Sound Power measurements according to IEC 61400-11

Siemens Wind Power

Siemens Wind Power A/S

Sound Power measurements according to IEC 61400-11

Tomas Hansen, Lars Enggaard
Siemens Wind Power A/S
email: trh@siemens.com

Sound Power measurements according to IEC
Outline

SIEMENS

- **Why Sound Power?**
- **The basic approach in IEC 61400-11**
  - The turbine as a point source
  - Anything New in ed. 3?
- **Is the approach still valid for modern turbines?**
  - Simple approximation using advanced technology
  - Is it still correct for large turbines?
- **How do Siemens as manufacturer use the method?**
  - For developing purposes
  - For sales and for verification purposes

SIEMENS

A Sound Power measurement is:

- A simple fast measurement
- As long as data from a suitable ranges of wind speeds are recorded the measurement method give good and comparable results
- Simple to perform noise propagation calculations using turbines as point sources
- Standardized methods makes it possible to compare different turbines

- In the IEC 61400-11ed. 3 the noise is related to wind speed in hub height which makes is possible to use the results for similar turbines with different hub heights

But –
are the results correct and valid for propagation calculations?

Sound Power measurements according to IEC

The basic approach in IEC 61400-11

SIEMENS

- IEC reference position:
- Down wind position
- Vertical distance from rotor centre equal to total height of the turbine

