

Wind Farms

Assessment of Noise Impact

Dr Andy McKenzie
Hayes McKenzie Partnership Ltd
Salisbury & Machynlleth



Wind Turbines & Noise

- Sources of Noise
 - Aerodynamic, mechanical
- Location
 - Elevated, usually rural, usually ‘quiet’
- Variation of Noise with Wind Speed
 - Rotor speeds – fixed, twin and variable
- Acoustic Features
 - Spectral, temporal



General Noise Assessment

- Compare predicted noise levels with:
 - Pre-existing level of specific noise (not valid for new development).
 - Absolute limit (used for noise from transport, construction, minerals).
 - Pre-existing background (used for noise from industrial sources).
- Noise from wind turbine sites
 - Guidance for industrial sources suggests comparison with ‘background’.
 - Lack of guidance for low noise environments (eg. Scope of BS4142)
 - Specific requirements for wind farms led to hybrid proposal (ETSU-R-97).
 - Takes into account variation in source noise and background with wind.
 - Relates to ‘worst case’ wind direction.



ETSU-R-97 Noise Limits

- X dB L_{A90} or 5 dB above ‘prevailing’ background, whichever is the greater.
 - X varies with time of day and other factors
 - Day-time: $X=35-40$
 - Night-time: $X=43$
 - Financially Involved: $X=45$
 - 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)
- Simplified Limit 35 dB L_{A90} for $V_{10} < 10\text{m/s}$



Status of ETSU-R-97

- PAN45 → ETSU-R-97
- TAN8 → ETSU-R-97
- PPS22 → ETSU-R-97
- PPS22 Companion Guide → ETSU-R-97

“The 1997 report by ETSU for the Department of Trade and Industry should be used to assess and rate noise from wind energy development.”

Planning guidance un-likely to suggest levels leading to un-acceptable impact.



Establish Prevailing Background

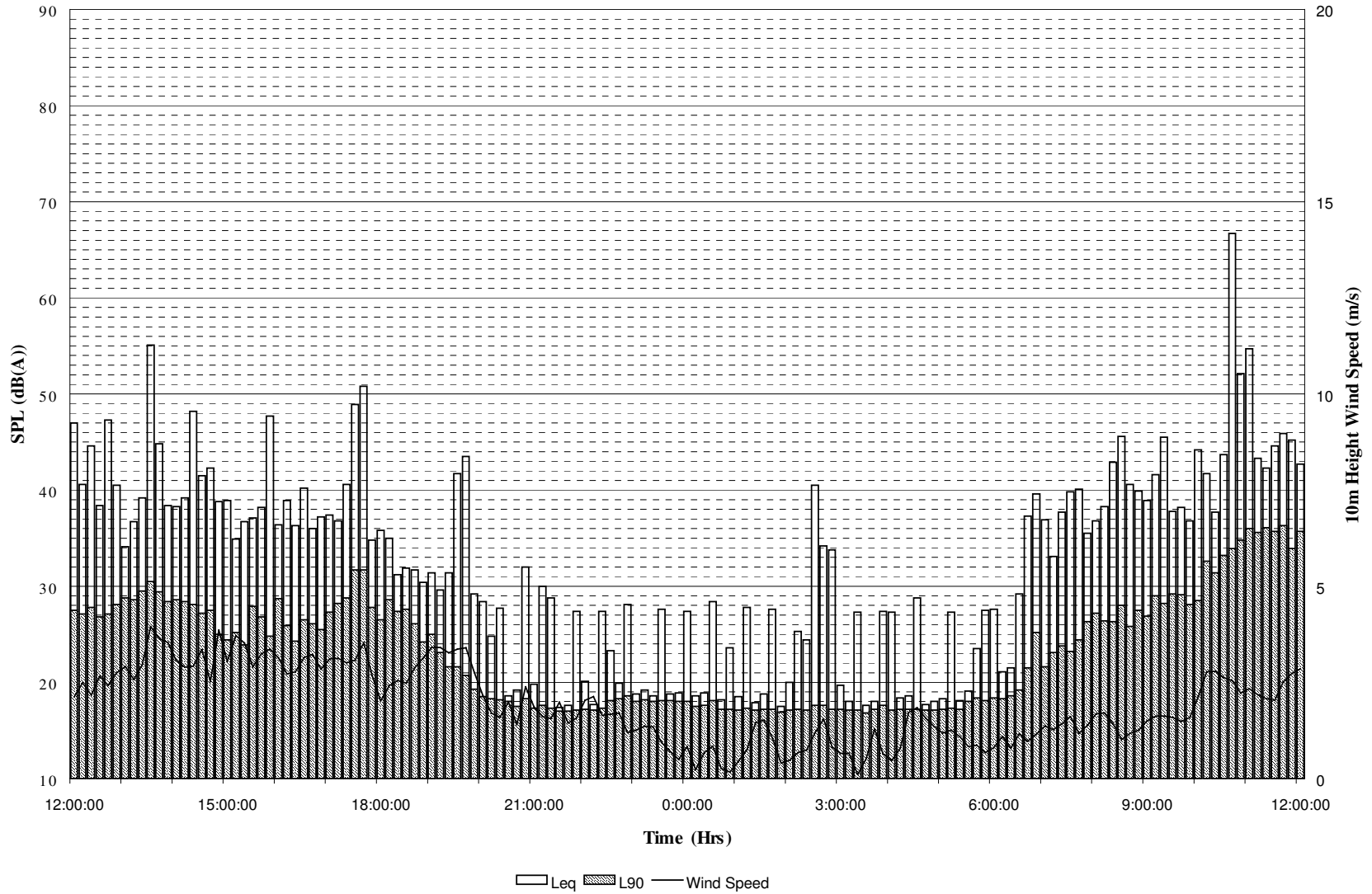
- Successive 10 min. L_{A90} noise levels
- Successive 10 min. synchronised w/s & w/dir
- Leave for two weeks
- Plot variation of noise & wind with time



