

Wind Energy Potential In Rural America

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Disclaimer

The views presented in this presentations are mine and do not necessarily represent the views of any governmental agency, industry group, or NGO.



Is thar gold in dem thar...

- Hills?
- Plains?
- Sea Shores?
- Rangeland?
- Soybeans?
- Wheat?



Take Home Message: A Complete Resource Assessment is Essential

- Wind speed and direction at multiple levels
- Extreme Weather Events – including historical records
- Air density (pressure and temperature)
- Environmental Issues – birds, bats, scenic views
- Transmission Issues
- More



Meteorological Assessment

- Minimum of 3 years
- Compare to historical record – tremendous economic loss if extreme events are not included



Importance of Knowing the Real Wind Energy Resource

- Momentum = mv
- Kinetic Energy = $\frac{1}{2} mv^2$
- Power = $\frac{1}{2} \rho v^3$
 - where air density, $\rho = P/R_d T_v$



Wind Power is a Cubic Function of the Wind Speed

How much more power will I get from a 15 mph wind compared to a 13 mph wind (assume same air density) ?

$$(15 \text{ mph})^3 / (13 \text{ mph})^3 =$$



Wind Power is a Cubic Function of the Wind Speed

How much more power will I get from a 15 mph wind compared to a 13 mph wind (assume same air density)?

$$(15 \text{ mph})^3 / (13 \text{ mph})^3 = 1.54$$



While I Cannot Tell the Difference Between 13 mph and 15 mph Wind

The wind power potential of the 15 mph
wind is 54% more than 13 mph.

That could be the difference between
making money and going broke!



Steps in the Wind Energy Resource Assessment: A Brief Outline

- Wind Energy Resource Maps
- Site Selection
 - Wind resources
 - Network Connectivity
 - Environmental Concerns
- Collect a minimum of 3 years of data
- Social-Economic Analysis
 - Tax benefits
 - Public Interest
 - Political Support
- Go or No Go

