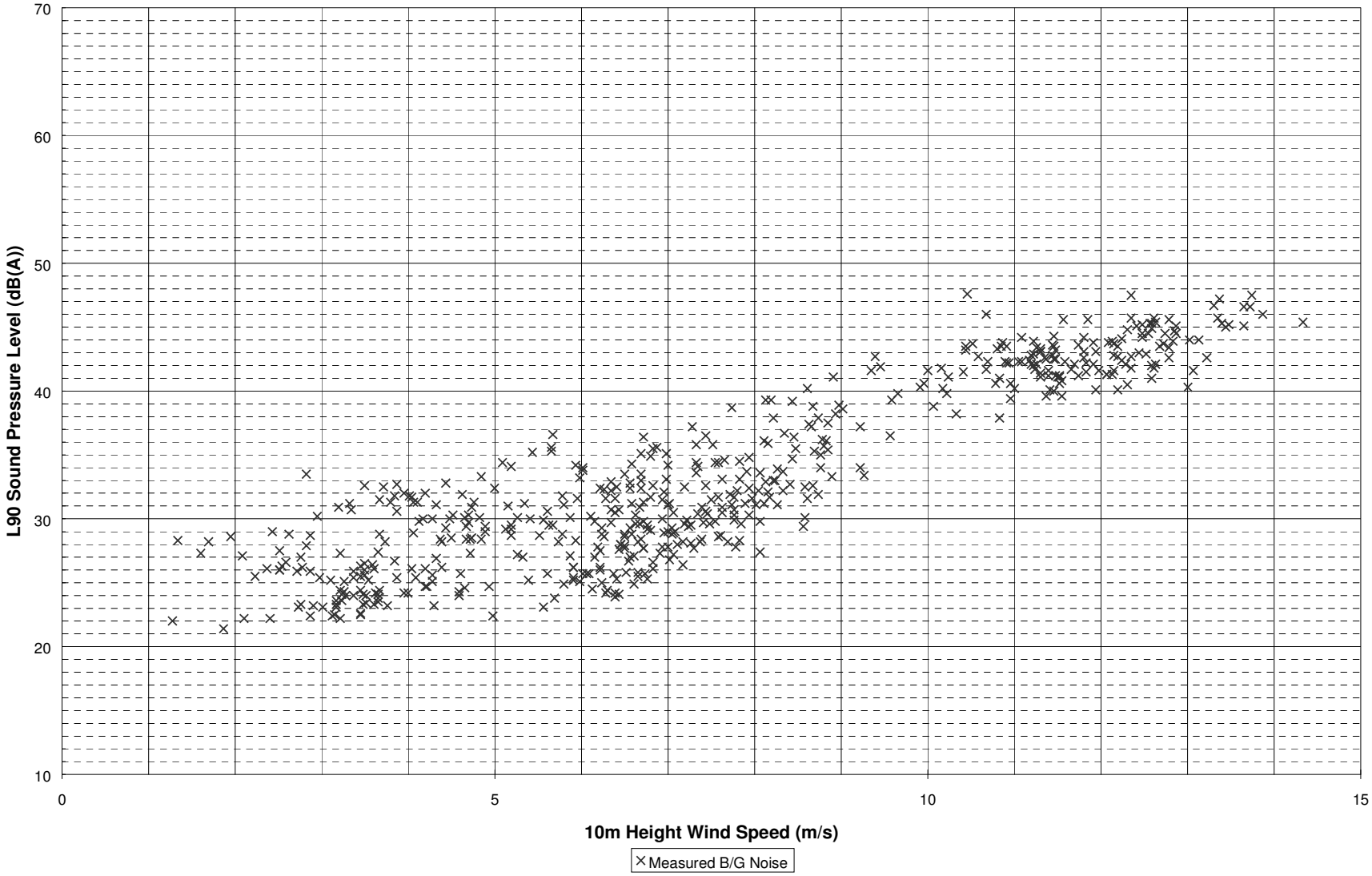
ETSU-R-97

- X dB L_{A90} or 5 dB above b/g, whichever is greater
  - X varies with time of day and other factors
    - → Day-time: X=35-40
    - → Night-time: X=43
    - → Land-owner: X=45
  - B/G quantified as a function of wind speed
  - B/G averaged over relevant period
    - → night 2300-0700
    - → 'sensitive' day-time hours (1800-2300, Sat pm and all day Sun)

