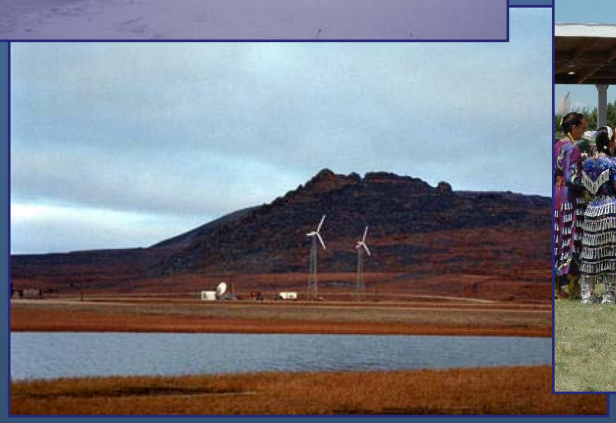
Wind Energy



Sizes and Applications

Small (≤10 kW)

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

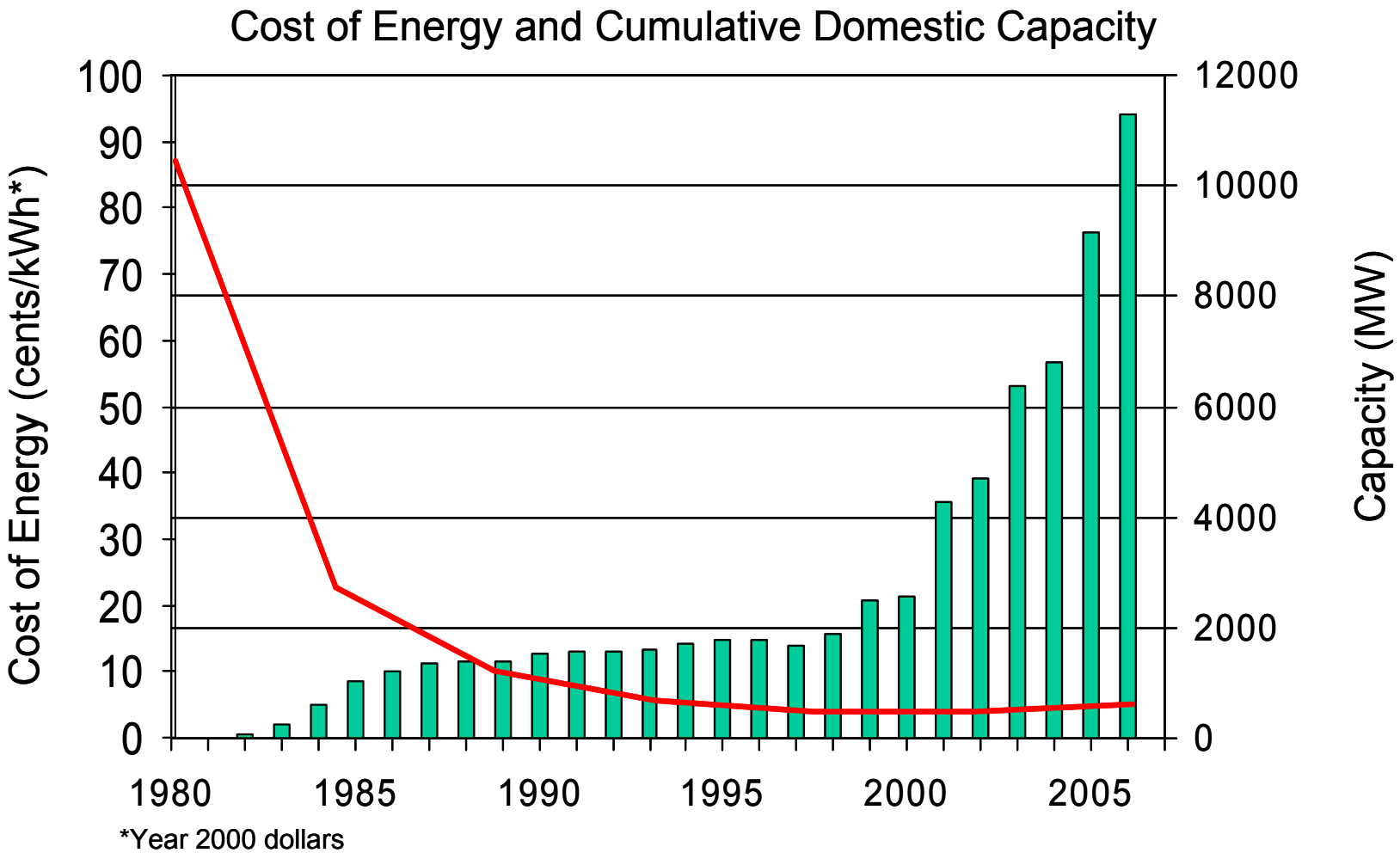
Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Small Distributed Power

Large (250 kW – 2+ MW)

- Central Station Wind Farms
- Community Distributed Power

Capacity & Cost Trends



Increased Turbine Size - R&D Advances - Manufacturing Improvements

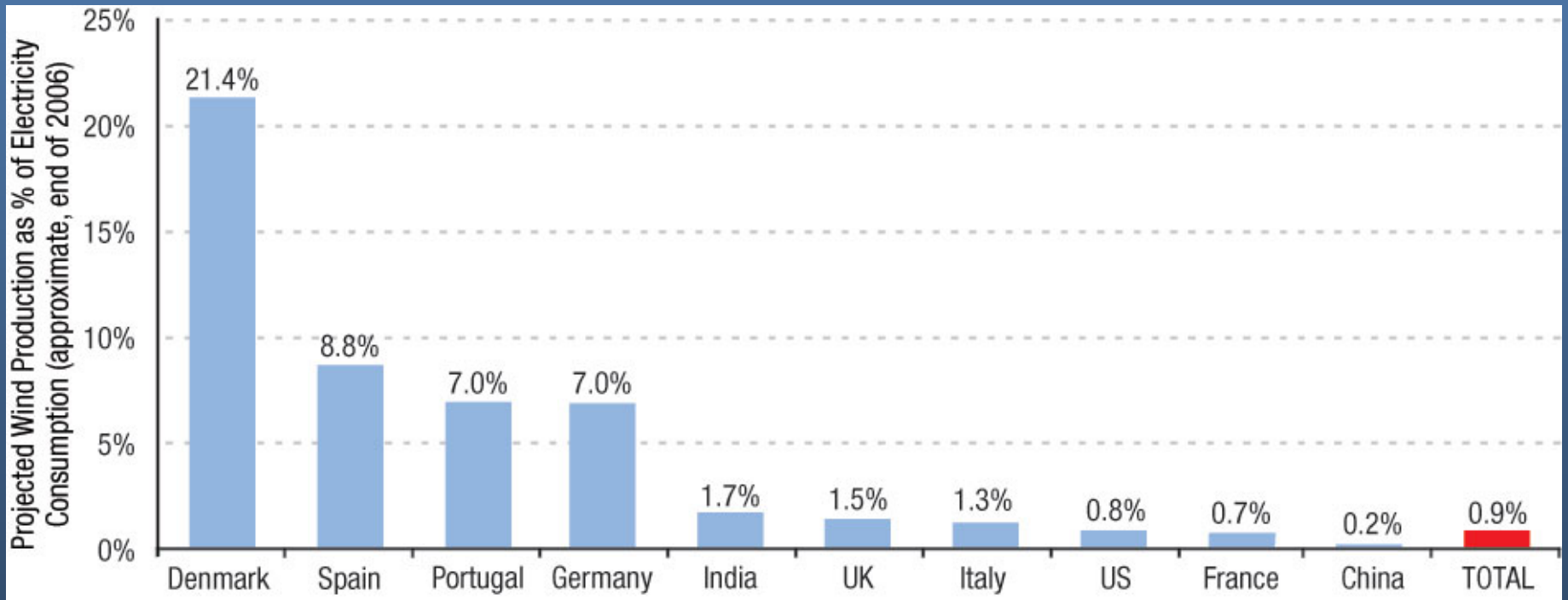
U.S. Leads World in Annual Wind Capacity Additions; Third in Cumulative Capacity

Table 1. International Rankings of Wind Power Capacity

Cumulative Capacity (end of 2006, MW)		Incremental Capacity (2006, MW)	
Germany	20,652	**US**	**2,454**
Spain	11,614	Germany	2,233
US	**11,575**	India	1,840
India	6,228	Spain	1,587
Denmark	3,101	China	1,334
China	2,588	France	810
Italy	2,118	Canada	776
UK	1,967	UK	631
Portugal	1,716	Portugal	629
France	1,585	Italy	417
Rest of Wold	11,102	Rest of World	2,305
TOTAL	**74,246**	**TOTAL**	**15,016**

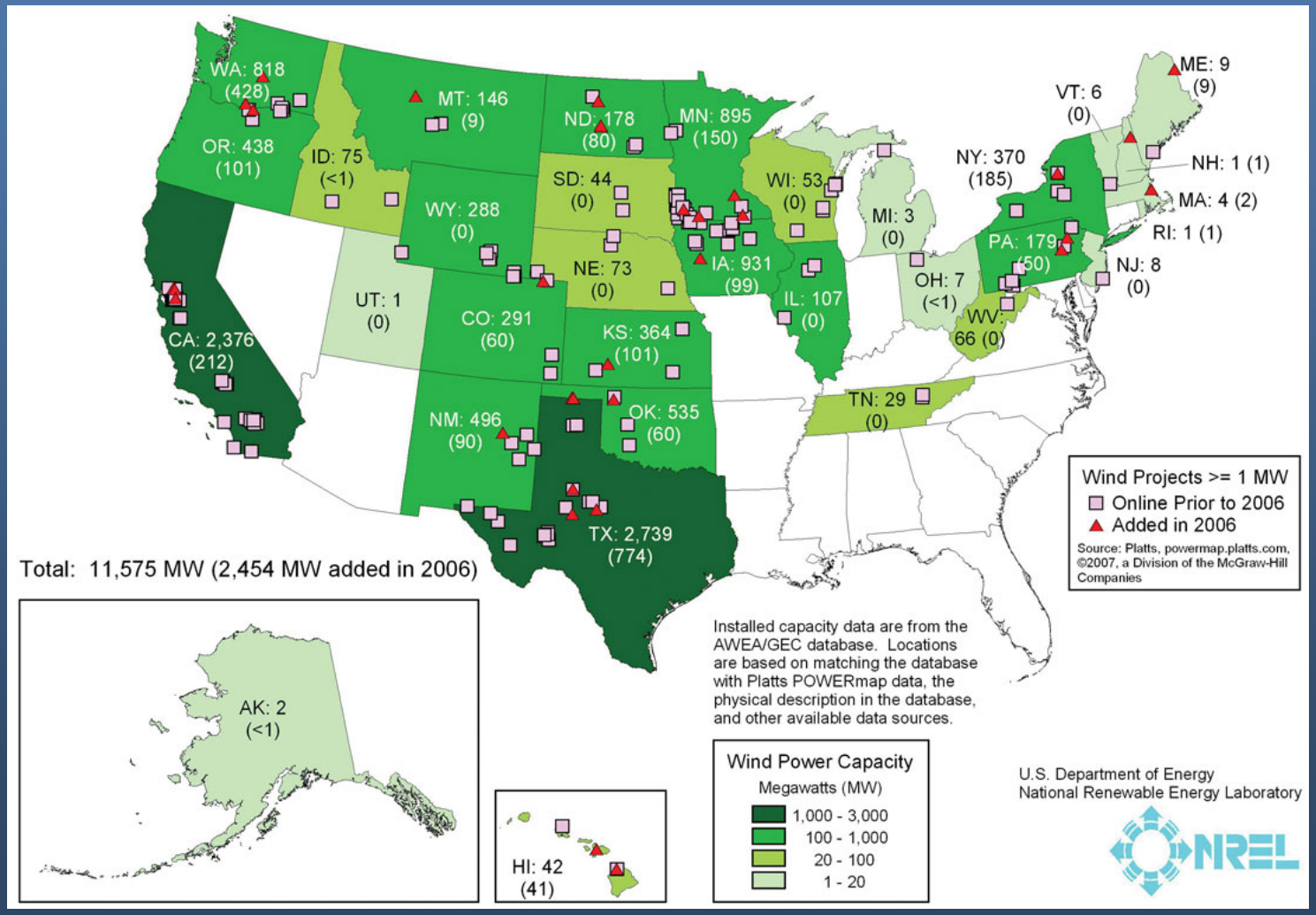
Source: BTM, 2007; AWEA/GEC dataset for U.S. cumulative capacity.