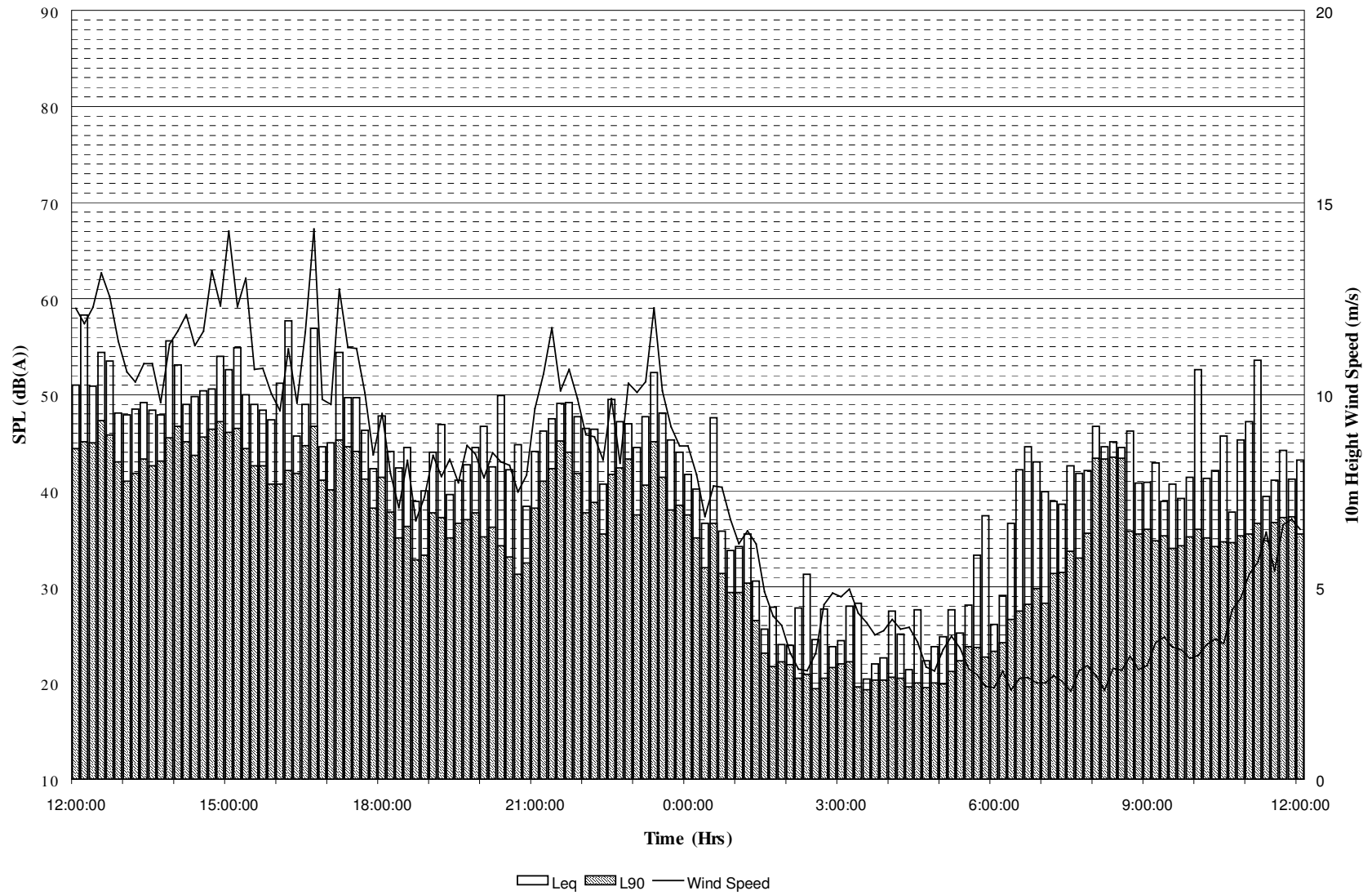
Siting



Wind Farm - Baseline Noise Data
16th/17th February 2002



Wind Farm - Baseline Noise Data
20th/21st February 2022

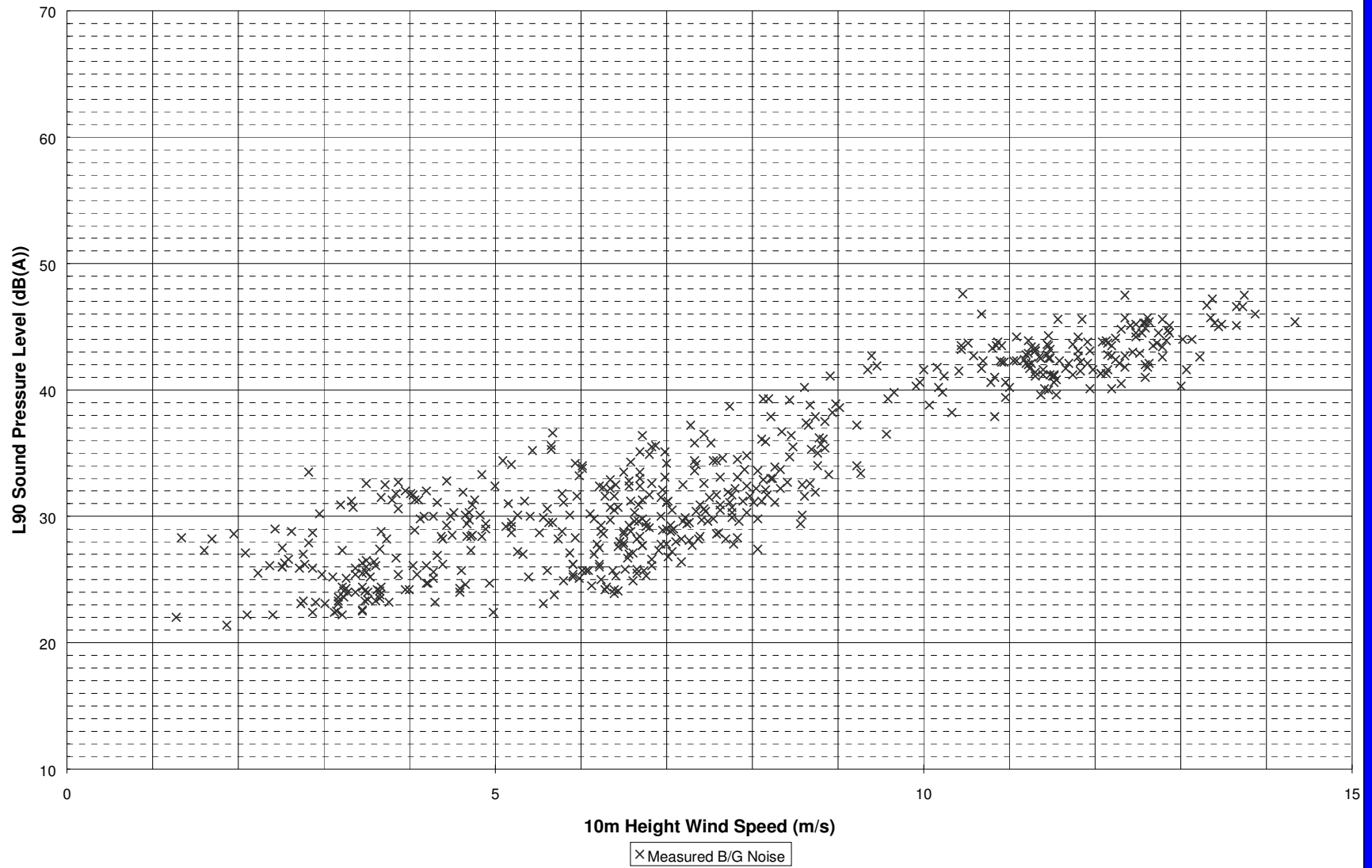


