Measuring and calculating turbine noise immission in the Netherlands

IEA Wind Expert Meeting Sound Propagation models
May 5th, 2009

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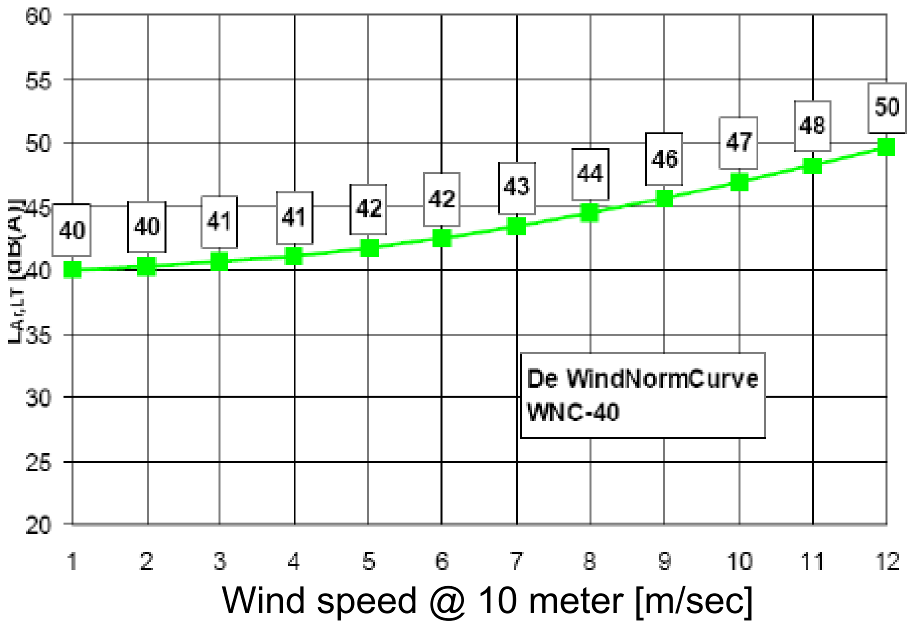
Content

- Background / present method used in Netherlands
- Why a new modeling method is needed
- Background information
- Possible adjustments to measuring method
- Possible adjustments to modeling method

Present model used

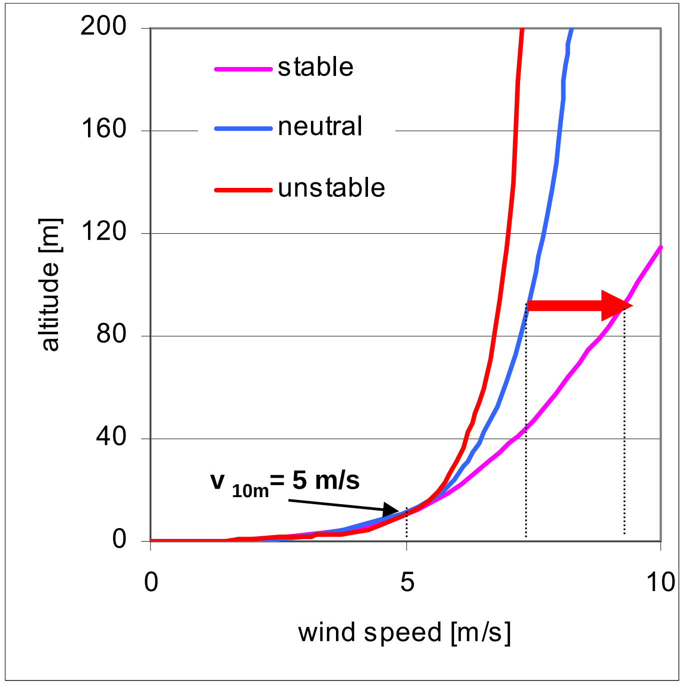
1999: directions “HMRI-1999” (modeling derived from ISO 9613)
- Measuring in accordance with IEC 1400-11