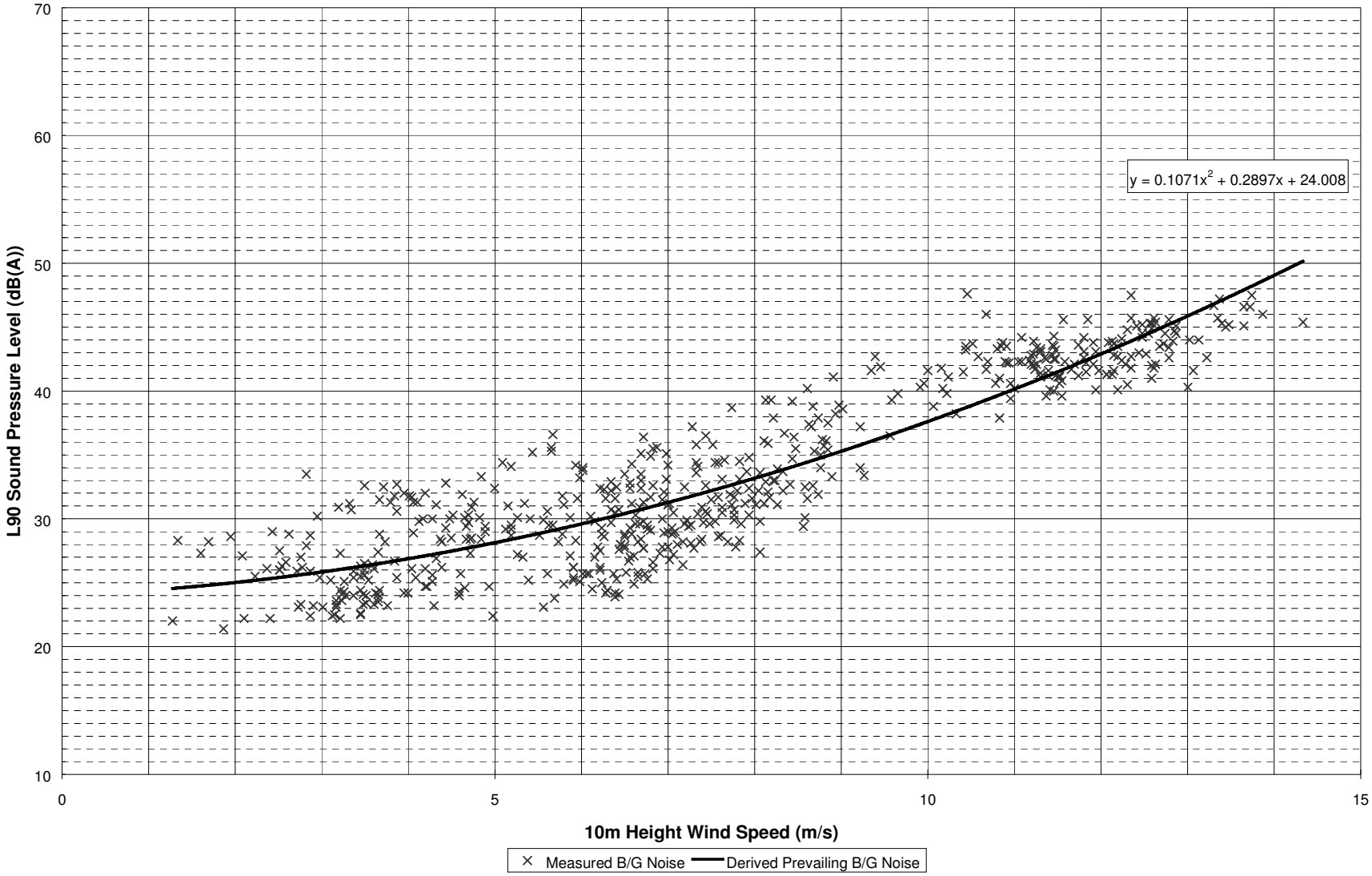
ETSU-R-97 Simple Noise Limit

- For smaller and more remote sites
  - 35 dB L_{A90} @ 10m/s (V_{10})
  - Removes requirement for b/g measurements