Derivation of Noise Limits

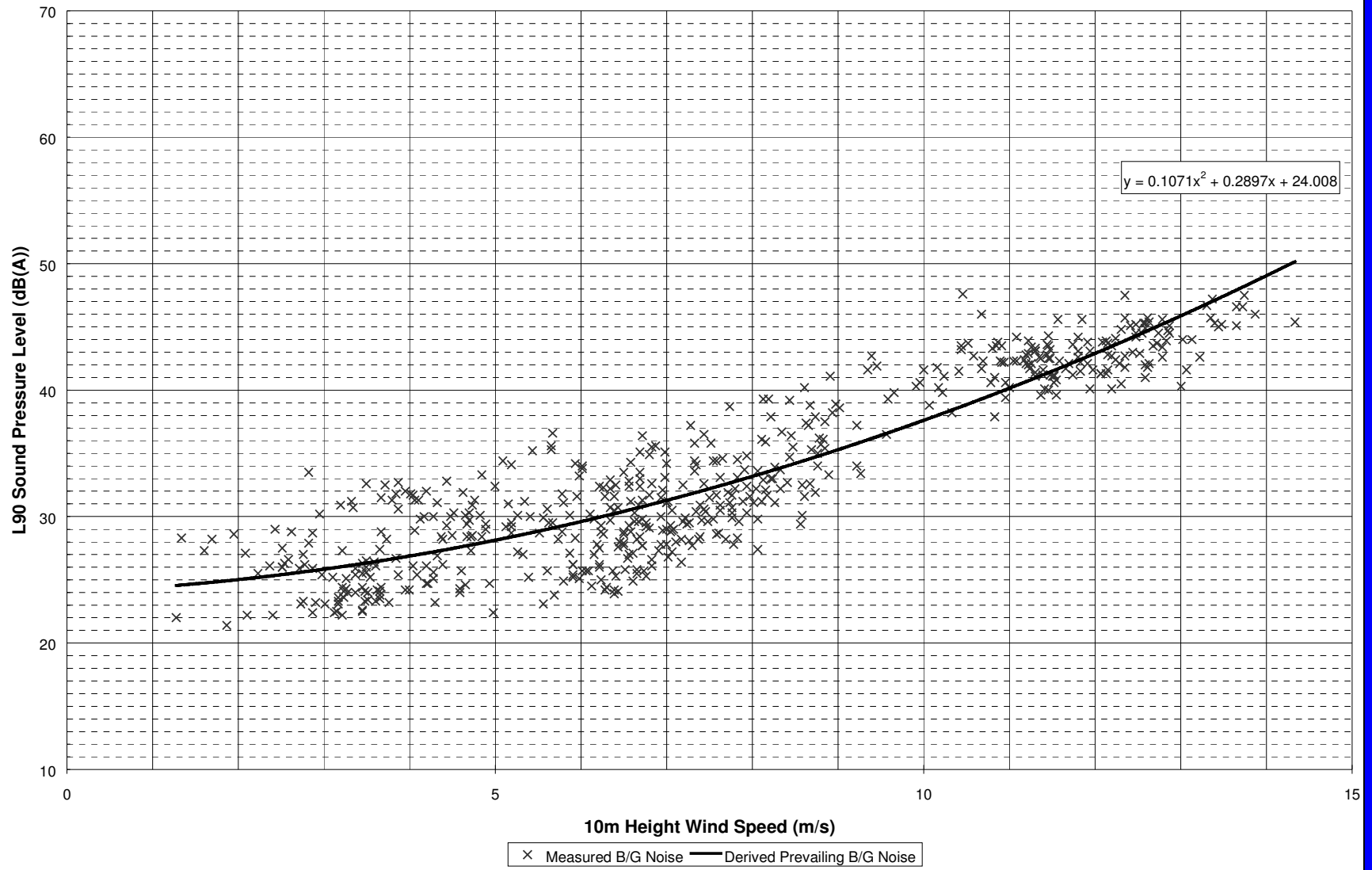
- For ‘sensitive’ day-time and night time hours:
- For each measurement location:
 - Plot noise against wind speed
 - Derive ‘prevailing’ b/g
 - Derive noise limits