U.S Lagging Other Countries for Wind As a Percentage of Electricity Consumption



Source: Berkeley Lab estimates based on data from BTM and elsewhere.

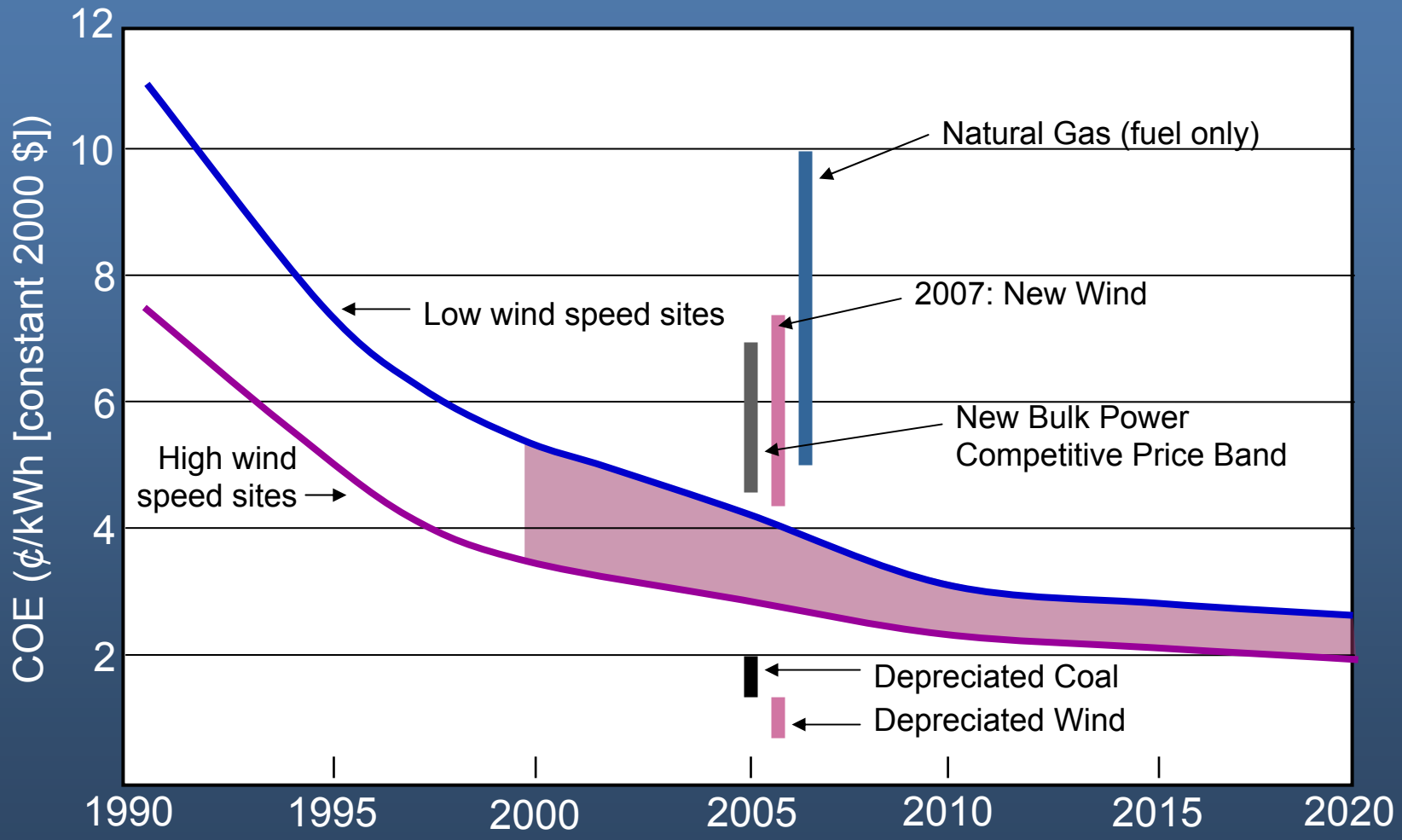
Geographic Spread of Wind Projects



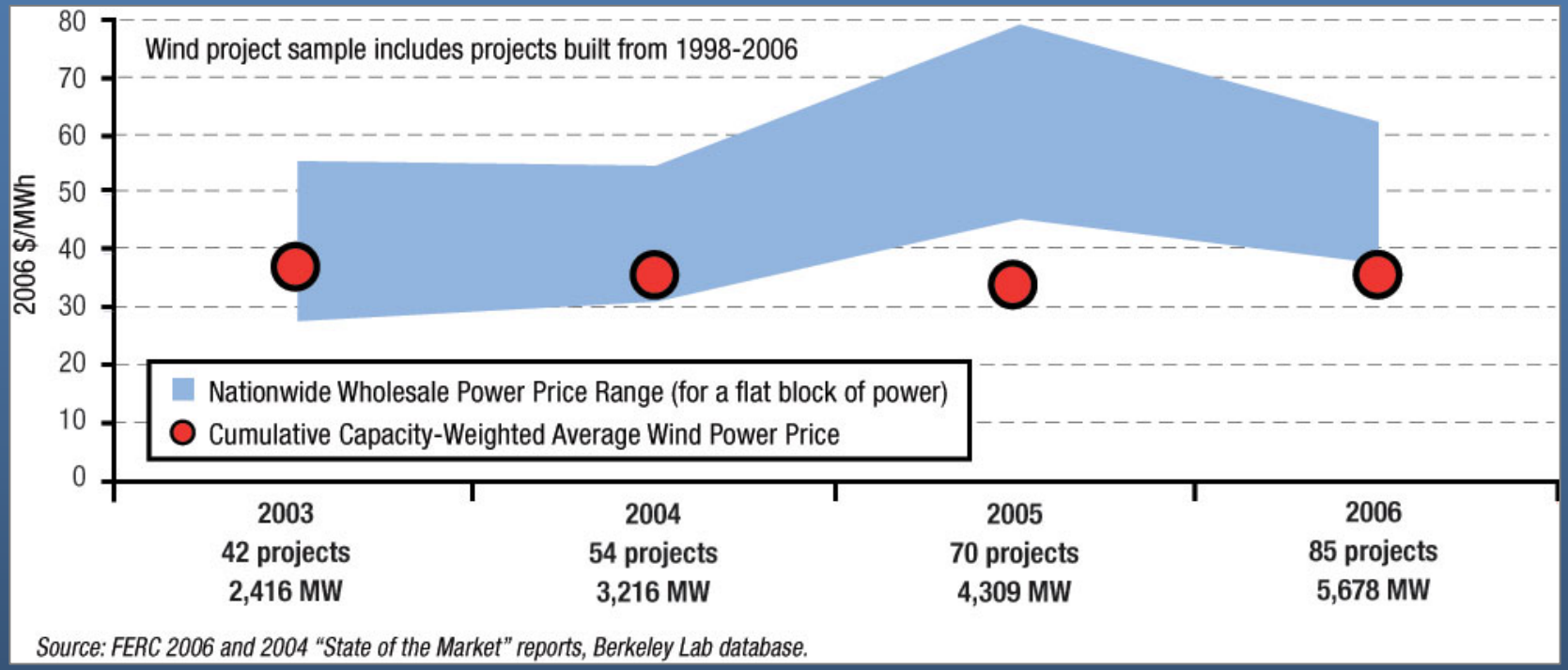
Drivers for Wind Power

- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Green Power
- Energy Security

Wind Cost of Energy

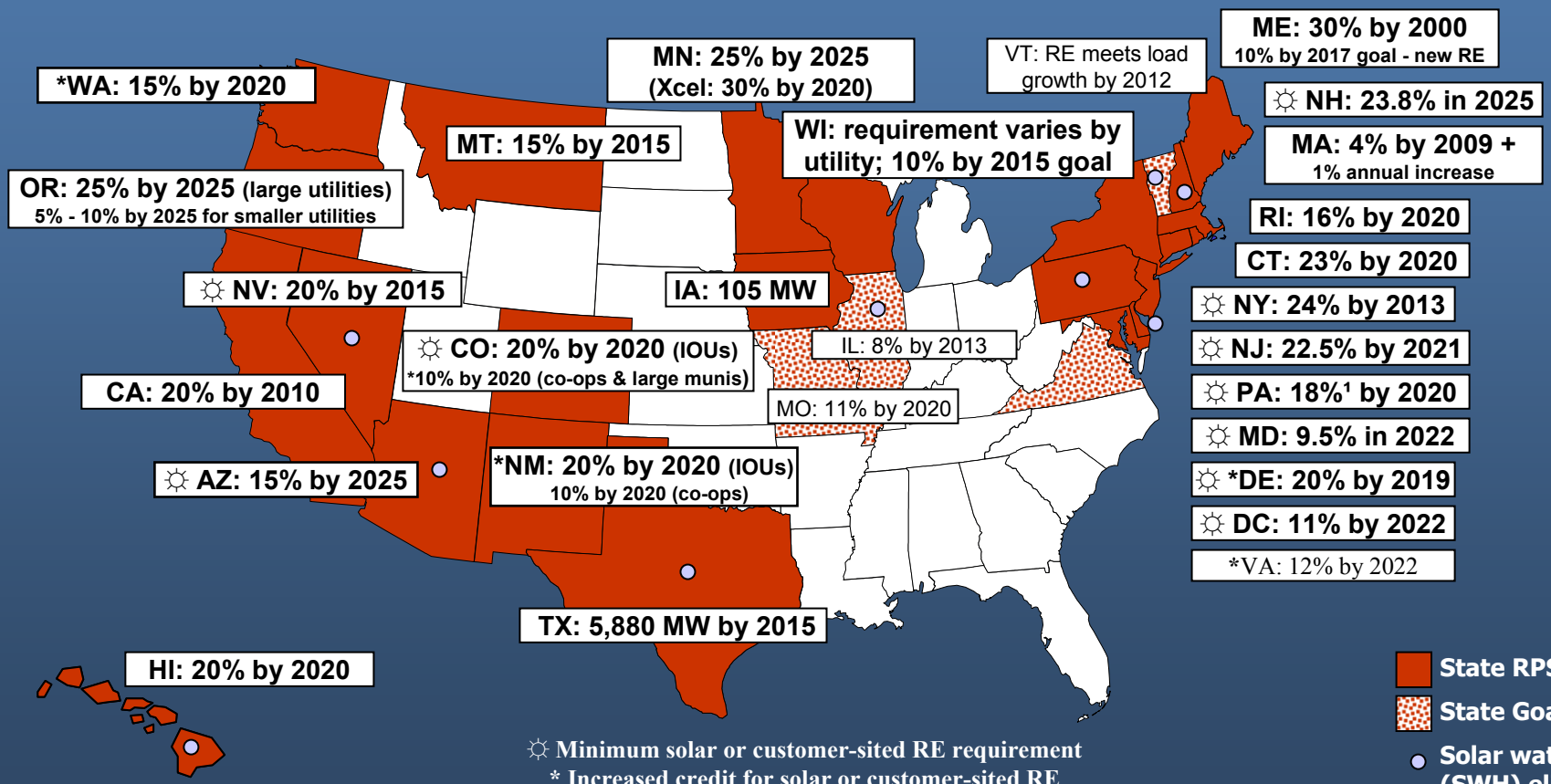


Nationally, Wind Has Been Competitive with Wholesale Power Prices in Recent Years



- Wind projects built from 1998-2006 have, in aggregate, been competitive relative to conventional wholesale prices over the 2003-06 timeframe
- Wholesale price range reflects a flat block of power across 26 pricing hubs in the U.S. (see map on previous slide)
- Wind costs represent capacity-weighted average price for wind power for entire sample of projects built from 1998-2006

Renewables Portfolio Standards



☼ Minimum solar or customer-sited RE requirement
* Increased credit for solar or customer-sited RE
¹PA: 8% Tier I / 10% Tier II (includes non-renewables); SWH is a Tier II resource

