

# Wind Monitoring Equipment and Measurement Programs

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- What do we monitor?
  - Wind speed (average and gusts)
  - Wind Direction
  - Temperature
- How often do we record it?
  - Every 10 minutes is best
  - Hourly is sometimes the most practical
- For how long?
  - 2 years is good
  - 1 year is a minimum



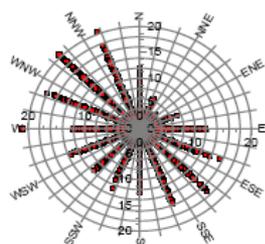
- How do we analyze the data?
  - Spreadsheets (e.g., Excel)
  - Custom software (e.g., WindPro, Windographer)
- Quality Control
  - Remove periods of bad data (icing, etc.)
- Statistics
  - Average Wind Power Density and Speed
  - Seasonal and Diurnal Variations
  - Variation with height above ground
  - Many others



**Project:** Pine Ridge  
**Source:** Data from file(s)  
 Y:\5000\shared\Anemometer\_Loan\_Programs\Native American Loans\SD - Pine Ridge - SO\Pine Ridge Raw Wind Data\0070204.N02  
 Y:\5000\shared\Anemometer\_Loan\_Programs\Native American Loans\SD - Pine Ridge - SO\Pine Ridge Raw Wind Data\0070527.N02  
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**Printed:** 5/2/2007 9:29 AM / 2  
**Licensee:** National Renewable Energy Laboratory  
 1617 Cole Blvd. (MS3811)  
 US-GOLDEN, CO 80401  
 +1 303-384-7027  
**Created:** 5/2/2007 9:29 AM/

**Meteo data report, height: 20.0 m**

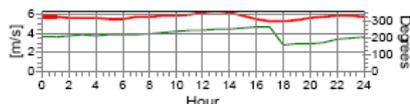
Name of meteo object: Pine Ridge #1 (KILI Radio Station)



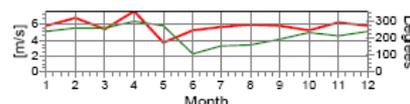
Monthly mean values of wind speed in m/s

Month	2001	2002	mean	mean of months
Jan	5.8	5.8	5.8	5.8
Feb	6.7	6.7	6.7	6.7
Mar	5.3	5.3	5.3	5.3
Apr	7.6	7.6	7.6	7.6
May	3.7	3.7	3.7	3.7
Jun	5.2	5.2	5.2	5.2
Jul	5.6	5.6	5.6	5.6
Aug	5.9	5.9	5.9	5.9
Sep	5.7	5.7	5.7	5.7
Oct	6.5	5.1	5.2	5.8
Nov	6.1	6.1	6.1	6.1
Dec	5.8	5.7	5.8	5.8
mean, all data	6.0	5.7	5.7	
mean of months	6.1	5.7		5.8

Wind speed [m/s]