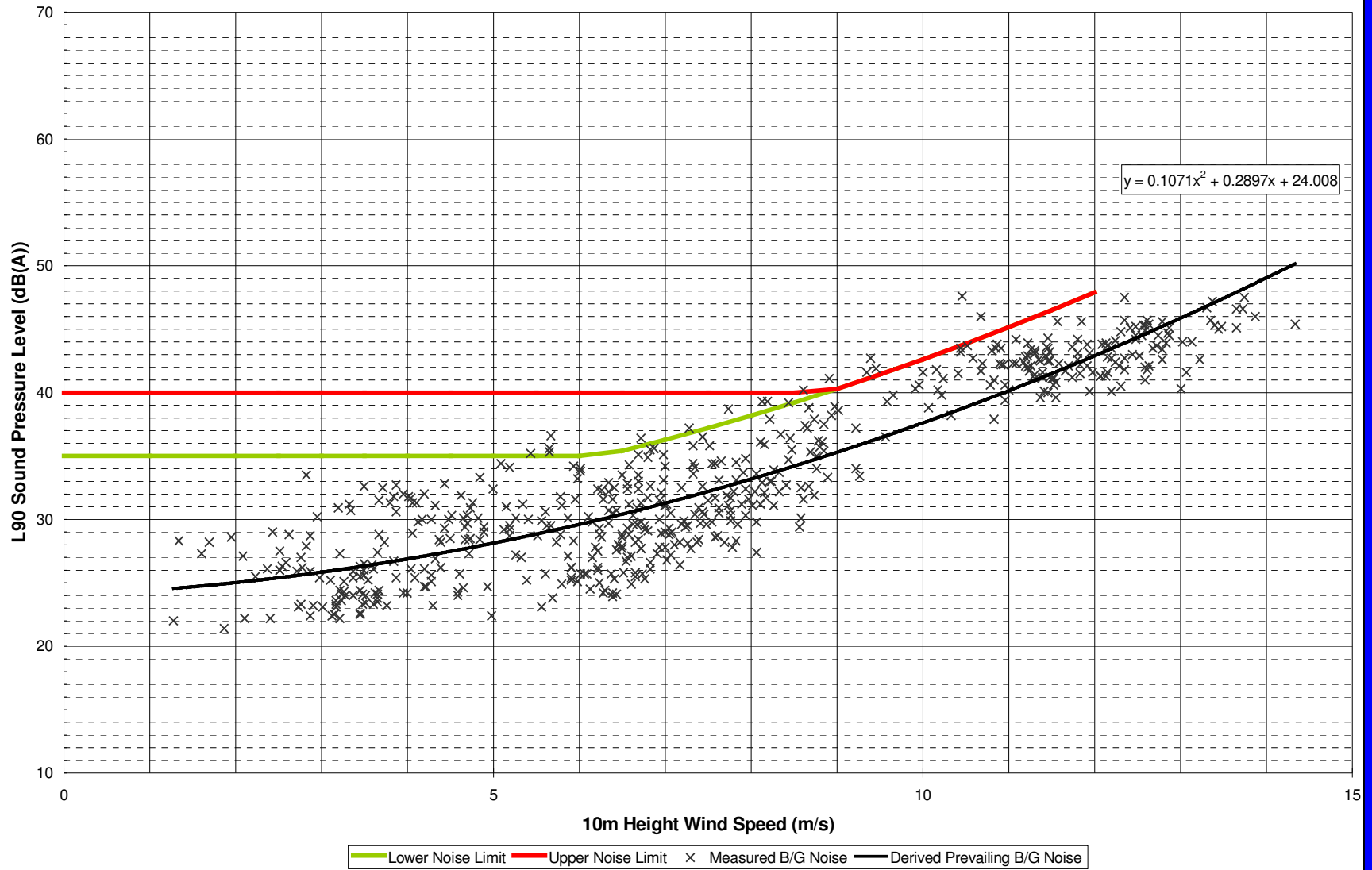
Wind Farm Noise Assessment Background Noise vs Wind Speed



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



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



Prediction

- Predicted noise level =
Source sound power level - Propagation Factors



Source Sound Level

- Measurement standard - IEC 61400-11
- Sound power level at integer V_{10} wind speeds
- Ideally cut-in to 12 m/s
- Octave or 1/3 octave band spectra
- Analysis of tonal noise





Prediction

$20 \log d + 11$



Hard Ground –
Worst Case

$$\bullet L_p = L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{scr} - A_{misc}$$

