IoA North-West Branch Meeting 2012

Sustainability and Renewable Energy

# Small Wind Turbines

# Approach to assessing noise from smaller scale wind turbines

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- Definition of Small/Micro Wind Turbines
- Noise Sources
- Standards for Assessing and Measuring of Noise from (small) Wind Turbines
- Planning Conditions
- Noise Limits

# Wind Turbines – Size (1)

- Offshore
  - Large rotor diameter, rated power currently up to 10 MW, shorter towers, large wind farms in designated areas
- Onshore
  - From single wind turbines to large wind farms, usually up to 2-3 MW machines, rural areas and urban wind turbines
- Single Turbines for FiT Schemes
  - Mostly up to 500 kW

# Wind Turbines – Size (2)

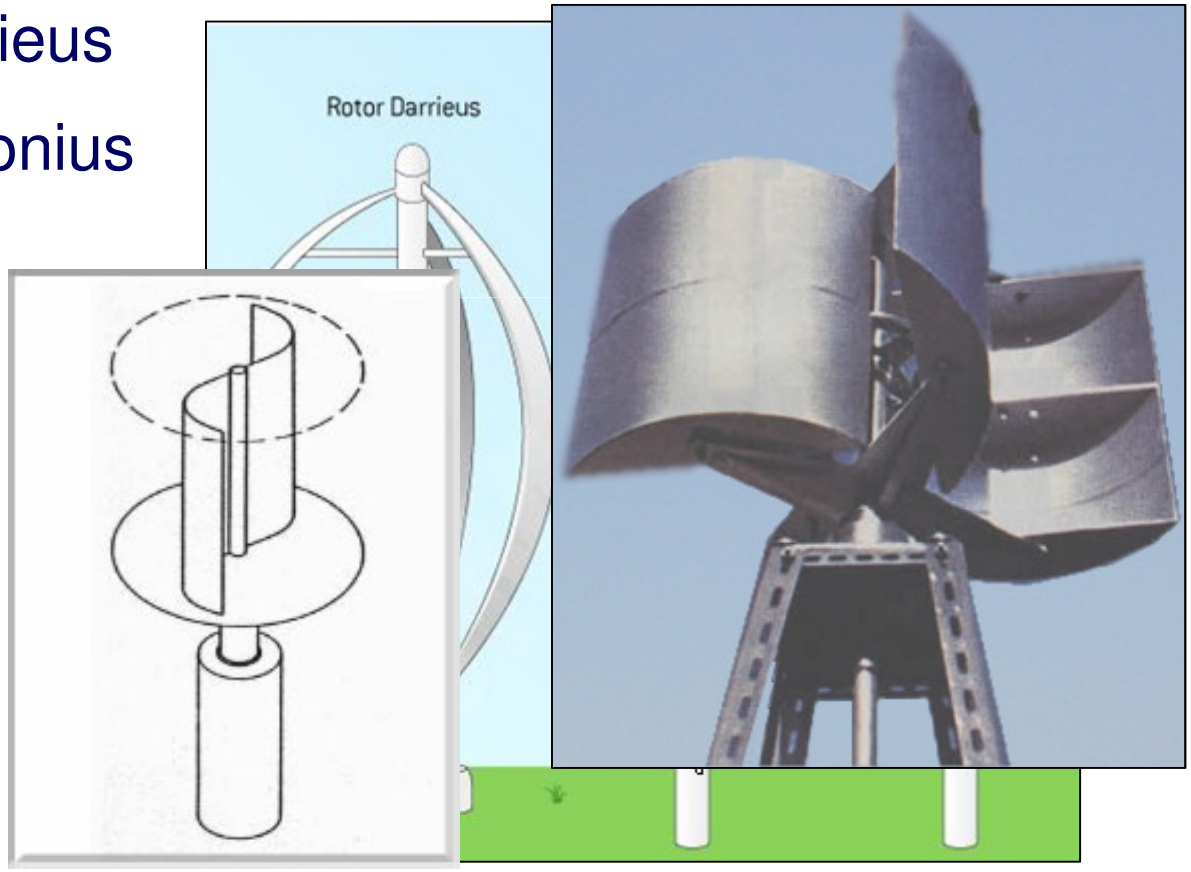
- Small Wind Turbines (BWEA Standard)
  - Rotor swept area of < 200 $m^2$ (approx. rotor diameter 16 m / 52 ft for horizontal-axis WT)
- Micro and Small Wind Turbines (MCS Requirements)
  - Rated / reference electrical power output up to 50 kW at 11 m/s wind speed
- Guide to Installing a Small Wind System (Renewable UK)
  - Micro wind: 0 – 1.5 kW (total height 10 - 18 m)
  - Small wind: 1.5 – 15 kW (total height 12 – 25 m)
  - Small-medium wind: 15 – 100 kW (15 – 50 m)

