Wind Energy: Technology, Markets, Economics and Stakeholders

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NREL
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Sizes and Applications

Small (≤10 kW)

- Homes
- Farms
- Remote Applications

(e.g. water pumping, telecom sites, icemaking)

Intermediate (10-100 kW)

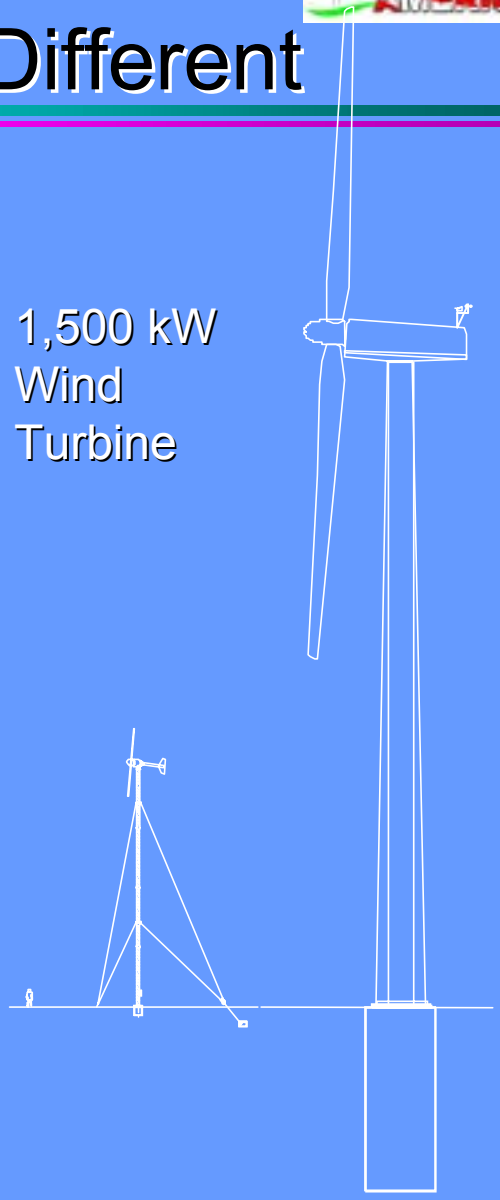
- Village Power
- Hybrid Systems
- Distributed Power

Large (660 kW - 2+MW)