Wind Energy Investors

SIEMENS

Environmental Benefits

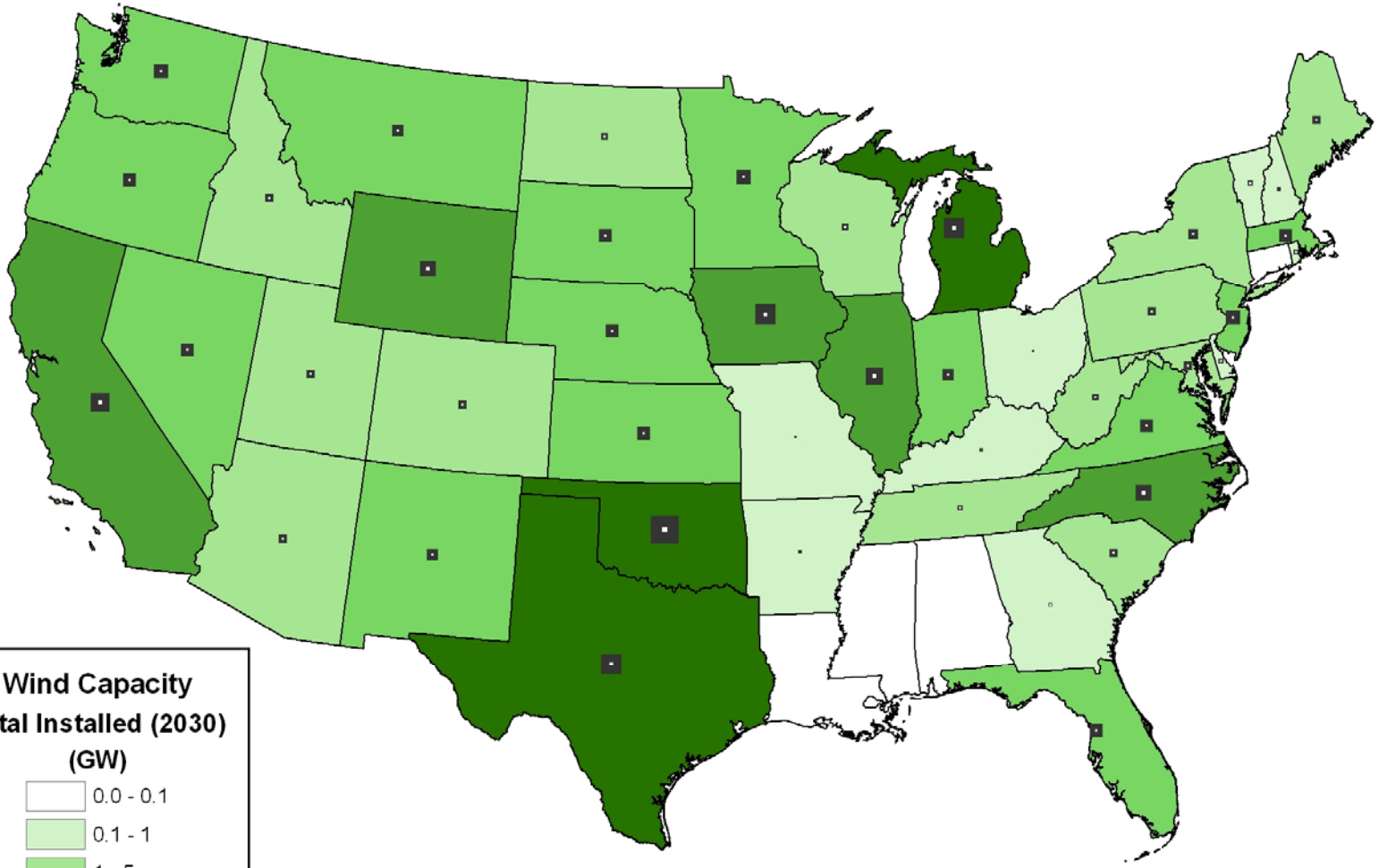
- No SOx or NOx
- No particulates
- No mercury
- No CO2
- No water

Energy-Water Nexus

Key Issues for Wind Power

- Policy Uncertainty
- Siting and Permitting: avian, noise, visual, federal land
- Transmission: FERC rules, access, RTO formation, new lines
- Operational impacts: intermittency, ancillary services, allocation of costs
- Accounting for non-monetary value: green power, no fuel price risk, reduced emissions

Installed Wind Nameplate Capacity by State (2030)



Wind Capacity Total Installed (2030) (GW)

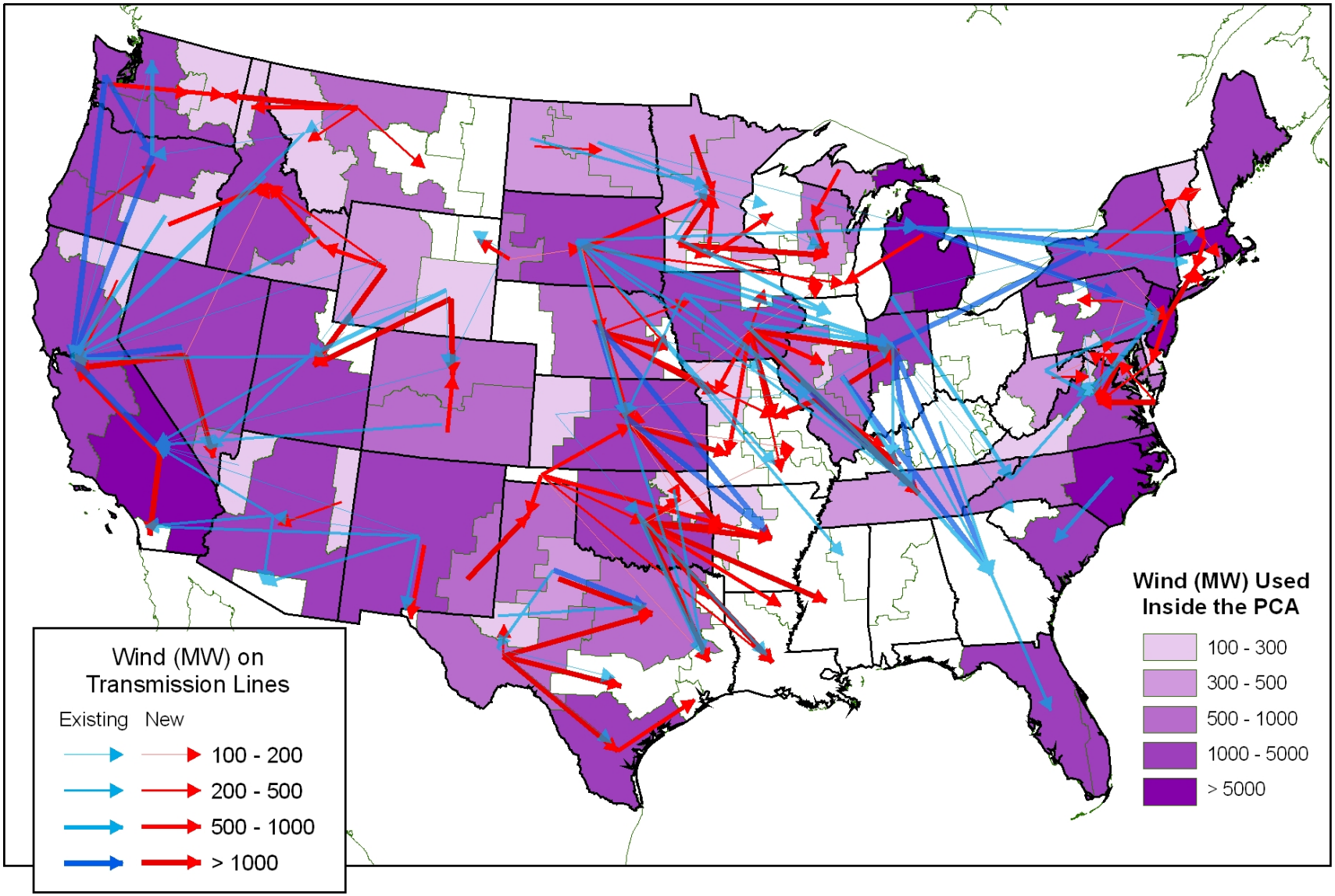
- 0.0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

The black square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The white square represents the actual land area that would be dedicated to the wind turbines (2% of the black square).

Wind_Vision_06-19-2007 - DRAFT

2030 - Between PCA Transfers and In-PCA Use for Wind (All Classes)

Total Between PCA Transfer >= 100 MW (all power classes, onshore and offshore)
Arrows originate and terminate at the centroid of the PCA for visualization purposes; they do not represent physical locations of transmission lines.



Wind_Vision_06-19-2007 - DRAFT

Dale Osborn's Famous Diagram
"Wind Project Development Process"

This is not always a straight forward process and the steps are not always in this order.
Sometimes the steps are repeated in an iterative fashion to optimize the economics of the project

Site Selection

Land Agreements

Wind Assessment

Environmental Review

Economic Modeling

Interconnection Studies

Permitting

Sales Agreements

Financing

Turbine Procurement

Construction Contracting

Operations & Maintenance

Site Selection

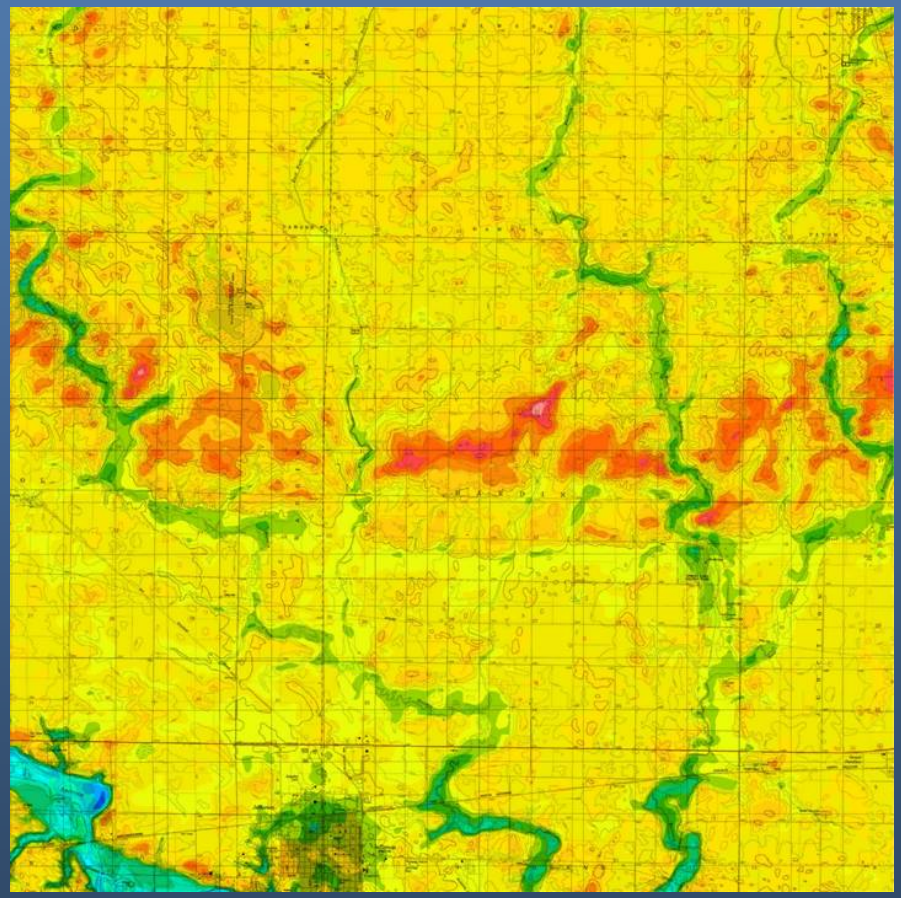
- Depends upon who the owner is and who the wind power is for
- Schools or businesses usually want turbine right at facilities
- Municipal and cooperative utilities want the turbine(s) to be near or in their service territory
  - This somewhat limits the suitable areas
- Larger projects are sited in windy areas relatively close to available transmission lines
- FAA height restrictions often affect projects near towns and cities

Land Agreements

Single 900 kW Wind Turbine
Owned By Waverly Light & Power
Connected to 13.8 kV
Distribution Line