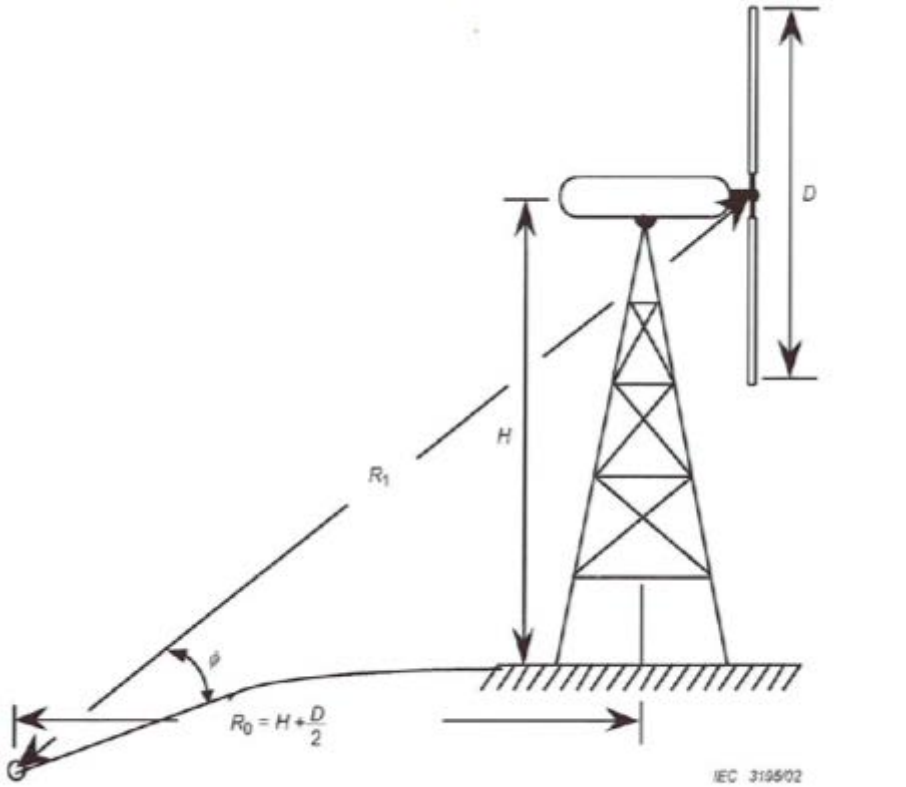


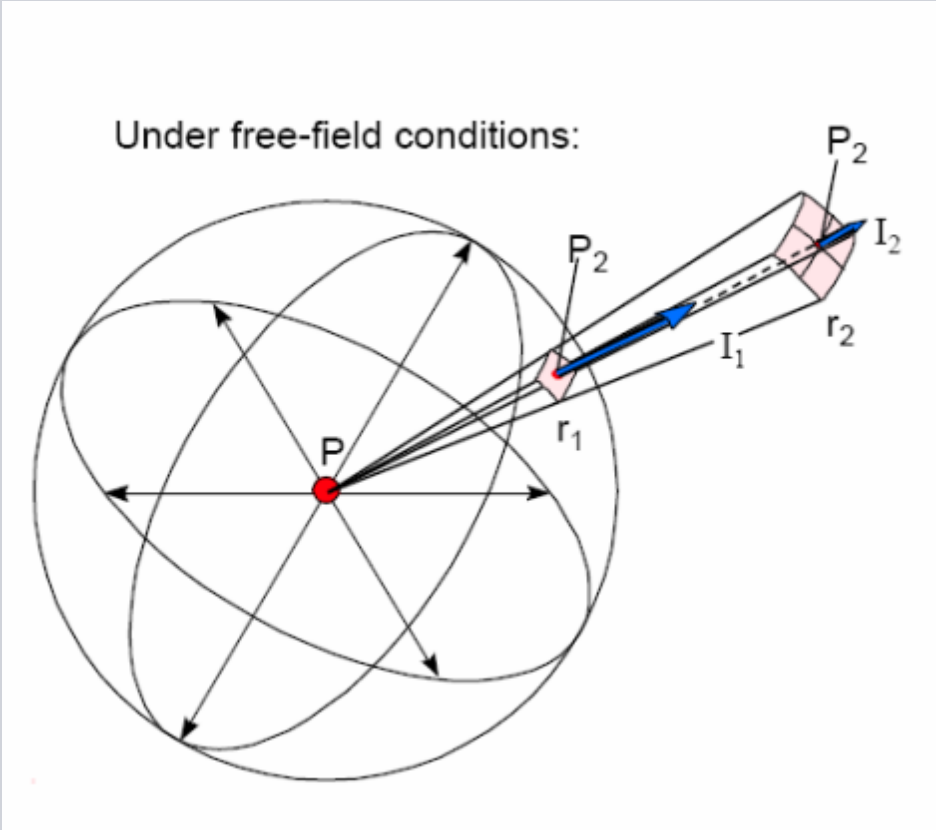
Figure 4a – Horizontal axis turbine

Sound Power measurements according to IEC

The basic approach in IEC 61400-11

SIEMENS

- IEC method is assuming that:
- The turbine is a point source equal to the rotor centre Sound Power can be calculated
- Integration of noise on the entire sphere can be done by use of one point because the noise on all points of the sphere is equal



Sound Power measurements according to IEC
The basic approach in IEC 61400-11

SIEMENS

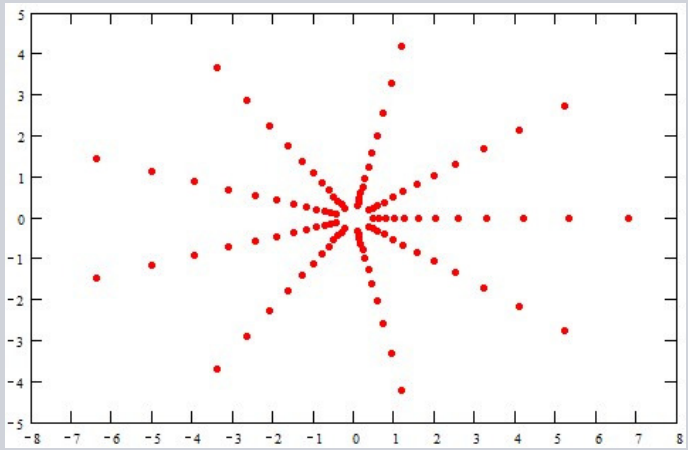
- The point source assumption was a good assumption for a small turbine with 30 m hub height and rotor diameters of 15-20 m
- This approach have not been changed in the new IEC 61400-11 ed. 3
- **Is the IEC assumption still valid for a large modern turbine with rotor diameters above 100 m?**
- We decided to investigate that by use of array measurements