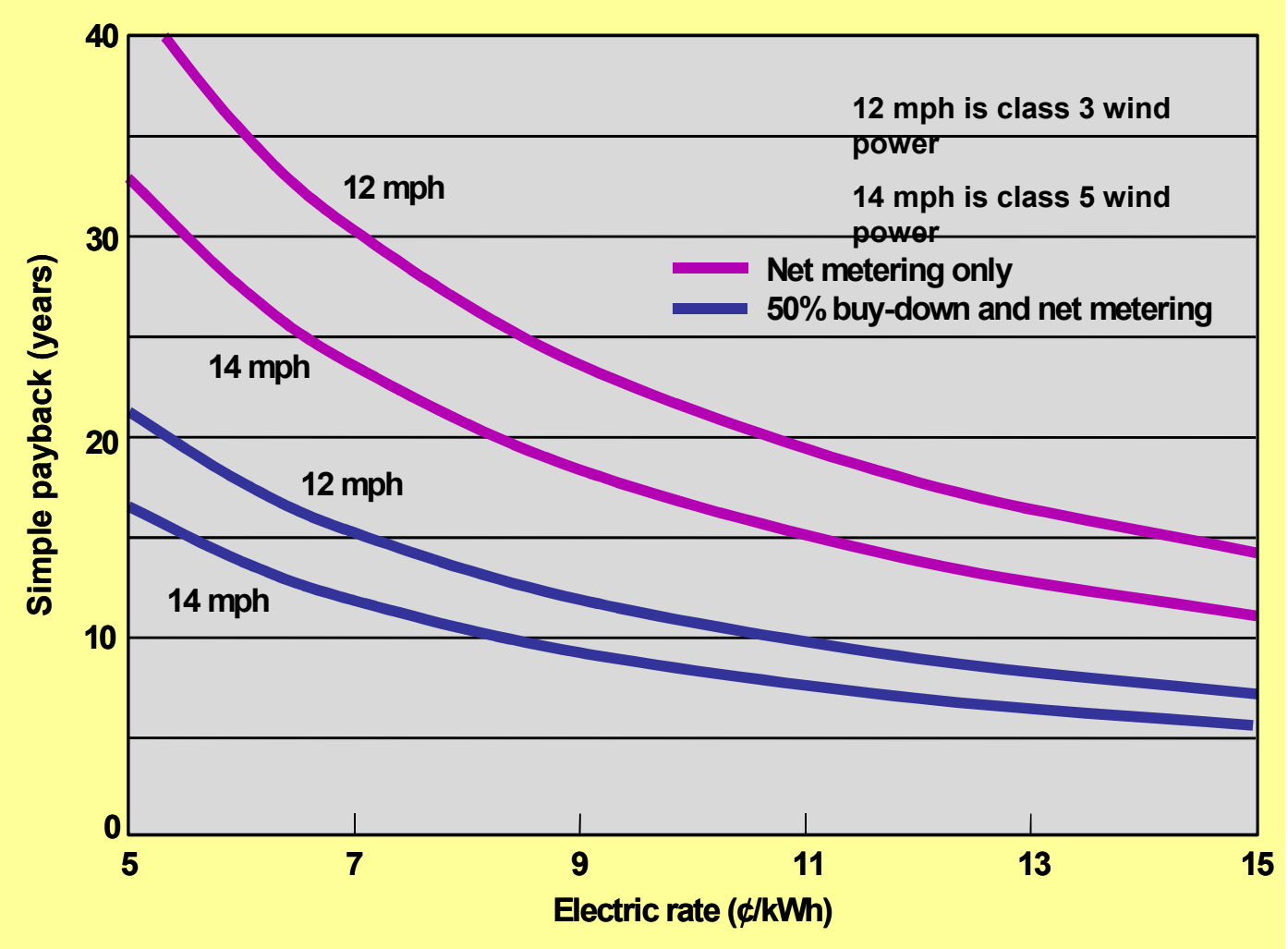
- Central Station Wind Farms
- Distributed Power

