Wind Monitoring Equipment and Measurement Programs

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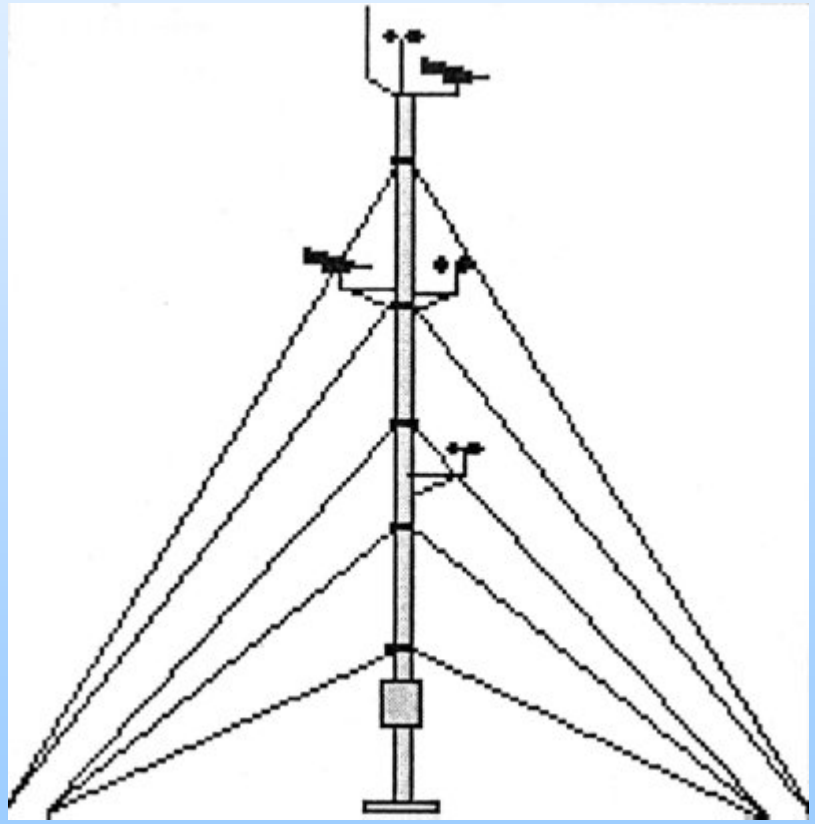
- What do we monitor?
  - Wind speed (average and gusts)
  - Wind Direction
  - Temperature
- How often do we record it?
  - Every 10 minutes is best
  - Hourly is sometimes the most practical
- For how long?
  - 2 years is good
  - 1 year is a minimum

- How do we analyze the data?
  - Spreadsheets (e.g., Excel)
  - Custom software
- 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

Wind Monitoring Equipment

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

Tower with Logger and Sensors



Anemometer & Wind Vane

Standard anemometer $115

Calibrated anemometer $285

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

Temperature Sensor

- $195
- Helps determine periods of icing

Other Sensors

- Barometric Pressure - $325
- Relative Humidity - $300
- Solar Radiation - $375

- Probably not essential for wind resource assessment

NRG Wind Explorer

- 1 anemometer, 1 wind vane, 1 analog channel
- Stores data on 128KB DataPlugs ($60)
- Cheap ($610)
- Complete systems: $3060 (30m) (no more 10m systems)

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
- $1250 plus add-ons
- Complete systems: $4125 (30m) to $13895 (60m)

SecondWind Nomad2 Logger

- Up to 12 anemometers
- Up to 8 wind vanes or other analog sensors
- Compact Flash memory cards
- about $1400

Campbell Scientific Logger

- 6 different models
- Good for wind turbine monitoring

Towers

- Tubular
  - Most common for wind evaluation
  - Tilt-up
  - Up to 60m
  - 20m = $800+, 30m = $3325, 60m = $12600
- Lattice
  - Existing communications towers
- Booms hold sensors away from tower

Measurement Towers

- Tubular
- Lattice

Tubular Towers

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

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

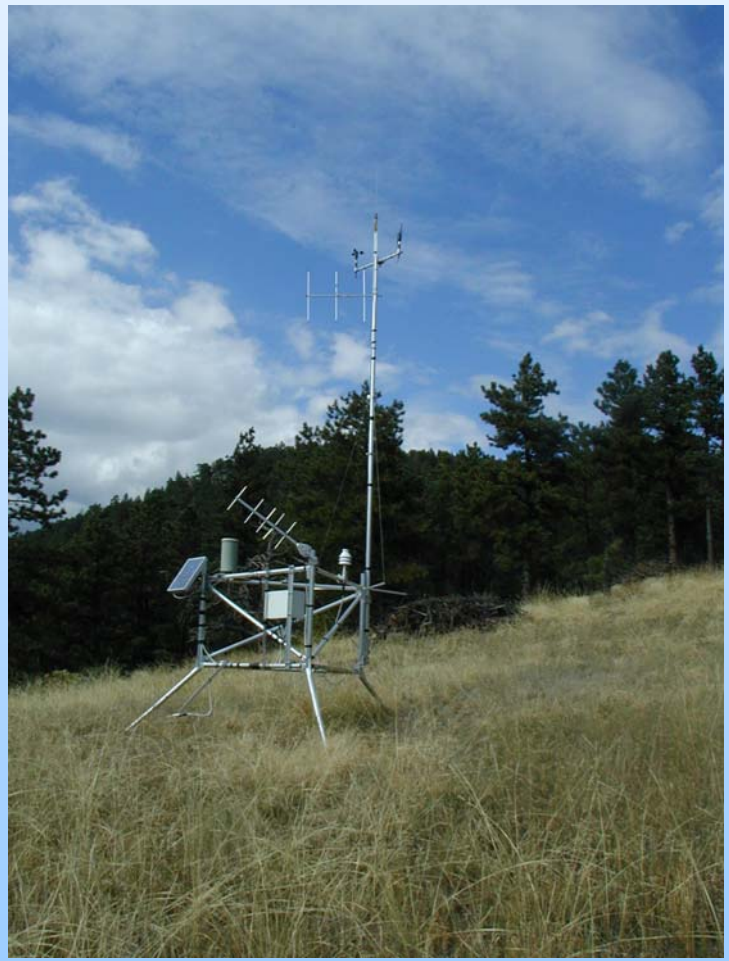
Wind Monitoring Equipment Manufacturers (cont.)

Campbell Scientific, Inc.
815 West 1800 North
Logan, Utah 84321-1784
Phone: 435.753.2342
Fax: 435.750.9540
Email:info@campbellsci.com
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)

Site with Good Exposure

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.)
- Use SODAR or other remote sensing techniques

Tall Tower Measurements

- State measurements supported by DOE cost-share (1 year). Existing tall towers:
  - Kansas (6)
  - Texas (2)
  - New York (3)
  - Indiana (5)
  - North Dakota (3)
  - California (4)
- Other states
  - Oklahoma
  - South Dakota
  - Minnesota

Tall Tower Measurements (cont'd)

- Offshore
  - Massachusetts
  - New Jersey
- 2004 DOE State Energy Program funding
  - 3 states
- Need more data!