  - Note use of L_{A90} measurement index (~L_{Aeq}-2)

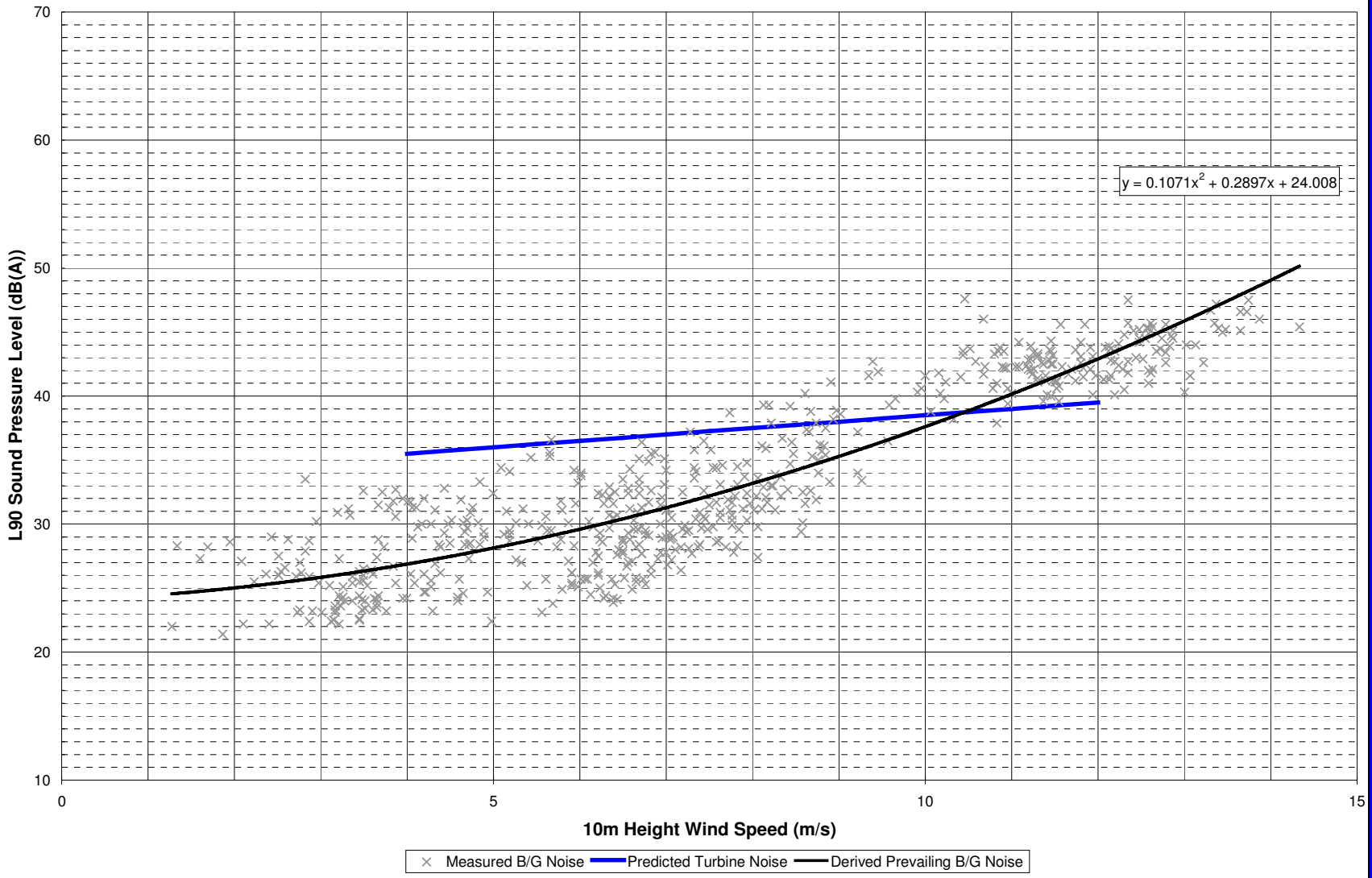
Wind Farm Noise Assessment
Background Noise vs Wind Speed