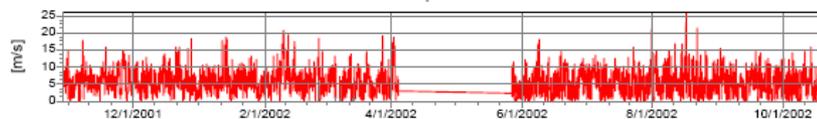


Wind speed. Height: 20.0 m  
Wind direction. Height: 20.0 m

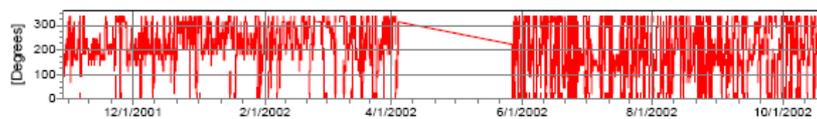


Wind speed. Height: 20.0 m  
Wind direction. Height: 20.0 m

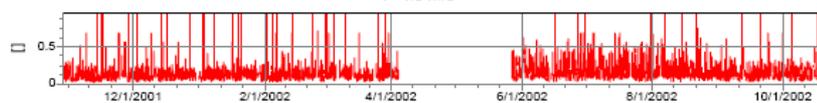
Wind speed



Wind direction



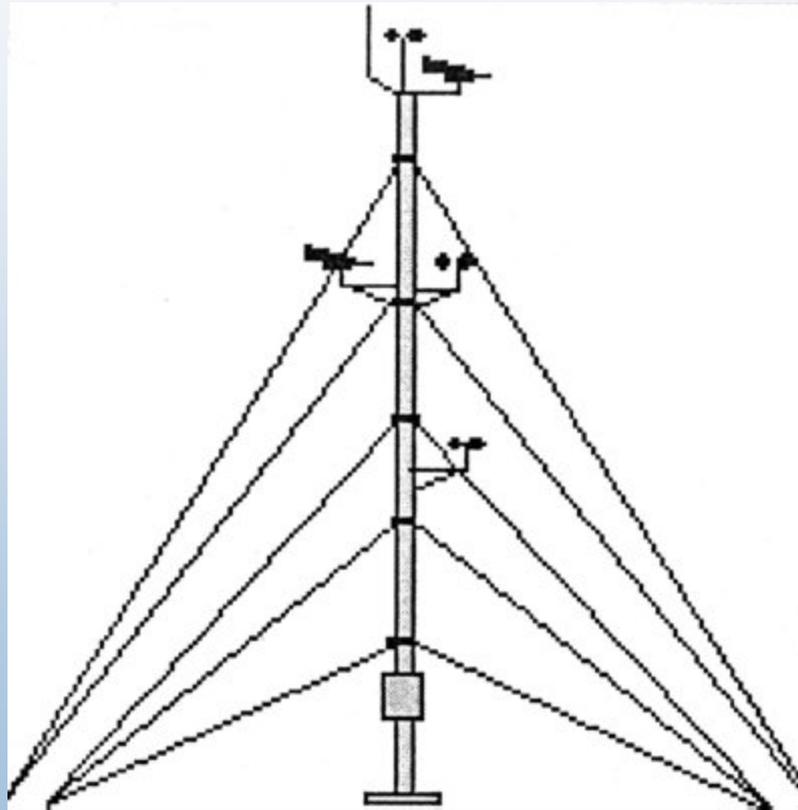
Turbulence intensity  
 $V > 4.0$  m/s



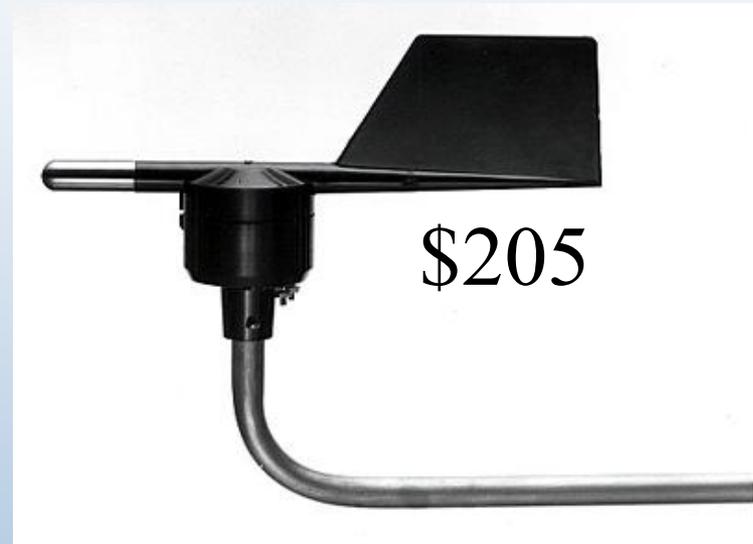
# Wind Monitoring Equipment

- Sensors (Speed, Direction, Temperature)
- Data Loggers
- Towers

# Tower with Logger and Sensors



# Anemometer & Wind Vane



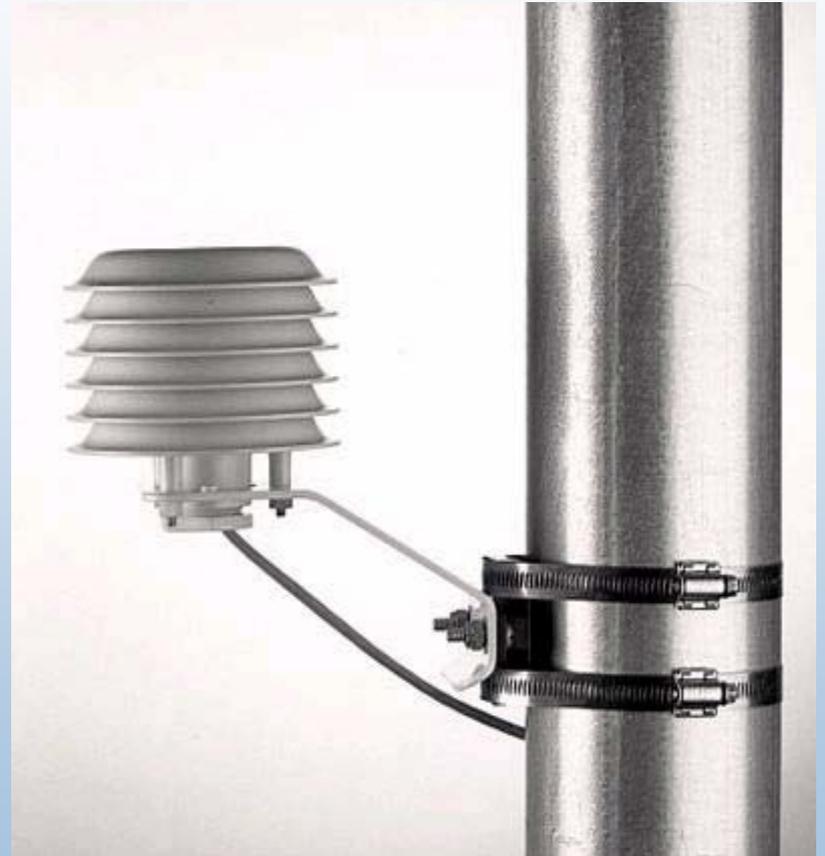
Standard anemometer \$115

Calibrated anemometer \$295

Heated anemometers and vanes for very cold climates \$970 each!

# Temperature Sensor

- \$195
- Helps determine periods of icing



# Other Sensors

- Barometric Pressure
- Relative Humidity
- Solar Radiation
  
- Probably not essential for wind resource assessment
- Barometric pressure requires additional power source

# Wind Data Loggers

# NRG Wind Explorer



- 1 anemometer, 1 wind vane, 1 analog channel
- Stores data on 128KB DataPlugs
- No longer in production, but still around
- Was cheap (\$590)
- Complete systems were \$1230 (10m) to \$3690 (30m)

# NRG 9300 Cell Logger



- Up to 6 anemometers