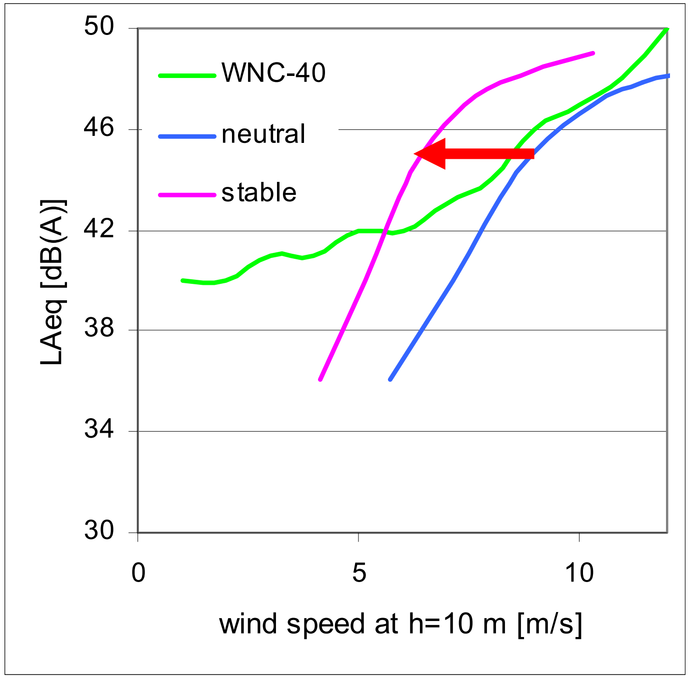
2001: AMvB 487 (Dutch regulation)
- Normation curve issued (WNC-40) for background noise
- Measuring in accordance with IEC 61400-11



Why a new model is needed

2002-2006: Research from RUG “v.d. Berg-effect”





- At stable meteo conditions (night time) relatively higher wind speed at higher altitude (~100 m)

Boundaries of new model

New:
- Use of L_{den} instead of $L_{Ar,LT}$ (new normation going to be in L_{den})
- Use of local meteo statistics at turbine axis height in combination with wind speed dependent sound power

Preserve the current modeling (HMRI'99) method as much as possible

Still undetermined boundaries:
- Model used for horizontal (HAWT) and vertical axis turbine (VAWT)?
- Model used of turbines larger than …?

Mechanical sound

Modern turbines produce less mechanical sound than aerodynamic sound.

Therefore focus on aerodynamic sound.

Aerodynamic sound (1)

Aerodynamic sound caused by:

- Trailing edge turbulence
- Turbulence in boundary layer (stall)
- Turbulence at the tip (tip vortex)
- Turbulence caused by irregularities in the blade
- Interaction between blade and tower
- Inflow turbulence

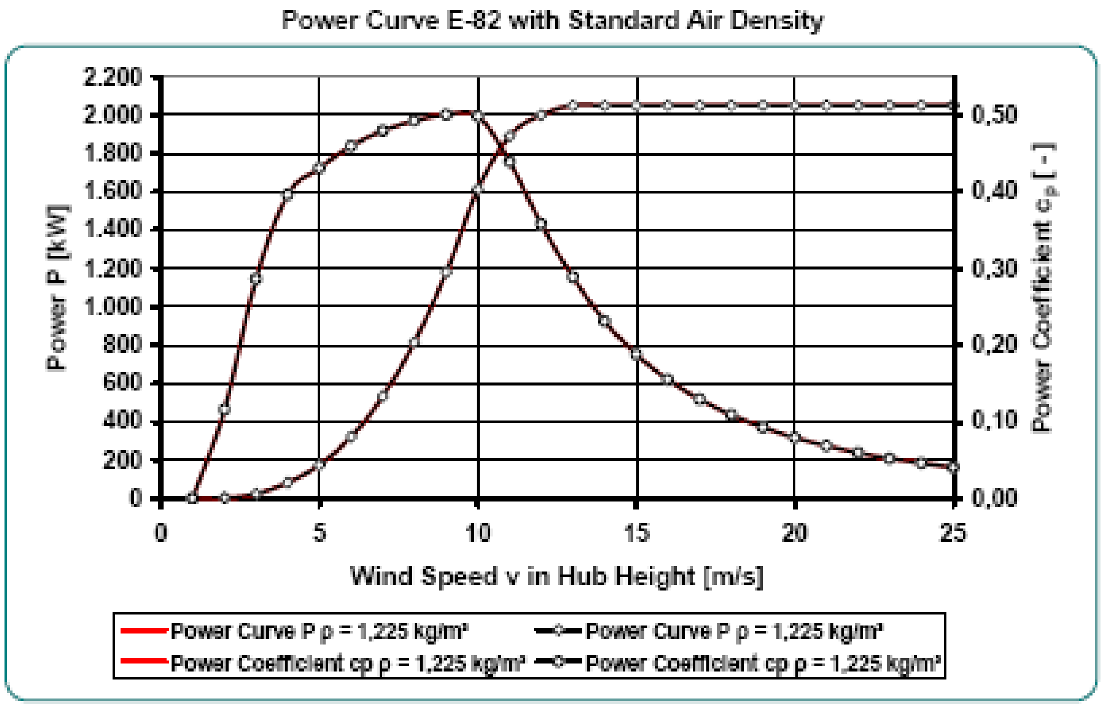
Aerodynamic sound (2)