Sound Power measurements according to IEC

Simple approximation using advanced technology

SIEMENS

- Portable Beamforming Array for wind turbine measurements
- Developed in close corporation with Brüel & Kjær
- 108 microphones in total
- Size: 18 x 9 m in total
- Shaped to ensure equal resolution in the entire rotor

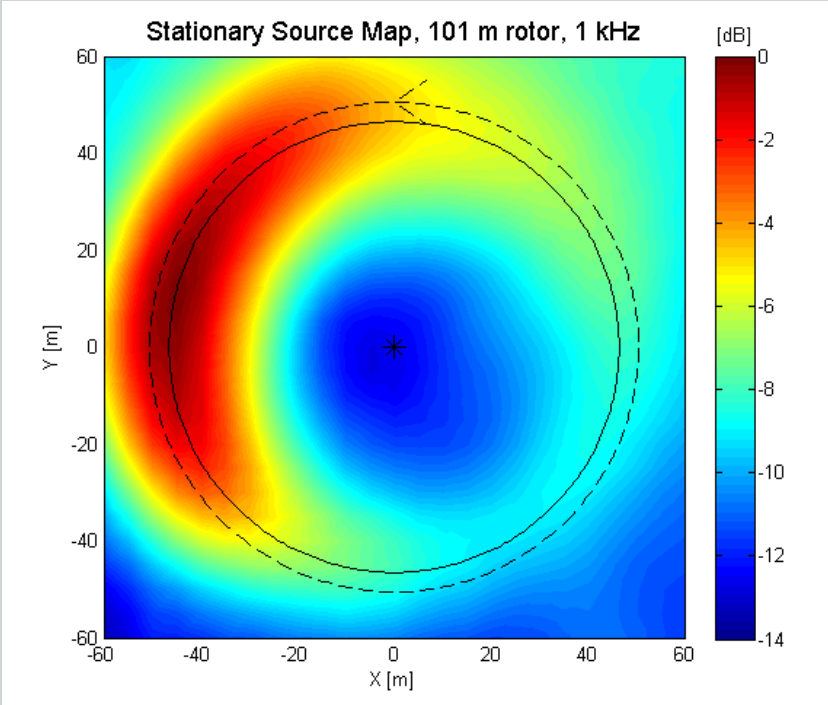


Sound Power measurements according to IEC

Simple approximation using advanced technology

SIEMENS

- 80 m hub height – rotor in the 100 m range
- Measurements downstream (IEC reference direction)
- The Array give us a clear distribution of the noise sources on the rotor
- Relative Sound Pressure 1 m from the rotor as the array measure
- Highest levels at 10 o'clock seen from downstream