Downwind –
worst case

- 2 dB / 10 dB

15 deg C
70% RH

Downwind
Bending

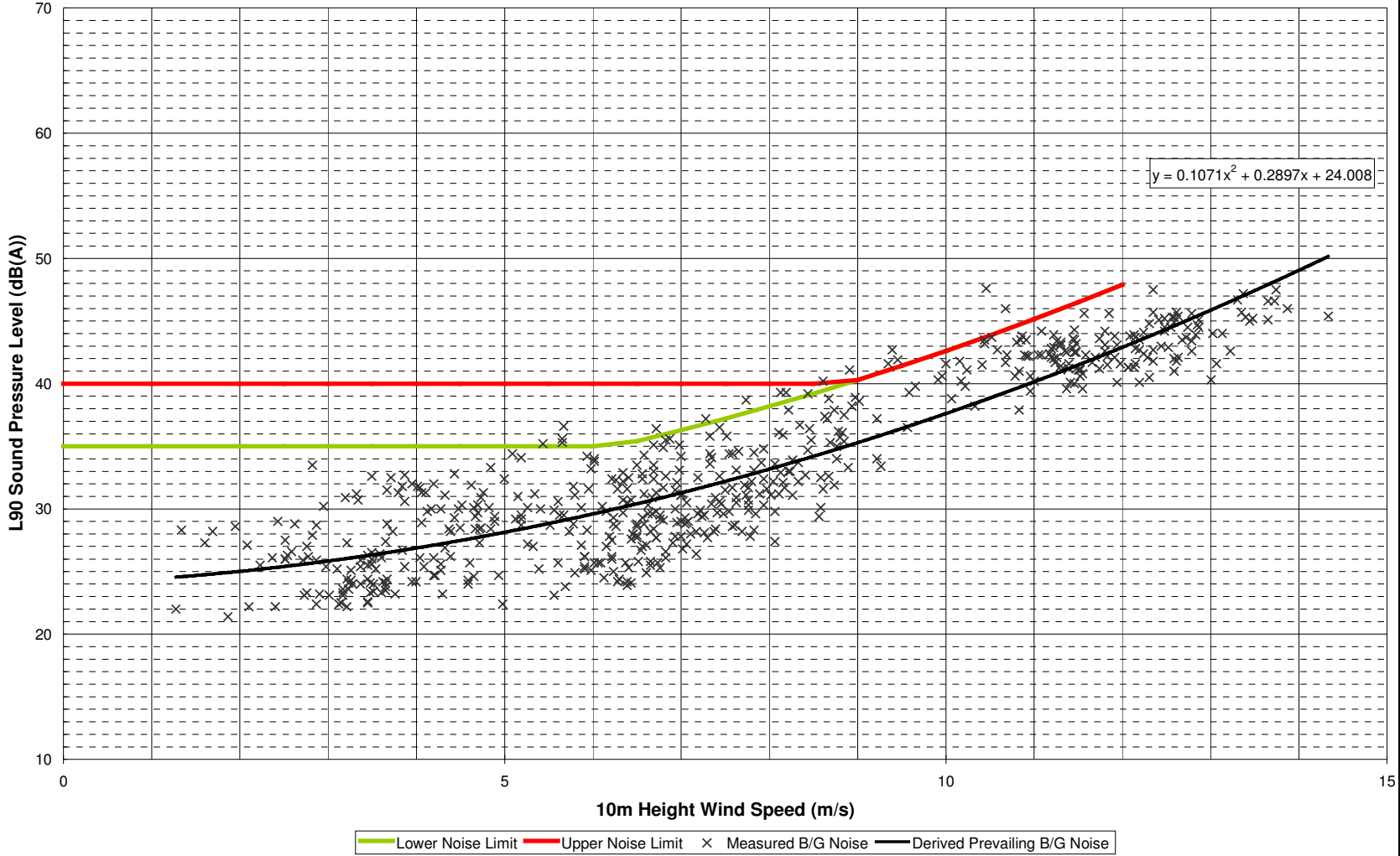


Impact Assessment

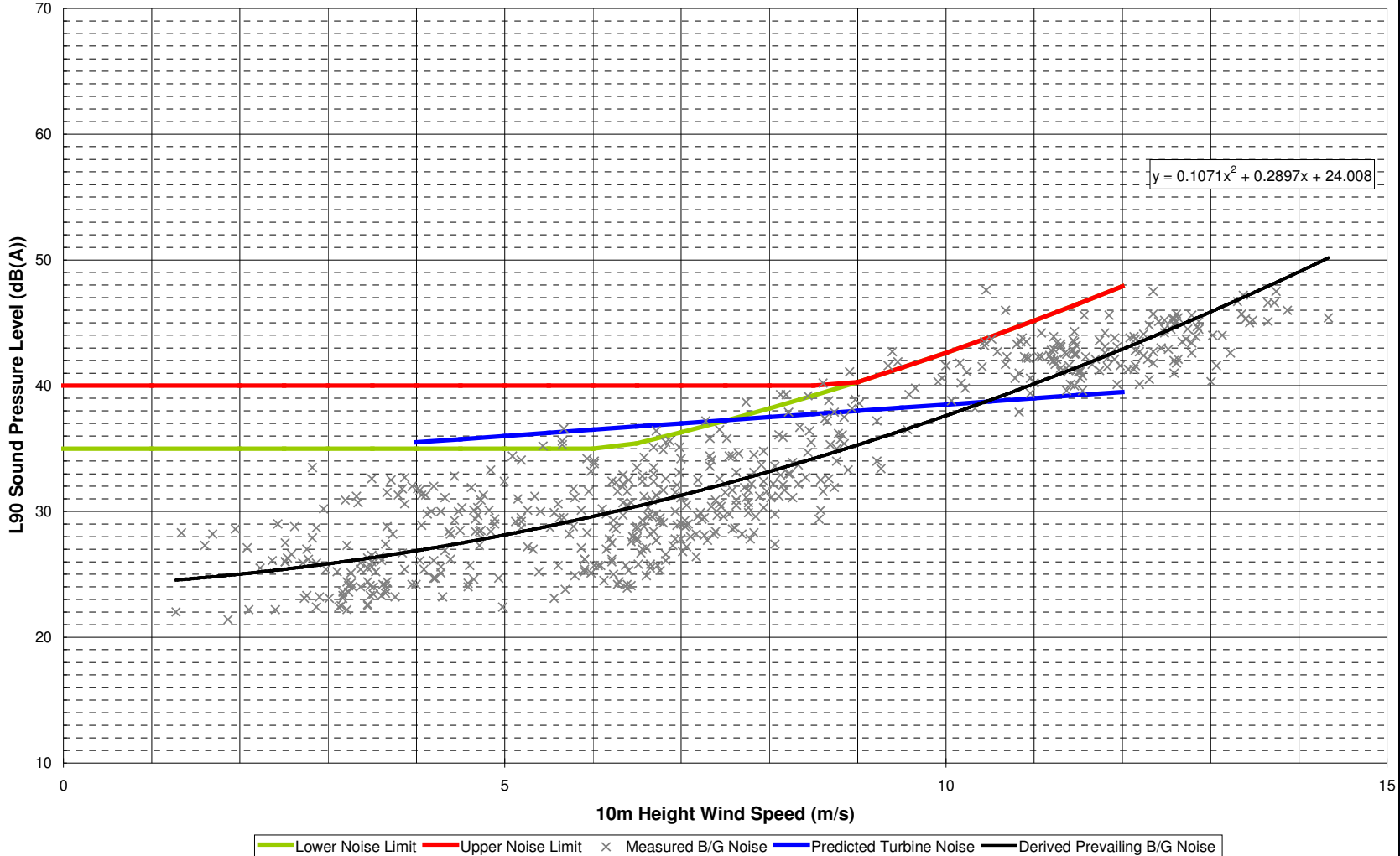
- Comparison of predicted level, over range of wind speeds, with:
 - ETSU-R-97 noise limits
 - Baseline
- For worst case wind direction