Small Wind Turbines are Different

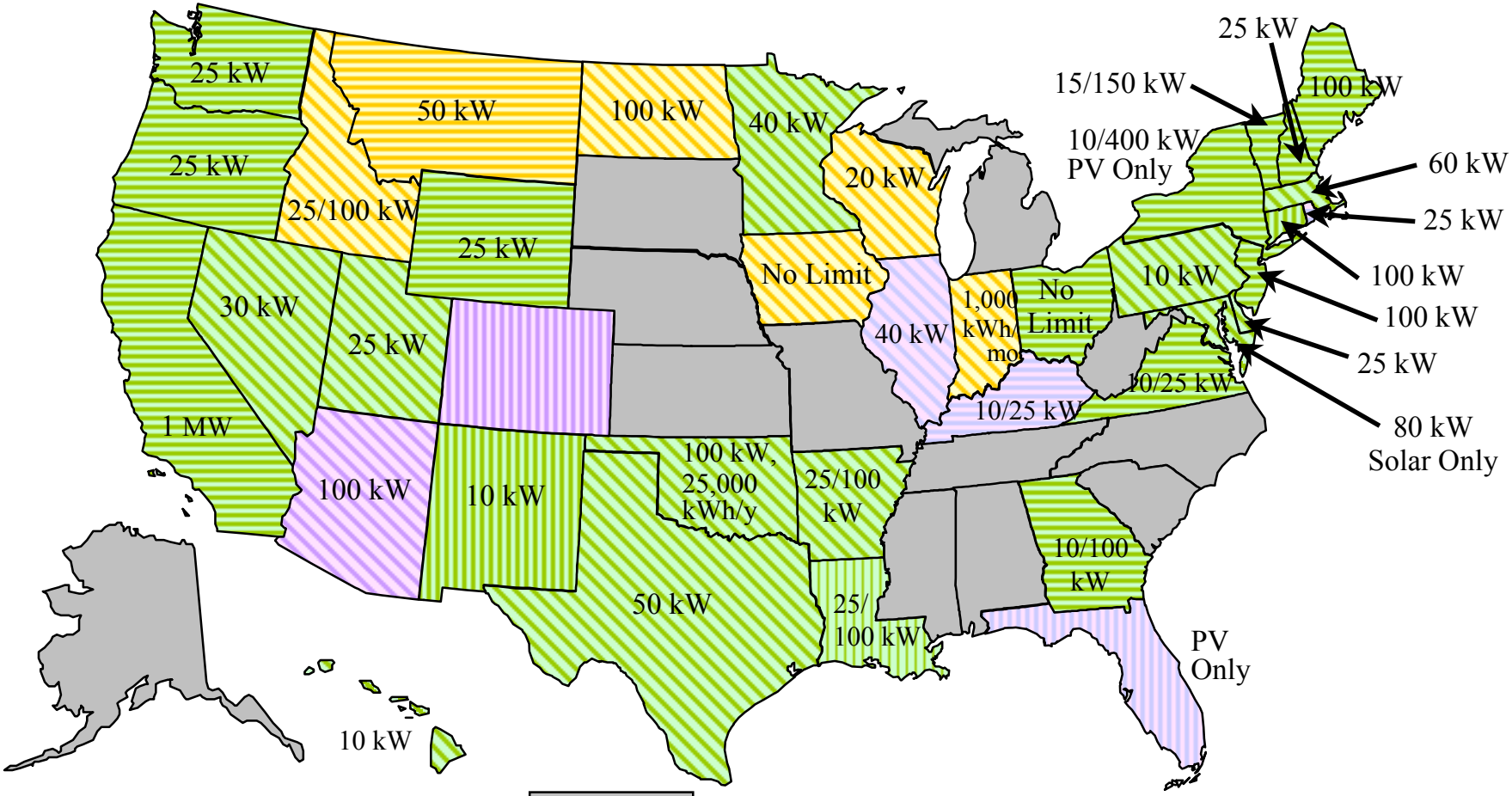
- Large Turbines (600-1800 kW)
  - Installed in Windfarms, 10 - 100 MW
  - Provide Low Cost Power to the Grid
  - < $1,000/kW
  - Require 6 m/s (13 mph) Average Wind Speeds
- Small Turbines (0.3-50 kW)
  - Installed Off-Grid or at On-Grid Facilities
  - $2,000-6,000/kW
  - Designed for Reliability / Low Maintenance
  - Require 4 m/s (9 mph) Average