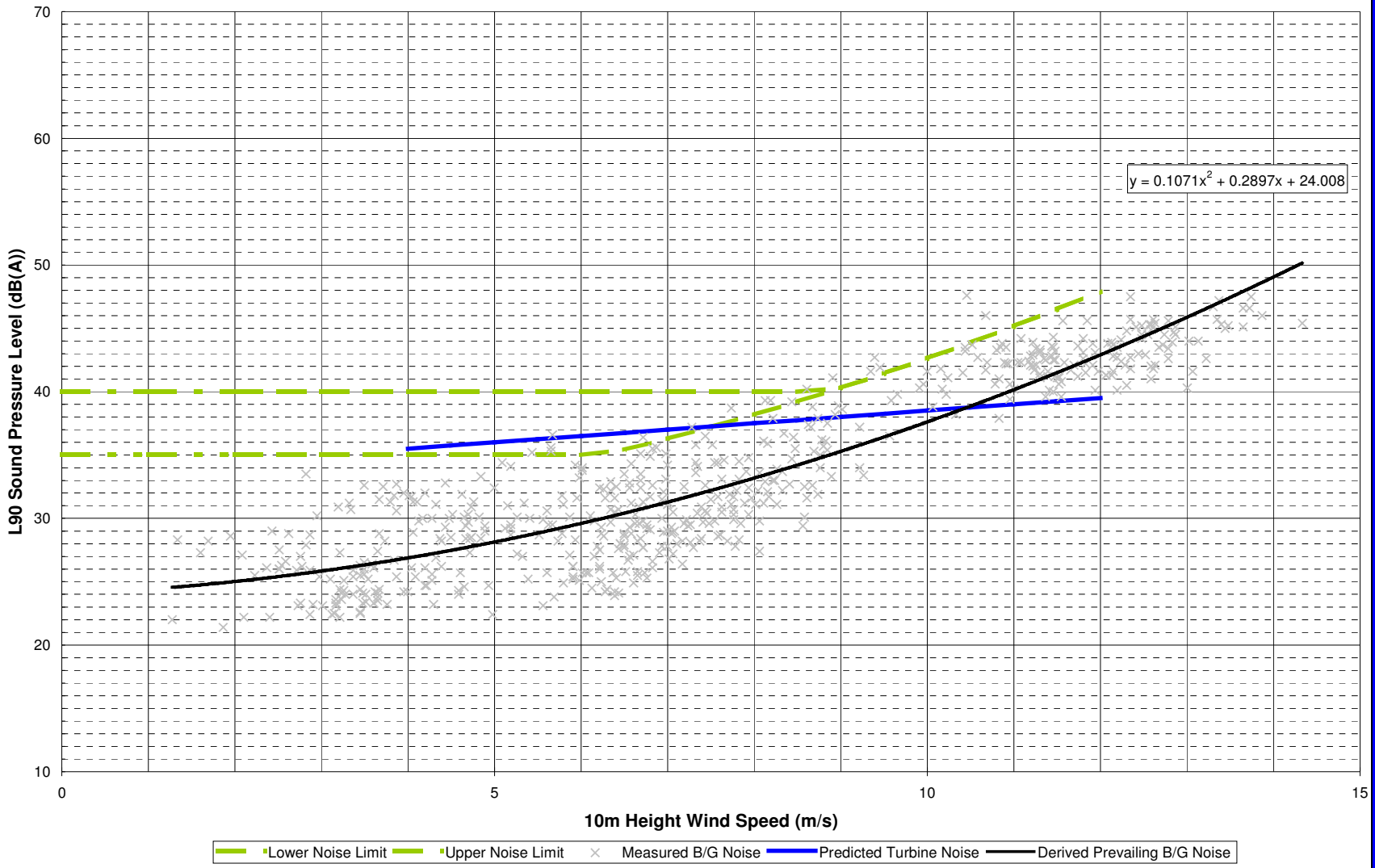
Wind Farm Noise Assessment
Background Noise vs Wind Speed
(Amenity Hours)