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



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

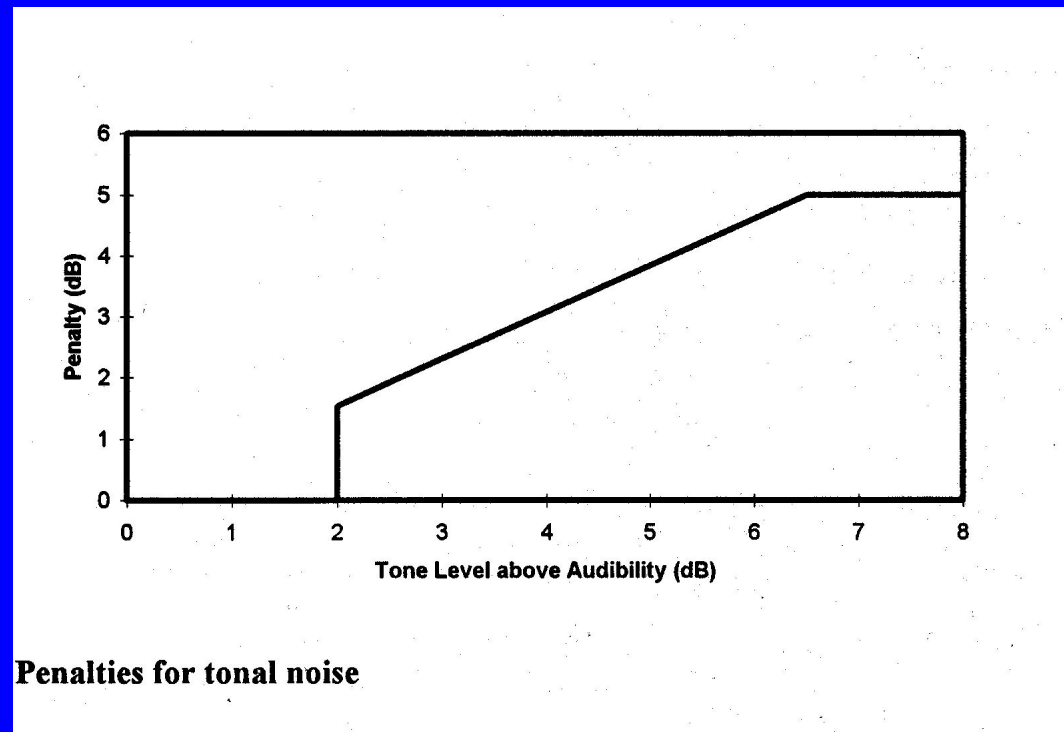


Other Issues

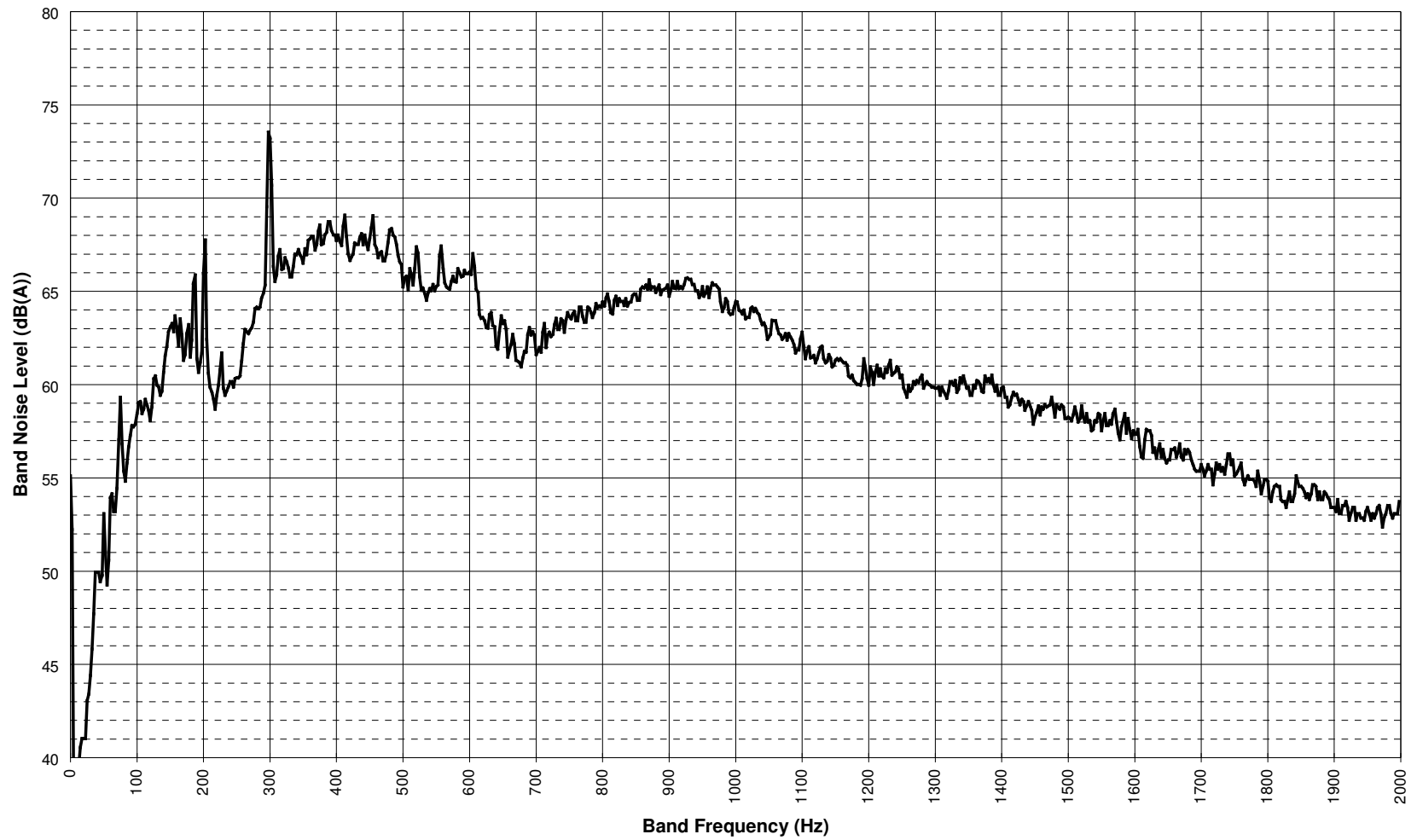
- Tonality
- Modulation
- Infrasound (<20 Hz)
- Low Frequency (20Hz – 200Hz)
- Wind Shear (variation of wind speed with height)