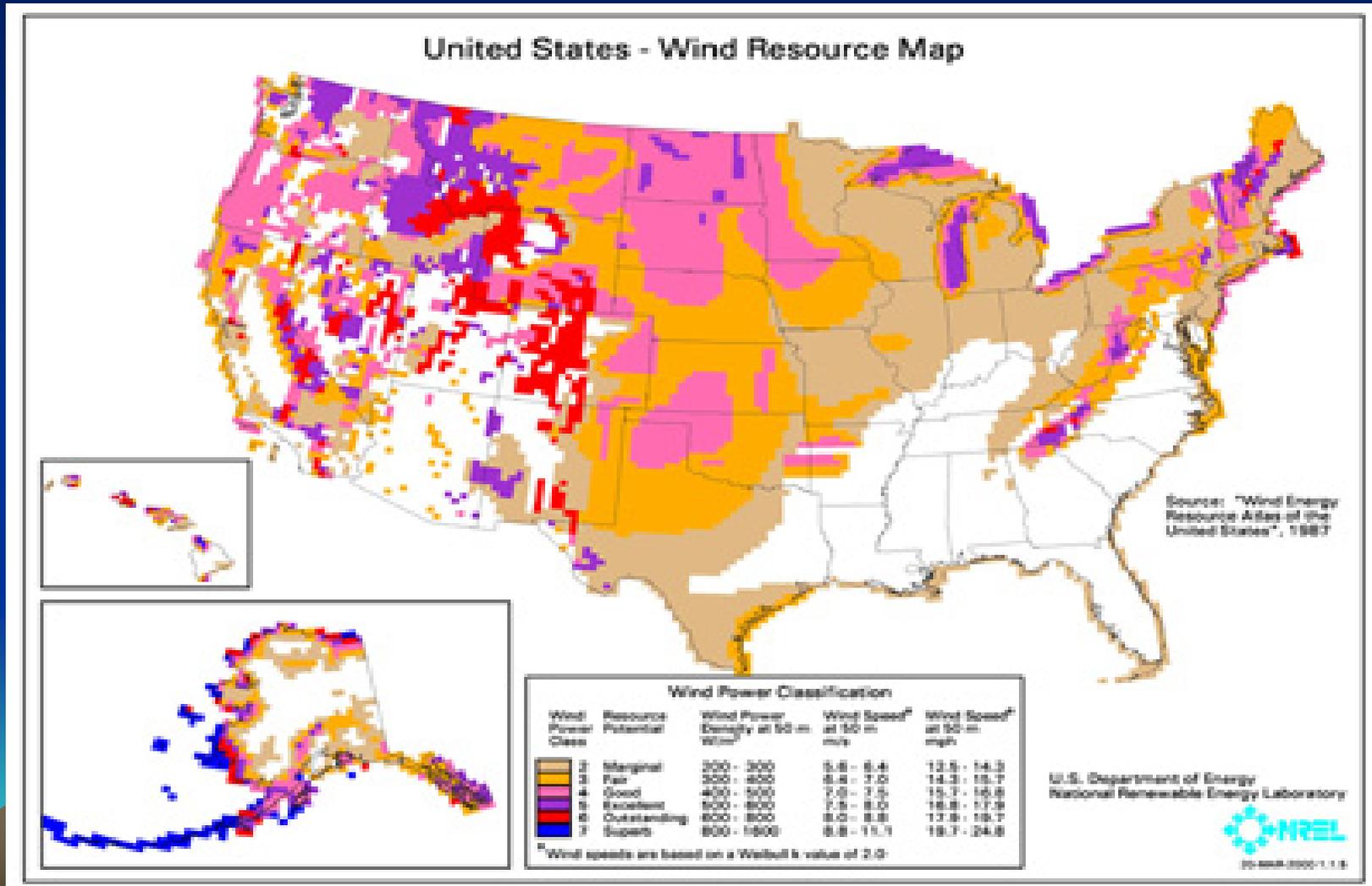


I Am Going to Concentrate On

- Wind Energy Resource Maps
- Site Selection
 - Wind resources
 - Environmental Concerns
- Collect a minimum of 3 years of data



1980s National Wind Energy Resource Assessment



Are you still using your 1980s computer? What did it do for you?

- Got you started
- You did excellent work for the 1980s – my dissertation was done on an Mac SE 30
- You showed us your potential
- And a few us became breakout leaders



Where Are We Now? Not in the 80s

- www.eere.energy.gov/windandhydro/windpoweringamerica/wind_maps.asp
- “windpoweringamerica” is one word
- State by state maps – much more detailed