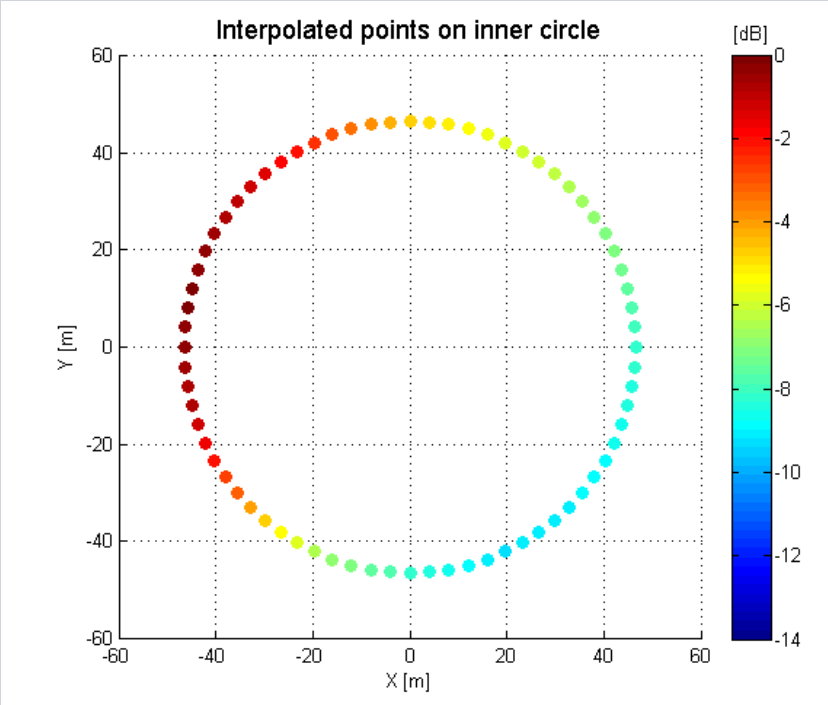


Sound Power measurements according to IEC

Simple approximation using advanced technology

SIEMENS

- Worst Case: Noise in distributed in a circle close to the tip
- In principle: Calculation Sound Pressure Level in the IEC reference position from each point and calculation total Sound Pressure Level
- Calculating the IEC level assuming the rotor centre is the source



Sound Power measurements according to IEC
Simple approximation using advanced technology

SIEMENS

- In order to calculate the real sound:
  - Calculating the noise as seen from IEC ref pos:

    Sum of the value of each point and the correct distance from the point to the ref pos

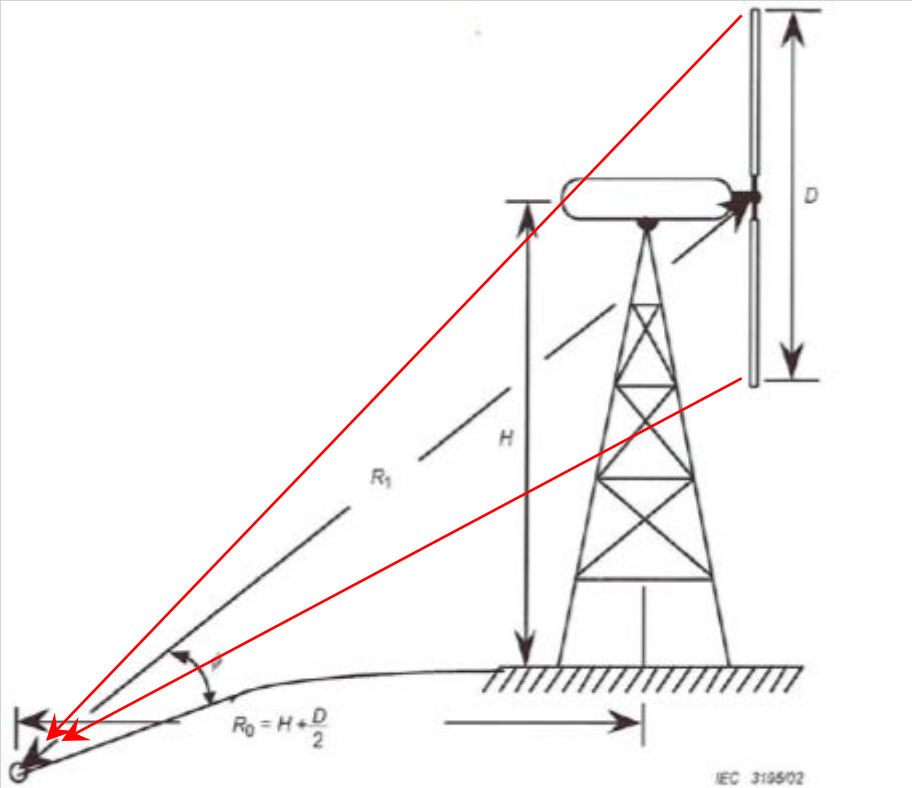


Figure 4a – Horizontal axis turbine

Sound Power measurements according to IEC
Simple approximation using advanced technology

SIEMENS

- In order to calculate the real sound:
  - IEC Sound Power:

    Assuming the rotor centre is THE point source – using the distance to the rotor centre only