Incentives Make Small Wind Systems More Economical



Net Metering By State

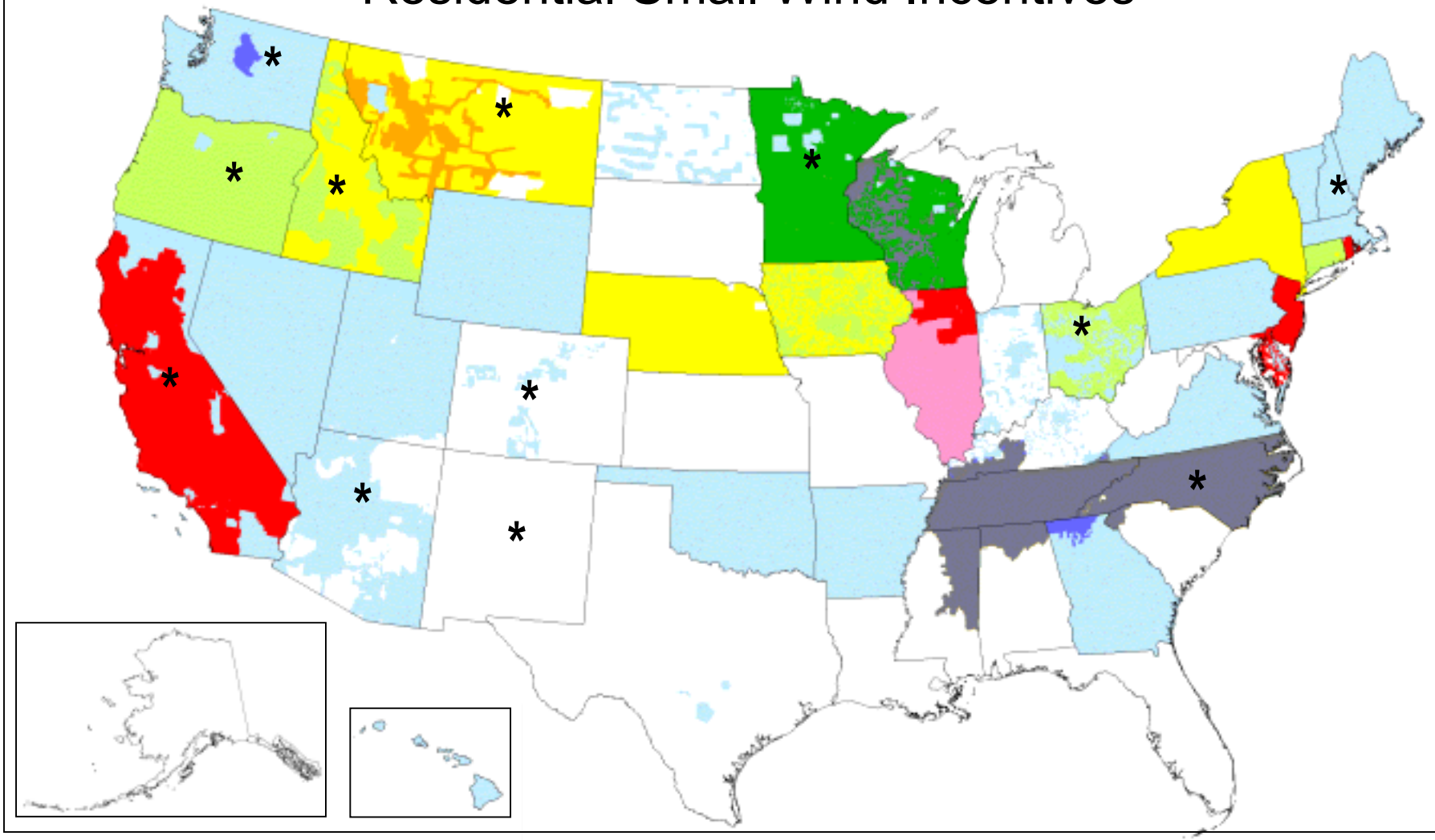


Monthly Net Metering
Annual Net Metering
Varies by Utility or Unknown

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

Revised: 26 Oct 03

Residential Small Wind Incentives



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