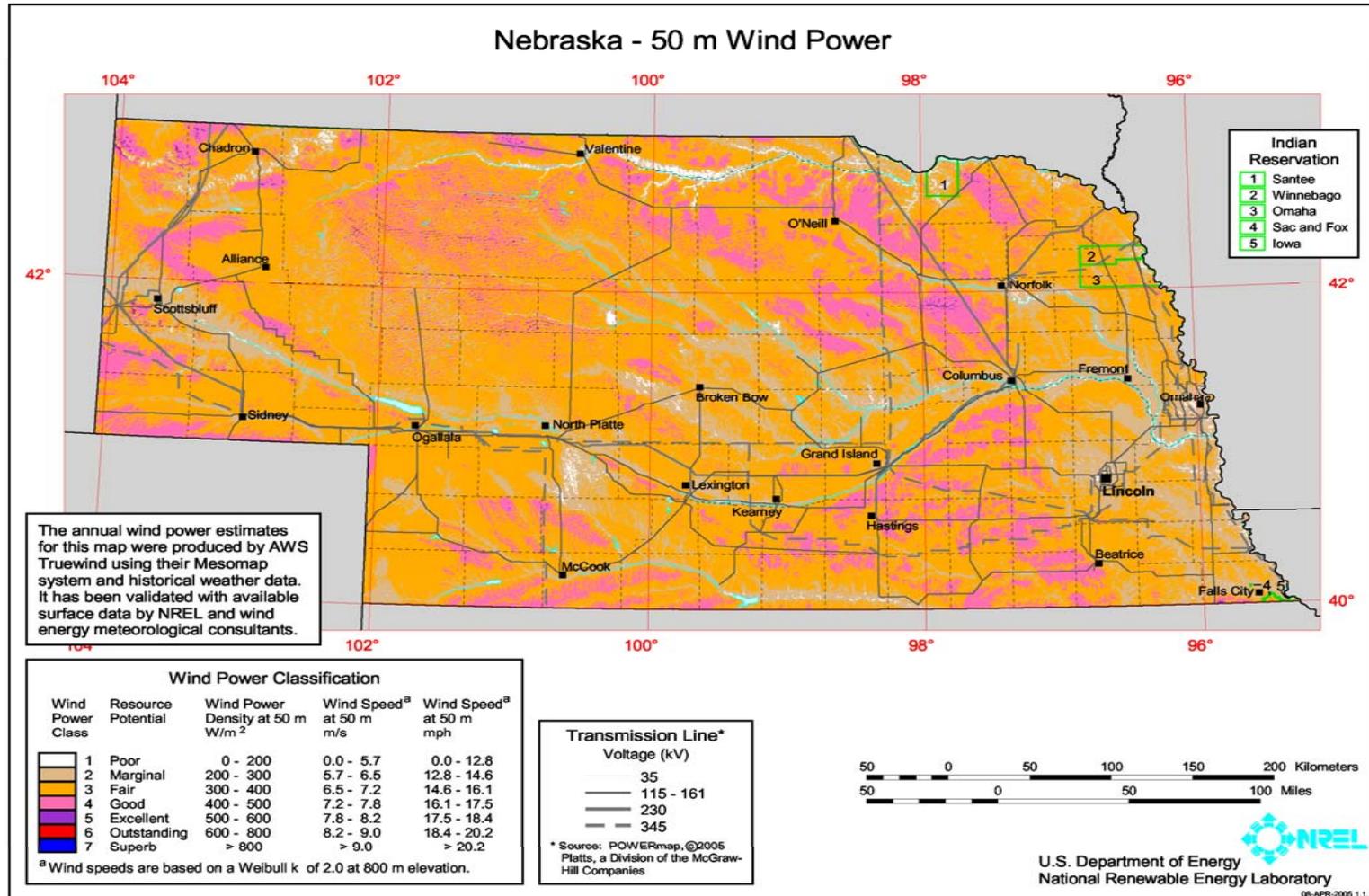


Caution

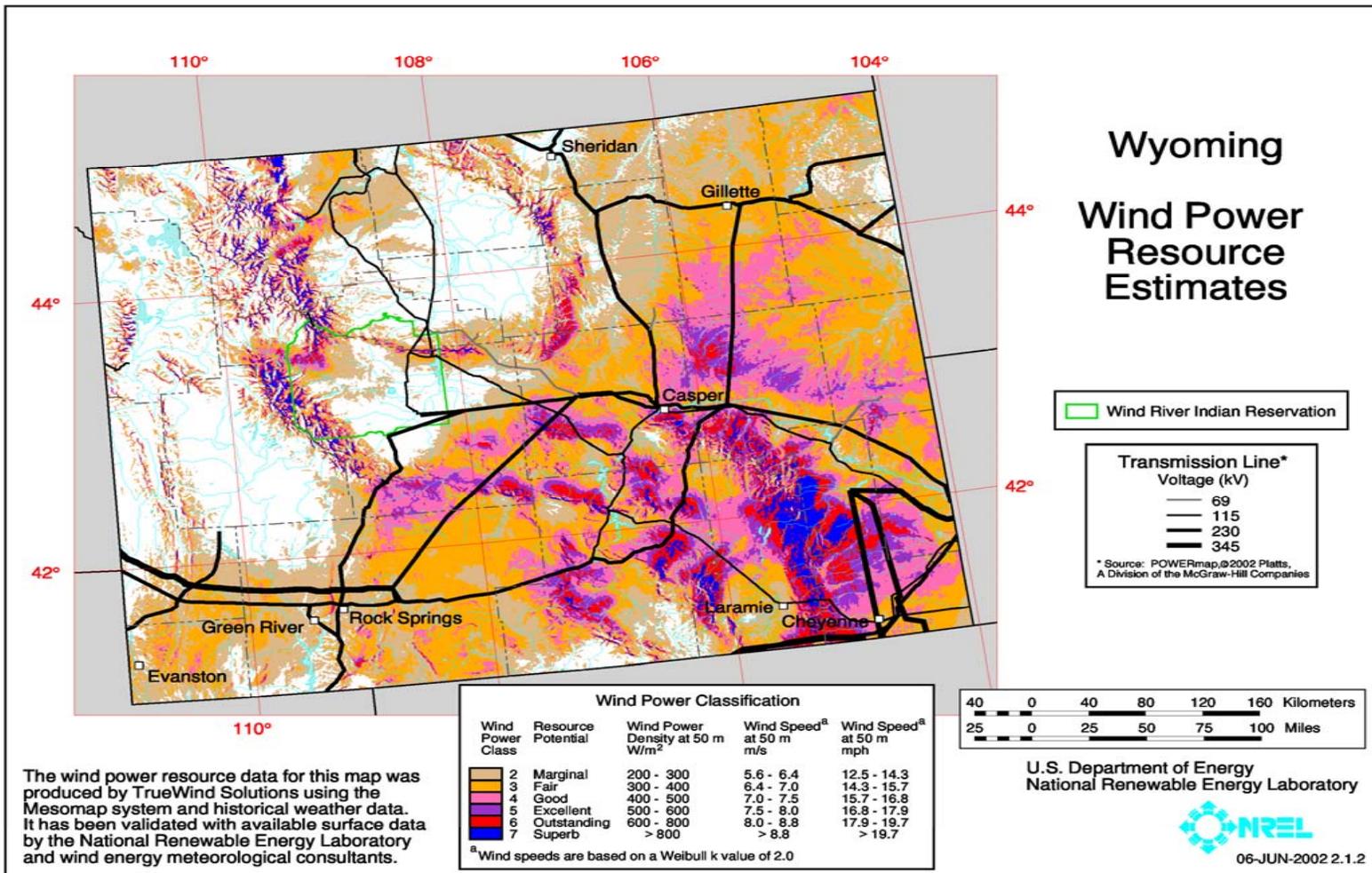
- A complete site specific wind energy resource assessment still needs to be done.
- The Take Home Message: A Complete Resource Assessment is Essential