Wind Farm Noise Assessment
Predicted Turbine Noise and Background Noise vs Wind Speed



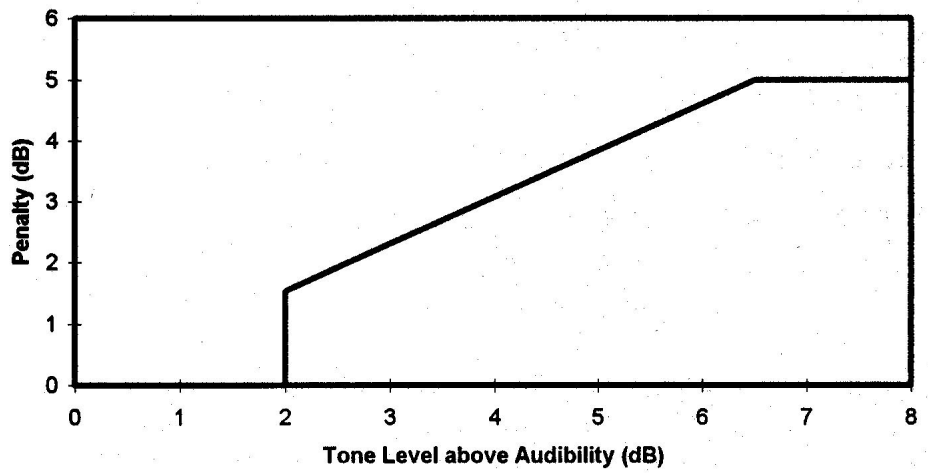
Wind Farm Noise Assessment
Predicted Turbine Noise and Background Noise vs Wind Speed
(Amenity Hours)