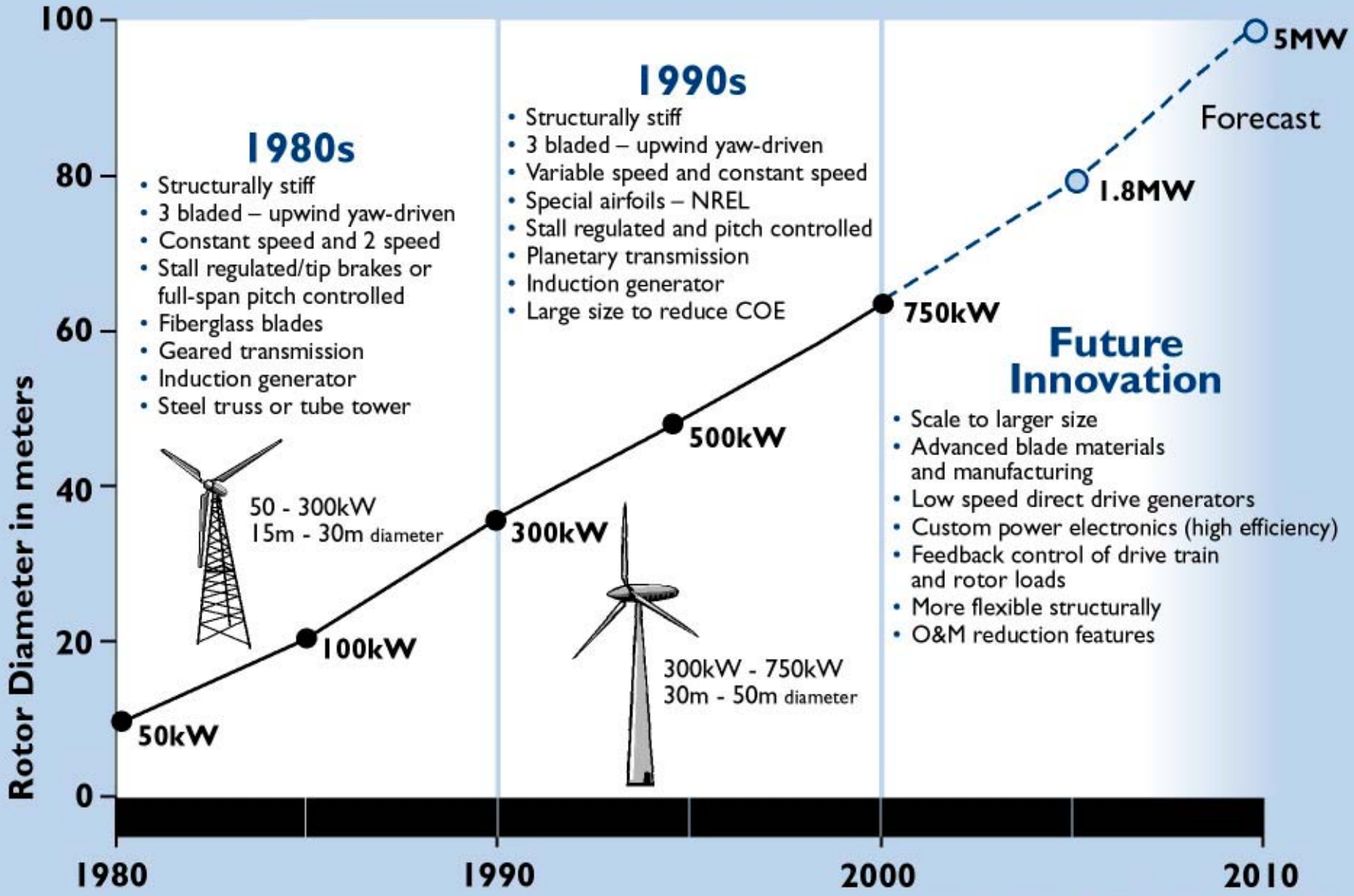
*In Minnesota, loans apply only to farmers.

May 6, 2003

“It seems only natural for rural utilities to do everything they can to advance both farm-based renewable energy development and rural economic development in a cost-effective way. In my opinion, wind energy is the next great chapter in the rural electrification story.”

