

Wind Technology & Market Overview



RE & EE for Tribal Community Development Workshop

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Presentation Overview

- Wind Characteristics & Energy Potential
- Wind Turbine Applications
- Wind Turbine Technology & Evolution
- State of the Market

Wind Characteristics & Energy Potential

Why Care About Wind Resource Assessment?

Project Economics

Energy Production

Wind Resource Estimate

An accurate wind resource estimate is the basis for estimating the performance and economics of a wind energy project

ENERGY AND POWER

ENERGY, ABILITY TO DO WORK

ENERGY = FORCE * DISTANCE

Electrical Energy , kWh

POWER = ENERGY/TIME (Rate at which
energy is being created or used)

Generator Size, kW

Energy is a quantity

Power is a rate (quantity/time)

Power in the Wind

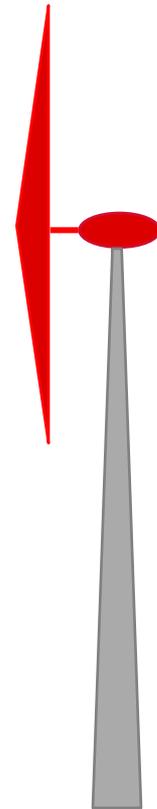
$$P = 0.5 \rho A v^3$$

P - power, watts

ρ - density of air, kg/m³

A - area, m² ($A = \pi D^2 / 4$)