- Up to 6 wind vanes or other analog sensors
- Stores data on FLASH memory cards
- (no longer in production)

# NRG Symphonie Logger



- Internet-enabled – data arrive by email
- Flexible configuration
- \$1350 plus add-ons

# SecondWind Nomad2 Logger



- Up to 12 anemometers
- Up to 8 wind vanes or other analog sensors
- Compact Flash memory cards
- Telephone, Internet or satellite data retrieval
- about \$1400 (plus add-ons)

# Campbell Scientific Logger



- 6 different models
- Good for wind turbine monitoring

## Beware of Analog Cell-phone Loggers!

- As of Feb. 18, 2008, US cell carriers are not required to provide analog coverage.
- There are still many analog cell phone loggers out there.
- They will continue to collect data, but data may have to be retrieved with site visits.



# Towers for Wind Resource Assessment

- Tubular Towers
  - Most common for wind evaluation
  - Tilt-up
  - Up to 60m (or even 80m)
  - 20m = \$1000, 60m = \$10000-12000
- Booms hold sensors away from tower

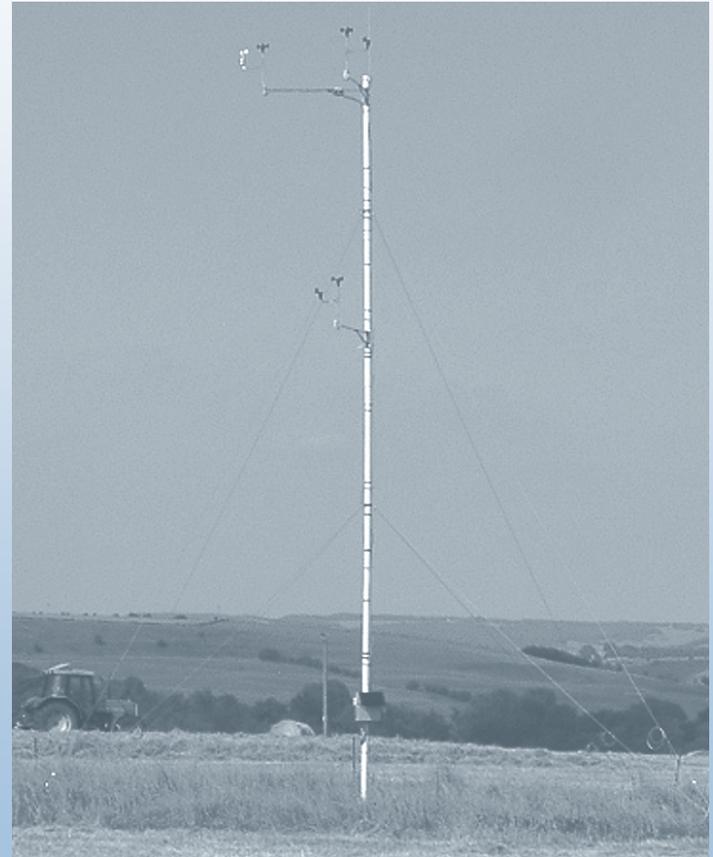


- Lattice Towers
  - Existing communications towers (broadcast, cell phone, etc.)
  - Up to 120m
  - Need permission from owner



# Plastic (FRP) Towers

- From NexGen (UK)
- 10m or 12m
- Around \$2000
- Under 100lbs (40kg)
- (new!)