Characteristics

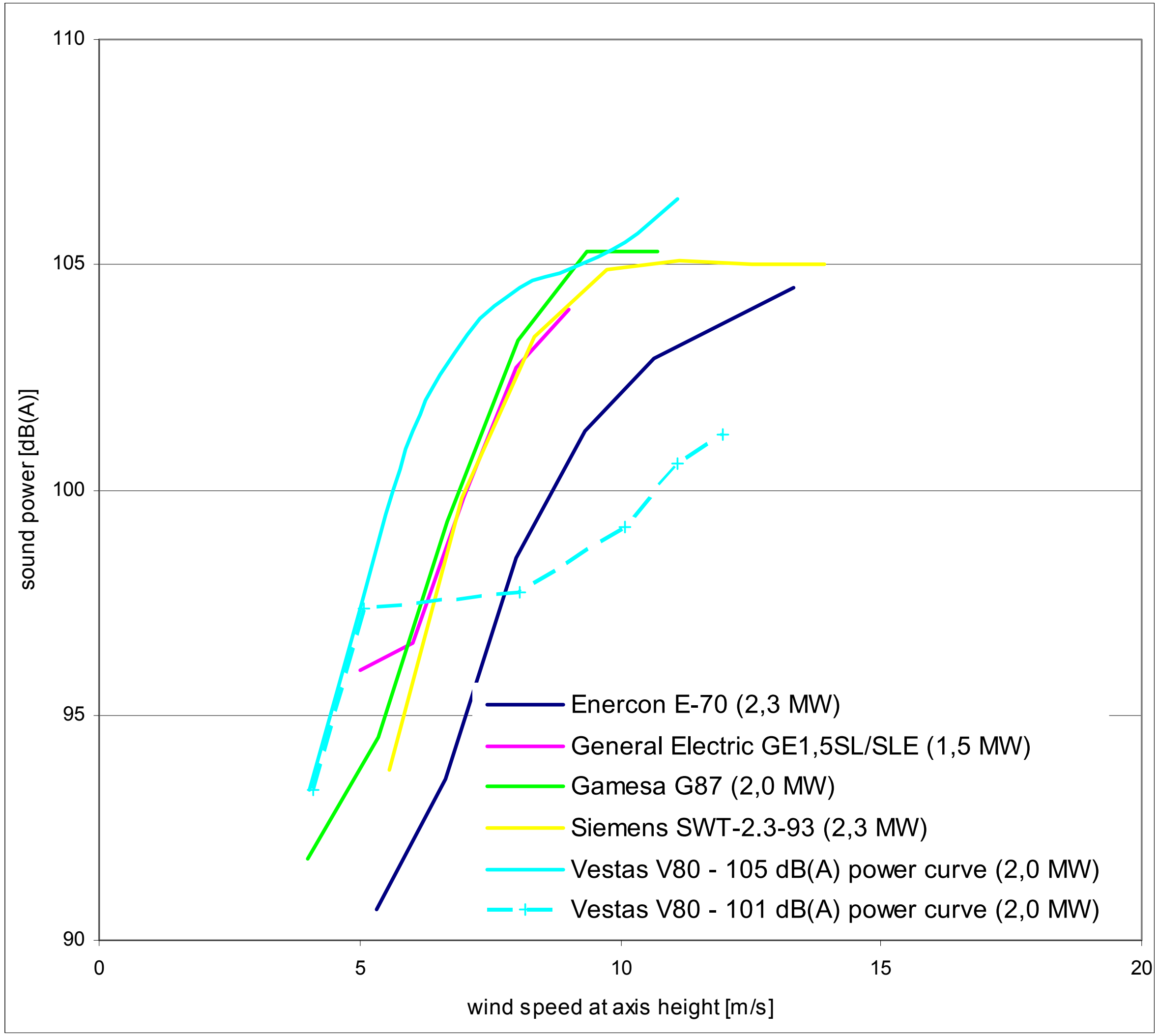
- Sound power proportional with 50log*v*
- Broad band emission
- Possible dipole- or quadripole emission