v - wind speed, m/s

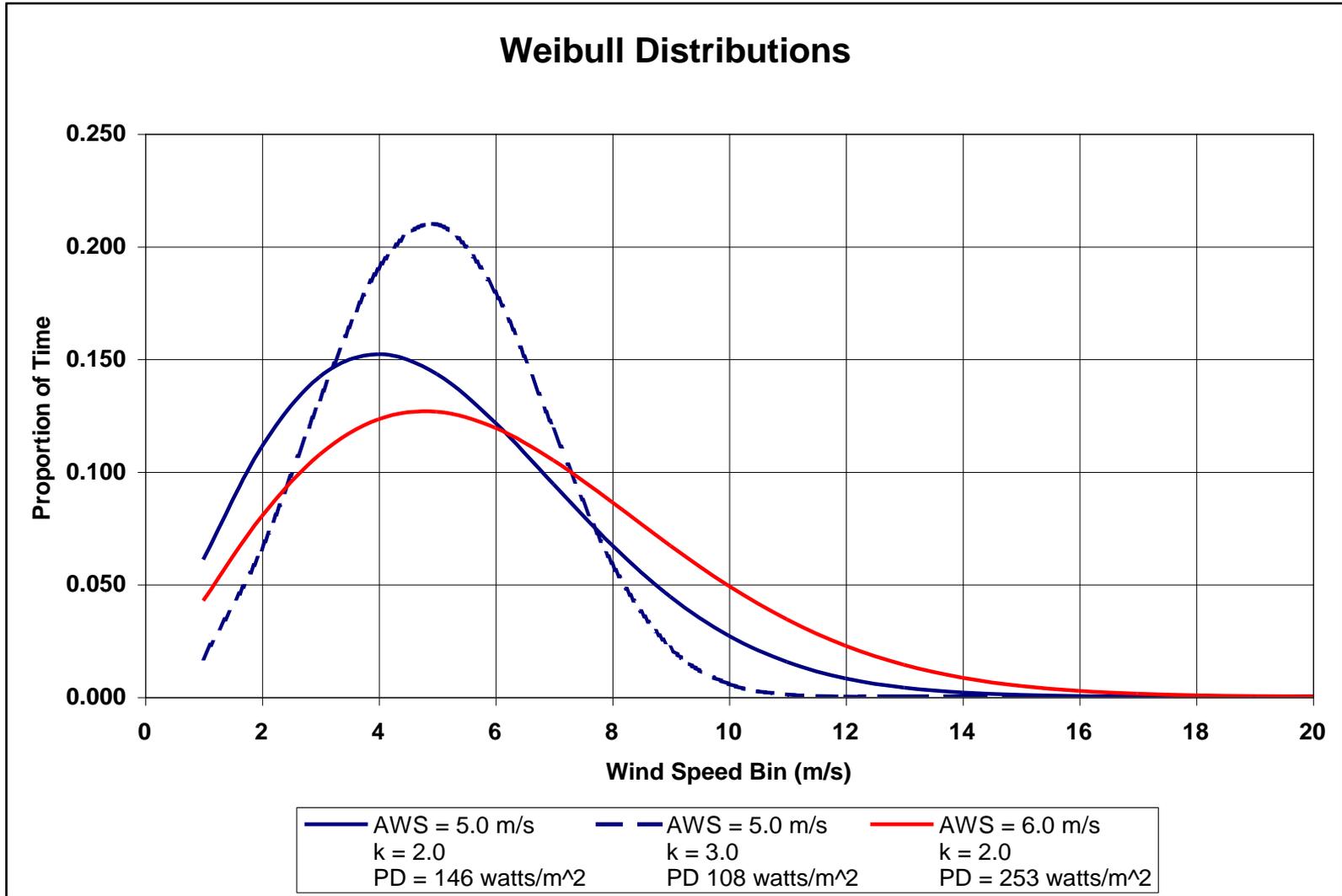


Power Density

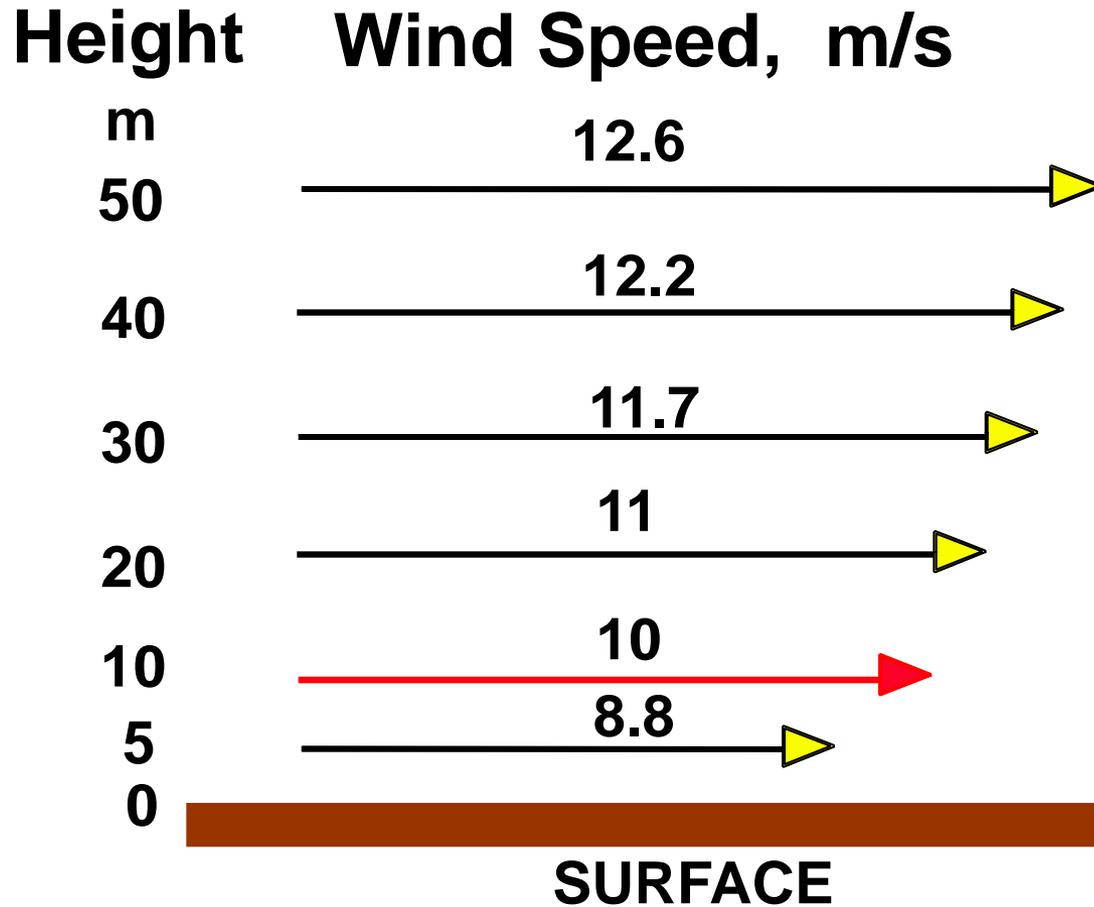
$$\text{Power Density} = P/A = 0.5 \rho v^3$$

Wind Class	W/m ² at 50 m	Wind speed at 50 m
1 m/s	0 - 199	0 - 5.9
2 m/s	200 - 299	5.9 - 6.7
3 m/s	300 - 399	6.7 - 7.4
4 m/s	400 - 499	7.4 - 7.9
5 m/s	500 - 599	7.9 - 8.4
6 m/s	600 - 699	8.4 - 8.9