# Tilt-up Tower Erection



Tilting up a 14m tower in Ulaanbaatar, Mongolia



# Wind Monitoring Equipment Manufacturers

NRG Systems, Inc.  
110 Commerce St.  
P.O. Box 509  
Hinesburg, VT 05461  
802-482-2255  
802-482-2272 fax  
<http://nrgsystems.com/>  
email:  
[sales@nrgsystems.com](mailto:sales@nrgsystems.com)

Second Wind Inc.  
366 Summer Street  
Somerville MA 02144-3132  
617-776-8520 v  
617-776-0391 fax  
<http://secondwind.com/>  
email:  
[sales@secondwind.com](mailto:sales@secondwind.com)



# Wind Monitoring Equipment Manufacturers (cont.)

Campbell Scientific, Inc.

815 West 1800 North

Logan, Utah 84321-1784

Phone: 435.753.2342

Fax: 435.750.9540

Email: [info@campbellsci.com](mailto:info@campbellsci.com)

Web: <http://www.campbellsci.com>

# Examples of Less-than-ideal Measurement Equipment and Sites

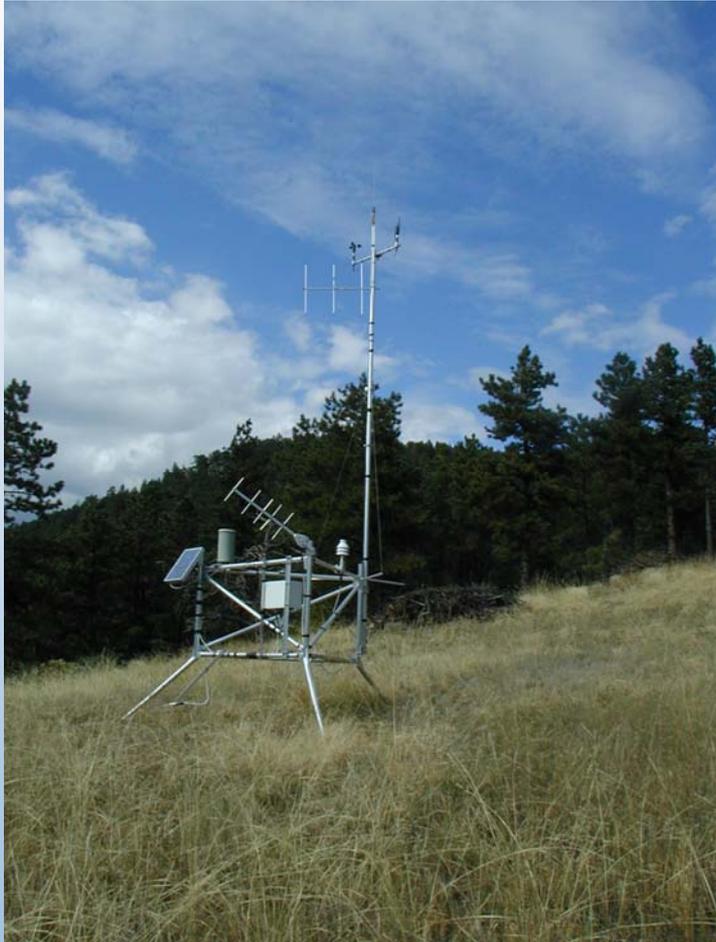
## Plate-type anemometers





# A sheltered city meteorological station, Ulaanbaatar, Mongolia





Anemometer at 6  
meters

Trees at 10-12  
meters

(US Forest Service  
Remote Automated  
Weather Station –  
RAWS)

## Example from a tower manufacturer's website



## Tall Tower Measurement Needs

- Measurement data at and above hub-heights of current and future turbines (100 m +)
  - Wind shear and turbulence characteristics, low-level jets, etc.
- Instrument existing tall towers (communication etc.)

# Remote Sensing of Wind Speed



SODAR or  
sonic profiler



LIDAR (using  
infrared laser)