# Wind Turbines – Design (1)

- Horizontal-axis wind turbines
  - Upwind / downwind
  - Two-bladed / three-bladed / occ. one or more than three

# Wind Turbines – Design (2)

- Vertical-axis wind turbines
  - Darrieus
  - Savonius



# Wind Turbines – Design (3)

- Mounting
  - Tower / pole-mounted
  - Building-mounted
- Off-grid (stand-alone systems) / grid-connected

# Wind Turbine Noise - Sources

- Mechanical Noise
  - Motion of mechanical and electrical components (gearbox, generator, cooling system (pumps), electrical systems)
- Aerodynamic Noise
  - Motion of air around the blade (blade swish, inflow turbulence, trailing edge noise, vortex shedding)
  - Due to speed regulation: separation-stall noise, furling

# Wind Turbine Noise

- Noise can be characterised as
  - Broadband, tonal, low frequency, infrasound, impulsive
- Specific to small wind turbines
  - Blade flutter
  - Furling as means of speed control
  - Stall noise due to fixed blades / rotational speed
  - Increased sound power level when unloaded
  - Potential for structure borne noise

# Measurement Standards

- IEC 61400-11 Wind turbine generator systems - Part 11: Acoustic noise measurement techniques (also British Standard)
  - Revised with appendix for small wind turbines, to be published soon
- BWEA (now RenewableUK) Small Wind Turbine Performance and Safety Standard
  - Allows for specifics of small wind turbines

# Assessment of Wind Turbine Noise 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
    - Financially Involved: X = 45
- B/G quantified as a function of wind speed
- B/G averaged over relevant period
  - Night 2300-0700
  - 'Quiet' day-time hours (1800-2300, Sat pm and all day Sun)
- 'Simple' Limit 35 dB $L_{A90}$ for wind speeds up to 10 m/s
  - For single / small wind turbines

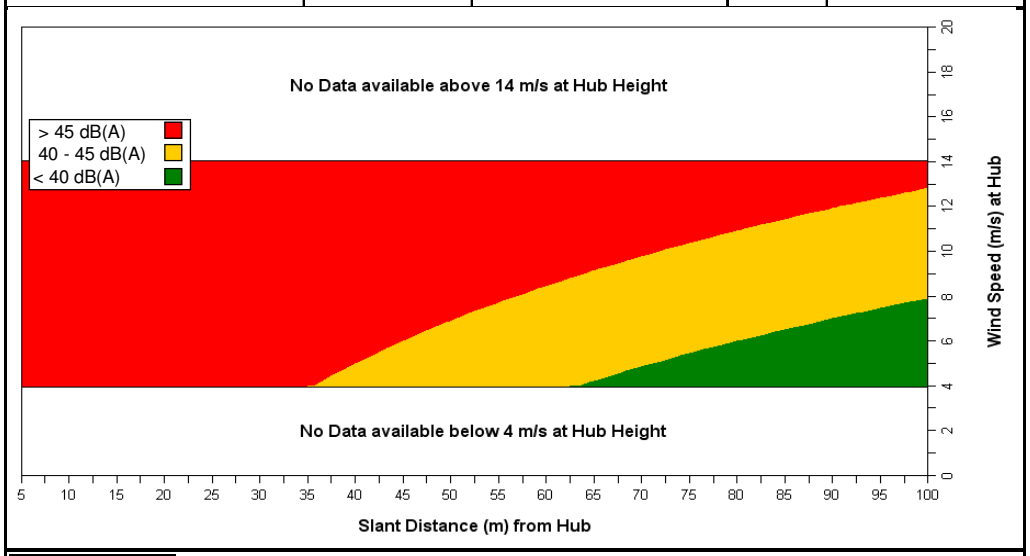
# Assessment of Wind Turbine Noise BWEA standard

- 'Immission Noise Map' (noise label)
  - Sound pressure level depending on
    - Slant distance (distance from rotor centre to receiver)
    - Wind speed (covering cut-in to cut-out wind speed if applicable)
- Regions of sound pressure level on noise map
  - Red: predicted noise level greater than 45 dB(A)
  - Amber: predicted noise level between 40 and 45 dB(A)
  - Green: predicted noise level below 40 dB(A)
- BWEA reference sound level
  - At 60 m (expected observer distance for small wind turbine)
  - At 25 m (expected observer distance for micro or domestic wind turbine)