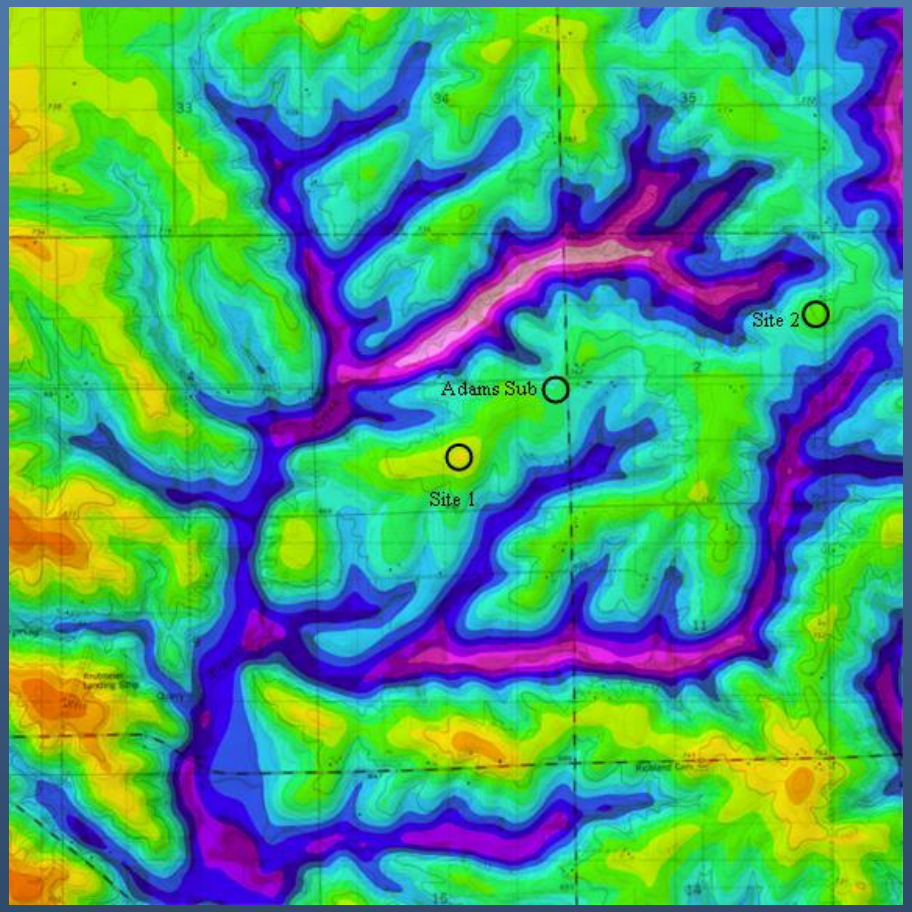
- Land may already be owned by turbine owners
  - Schools, businesses
- Land may be owned by project beneficiaries
  - municipal and cooperative utilities
- Land owned by unrelated third parties
- Agreements have options to exercise in a given amount of time and agreements specify the payment rates
  - Typically $3,000 to $6,000 per turbine / year

Wind Assessment



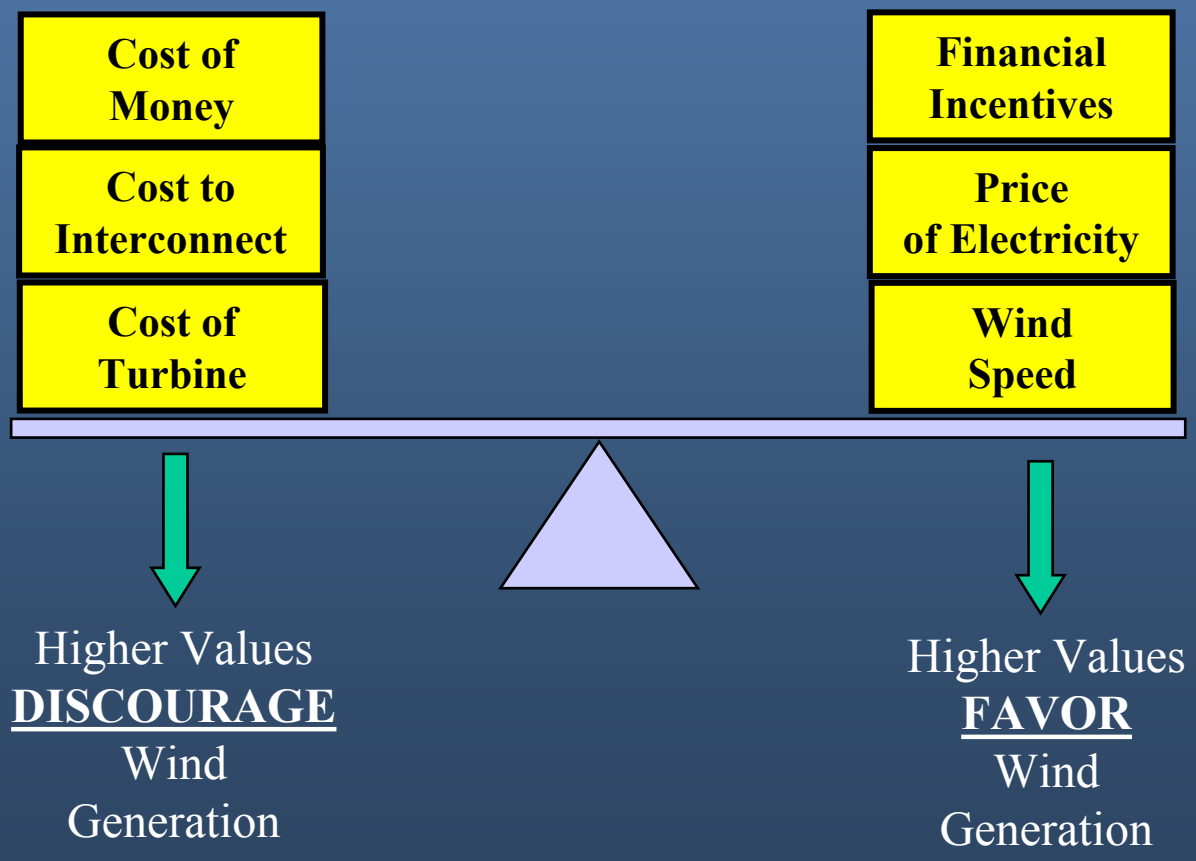
- Historically, met towers have been used with 1 year of data being required, depending on the project size and financing requirements.

Economic Modeling

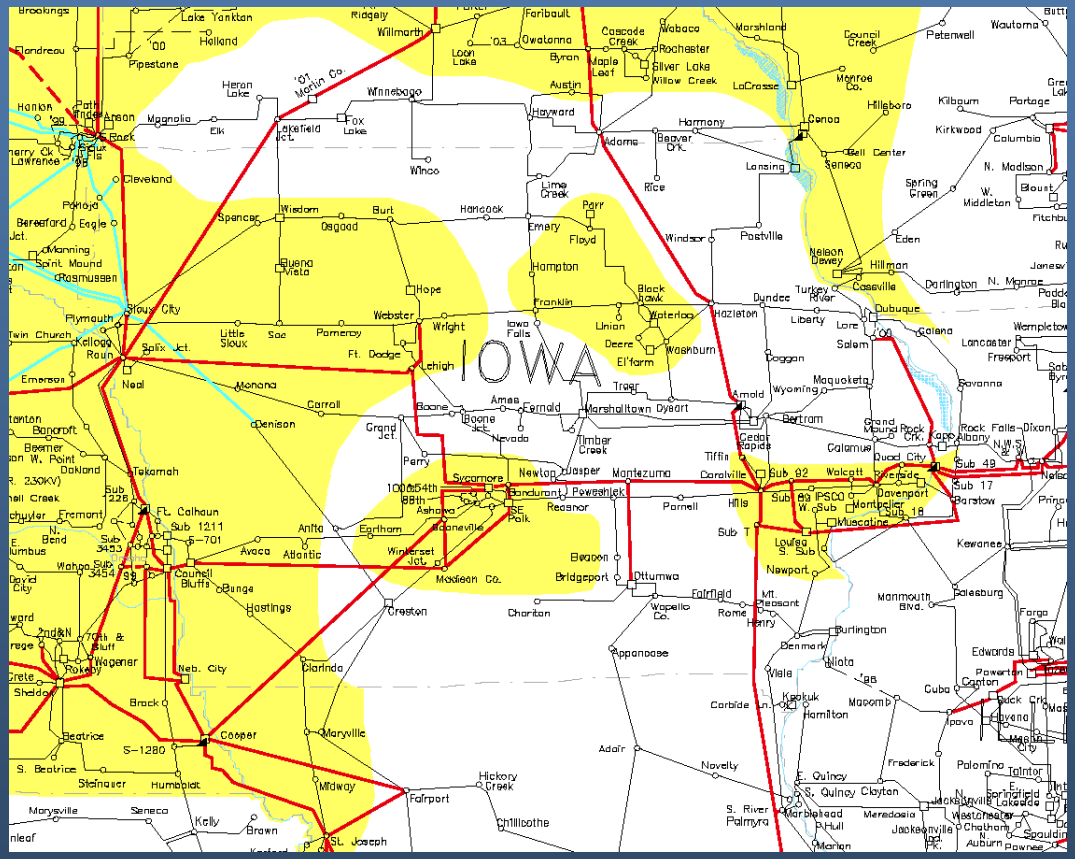


- Extremely important
- Preliminary evaluations are often done for site selection purposes
- More detailed evaluations are done for design and layout optimization
- Very comprehensive for due diligence for outside financing

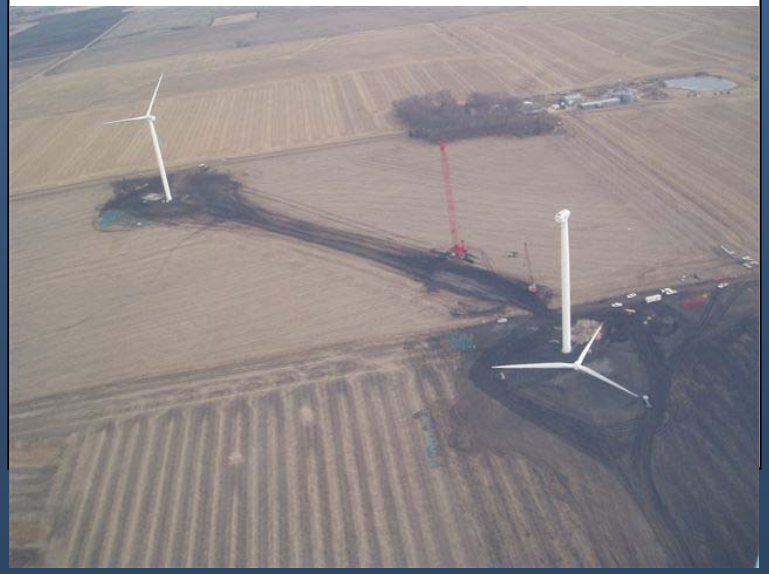
The Overall Economics of Wind Generation is Determined by a Balance of Factors



Interconnection Studies


IOWA
Sioux City
Council Bluffs
Cooper
Ft. Calhoun
Neal
Cedar Rapids
Davenport
Muscatine
Ottumwa
Burlington
Marshalltown
Ames
Boone
Creston
Fairport
St. Joseph
Marshalltown
Dyersart
Arnold
Bertram
Tiffin
Carolville
Walcott
Riverside
Newton
Sycamore
Bondurant
Powershiek
Montezuma
Pomell
Hills
Louisa
Newport
Fairfield
Mt. Pleasant
Henry
Rome
Wapello Co.
Bridgeport
Bagoon
Madison Co.
Winterset Jct.
Adaire
Novelty
Hickory Creek
Chillicothe
Midway
Maryville
Clarinda
Neb. City
Hastings
Bunge
Atlantic
Avoca
Anita
Earlham
Adaneville
Ashawa
SE Polk
Pleasant Hill
Davenport
Moline
Rock Falls
Dixon
Albany
Clinton
Cedar Rapids
Iowa Falls
Webster
Wright
Ft. Dodge
Lehigh
Boone Jct.
Nevada
Grand Jct.
Perry
Denison
Carroll
Monona
Sioux City
Plymouth
Kellogg
Raun
Spencer
Wisdom
Osgood
Burt
Hancock
Emery
Floyd
Parr
Lime Creek
Hampton
Franklin
Union
Deere
El'farm
Washburn
Waterloo
Black Hawk
Hazleton
Dundee
Liberty
Lore
Salem
Maquoketa
Wyoming
Postville
Windsor
Nelson Dewey
Hillman
Casville
Turkey River
Dubuque
Galena
Eden
Lansing
Seneca
Bell Center
Cenoa
Harmony
Adams
Beaver Crk.
Rice
Austin
Hayward
Winneboro
Winco
Lake Yankton
Ridgely
Willmarth
Faribault
Owatonna
Byron
Loon Lake
Cascade Creek
Wabaco
Rochester
Maple Leaf
Silver Lake
Willow Creek
Marshland
LaCrosse
Council Creek
Monroe Co.
Petenwell
Wautoma
Hillsboro
Kilbourn
Portage
Kirkwood
Columbia
N. Madison
Spring Green
W. Middleton
Bloust
Fitchb
Darlington
N. Monroe
Janesv
Lancaster
Freeport
Wampleto
Savanna
Rock Falls
Albany
Davenport
Moline
Muscatine
Burlington
Mt. Pleasant
Fairfield
Ottumwa
Centerville
Chariton
Creston
Corydon
Leon
Mt. Ayr
Bedford
Clarinda
Shenandoah
Red Oak
Atlantic
Avoca
Anita
Carroll
Denison
Monona
Neal