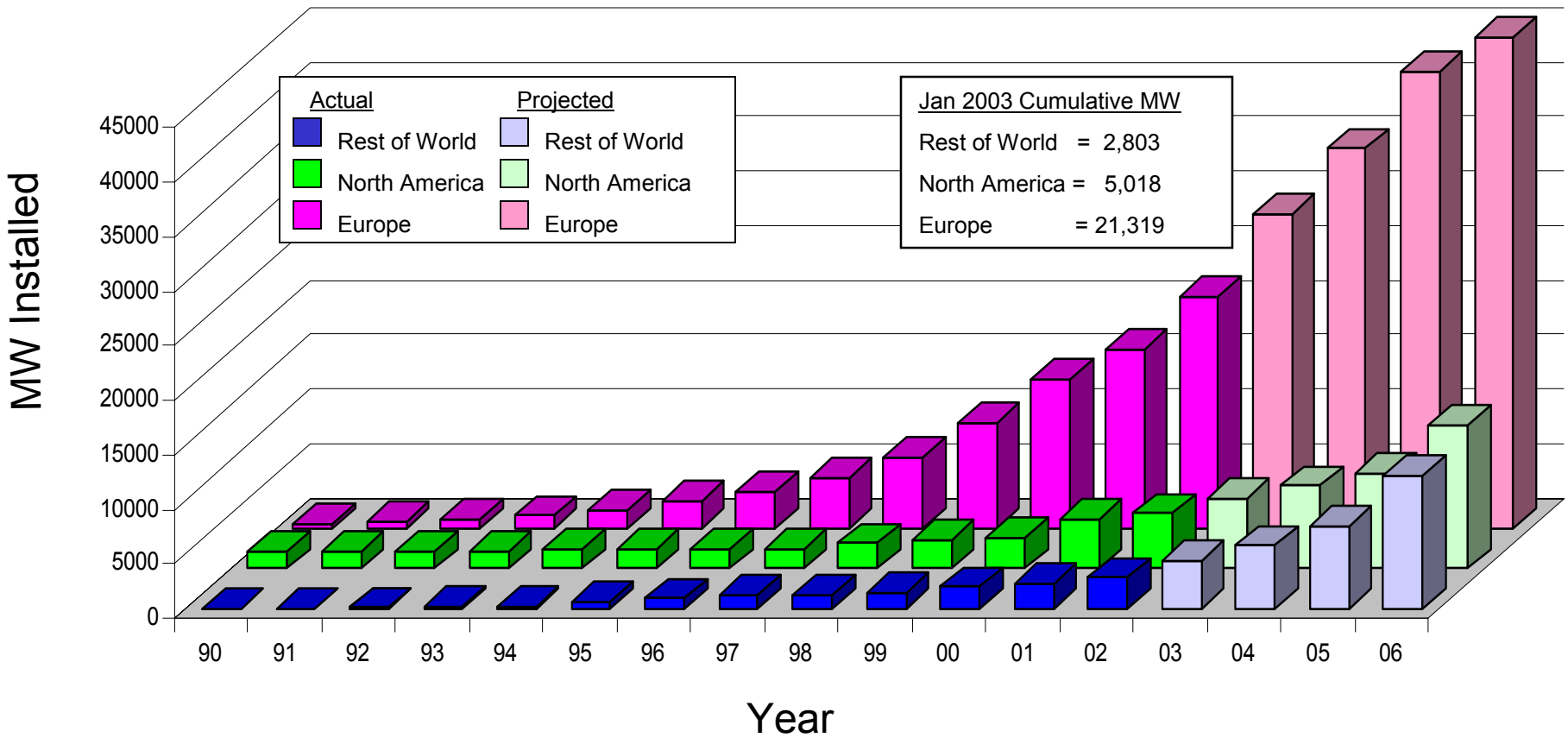
Aaron Jones, Washington Rural Electric Cooperative Association; Olympia, WA