ETSU-R-97 Tone Penalty



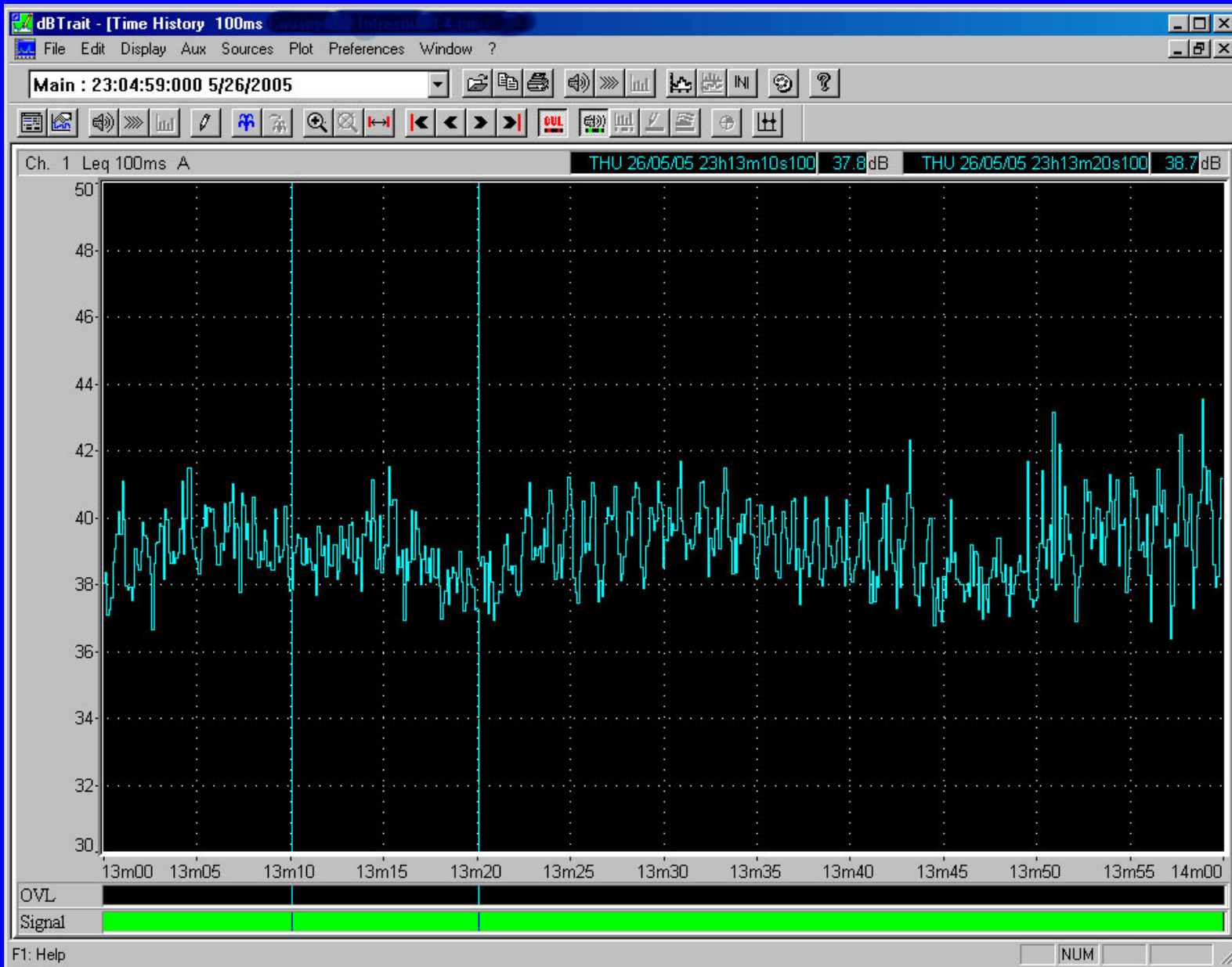
Wind Turbine
Tonal Noise Analysis
Power Output 199.3 kW



Modulation

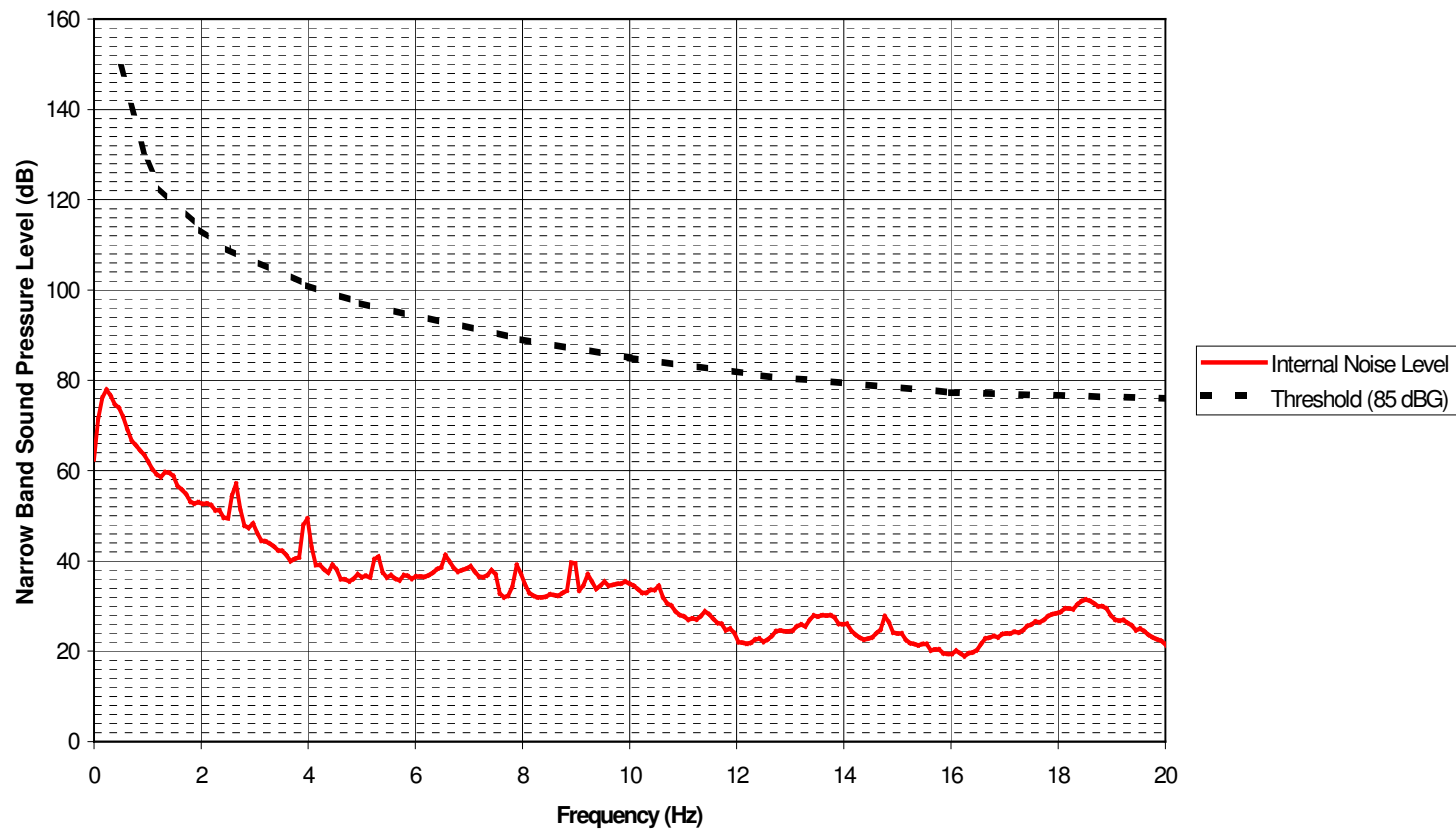
- ETSU-R-97 noise limits allow for the fact that there may be a degree of fluctuation at times.
- Occurs at turbines but diminishes with distance.