Permitting



- May be very simple for small projects in rural areas that have few regulations
- Typically county or city approvals needed
- May include state environmental agencies
- Some states have formalized processes depending upon size of project
- FAA rules often impact siting

Sales Agreements

- If turbine is used to supply owner with power that it uses, then no sales agreement is needed unless there is excess power to be sold to the utility
  - Schools & businesses
  - Municipal, cooperative utilities
- Larger projects usually need a Power Purchase Agreement (“PPA”) because all power is sold

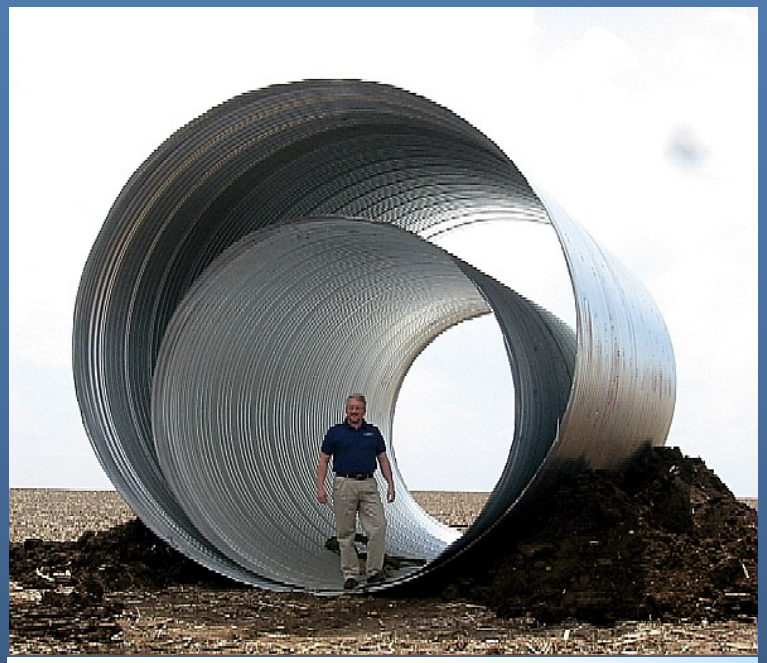
Financing

- Some projects are financed internally
  - usually very small projects when the owners use available cash, or
  - Large projects owned by large corporations or utilities, such as BP, FPL, or MidAmerican Energy
- Usually commercial loans or bonds are needed
- If income tax benefits can't be used by owners, then an outside equity partner is usually needed with a partnership flip financial structure

Turbine Procurement

- Difficult today
- Manufacturers can be picky…. they can select their customers
- May need to use small niche manufacturers
- Can get turbines through larger developers who buy them in large lots. They will likely want to be partners in the project
- Various types and numbers of turbines become available due to changes in developer's plans

Construction Contracting



- Small projects may use local contractors or project managers that hire various local area subcontractors
  - May be a turnkey contract
- Large projects may hire large companies to provide a variety of engineering, procurement, and construction services.

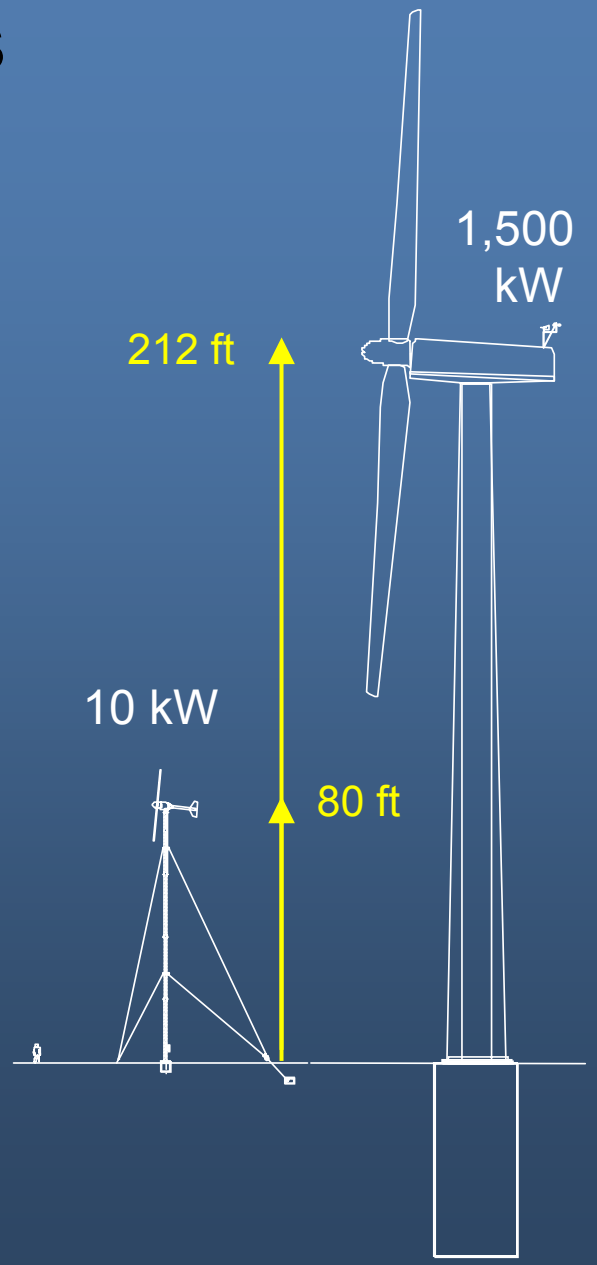
Operations & Maintenance

1

- Small projects
  - May use manufacturer's personnel initially
  - May use local staff members after they are trained
- Larger projects will often rely on manufacturers during the warranty period, and then hire their own staffs after that

Small Wind Turbines Are Different

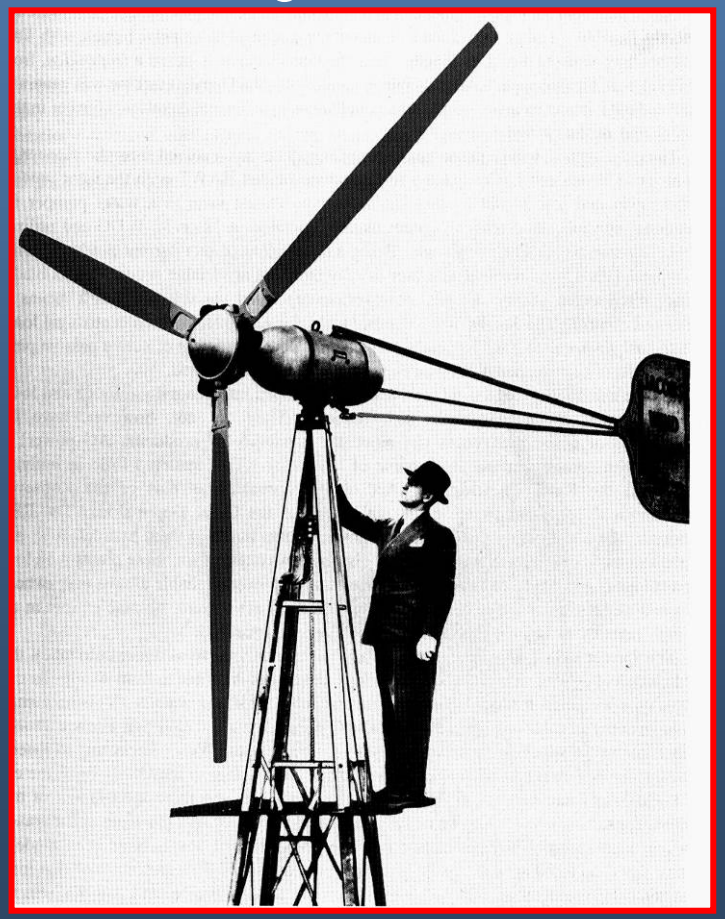
- Utility-Scale Wind Power
  1,000-2,500 kW wind turbines
  - Installed on wind farms, 10–300 MW
  - Interconnected to transmission
  - Professional maintenance crews
  - Class 4-6 wind resource
- Small Wind Power
  up to 100 kW wind turbines
  - Installed at individual homes, farms, businesses, schools, etc.
  - Interconnected to distribution, on the "customer side" of the meter
  - High reliability, low maintenance
  - Class 2-3 wind resource



Wind Energy History in Rural America

Water-pumping wind mills, from about 1860

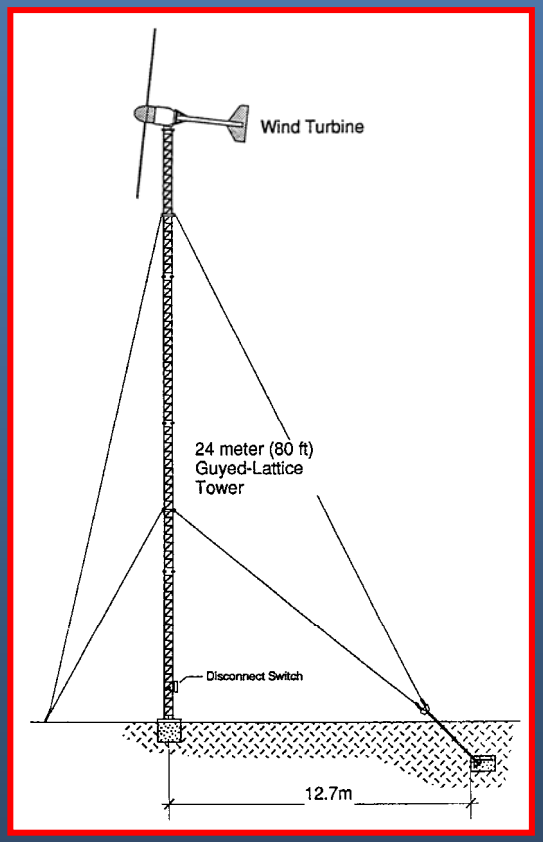
"Wind-chargers" for electric power, during the 1930's - 50's



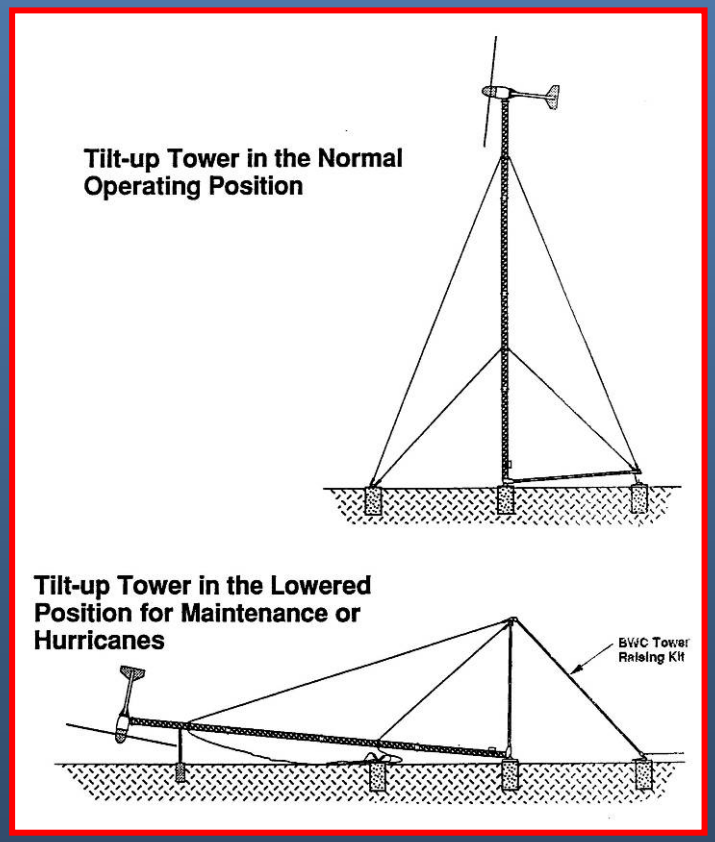
Small Turbine Technology Trends

- Advanced blade manufacturing methods
- Rare earth permanent magnets
- Grid-connected inverters
- Induction generators
- Design for low wind speeds
- Alternatives to furling for rotor speed control
- Reduced rotor speeds → reduced noise
- Design standard