# Assessment of Wind Turbine Noise BWEA standard

- ‘Immission Noise Map’ (noise label)

| Acoustic Noise Levels | | | | |
|---|---|---|---|---|
| **Turbine Make:** | Gaia-Wind Ltd | | **Model:** | GW 11 |
| **NOISE EMISSION LEVEL** | | | | **NOISE PENALTY** |
| **Sound Power $L_{Wd,8m/s}$** | **88.1 dB(A)** | **Noise Slope, SdB (dB/m/s)** | **1.015** | **NO** |




HM: 2064/R1
Melton Mowbray Turbine Test

Tested and Issued by:
Hayes McKenzie Partnership Ltd.
February 2009

# Assessment of Wind Turbine Noise Others

- MCS Planning Standards: MCS 020
  - For permitted development installations of wind turbines and air source heat pumps on domestic premises
    - Noise limit 42 dB $L_{Aeq,5\ min}$
    - Noise label showing
      - red areas for predicted noise level above the permitted development noise limit
      - green areas for predicted noise level below the permitted development noise limit
- Planning Guidance of LPA
  - Cornwall Council's Wind Turbine Assessment Advisory Note (in progress)

# Noise Data

- Acoustic Performance Test with detailed measurement report according to BWEA standard / IEC 61400-11
- Single values with no reference to distance or measured variable
- ‘Quiet’
- Presence/Absence of tones
  - Two methods allowed with potentially different outcome

# Roof-Mounted Wind Turbines

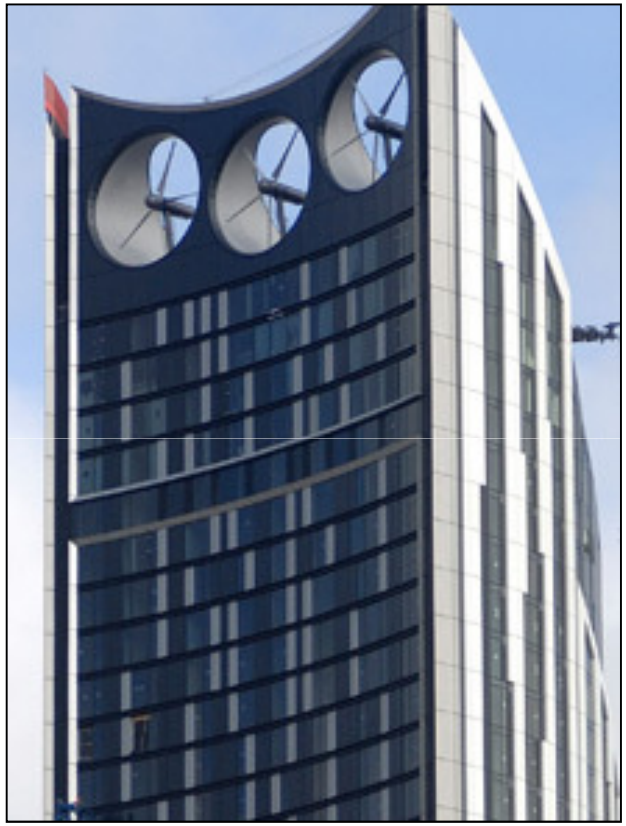

www.quietrevolution.com


www.swiftwindturbine.com

# Roof-Mounted Wind Turbines

- Noise inside the building
- Vibration transmitted through pole
- Structure borne noise caused by vibration
- Structural damages if supporting elements not strong enough for turbine weight
- Turbulence due to interaction of wind with buildings increases stress on turbine blades and noise levels

# Building Integrated Wind Turbines



Strata Tower, London

Bahrain World Trade Centre

# Planning Process / Conditions (1)

- Which assessment method should be used?
  - ETSU-R-97
  - BWEA or MCS
  - Or other (e.g. WHO external noise levels)?
- What are appropriate noise limits?
  - Single value (35 dB $L_{Aeq}$ or $L_{A90}$, 42 dB $L_{Aeq}$)
  - Relating to background noise (BG + 5 dB, BG -10 dB, equal to BG)
  - Arbitrary boundary limits
  - Inside/outside noise levels

# Planning Process / Conditions (2)

- Is a simplified method justified or should small wind turbines be treated like their bigger brothers?
  - ➢ No noise assessment but fixed separation distance

    (e.g. Proposed Planning document for Scotland (2010) – 100 m for micro turbines with rotor diameter <3.5 m and total height of 11.1 m)
- Penalty for audible tones
  - ➢ assessed in accordance to ETSU-R-97
  - ➢ or ISO 1996-2:2007 Annex D based on 1/3 octave band levels

# Potential Problems

- Quality of Noise data
- Different Sound Power Level (declared, reference wind speed)
- Poor positioning can cause problems with the neighbours
- Noise characteristic can cause annoyance
- Background noise measurements can be expensive if required/requested
- Show compliance with planning limits for noise levels below or approx. the same as background noise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