Wind Speed Distribution



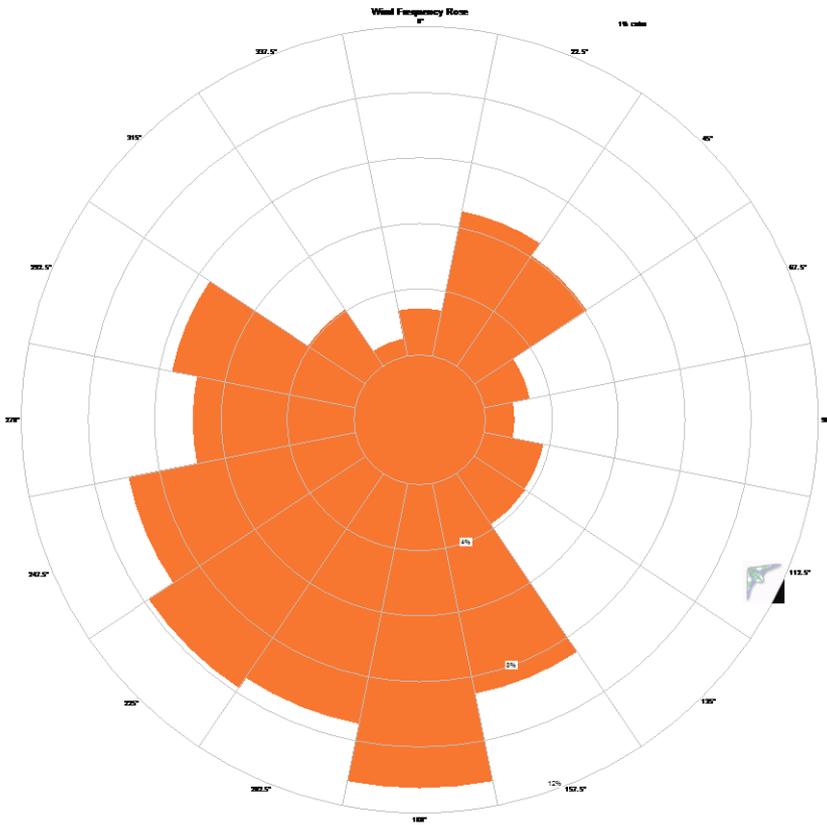
WIND SHEAR



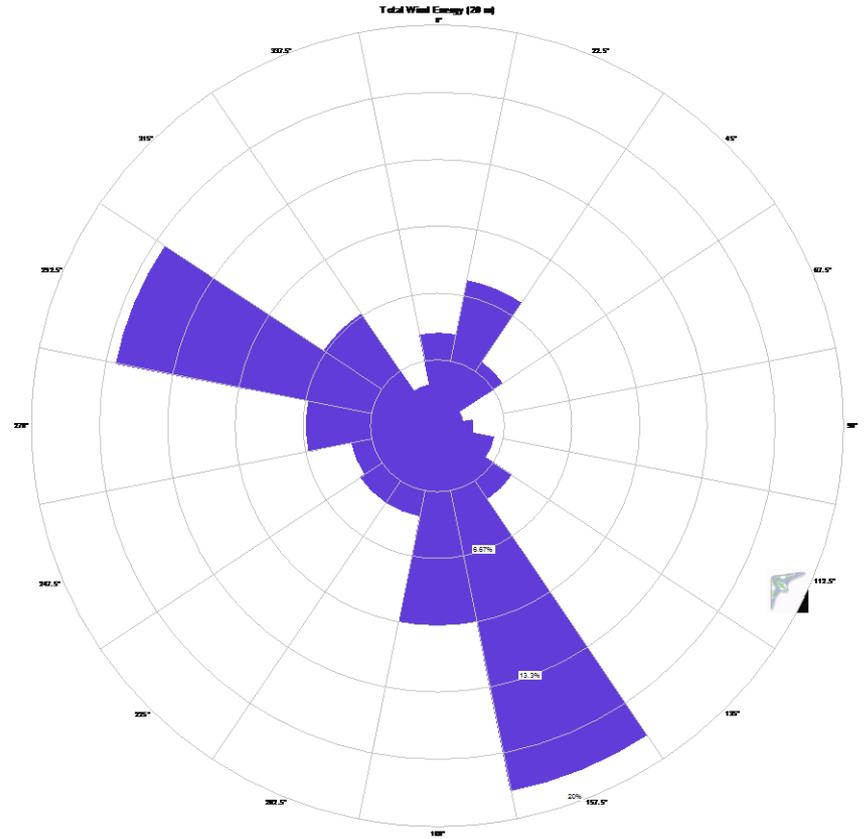
Courtesy: Alternative Energy Institute

WIND ROSE

Chadron, NE

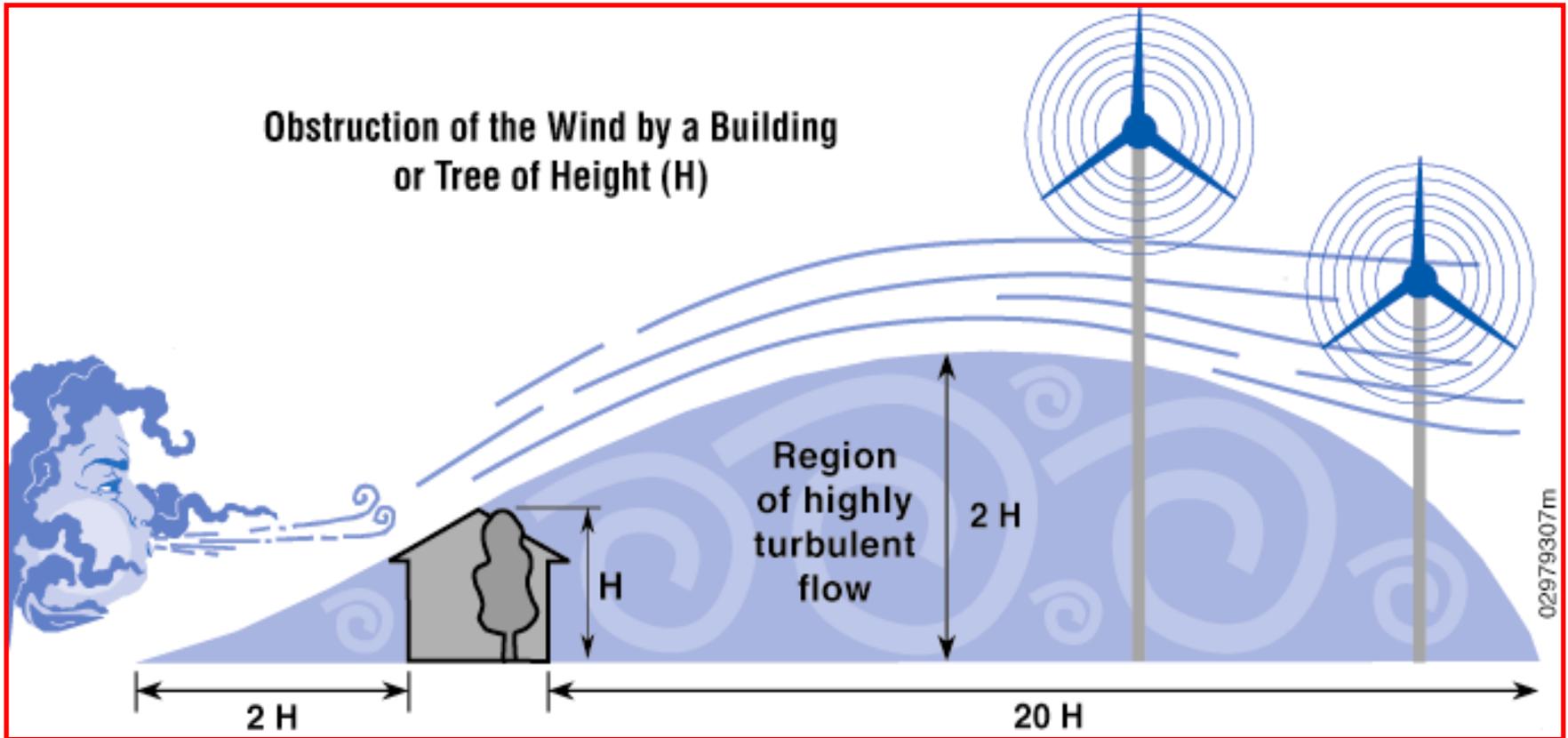


Wind Rose



Energy Rose

Importance of “Micro-Siting”



Sources of Wind Data

Wind Maps (Static and interactive)

- State wind maps: http://www.eere.energy.gov/windandhydro/windpoweringamerica/wind_maps.asp
- 3TIER First Look: <http://firstlook.3tiergroup.com/>
- AWS Truewind Wind Navigator: <https://windnavigator.com/>
- Renewable Energy Atlas of the West:
<http://www.mapcruzin.com/renewable-energy-atlas-of-the-west.htm>
- Some states have additional data. Try searching the web site of your state energy office.

Sources of real data

- Real data from the area (airports, etc.). Data quality will vary
- Consider on-site monitoring if your project is 500-1000 kW or larger

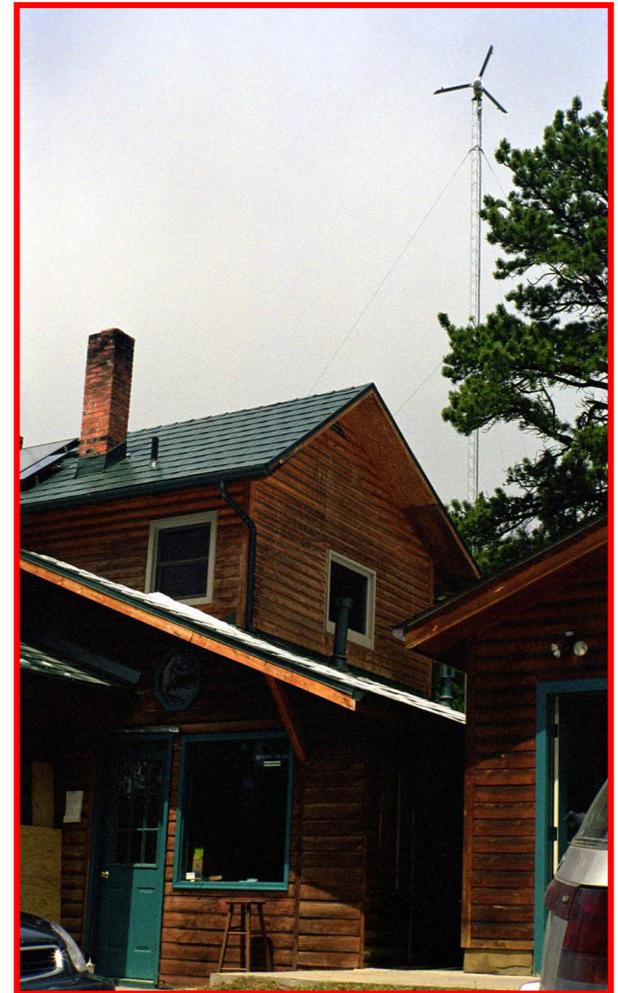
Cautions regarding wind maps

- Take seriously the uncertainties in the average wind speed values!
- The values typically assume good exposure to the wind