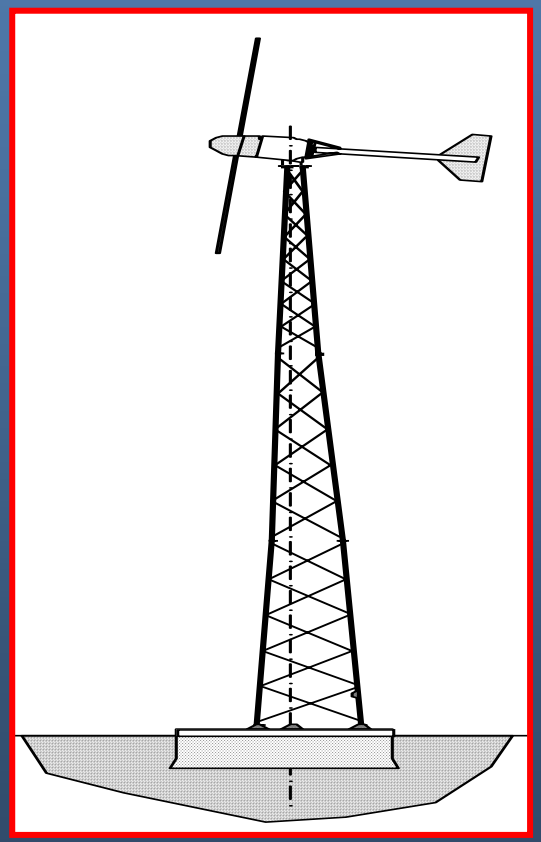
Small Wind Turbine Towers



Guyed Tower



Tilt-Up Tower



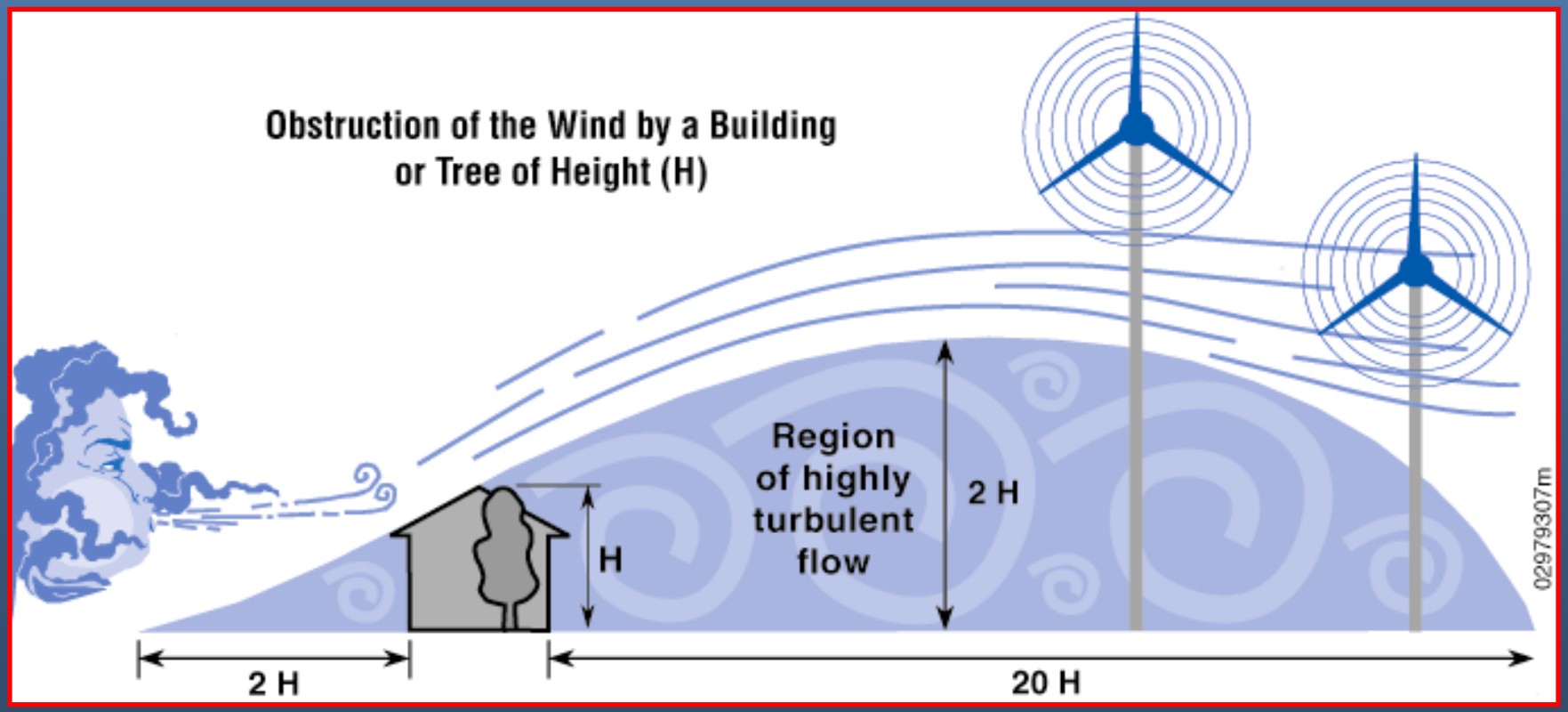
Self-Supporting Tower

Example: Wind Turbine Installed Cost

Updated: 5-Jul-07

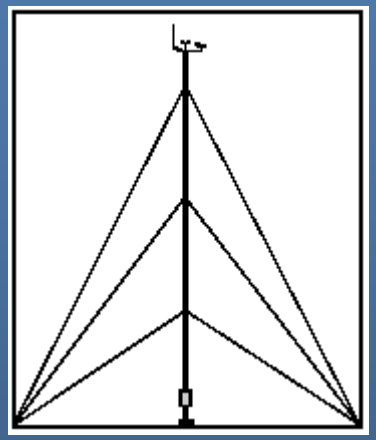
Bergey Excel-S (10 kW)		High Cost	Low Cost
Wind turbine & inverter	**$27,900**	$27,900	$27,900
Tower (100 ft guyed)	**$9,200**	$31,950	$7,400
Tower Wiring Kit	**$1,000**	$1,140	$860
Shipping	**$1,500**	$2,000	$1,000
Installation	**$8,000**	$18,000	$2,000
Permits/Fees	**$500**	$6,000	$0
Sales Tax, 2%	**$952**	9%	none
Total	**$49,052**	$94,279	$39,160

Importance of “Micro-Siting”



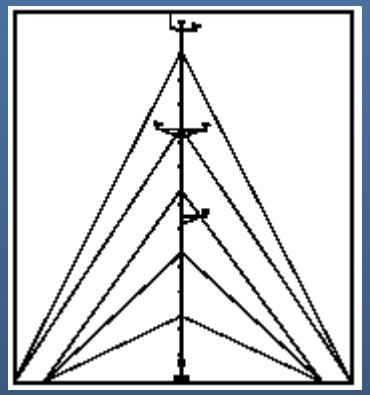
Take Measurements

Sensors



20m tower

Towers



40m tower

Loggers

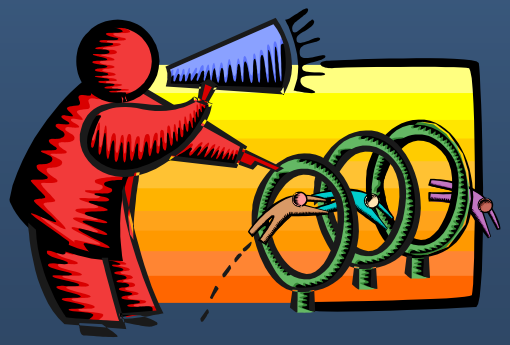
Great Lakes Science Center

Cleveland - “The green city on the blue lake.”

Small Wind Power for Home, Farm, Business, & Schools

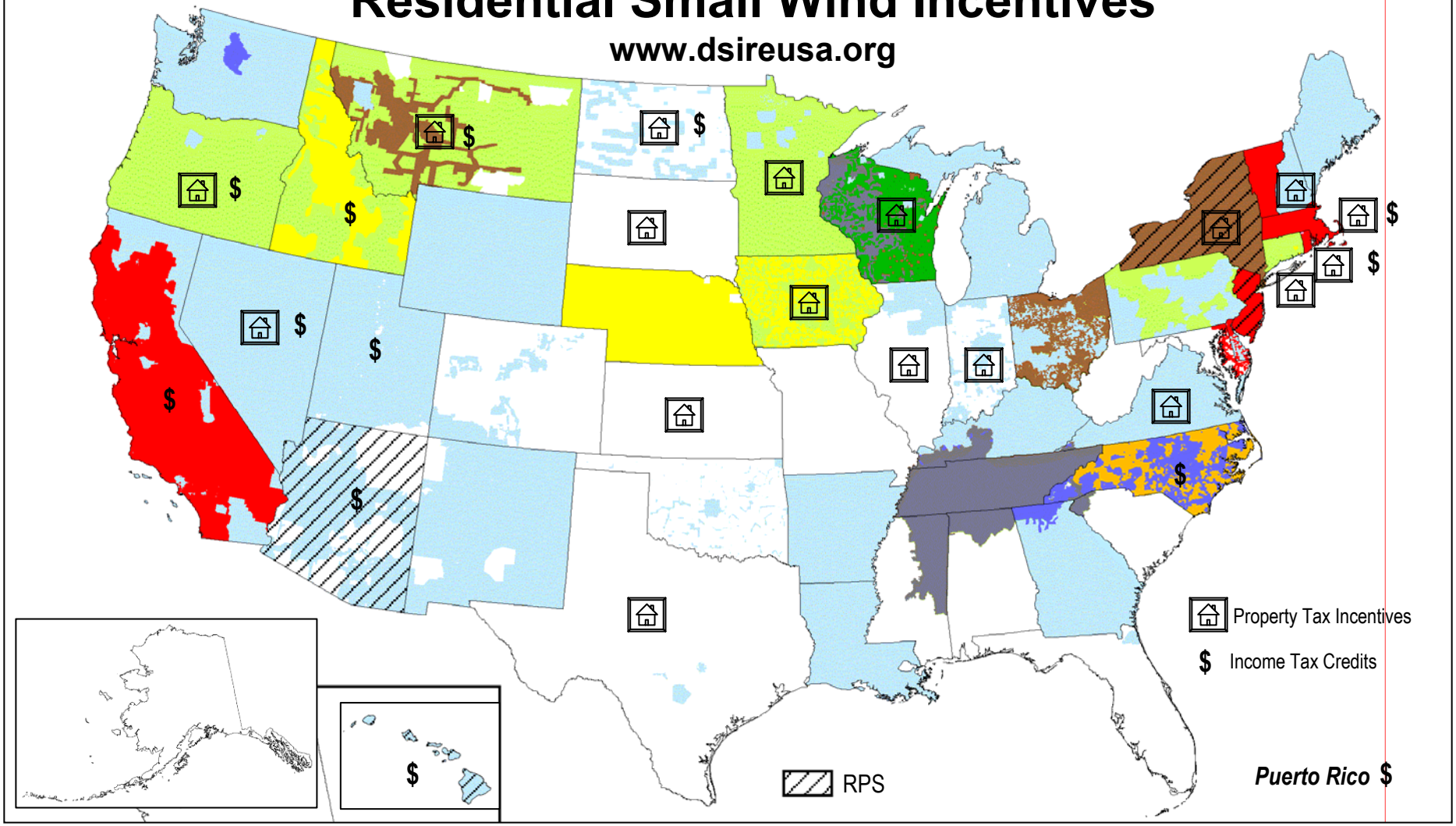
Steps to Implement a Small Wind Project

1. Assess your electricity consumption, cost, and utility tariff
2. Wind resource & micro-siting
3. Select turbine size (model) and tower height
4. Incentives & economics
5. Zoning (including neighbor notification)
6. Utility interconnection agreement
7. Building permit
8. Order turbine and tower
9. Installation
10. Commissioning



Residential Small Wind Incentives

www.dsireusa.org



BUYDOWNS

- Buydown & Net Metering
- Buydown, Net Metering, & Loans

PRODUCTIVITY INCENTIVES

- Productivity Incentives & Loans
- Productivity Incentives
- Net Metering, Loans & Prod. Incentives
- Net Metering & Prod. Incentives

MINOR INCENTIVES

- Loans
- Net Metering & Loans*
- Net Metering

*In Minnesota, loans apply only to farmers.