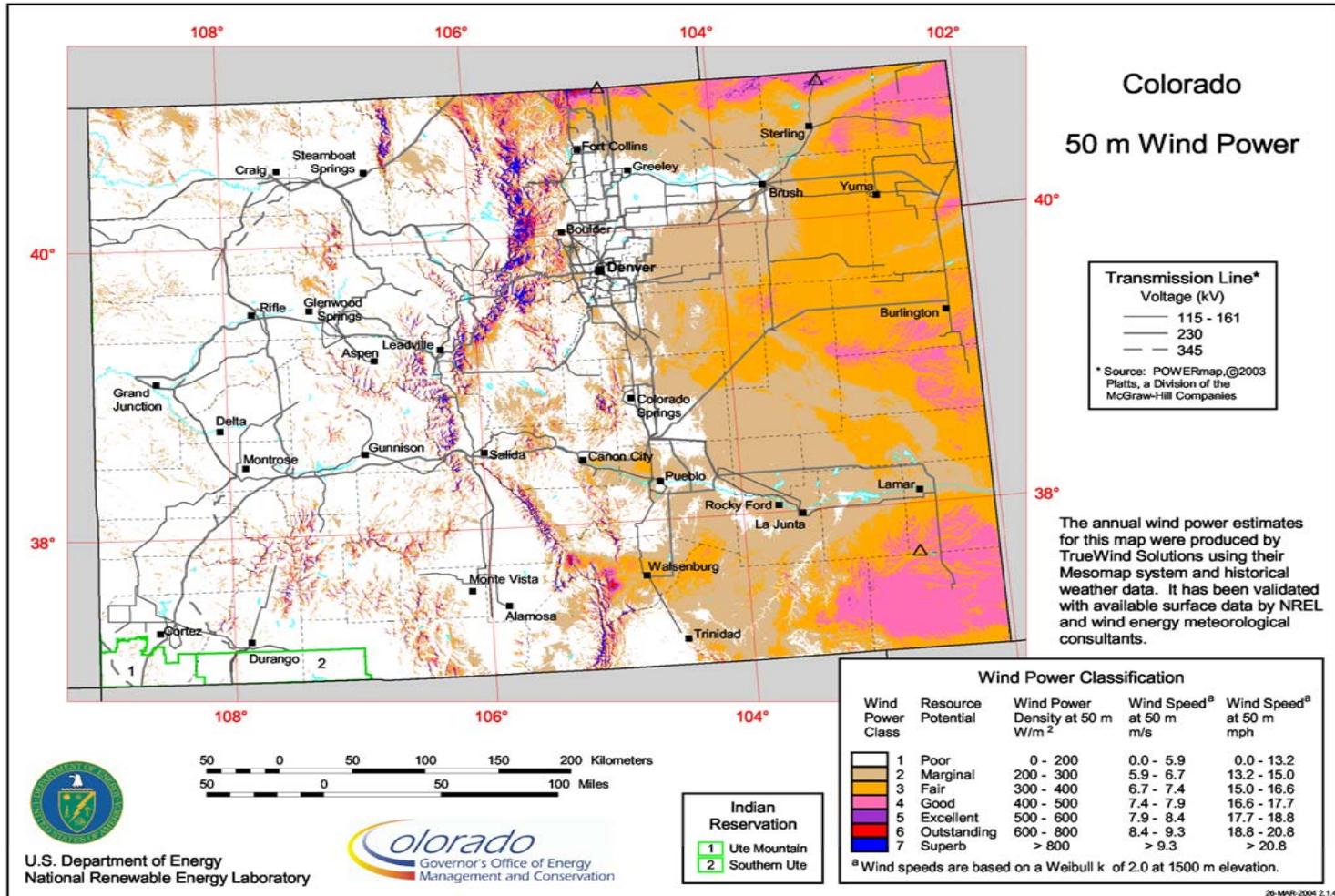
Nebraska



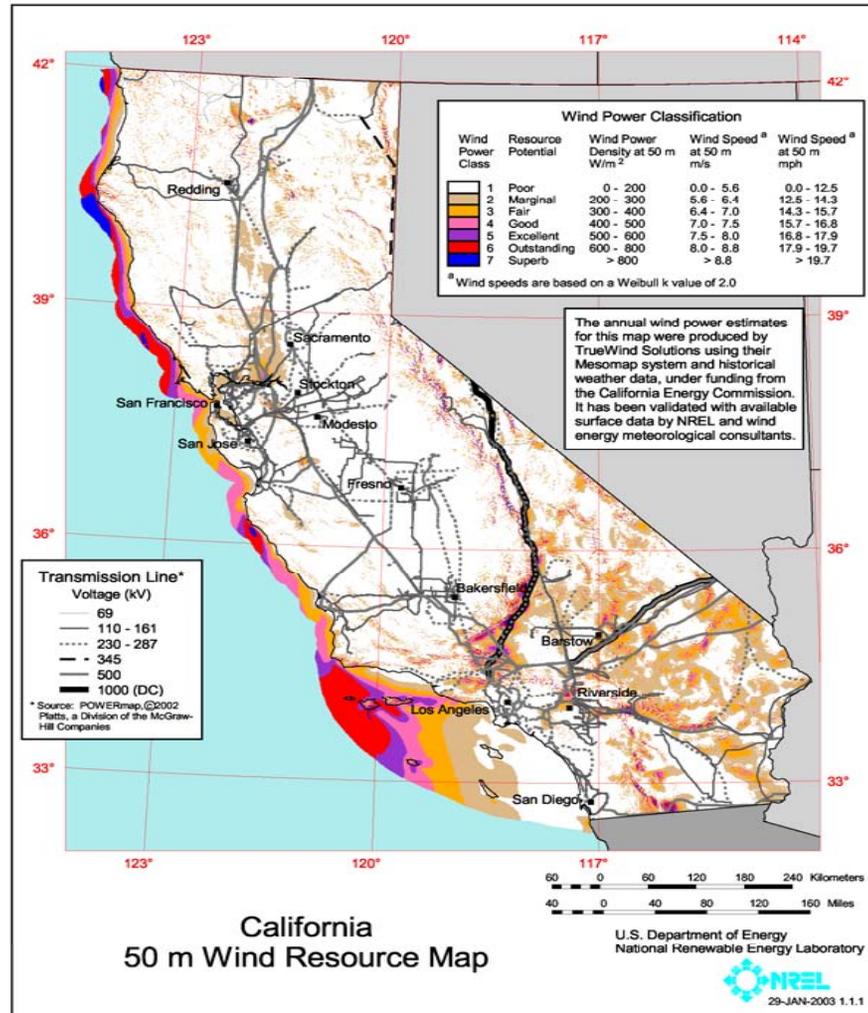
Wyoming



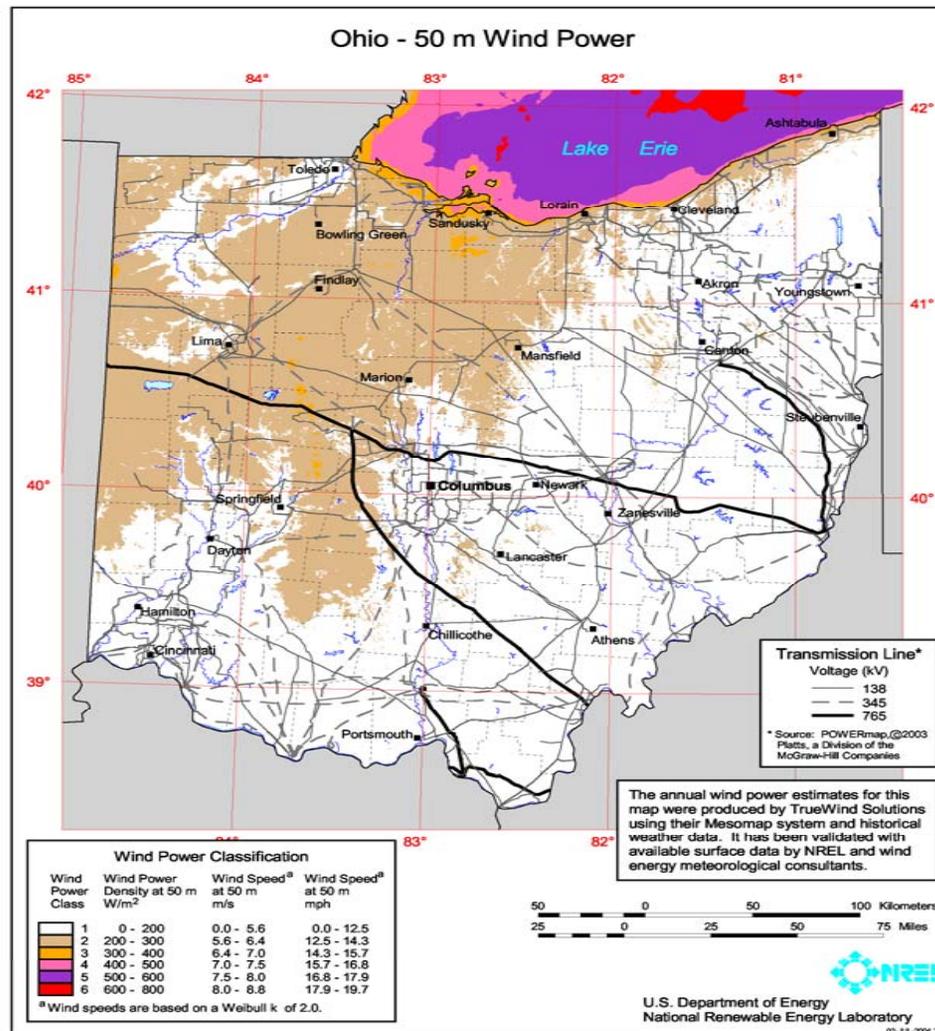
Colorado



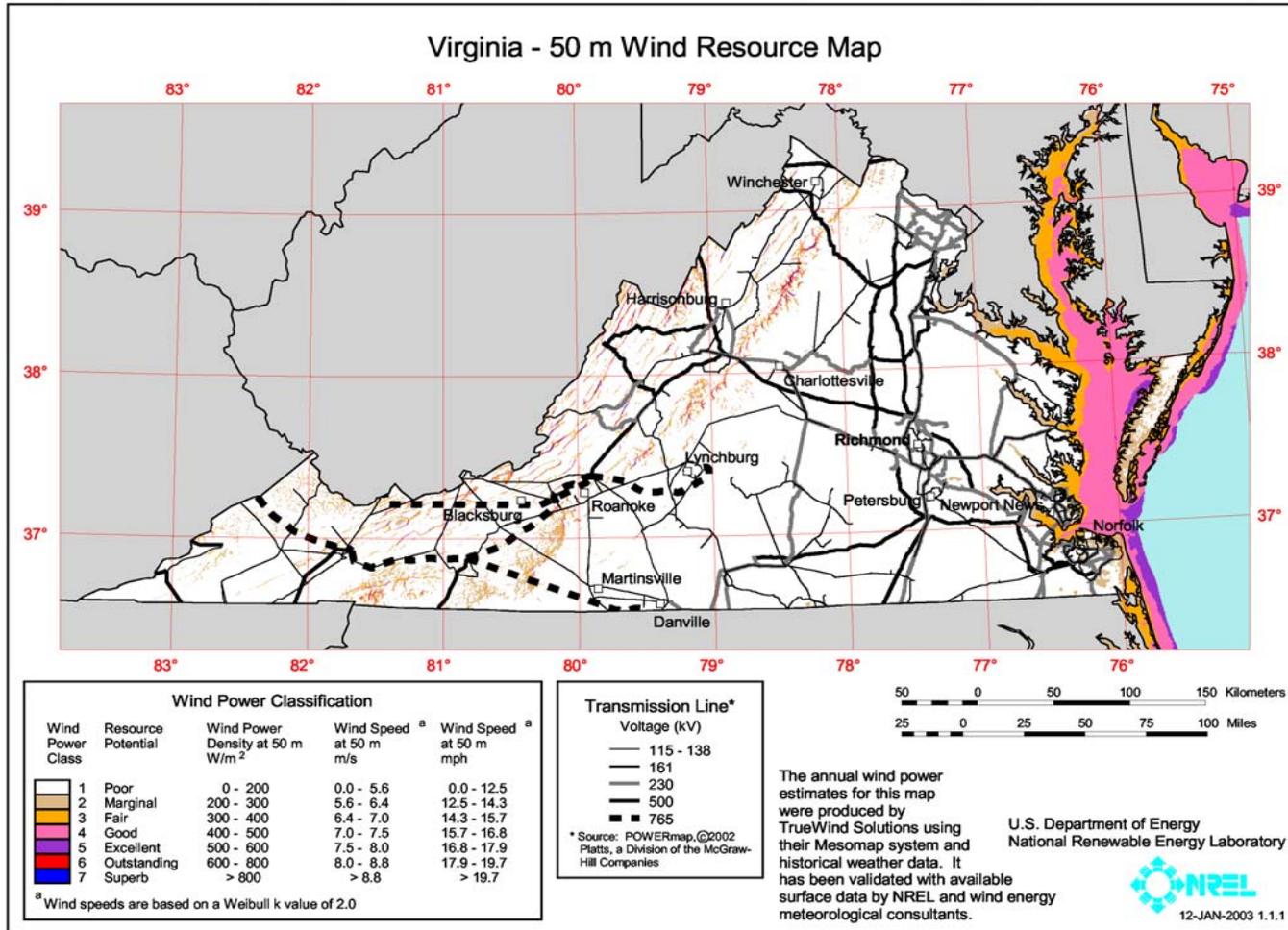
California



Ohio

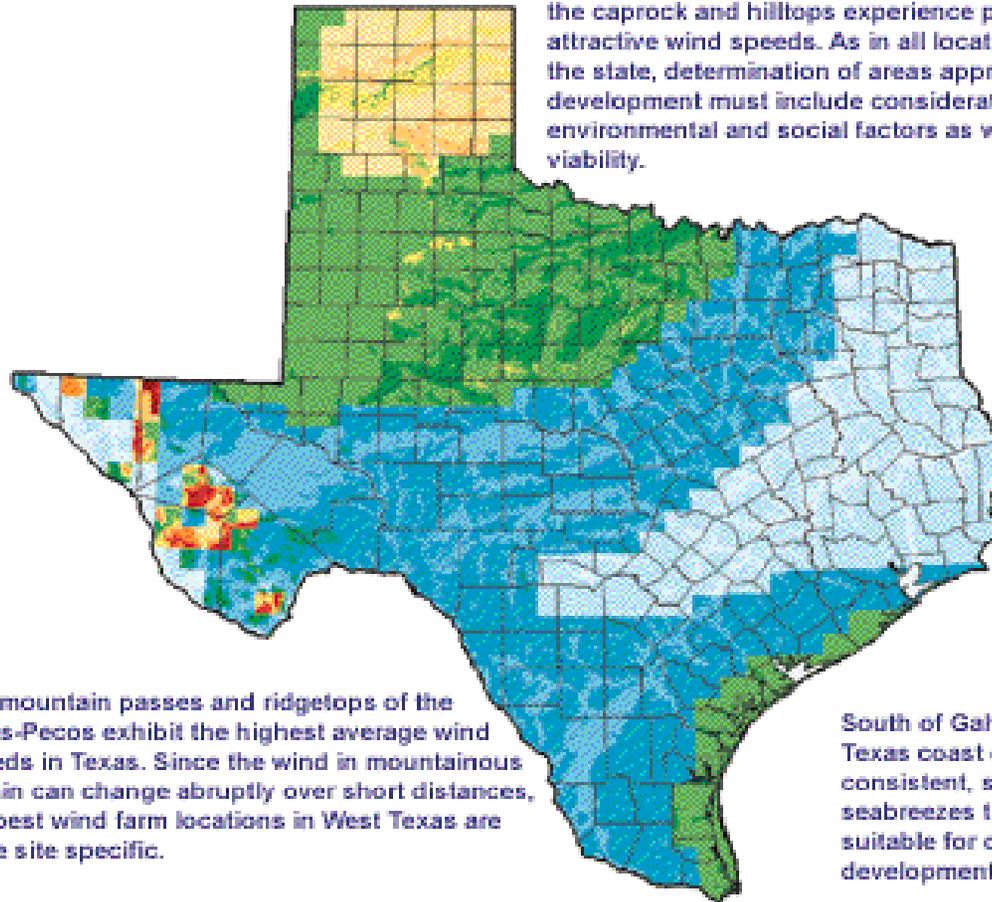


Virginia



Texas

The Panhandle contains the state's greatest expanse with high quality winds. Well-exposed locations atop the caprock and hilltops experience particularly attractive wind speeds. As in all locations throughout the state, determination of areas