Wind Turbine Applications

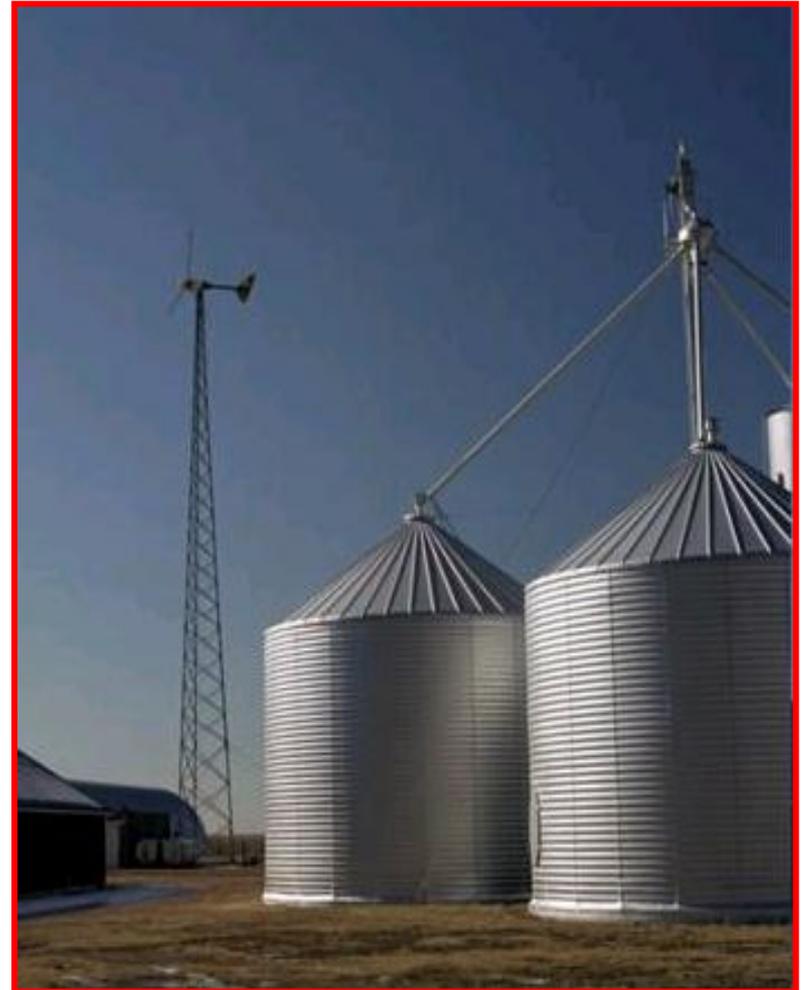
Off-Grid Home with Wind/PV System

- West of Boulder, CO, at 9,000 ft
- Bergey 1500 wind turbine, 1.5 kW, 70 ft tower
- Solarex PV panels, 480 W
- 24 VDC battery, 375 Ah
- Onan generator, propane-fueled, 3 kW (at altitude)
- Trace inverter, 120 VAC, 1 phase
- Propane used for range, refrigeration, space heat, hot water (w/solar pre-heat)
- First wind turbine installed in 1978, fourth wind turbine now in service
- PV installed 1984 w/ tax credits
- System cost about \$20,000



On-Grid Farm with Wind System

- Southwestern Kansas
- Utility bill reduction
- Bergey Windpower Excel wind turbine
10 kW, 23 ft rotor, 100 ft tower
- ~21,000 kWh/year generation,
utility bill savings ~\$2,800/year
- Installed in early 1980s, ~\$20,000,
received federal tax credit
- Maintenance costs \$50/year
- One lightning strike, damage was
covered by farm insurance



Selawik, Alaska

- 4 x 50 kW Wind Turbines
- Turbine Manufacturer: AOC
- Developer/Owner: AVEC
- Capacity: 200 kW



Hull, Massachusetts

- Turbine Size: 660 kW
- Turbine Manufacturer: Vestas
- Developer/Owner: Hull Municipal Lighting Plant
- Capacity: .66 MW



Ponnequin, Colorado



- Turbine Manufacturer:
Vestas, NEG Micon
- Developer/owner:
DisGen/Xcel Energy
- Turbine Size: 660-750 kW
- Capacity: 31.5 MW
- Commissioned: 1999