Federal Incentives: Mainstay Energy – green tag purchase (CA excluded); USDA Federal Farm Bill Title 9006 – grant for rural areas

May 30, 2006

USDA Farm Bill Section 9006

www.rurdev.usda.gov/rbs/farmbill

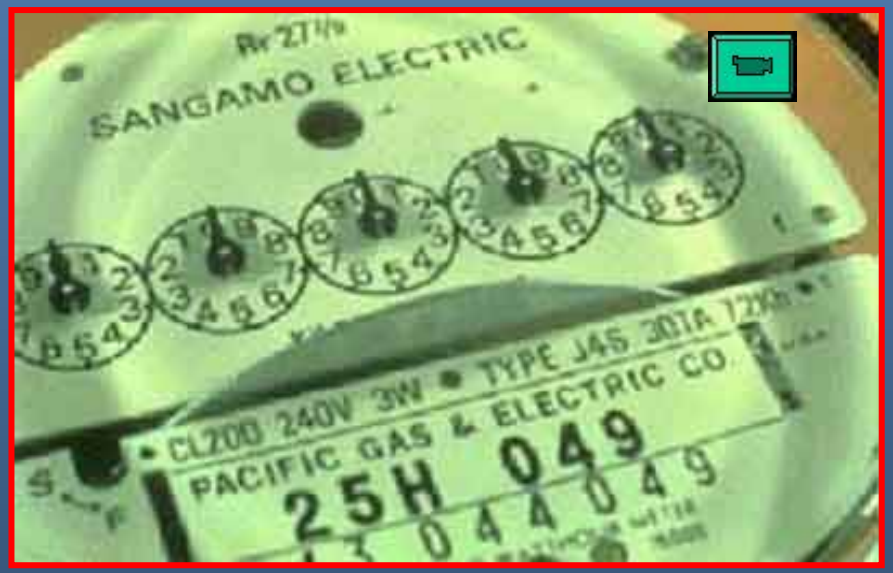
Renewable Energy & Energy Efficiency:

wind	solar	biomass
geothermal	hydrogen	energy efficiency

- For rural farms, ranches, small businesses (not for residential systems)
- Grants (up to 25% of project cost), and/or
  Loan Guarantees (up to 50% of project cost)
- In 2005, a total of $21 million in grants were distributed to 150 projects in 32 states.
- Work with rural energy coordinators at your USDA State Rural Development Office
- Simplified application in 2006 for projects < $200,000

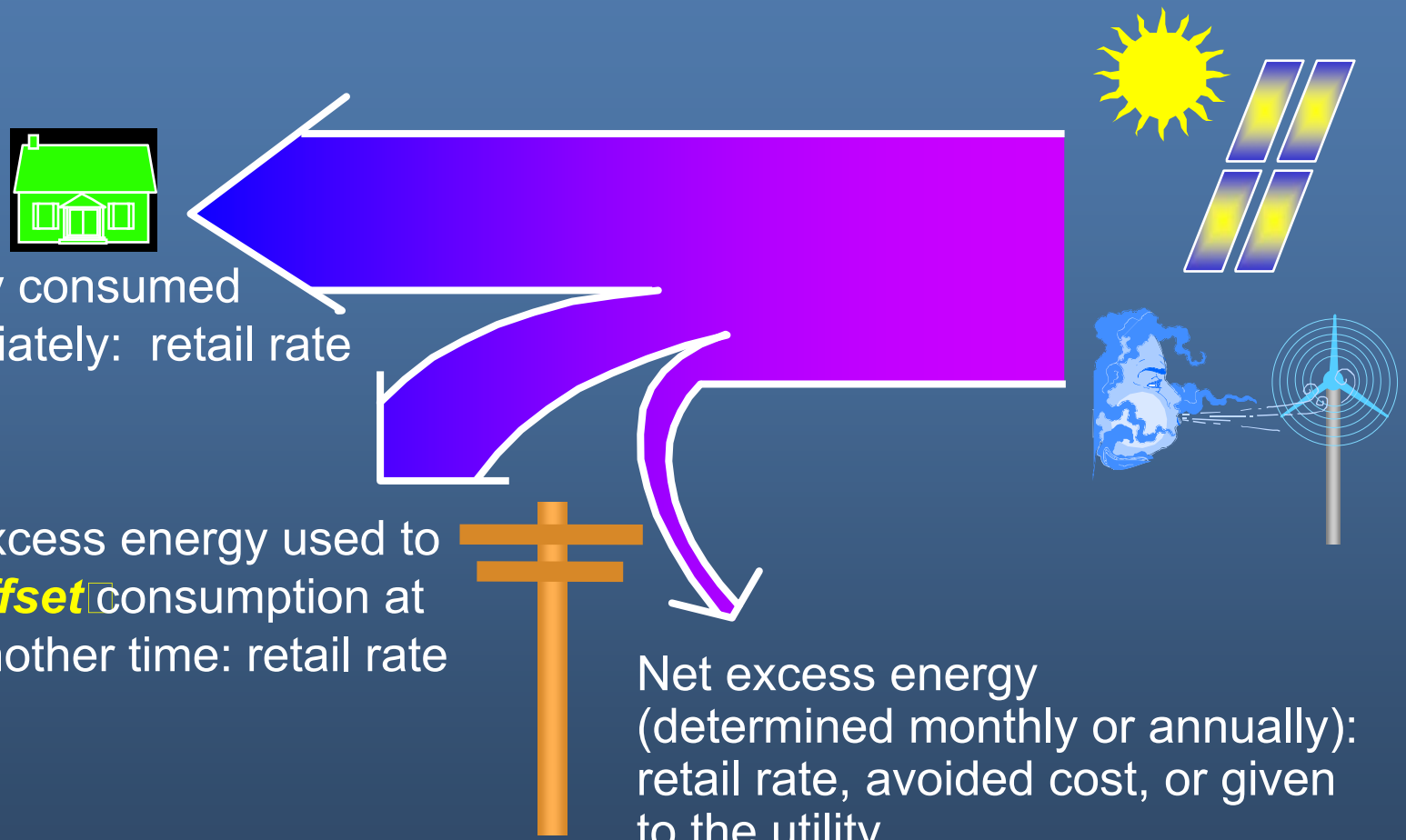
Net Metering of Renewable Energy

- Excess wind power turns the electric meter backward
- Bill is based on the “net” consumption/generation (monthly or annually)



- Net metering of wind energy is available to:
  - All residential (including rural) customers in 25 states
  - Some residential customers (mostly urban) in 15 other states

Net Metering of Renewable Energy



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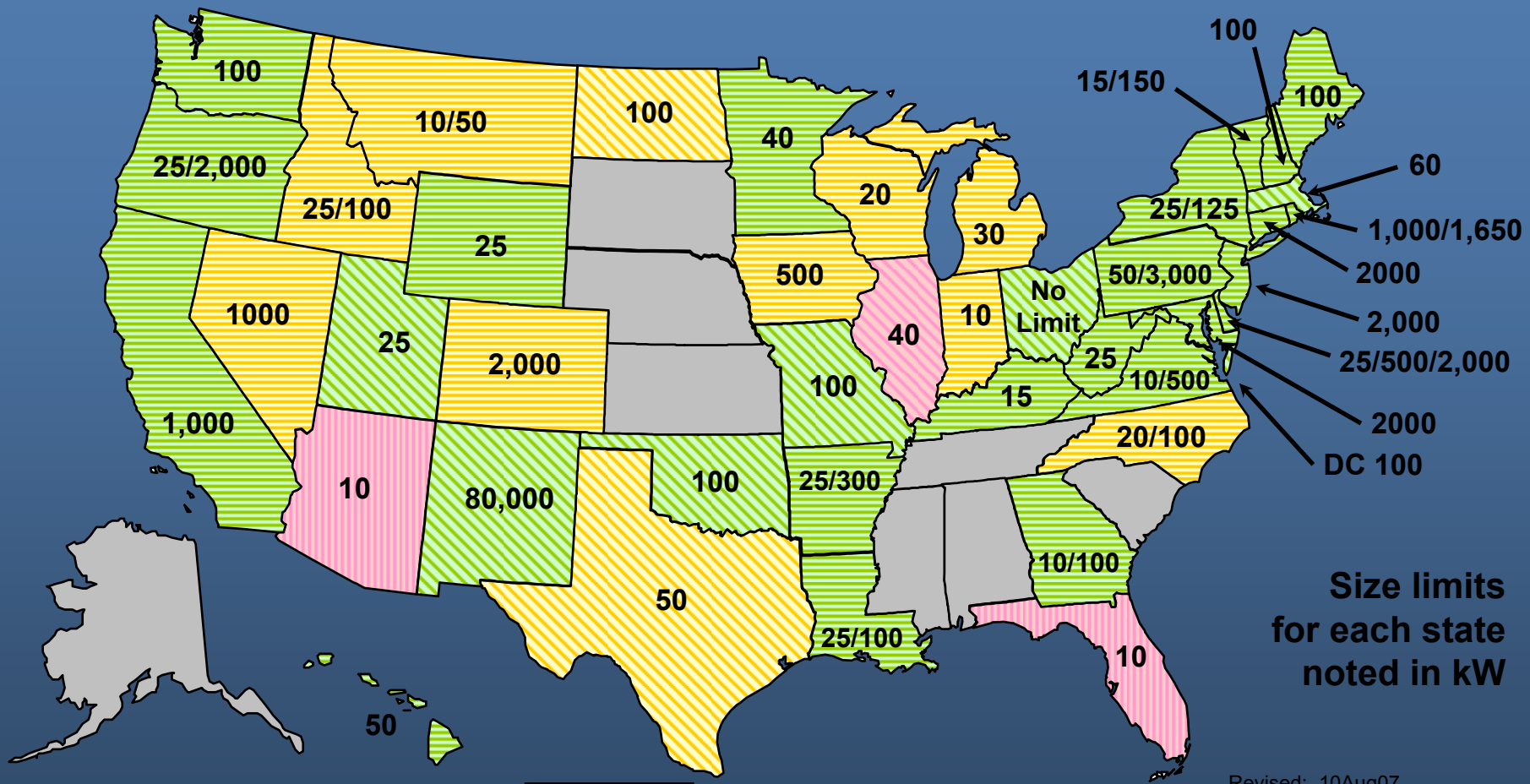
Net Metering for Wind

28 states have net metering for all rural electric consumers



Size limits for each state noted in kW

Revised: 10Aug07
Source: www.dsireusa.org

Treatment of Net Excess Energy:

- Monthly
- Annual or monthly @ retail rate
- Varies by utility

- None
- Individual Utilities
- Investor-Owned Utilities Only, Not Rural Cooperatives
- Investor-Owned Utilities and Rural Cooperatives

Economics of a Wind Project

- "Simple Payback" is an easy way to measure the economic merit of a wind turbine project:

  (Installed cost, $) ÷ (kWh/y X Price of Electricity, $/kWh)

  (years)

- "Cost of Energy" is another measure of economic value:

  Annual Cost of Ownership ÷ Annual Energy Production

  (cents/kWh)