appropriate for development must include consideration of environmental and social factors as well as technical viability.



The mountain passes and ridgetops of the Trans-Pecos exhibit the highest average wind speeds in Texas. Since the wind in mountainous terrain can change abruptly over short distances, the best wind farm locations in West Texas are quite site specific.

South of Galveston, the Texas coast experiences consistent, strong seabreezes that may prove suitable for commercial development.

Georgia Research

- On Shore
 - Class 3 east of I-95
 - Sea Breeze
 - Afternoon Peaking

Probably holds true for the southeastern states in general – marginal to good along the coast for peaking power

Better wind energy potential in the southern mountains but the economic value of the vistas is more important



Meteorological Data Collection

- Now that we have a good idea where to look
 - Good wind energy potential based on wind energy resource potential maps
 - Connectivity Issues
 - Known environmental or social-political stoppers

- It is time to collect the data



Meteorological Data Collection

- Warning: Don't fall into the trap that you are collecting data for the region and not for a particular site. I have seen too many regional wind energy resource data collection studies become site specific studies.



Meteorological Data Collection

- ***For the Most Recent Standards***
 - ***Standard Procedures for Meteorological Measurements at a Potential Wind Turbine Site - Standard 8.1***

American Wind Energy Association (AWEA)



What Data Do You Need?

