Wind Farm Noise

Eversheds

3rd September 2009

Wind Shear and the IoA Bulletin Agreement
Wind shear ......

• What is wind shear?

• What causes wind shear?

• Can a single value of site specific wind shear be defined?

• Why is wind shear an issue for wind farm noise assessment?

• How can wind shear be dealt with?

• The IoA Bulletin Agreement
What is wind shear?
What causes wind shear?

- Ground Roughness

- Atmospheric Factors
  - In practice a combination of both occur
Modelling wind shear due to ground roughness

\[ V_U = V_L \times \frac{\log(H_U/z_0)}{\log(H_L/z_0)} \]

\( z_0 = \) ground roughness length

<table>
<thead>
<tr>
<th>Type of Terrain</th>
<th>Roughness Length ( z_0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water areas, snow or sand surfaces</td>
<td>0.001m</td>
</tr>
<tr>
<td>Open, flat land, mown grass, bare soil</td>
<td>0.01m</td>
</tr>
<tr>
<td>Farmland with some vegetation</td>
<td>0.05m</td>
</tr>
<tr>
<td>Suburbs, towns, forests, many trees and bushes</td>
<td>0.30m</td>
</tr>
</tbody>
</table>

Ground roughness is fixed for a given site
Modelling wind shear due to atmospheric effects

\[ V_U = V_L \times \left( \frac{H_U}{H_L} \right)^m \]

\( m = \text{shear exponent} \)

<table>
<thead>
<tr>
<th>Pasquill class</th>
<th>name</th>
<th>shear exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – B</td>
<td>(very – moderately) unstable</td>
<td>( m \leq 0.21 )</td>
</tr>
<tr>
<td>C</td>
<td>near neutral</td>
<td>( 0.21 &lt; m \leq 0.25 )</td>
</tr>
<tr>
<td>D – E</td>
<td>(slightly – moderately) stable</td>
<td>( 0.25 &lt; m \leq 0.4 )</td>
</tr>
<tr>
<td>F</td>
<td>very stable</td>
<td>( 0.4 &lt; m )</td>
</tr>
</tbody>
</table>

Atmospheric effects are not fixed for a given site and vary, particularly by time of day.
Can a single value of site specific wind shear be defined?

- No…
- Because…

No fixed value of ‘$z_0$’ or ‘m’ can be used to define the speed up from one height to another.

Varies with atmospheric conditions which means it varies with:

- Weather (including wind)
- Time of day
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 1.5 - 2.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 2.5 - 3.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 3.5 - 4.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 4.5 - 5.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 5.5 - 6.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 6.5 - 7.5 m/s
Wind shear as a function of time of day for increasing wind speed

Measured 10 Metre Height Wind Speed 7.5 - 8.5 m/s
Why is wind shear an issue for wind farm noise assessment?

- ETSU-R-97 use of 10m height wind speed for quantification of background noise.

- IEC61400-11 use of ‘standardised’ 10m height wind speed for quantification of turbine noise (ie. based on ground roughness of 0.05 – equivalent to unstable conditions / low wind shear).
And …

- The inherent assumption in ETSU-R-97 that referencing everything to 10m height in this manner provides a comparison between predicted turbine and background noise under the same wind conditions (at the hub / or is it?).
Effects of Wind Shear with 10m Height Measurements

Wind Farm Noise Assessment
Predicted Turbine Noise, Background Noise and Noise Limits vs Wind Speed
(Night Hours 2300-0700)
Effects of Wind Shear with 10m Height Measurements

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Predicted Turbine Noise, Background Noise and Noise Limits vs Wind Speed
(Quiet Day-Time Hours)
Effects of Wind Shear with 10m Height Measurements

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Predicted Turbine Noise, Background Noise and Noise Limits vs Wind Speed
(Quiet Day-Time Hours)

L90 Sound Pressure Level (dB(A))

10m Height Wind Speed (m/s)

Lower Limit
Upper Limit
Measured B/G Noise
Avg Wind Shear Corrected Turbine Noise
Prevailing B/G Noise
Effects of Wind Shear with 10m Height Measurements

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Predicted Turbine Noise, Background Noise and Noise Limits vs Wind Speed
(Quiet Day-Time Hours)
An alternative approach?

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![Graph showing noise assessment](image-url)
An alternative approach?

Wind Farm Noise Assessment
Predicted Turbine Noise, Background Noise and Noise Limits vs Wind Speed
(Quiet Day-Time Hours)
The best approach?

- Correlate background noise measurements with hub height wind speed derived from:
  - Measurements at multiple anemometry heights
  - Direct anemometry measurement
  - Remote sensing by LIDAR / SODAR

- Standardisation to 10m height adds confusion
  - Necessary for consistency with ETSU-R-97
  - Necessary for consistency with manufacturers data
  - IEC61400-11 change to quantify WT noise wrt Hub Height
Consistent with approach advocated by:
Who produced this?

Dick Bowdler, Andrew Bullmore, Bob Davis, Malcolm Hayes, Mark Jiggins, Geoff Leventhall (Section 4), Andy McKenzie

The authors were the independent noise consultants who sat on the DTI/BERR Noise Working Group on wind farm noise in 2006/2007.

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• Is not official IoA Guidance and should not be regarded as such.
How does it tackle wind shear?

• As for ‘best approach’, background noise measurements correlated with hub height wind speed ‘standardised’ to 10 m height.

• If HH WS not measured directly then derive shear exponent ‘m’ from measurements at heights H1 and H2 for each 10 minute period.
  – H1 >=60% of HH
  – H2 = 40–50% of HH

• Derive HH WS from measurements at H1 and derived values of ‘m’ for each 10 minute period.
What are positive implications of this approach for planning purposes?

+ Clear methodology taking wind shear into account without possibility of ‘risk’ (to developers).

+ Allows meaningful evaluation of whether limits in planning conditions can be met.
What are negative implications of this approach for planning purposes?

- Creates more ‘scatter’ around trendline through baseline data. ETSU-R-97 already criticised for ‘average’ approach to baseline data.

- Problems for small schemes where costs of deriving hub height wind speeds may be prohibitive. Will need to keep to <35 dB LA90 unless non-wind related b/g shown to be > 30 dB LA90 in the absence of hub height wind data.