Case Study: On-Grid Farm

Jess Alger's Ranch - Stanford, MT

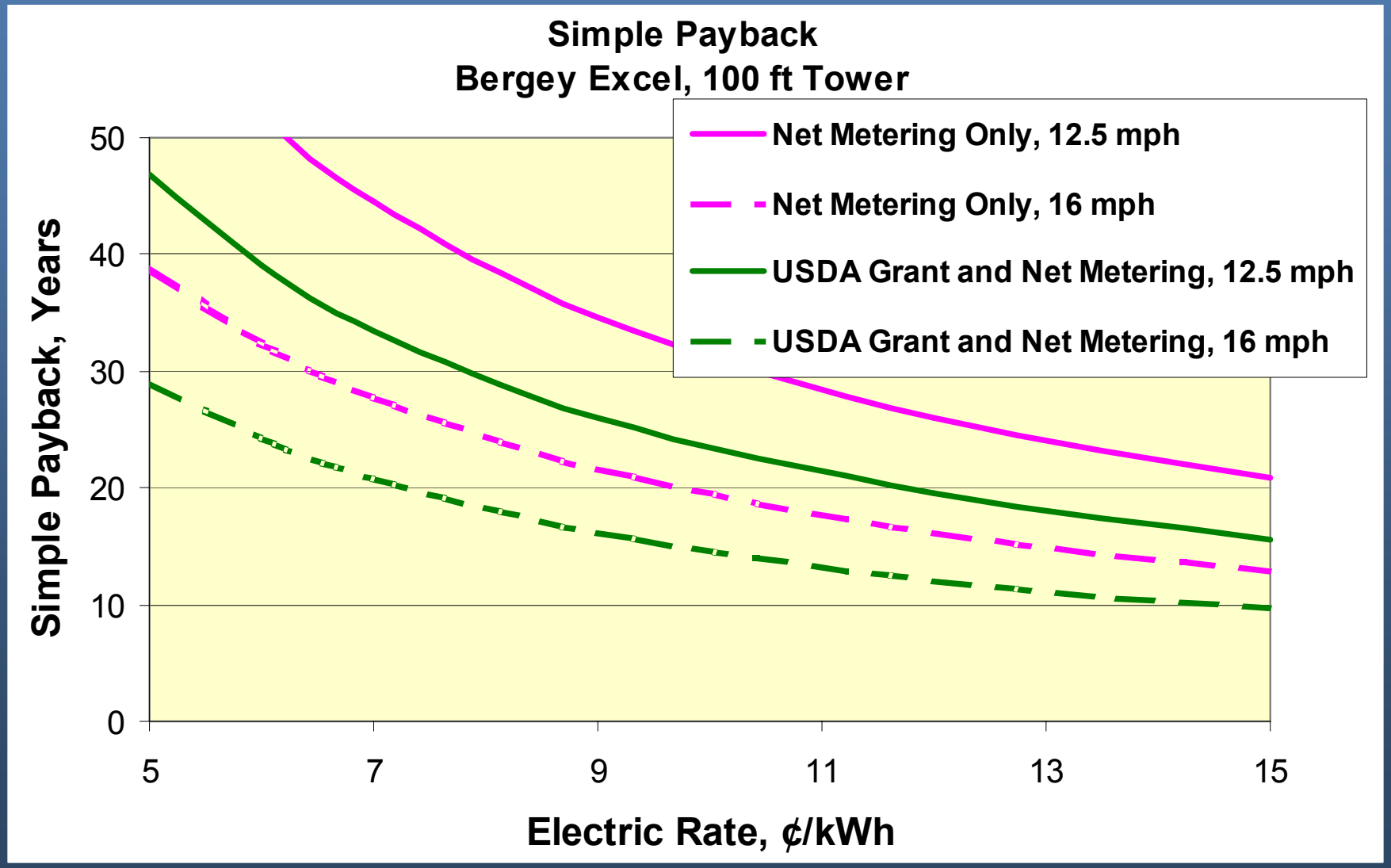
- Fourth generation Montana farmer 1,200 acre ranch/farm
- Wind used to offset electricity consumed by home and farm operations
- Turbine installed September 2003
- 12 mph annual average wind speed (Class 3)
- 10kW turbine on a 100 foot tower

Alger's Estimated Cost and Production

- Installed Turbine System - $36,850
  - Lower than typical
    - Turbine system costs only, no dealer payment
    - Site preparation done by J. Algers
- USDA RESG (25% grant) - $7,696
- Montana NCAT USB Funds - $12,500
- Estimated electricity used 14,200 kWh/yr
- Estimate electricity produced 18,000 kWh/yr (based on Class 3 wind site)

Small Wind Economics

Bergey Excel on 100ft Tower



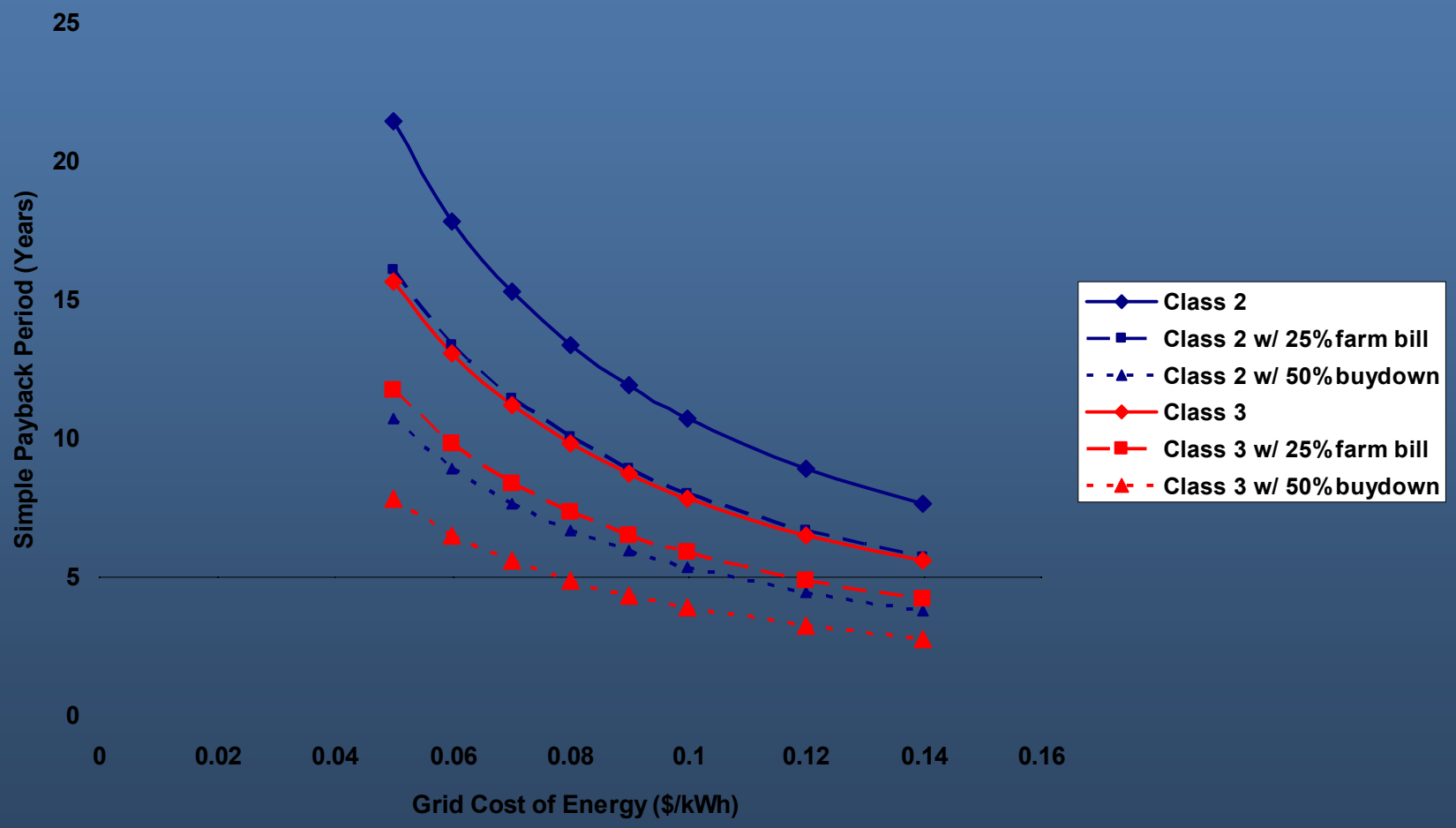
Case Study - 3 phase grid-connect

Wubben Wood Products

- Small Industry - finished wood products for homebuilders
- Installed in June 2004
- 3 – Micon 65 kW turbines on 110’ towers at a cost of $85k per turbine
- $45k/turbine from WI Focus on Energy (max 35% of project cost)
- 256,560 kWh/yr (enough energy for 26 homes) expected or ~80% of electrical needs
- Payback expected in 12 years

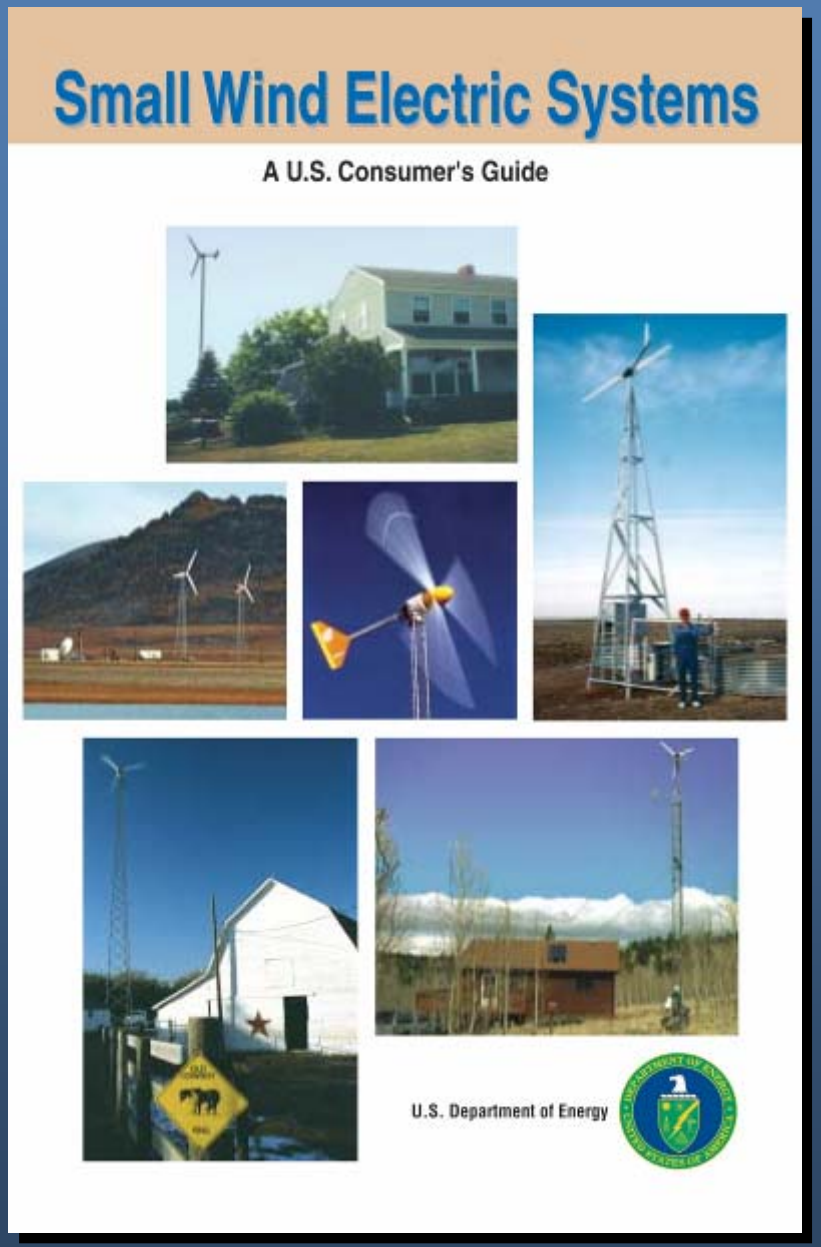
Small Wind Economics

Micon 65kW on 110ft Tower



Small Wind Consumers Guide

A U.S.guide and about 40 state- and region specific specific guides are available from the National Renewable Energy Laboratory: http://www.eere.energy.gov/windpoweringamerica/small_wind.html



Other Sources of Information

- American Wind Energy Association http://www.awea.org/
  - A 63 minute video “An Introduction to Residential Wind Systems with Mick Sagrillo”
  - AWEA Small Wind Toolbox: www.awea.org/smallwind.html
- Danish Wind Industry Association guided tour and information. http://www.windpower.org/en/tour/
- AWS Scientific Inc. “Wind Resource Assessment Handbook” produced by for the National Renewable Energy Laboratory, Subcontract number TAT-5-15283-01, 1997 http://www.nrel.gov/publications
- Wind Energy Explained, J. F. Manwell, J. G. McGowan, A. L. Rogers John Wiley & Sons Ltd. 2002.