Other Issues

- Tonality
- Modulation
- Infrasound
- Low Frequency
- Wind Shear

ETSU-R-97 Tone Penalty



Penalties for tonal noise

Modulation

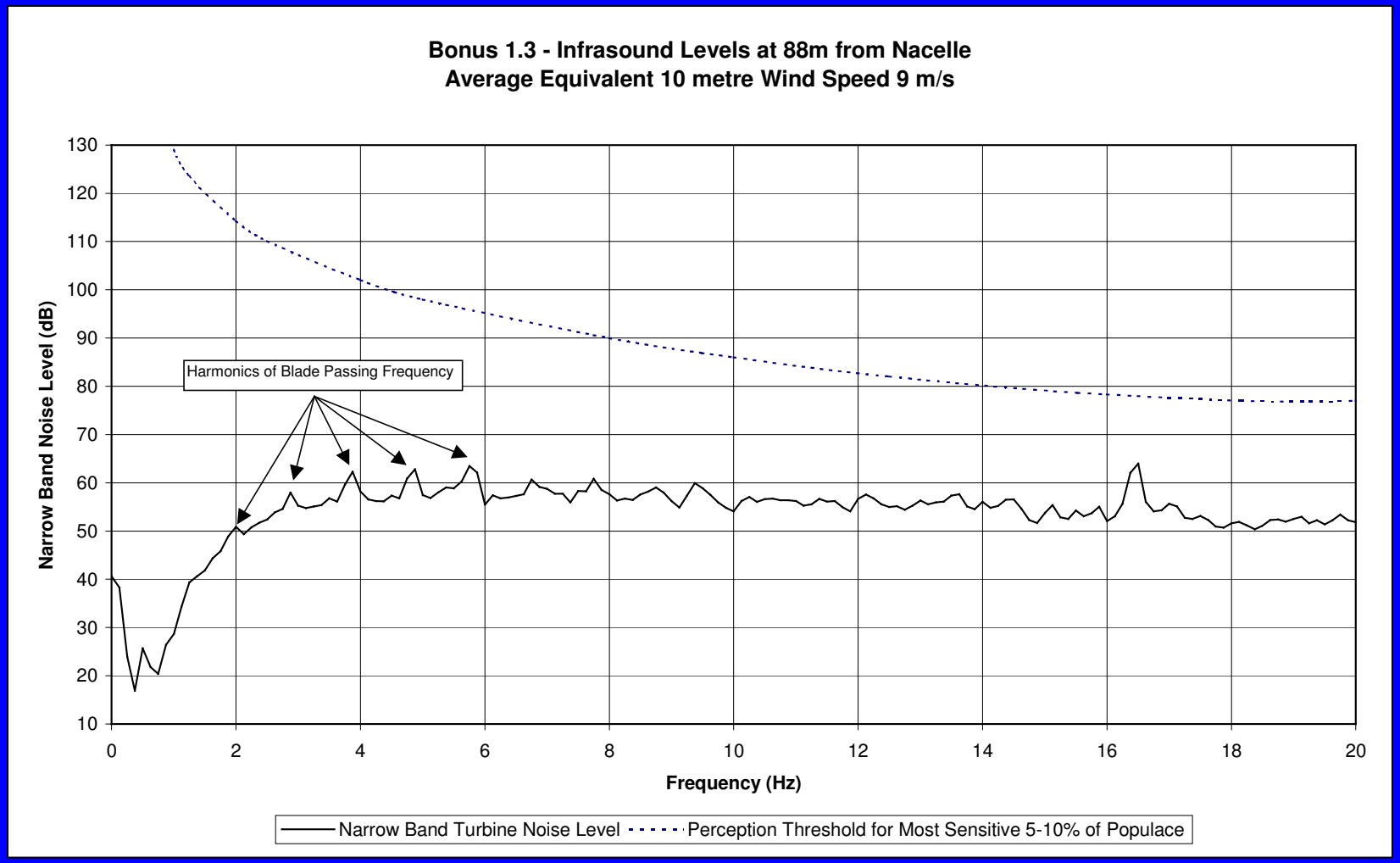
- ETSU-R-97 noise limits allow for the fact that there may be a degree of fluctuation at times.