Brownsville, Wisconsin



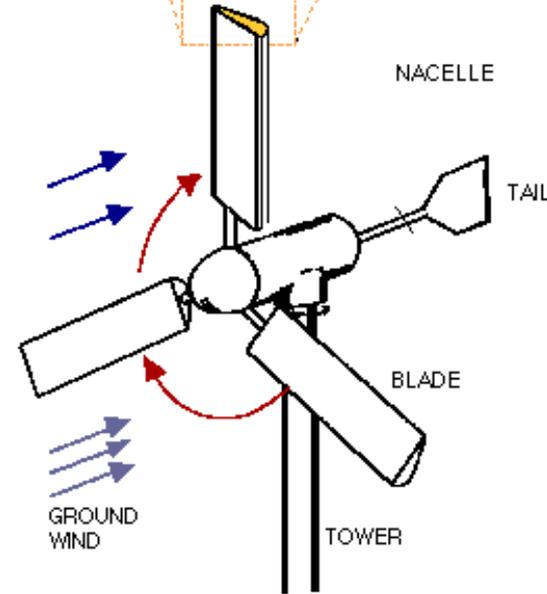
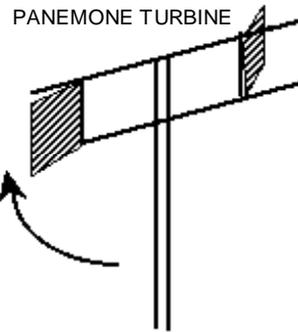
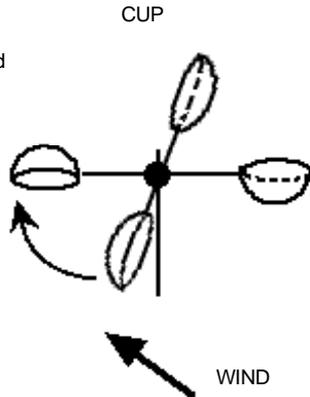
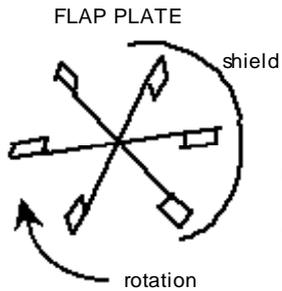
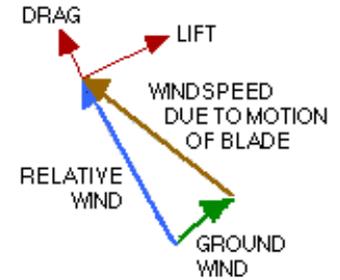
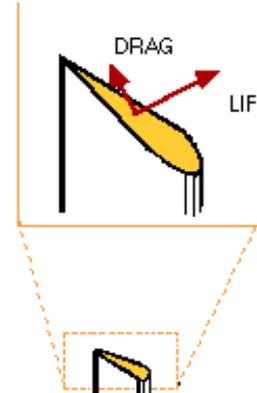
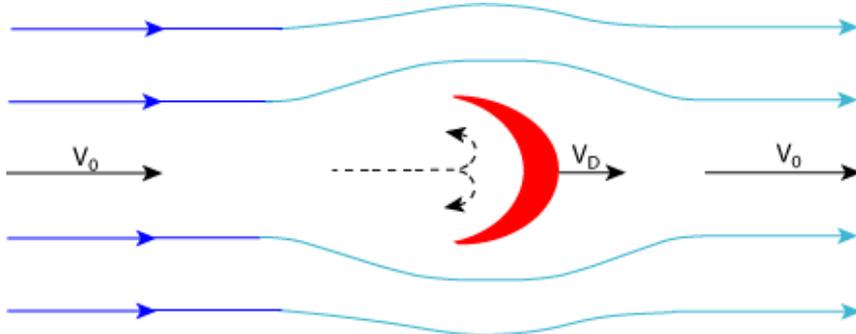
- Forward Wind Energy Project
- Turbine Manufacturer: GE
- Developer: Invenergy
- Turbine Size: 1.5 MW
- Capacity: 129 MW
- Commissioned: 2008

Wind Turbine Technology & Evolution

Wind Turbine Topologies

- Drag vs Lift machines
- Horizontal Axis vs Vertical Axis
- Upwind vs Downwind
- Two vs Three blades

Drag vs Lift Machines



Courtesy: Alternative Energy Institute

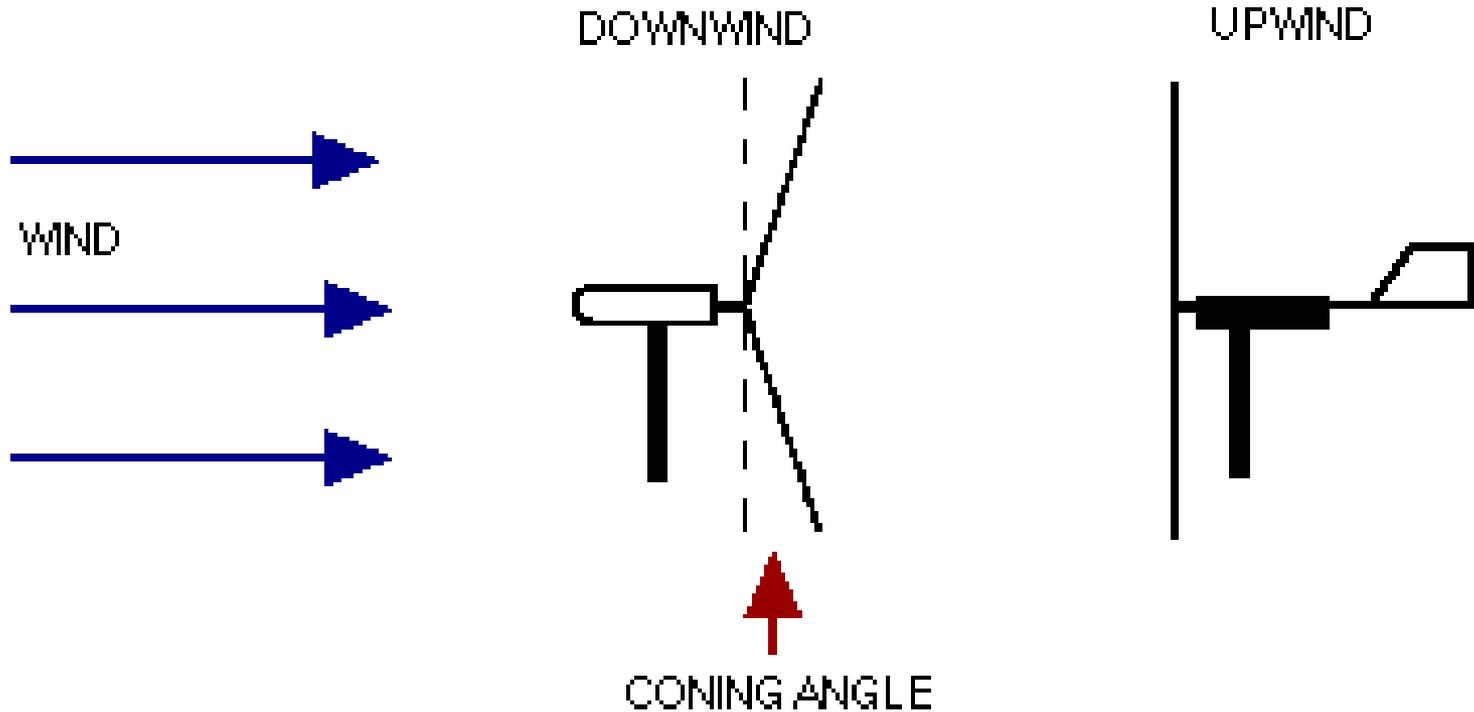
HAWT



VAWT



Downwind & Upwind



Courtesy: Alternative Energy Institute

3 Bladed vs 2 Bladed





Courtesy: Alternative Energy Institute



ROTOR AREA = 2460 m²

Courtesy: Alternative Energy Institute

Sizes and Applications



Small (≤ 10 kW)

- Homes
 - Farms
 - Remote Applications
- (e.g. water pumping, telecom sites, icemaking)