Power curve of turbine

- Relation between wind speed at axis height and generated electrical power
- Defines:
  - v_{ci},
  - v_{rated}
  - v_{co}
- Can be used to derive the wind speed at axis height.



Relation between sound power and wind speed



Possible adjustment for measuring sound power

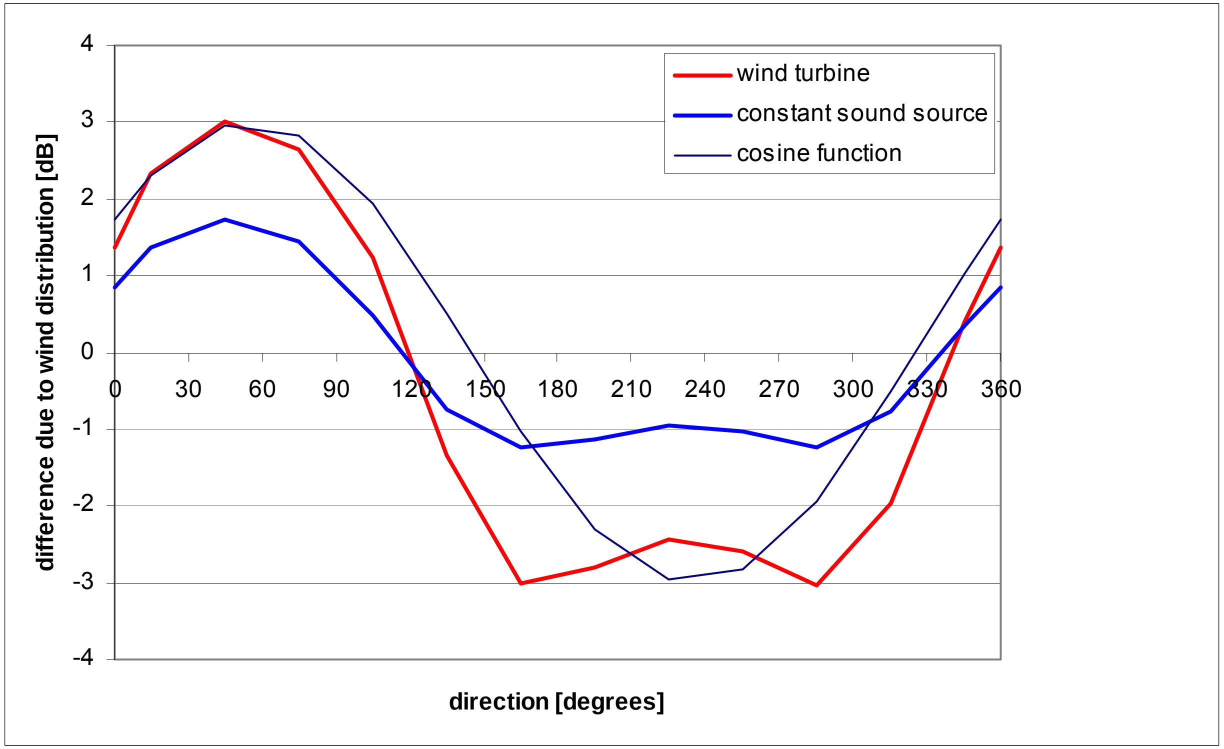
- Define wind speed at axis height (instead of at 10 m)
- Use more measurement at more wind speeds, for example 4,5,6,…..,12 m/s at axis height
- Measuring of directivity of sound or use a defined directivity