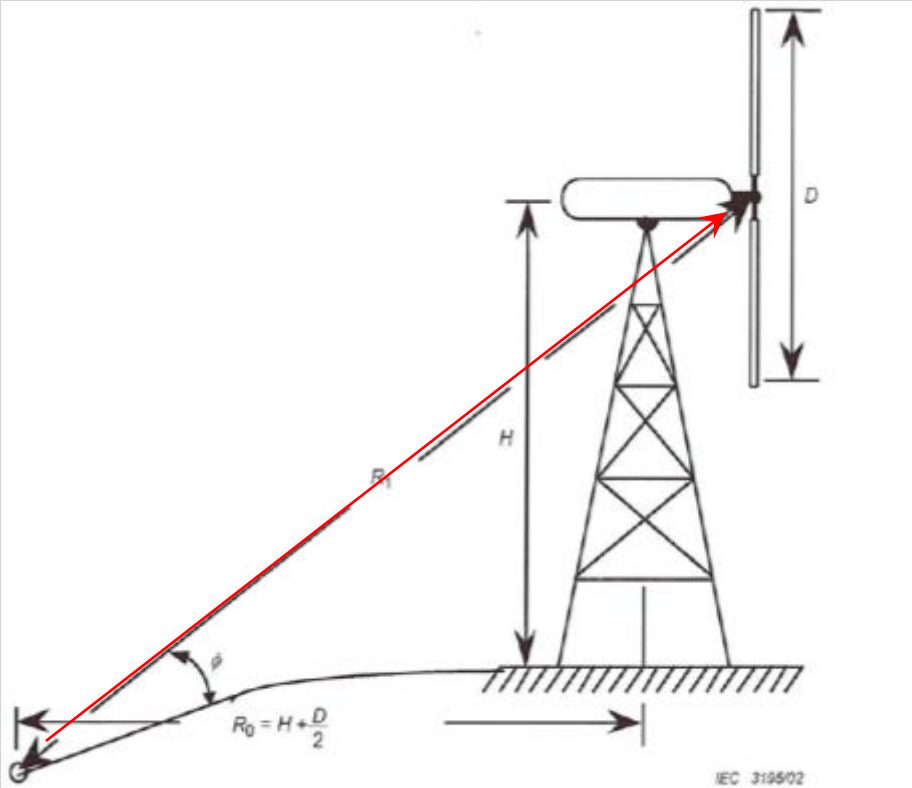


Figure 4a – Horizontal axis turbine

Sound Power measurements according to IEC
Simple approximation using advanced technology

SIEMENS

- In order to calculate the real sound:
  - A more correct Sound Power Level can be obtained by:

    Calculating the Sound Power from each point using the correct distances – and then sum the result