Intermediate (10 kW-1 MW)

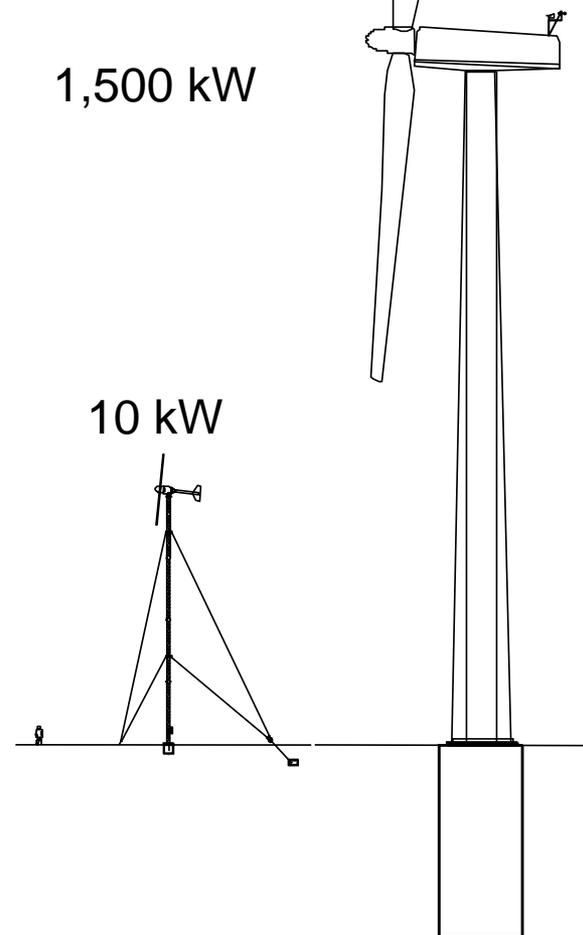
- Village Power
- Hybrid Systems
- Distributed Power



Large (1 MW +)

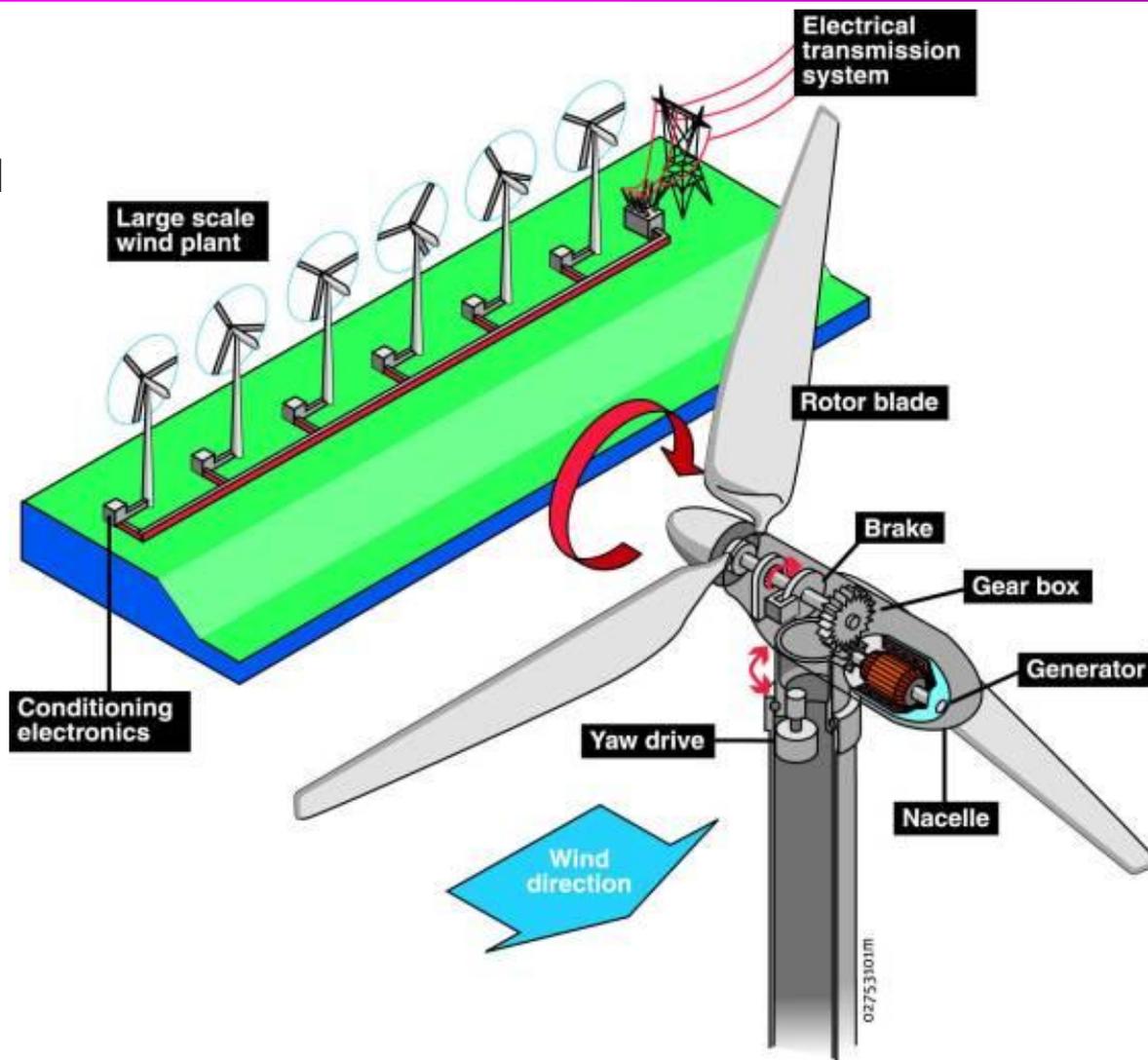
- Central Station Wind Farms
- Distributed Power
- Community Wind

- **Utility-Scale Wind Power**
1,000 - 3,000 kW+ wind turbines
 - Installed on wind farms, 10 – 300 MW
 - Professional maintenance crews
 - 13 mph (6 m/s) average wind speed
- **Small Wind Power**
300 W - 100 kW wind turbines
 - Installed at individual homes, farms, businesses, schools, etc.
 - On the “customer side” of the meter, or off the utility grid entirely
 - High reliability, low maintenance
 - 9 mph (4 m/s) average wind speed