Distribution of wind in the Netherlands

- 50% of the time wind originates from the ZW ±60°
- 75% of the wind energy originates from the ZW ±60°

Distribution of wind in the Netherlands

illustration of sound immisson effect under following wind conditions at great distance from the source



X-axis: orientation of sound source – receiver point in degrees (0=North)

(at great distance form the source, sound immision during opposing wind condition can be neglected)

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Sound sources at high altitude

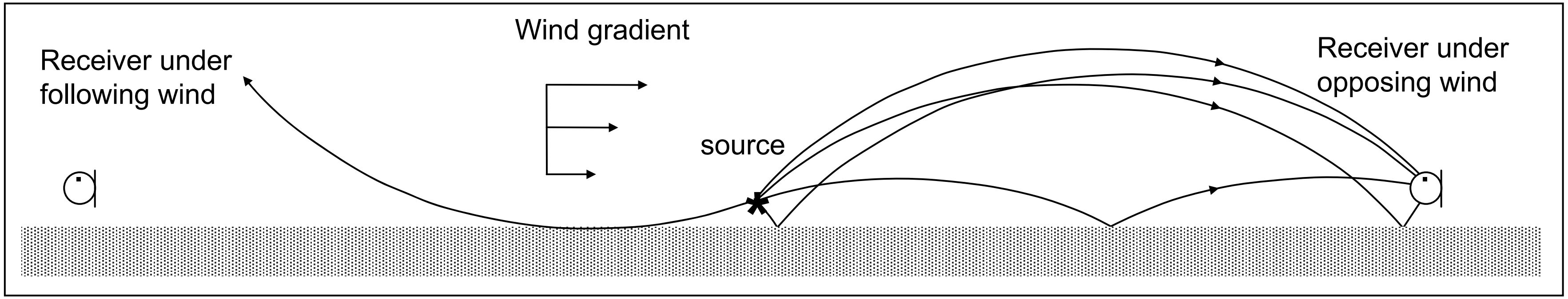
Wind gradient causes sound radiation bending and influents sound immision at great distance:

For low sound sources

- Wind gradient approximately constant

For high sound sources

- Wind gradient strongly depends on meteo



Directivity of turbines

- Trailing edge turbulence: dipole effects
- Measured: sound immission in direction of the axis about 3 dB higher than perpendicular to the axis
- Depends on the wind direction
- Independent of distance to the turbine

Overview of the three effects

- The local distribution of wind direction and speed causes different sound immision at great distance from the turbine
  - estimated effect in surroundings: ±3 dB
- Due to small wind gradient speed (under unstable conditions), the sound rays are curved less and are shielded less by the ground at great distance
  - estimated effect in surroundings: +2 dB ?
- Due to dipole effect of the sound radiated by the turbine, the sound immission is less perpendicular to the axis
  - estimated effect in surroundings: ± 2 dB

Possible adjustment for C_m

normal $r \leq 10(h_b+h_o)$

$C_m = 0$

suggestion

$$C_{m,WT} = C_{m,dipool}(*)$$

normal $r \geq 10(h_b+h_o)$

$$C_m = 5\left[1-10\left(\frac{h_b+h_0}{r}\right)\right]$$

suggestion

$$C_{m,WT} = 5\left[1-10\left(\frac{h_b+h_o}{r}\right)\right] + C_{m,dipool}(*) + C_{m,\,as.\,windroos}(**)$$

$h_b \neq H_{axis}$? (correction for wind gradient under unstable conditions
and/or big sound source of turbine

(*) possible function of cos(α-45)

(**) possible function of cos(α-45), dependent of distance r

Questions?