- However, law on statutory nuisance still applies

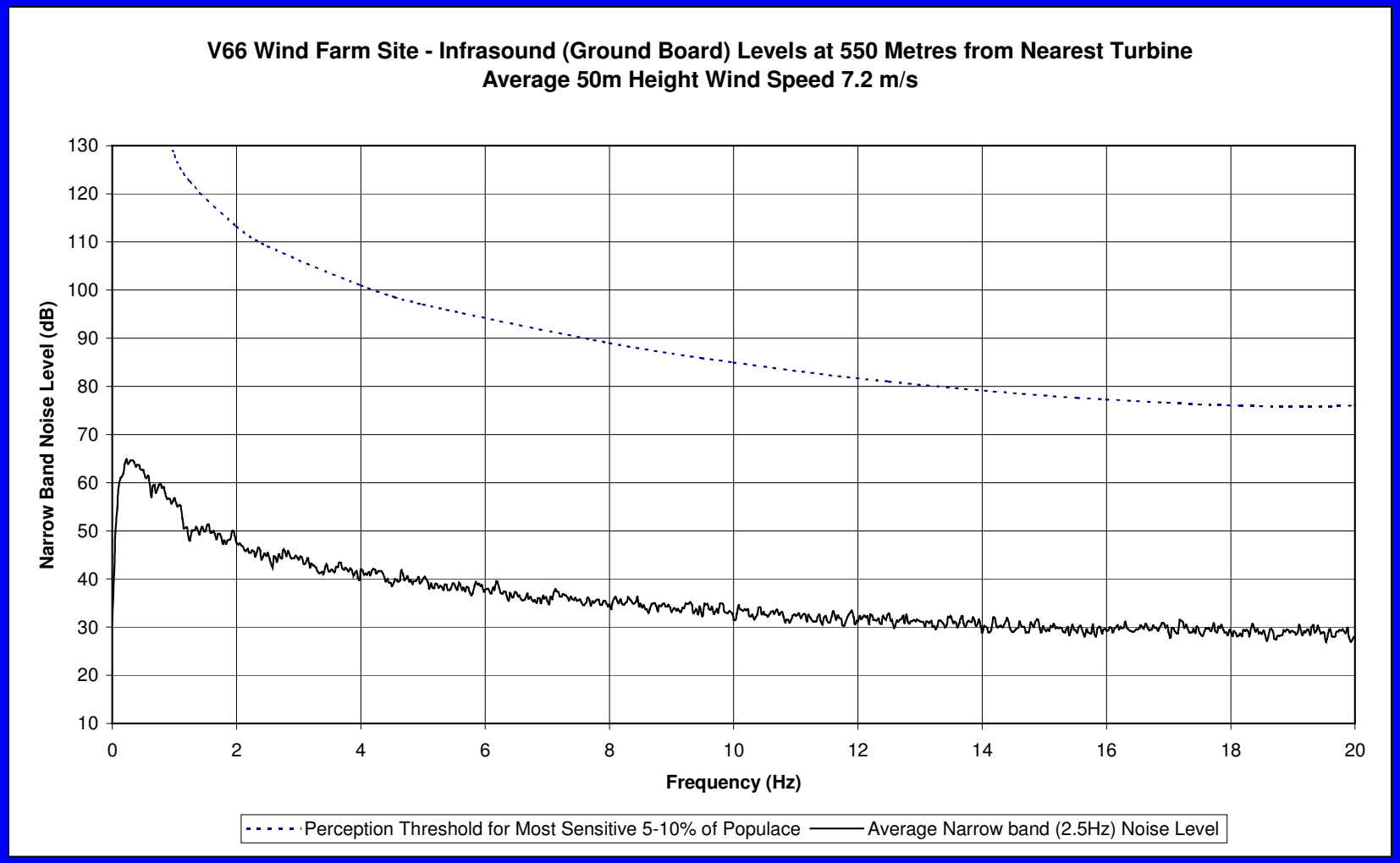
(Audible) Low Frequency Noise

- As distance increases, low frequency bias in spectra increases.
- Not an issue for on-shore sites.

Infrasound from Wind Turbines



Infrasound from Wind Turbines



Wind Shear

- Noise quantified for wind at 10 m height.
- Hub height wind depends on wind shear.
- Claims of higher levels of wind shear at night
- May be true but probably only around 10% increase
- Guaranteed noise levels still apply at night!!

Noise

- What is noise?
- What are the effects of noise?
- How is it assessed?

- Noise from Wind Turbines

Conclusions

- Renewable energy developments normally assessed in standard manner.
- Specific procedures apply for wind turbine sites.

Wind Turbine Noise

- Wind turbine noise may be audible at nearest properties for worst case propagation conditions.

- With proper design to meet specified limits for worst case, the noise levels generated should be acceptable.

How is't with me, when every noise appals me?

Macbeth, Act 2 Scene 2

Hang, cur, hang! You whoreson, insolent noisemaker…

The Tempest, Act 1 Scene 1