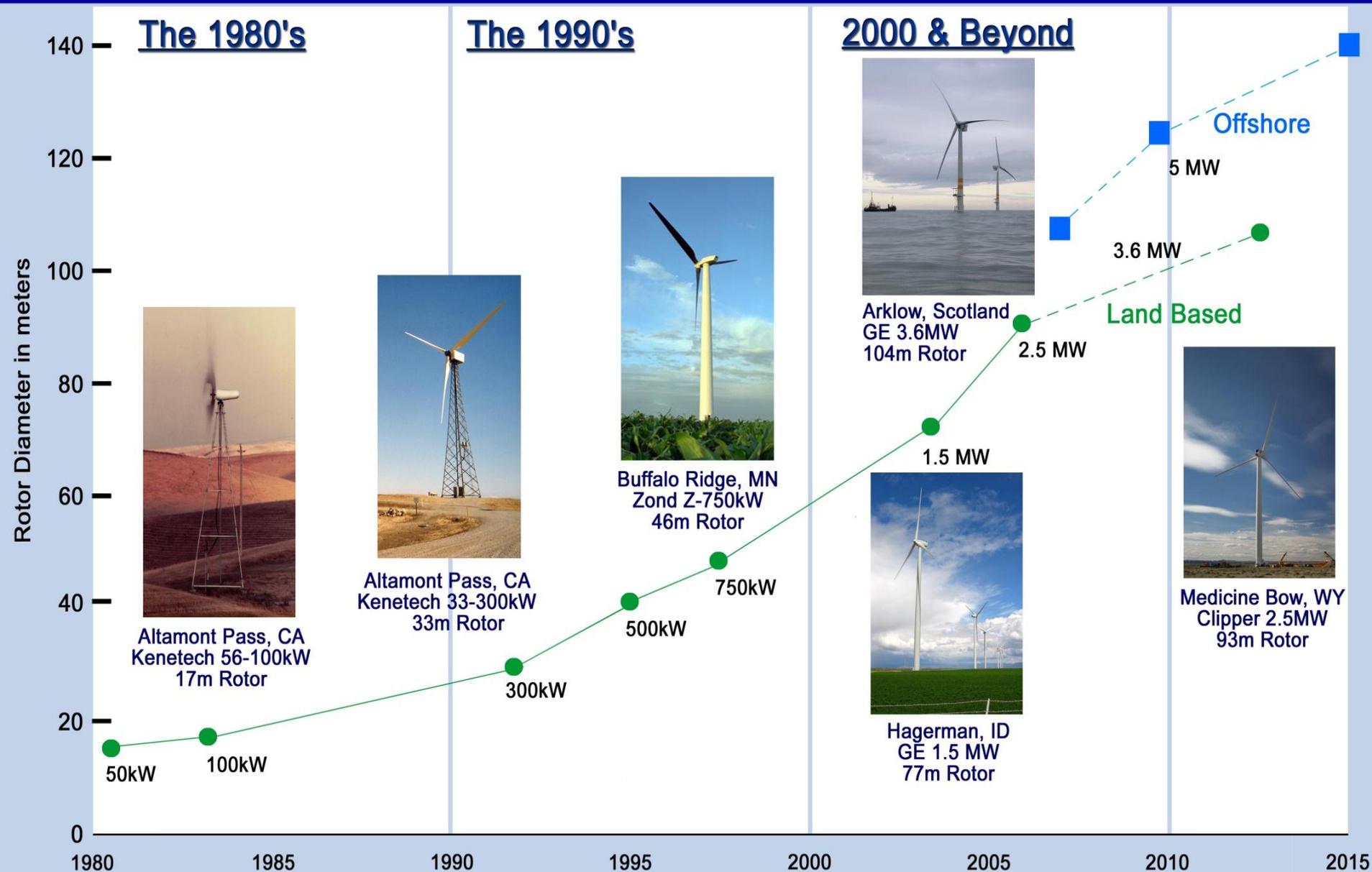


Utility Scale Wind Energy Technology

At it's simplest, the wind turns the turbine's blades, which spin a shaft connected to a generator that makes electricity. Large turbines can be grouped together to form a wind power plant, which feeds power to the electrical transmission system.