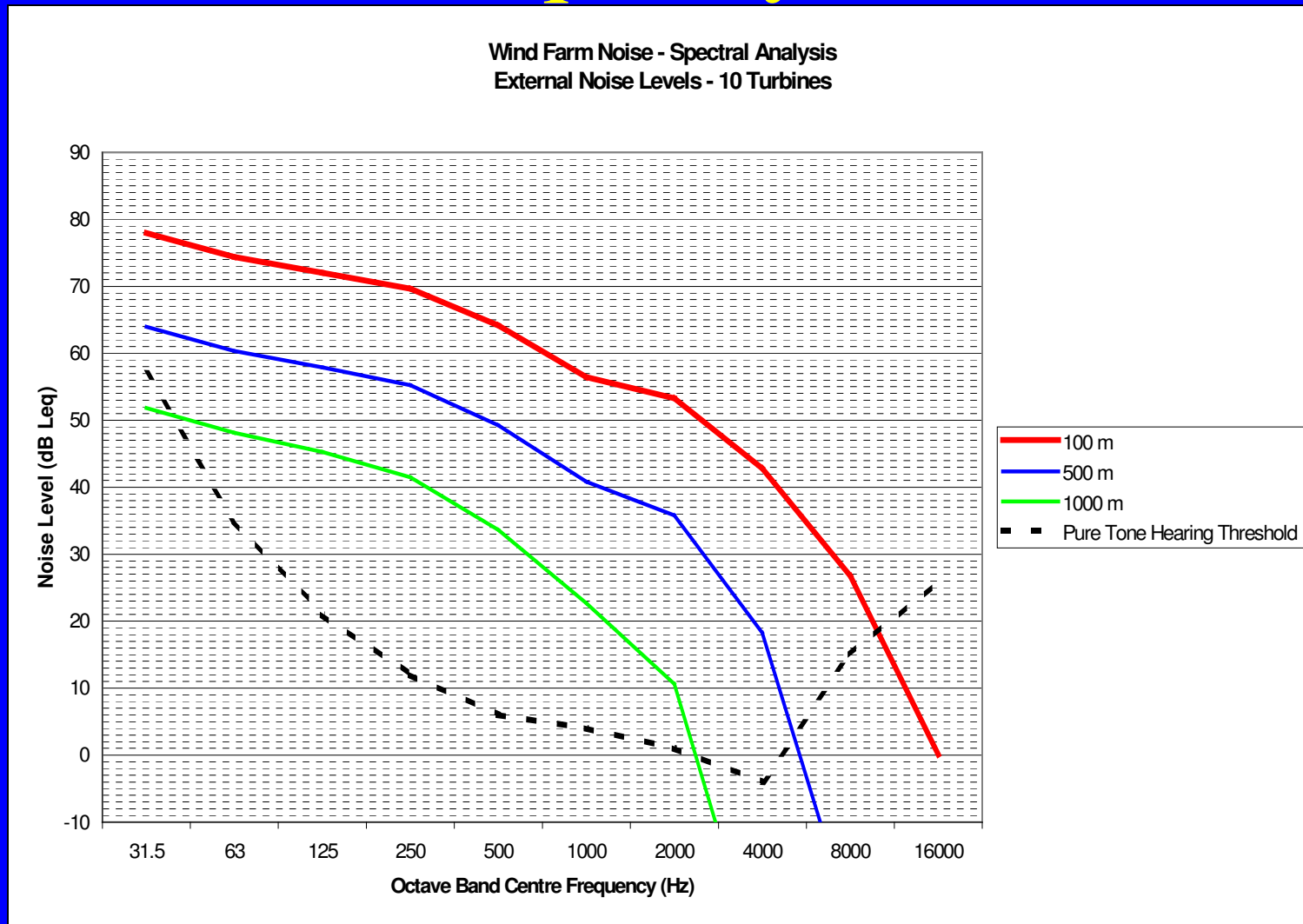


Infrasound

Internal Infra-Sound Levels
Turbine Output Power 500 - 1MW
Nearest Turbine at 500 m



Low Frequency Sound



Wind Shear

- Speed up from reference height (10m) to hub height may be greater than predicted from ground conditions alone.
- A modification to the ETSU-R-97 methodology is suggested such that baseline measurements are referenced to derived hub height wind speeds.
- Wind speed for baseline noise and source noise are then corrected to 'standardised' 10m height.



Conclusion

- Noise from wind farms is assessed using methodology described in ETSU-R-97, *Assessment and Rating of Noise from Wind Farms*, as required by PS22, *Renewable Energy*.
- This methodology remains as valid today as when it was introduced in 1996 subject to baseline noise measurements being referenced to derived or measured hub height wind speed prior to being ‘standardised’ to 10m height.