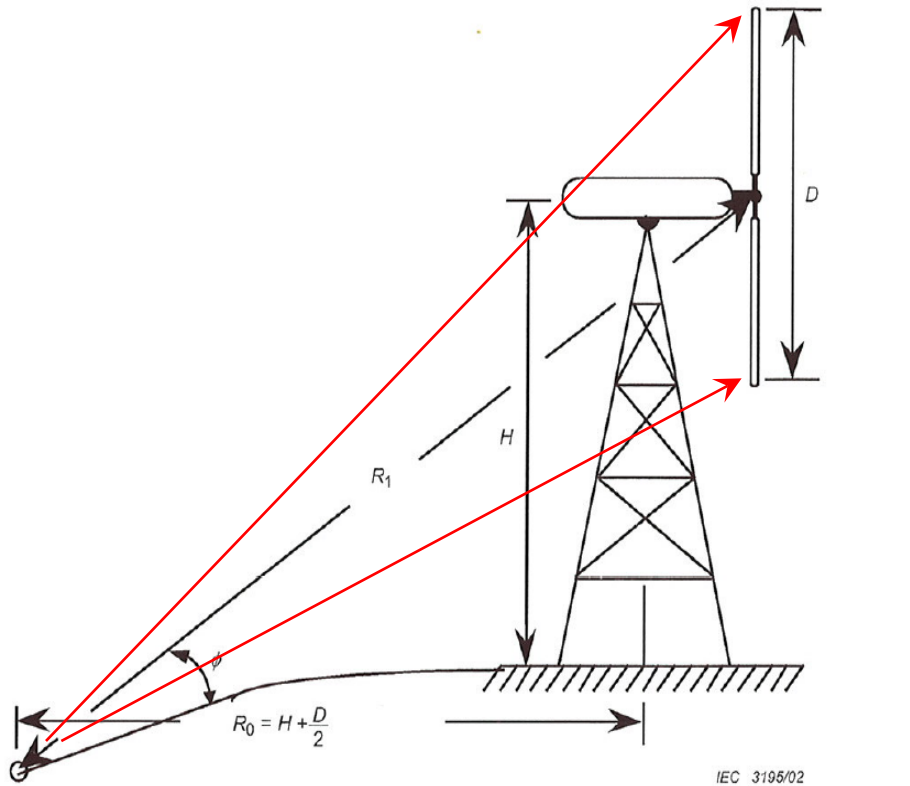


Figure 4a – Horizontal axis turbine

Sound Power measurements according to IEC
Simple approximation using advanced technology

SIEMENS

- Table below shows the results

	80 m tower			100 m tower		
	Yaw dir.			Yaw dir.		
	-15°	0°	+15°	-15°	0°	+15°
IEC dist -20%	0.24	0.54	0.75	0.17	0.41	0.60
IEC dist	0.18	0.45	0.65	0.13	0.35	0.53
IEC dist +20%	0.12	0.37	0.56	0.09	0.29	0.46

- Numbers are underestimated levels in the reference positions
- Largest number is 0.75 dB on the corner of the acceptable IEC position

SIEMENS

- **Conclusions:**
  - Because it is depending on the differences in of the angle to the tip's the result will not change as long as the relation between hub height and rotor diameter remains the same
  - Underestimation larger for large rotor on small tower, smaller for small rotor on high tower

Sound Power measurements according to IEC
Simple approximation using advanced technology

SIEMENS

- **Conclusions:**
  - Because it is depending on the differences in of the angle to the tip's the result will not change as long as the relation between hub height and rotor diameter remains the same
  - Underestimation larger for large rotor on small tower, smaller for small rotor on high tower
  - Necessary that the microphone can see the ENTIRE rotor – not just the rotor centre!

Sound Power measurements according to IEC
How do Siemens as manufacturer use the method?

SIEMENS

- **For developing purposes**
  - Optimizing the aerodynamics on the rotor
  - Looking at the 1/3 octave bands, one can learn a lot about how the rotor perform
  - Optimizing control parameters: Speed, Torque, Pitch etc.

- IEC 61400-11 ed. 3 give much more detailed results
- But also more results and require automatic analysis software and structured data storage

- At Siemens a database is used for noise measurements to ensure that we learn as much as possible from the measurement
- This makes it possible to compare and understand effects of site and turbine specific differences

Sound Power measurements according to IEC
How do Siemens as manufacturer use the method?

SIEMENS

- **For developing purposes**

- Even though it will always be a challenge to measure and ensure good and valid results when measuring in the field

Sound Power measurements according to IEC
How do Siemens as manufacturer use the method?

SIEMENS

- **For sales and verification purposes**
  - As a manufacturer we need to have a simple method to describe the turbines
  - Noise is more and more important as turbines are installed closer and closer to dwellings
  - It is necessary to be able to demonstrate
    - compliance with the warranty given
    - compliance with local regulations, which is based on Sound Power assumptions in some parts of the world

Sound Power measurements according to IEC
Conclutions

SIEMENS

- **A Sound Power measurement is a simple way to describe the Sound Power from a wind turbine**
- **A way to show that the method is valid is proposed. The result is:**
  - For most cases the method in the IEC standard will result in a minor underestimation of the noise due to distribution of sources
  - The magnitude of the underestimation is not related to size of turbine but to hub height / rotor diameter. Therefore the method will be valid for larger turbines
- **The IEC method gives comparable and reproducible results**

SIEMENS

Thanks for your attention