- Times have changed
 - Early 1990s: Hub height 35 m
 - Middle 1990s: Hub height 50 m
 - Late 1990s: Hub height 65 m
 - 2006: Hub height 80 m
 - Soon: Hub height 100 m



Reason for Increasing Hub Height

The wind speed generally increases with height

Historically micrometeorologists used the $1/7^{\text{th}}$ power law. It almost never works; the atmosphere is not that simple.



The 1/7th Power Law

$$[S_{(z)} / S_{(z_{ref})}] = [z / z_{ref}]^a$$

Where $a = 1/7$ (0.13)

Once wind developers started making actual measurements, they found that the assumed 1/7th generally underestimated the actual increase in wind speed with height in the plains.



The 1/7th Power Law

$$S(z) = S(z_{\text{ref}}) [z / z_{\text{ref}}]^{0.13}$$



What Is the Expected Wind Speed and Increase in Power Potential at Various Heights if the 25 m Wind Speed is 10 mph?

- Early 1990s: Hub height 35 m → 10.4 mph (12 %)
- Middle 1990s: Hub height 50 m → 10.9 mph (30%)
- Late 1990s: Hub height 65 m → 11.3 mph (44%)
- 2006: Hub height 80 m → 11.6 mph (56%)
- Soon: Hub height 100 m → 12.0 mph (73%)

Assumed $1/7^{\text{th}}$ power law



The Exponent is Site Specific

My Recommendation for Wind Speed and Direction Measurements

5 minute average wind speed and direction and peak wind speed at

10 m

25 m

50 m

80 m

100 m



Other Meteorological Elements

- Surface pressure
- Temperature and Humidity at least at 10 m and hub height (100 m)
- Solar Radiation (it is cheap and easy to gather this data, might be useful later)



Other Meteorological Issues

Surface roughness & shear

Escarpments

Variable winds

Turbulence

Wind obstacles

Wind shade

Wake

The park effect

The tunnel effect

The hill effect

Turbine siting



Other Meteorological Data Recommendations

- I am an atmospheric scientist – the more data the better
- Used Calibrated Instruments that are traceable back to a standard – regional resource assessments have a tendency to become site specific
- QC/QA the data daily – with cellular modems this should not be an issue any more – besides equipment failure, watch for instrument drift
- Have a maintenance budget and schedule, complete checks should be done at least twice a year; calibrations at least once a year
- Wind energy projects are investments of millions of dollars – don't skimp on data collection, use good equipment



Environmental Issues

- Wind Turbine are Ugly and Noisy
 - The choice is not wind turbines or no wind turbines
 - What is beauty?
 - Modern vs. ancient (1980s wind turbines)
- Wind Turbines Kill Raptors
 - Yes birds are killed by wind turbines, automobiles, buildings, etc.
 - Numbers killed have been greatly reduced
- Wind Turbines Do Not Offset Pollution because they only operate part of the time
 - Properly sited turbines will operate 65 to 80% of the time (AWEA)
 - No power plant is online 100% of the time
 - Redundancy in the system
 - Depends on the purpose, base power or peaking power

Economic Benefits for Rural America

Yes!

If the homework is done first!

Very location specific.

Follows the three most important rules in real estate ...



Economic Benefits for Rural America

Can be combined with farming and ranching

- An additional, stable source of income
- Increases local tax base
- Home “grown” energy
- Modular, can grow over time and take advantage of improved technologies
- Stable Energy Prices – the input, wind, is free



Economic Benefits for Rural America

Landowners with wind development on their property receive \$2,000 to \$5,000 per turbine per year. US DOE

(web accessed 02/14/2006

www.eere.energy.gov/windandhydro/windpoweringamerica/ag_sector.asp)







Additional Web Resources

**DOE: Wind Energy Development and the
Agricultural Community**

www.eere.energy.gov/windandhydro/windpoweringamerica/ag_sector.asp



Additional Web Resources

DOE: National Renewable Energy Lab

www.nrel.gov/wind/



Additional Web Resources

Farm Bureau

www.iowafarmbureau.com/windassessments/

Iowa Farm Bureau launches online wind
energy assessments (Oct. 7, 2005)



Additional Web Resources

Alternative Energy Institute (1977)

West Texas A&M University

www.windenergy.org/index.htm

Excellent source of semi-technical to technical research reports and books.



Additional Web Resources

American Wind Energy Association

www.awea.org



Additional Web Resources

www.eere.energy.gov/windandhydro/windpoweringamerica/ag_sector.asp

www.nrel.gov/wind/

www.iowafarmbureau.com/windassessments/

www.windenergy.org/index.htm

www.awea.org



