Welcome to the world of wind energy

Wind Measurement
Lidar-Sodar

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OPWP Renewable Energy Training Program
11-14 December 2016
Muscat, Oman

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How can we use light or sound in measuring wind speed and wind direction at various heights?

**Light Detection And Ranging (LIDAR)**

**Sound Detection And Ranging (SODAR)**

Lidar=transmits & detects light  
Sodar=transmits & detects sound

It is necessary to determine wind over whole turbine rotor
Applications: Pre-site evaluation of a wind farm, onshore. Meteorological observations, Vertical profiling of atmospheric wind 40-250 m AGL.
• Measures **wind speed and direction** at each altitude remotely and in real time,
• Environmentally resistant,
• Selects the optimal parameter settings automatically according to the atmospheric conditions,
• It is possible to remote control it and see data display.

**Applications:** Pre-site evaluation of an offshore location. Meteorological observations, Vertical profiling of atmospheric wind.
A Doppler lidar compared to a met mast
Doppler Lidar

- Can be used for **power performance** of wind turbines,
- Controls the yaw angle and blade pitch according to the incoming wind, hence improves power generation efficiency,
- **Detects** incoming **gusts** and controls the blade pitch to feather it against the wind, thus protects the wind turbine and reduces maintenance costs.
Measures and visualizes the wind condition of the wind farm so to:
   - adjust the yaw angle of the wind turbines
   - Keep a check on the wind conditions
Can be used to adjust turbine operation so to minimize the effect of wakes and turbulences to improve the power generation efficiency and decrease the turbine failure rate.
The wind carries natural aerosols such as:
- Dust
- Water droplets
- Pollution
- Pollen
- Salt crystals

It measures the Doppler shift of radiation scattered by the natural aerosols.
The system transmits a laser beam into the air, receives the light backscattered by aerosols*, and analyzes the atmospheric properties using the received signal. The signals from moving objects have a Doppler shift proportional to their speed, which enables the velocity of the aerosols to be calculated. As a result, the direction and speed of the wind can be measured. Since a Doppler Lidar transmits pulses of light repetitively while scanning the backscattered light from aerosols, the range and direction of particles can be measured simultaneously.

*Tiny particles with diameters of 1/10 to several microns in the atmosphere.
Example of Data Display

Blue = real time
Light green = 10 min average
Red = 10 min minimum
Green = 10 min maximum

Horizontal wind speed
- 500 m
- 300 m
- 100 m

Wind direction
- 180 deg

Vertical wind speed
- 4 m/s
- 15 m/s
- 30
Lidar from various manufacturers
It is advisable to match reference point of mast and Lidar heights.

The measured points form the Lidar must be in relation to the calibrated reference values of the monitoring mast. This will permit the wind profile to be determined in detail even beyond the hub height.
Comparing average 10 minute wind speed and direction data from a lidar and a cup anemometer.

Wind shear across the rotor layer
Profiles of mean horizontal velocity composited for each night of HRDL observations during LLLJP, showing almost linear wind shear up to 100-200 m.

The numbers refer to the time of day, e.g. 3=3 AM, 13=13 PM
Greece: Lidar measurements at 52 m AGL compared to cup anemometer measurements at the same height
Greece: Lidar measurements between 52 and 175 m AGL
SODAR (SOnic Detection And Ranging), also written as sodar, is a meteorological instrument used as a wind profiler to measure the scattering of sound waves by atmospheric turbulence. SODAR systems are used to measure wind speed at various heights above the ground. Sodar systems are like radar (radio detection and ranging) and lidar (light radar) systems except that sound waves rather than radio or light waves are used for detection. Other names used for sodar systems include sounder, echosounder and acoustic radar.
SODAR

Emits short pulse of sound at certain frequency to the atmosphere. Sound propagates upwards and at the same time a part is reflected back.
The SODAR sends out sound pulses in a specific (and unpleasant sounding) frequency, mainly vertically but also in northern, eastern, southern and western directions. However, these only differ from the vertical beam by about 20°. As the air above us is neither constant in temperature nor in density, these fluctuations scatter back the sound waves. The SODAR receives this backscattered signal that has now shifted in frequency (Doppler Shift). Using these deviations and the traveling time of the waves through the atmosphere, it is possible to calculate the wind SPEED and DIRECTION.

SODAR (SOnic Detection And Ranging),
Various sodar systems
A small size Sodar. Remtech, PA-XS weighs 7.3 kg. Reaches an average altitude range of 400 meters. Power consumption (18W) a solar power system with 1.75 square meter solar panel is sufficient. This wind profiler uses multi-frequency coding and includes the latest hardware design: GPS, digital compass and 2D inclinometer, Wi-Fi, as well as pressure, temperature and humidity measurements. Wireless modem or satellite connections are also available. Temperature range -40 to +85°C with up to 100% relative humidity.
Scatter plot showing the correlation of the sodar-measured (vector) wind speed at 50 m and the anemometer-measured (scalar) wind speed at 54 m AGL. 

*Courtesy of Atmospheric Research and Technology, Inc.*