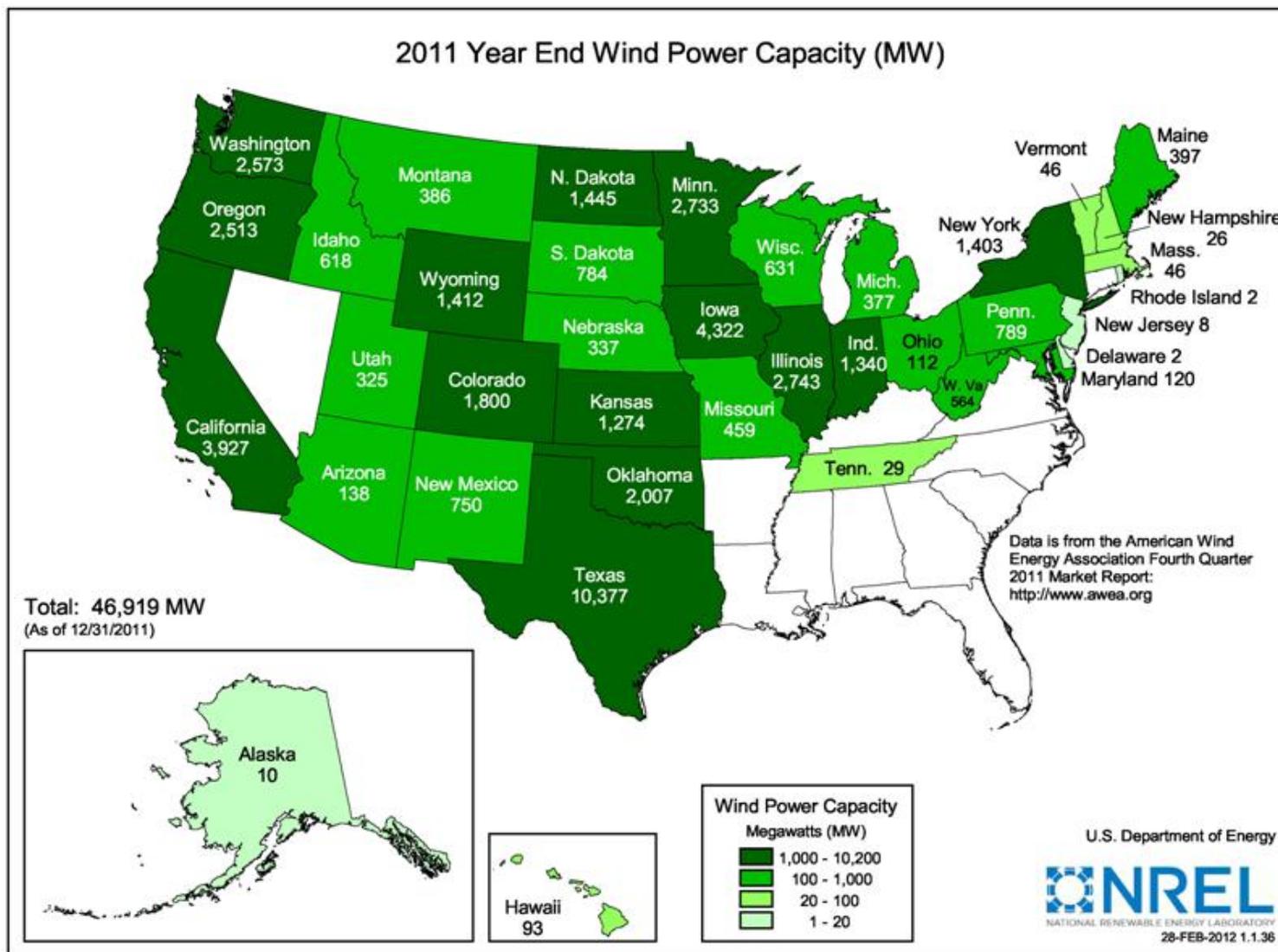


Evolution of U.S. Commercial Wind Technology



State of the Market

U.S. Installed Wind Capacity



Market Trends



Small

- Certification
- Vertical Axis Turbines

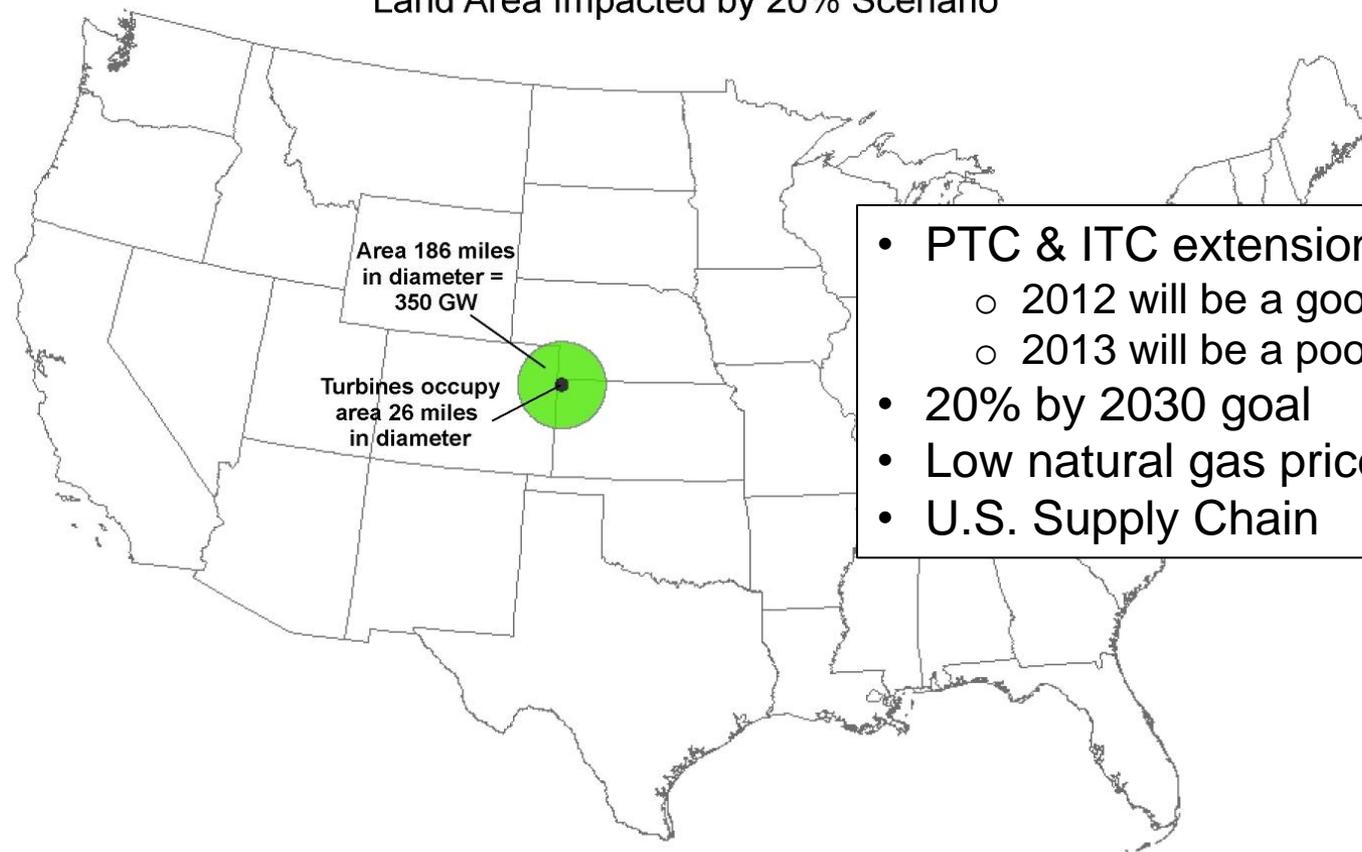
Large

- Taller Towers
- “Low(er) Wind Speed” Turbines with extra large rotors
- Interest in Offshore



Current Issues

Land Area Impacted by 20% Scenario



- PTC & ITC extension uncertainty
 - 2012 will be a good year
 - 2013 will be a poor year
- 20% by 2030 goal
- Low natural gas prices
- U.S. Supply Chain

- WindPowering America web site: [http://www. Windpoweringamerica.gov](http://www.Windpoweringamerica.gov)
- American Wind Energy Association (AWEA): <http://www.awea.org>
- Distributed Wind Energy Association (DWEA): <http://www.distributedwind.org>
- WindPowering America web site: <http://www. Windpoweringamerica.gov>
- National Wind Technology Center (NWTCC) Web site: <http://www.nrel.gov/wind>
- Homepower Magazine (& web site): <http://www.homepower.com>
- Windustry: <http://www.windustry.com>
- National Wind Coordinating Committee: <http://www.nationalwind.org>
- Utility Wind Interest Group site (in the process of changing its name to the “Utility Variable-Generation Group” (UVIG): <http://www.uwig.org>
- Wind turbine manufacturer web sites
- Tribal Energy Program: <http://apps1.eere.energy.gov/tribalenergy/>
- Database of State Incentives for Renewable Energy: <http://www.dsireusa.org/>



Carpe Ventem

www.windpoweringamerica.gov