The Evolution of Commercial U.S. Wind Technology



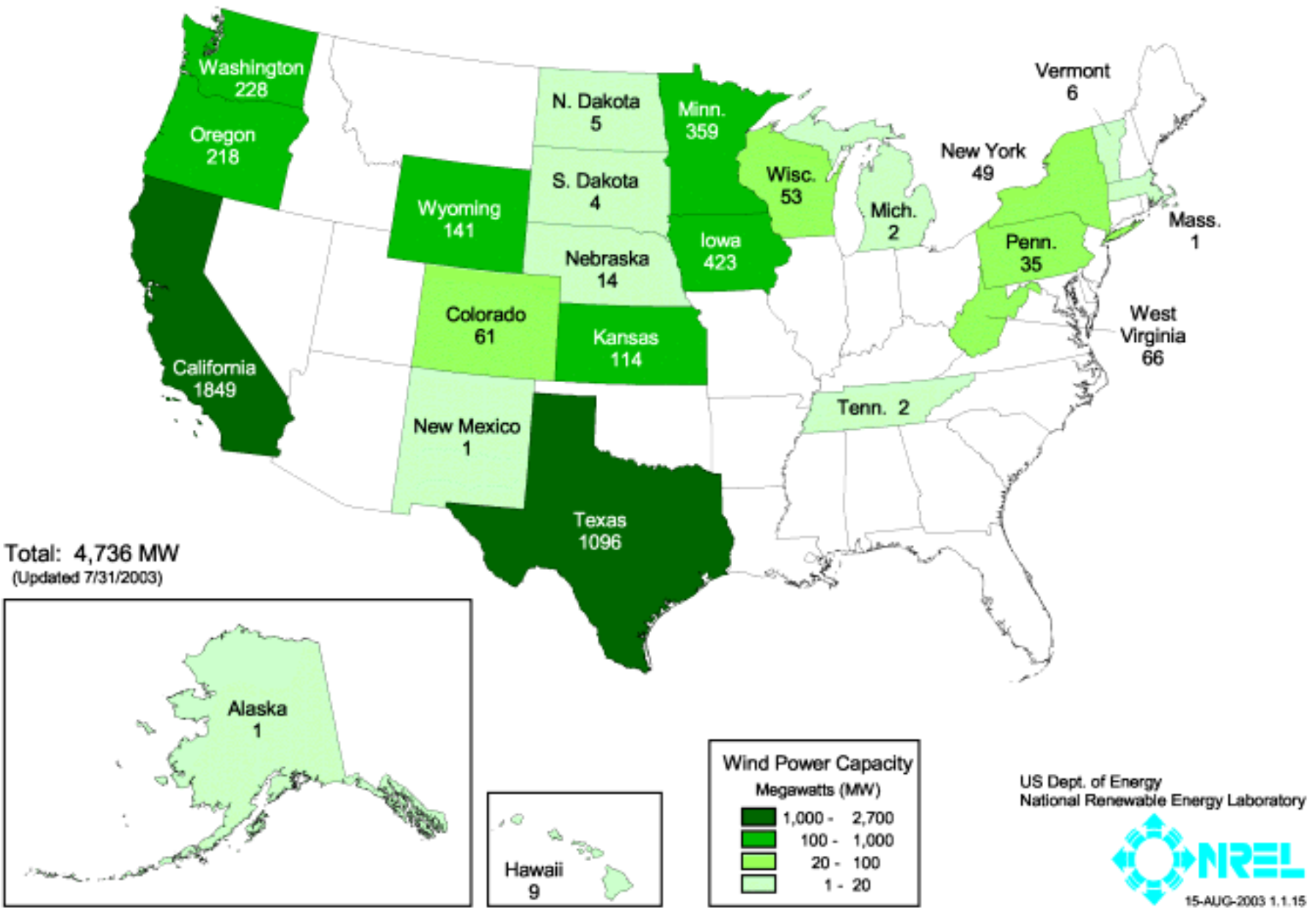
Source: Thresher & Dodge, Wind Energy Journal 1998

Growth of Wind Energy Capacity Worldwide



Sources: BTM Consult Aps, March 2001
Windpower Monthly, January 2003

United States - Wind Power Capacity (MW)



Total: 4,736 MW
(Updated 7/31/2003)

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National Renewable Energy Laboratory

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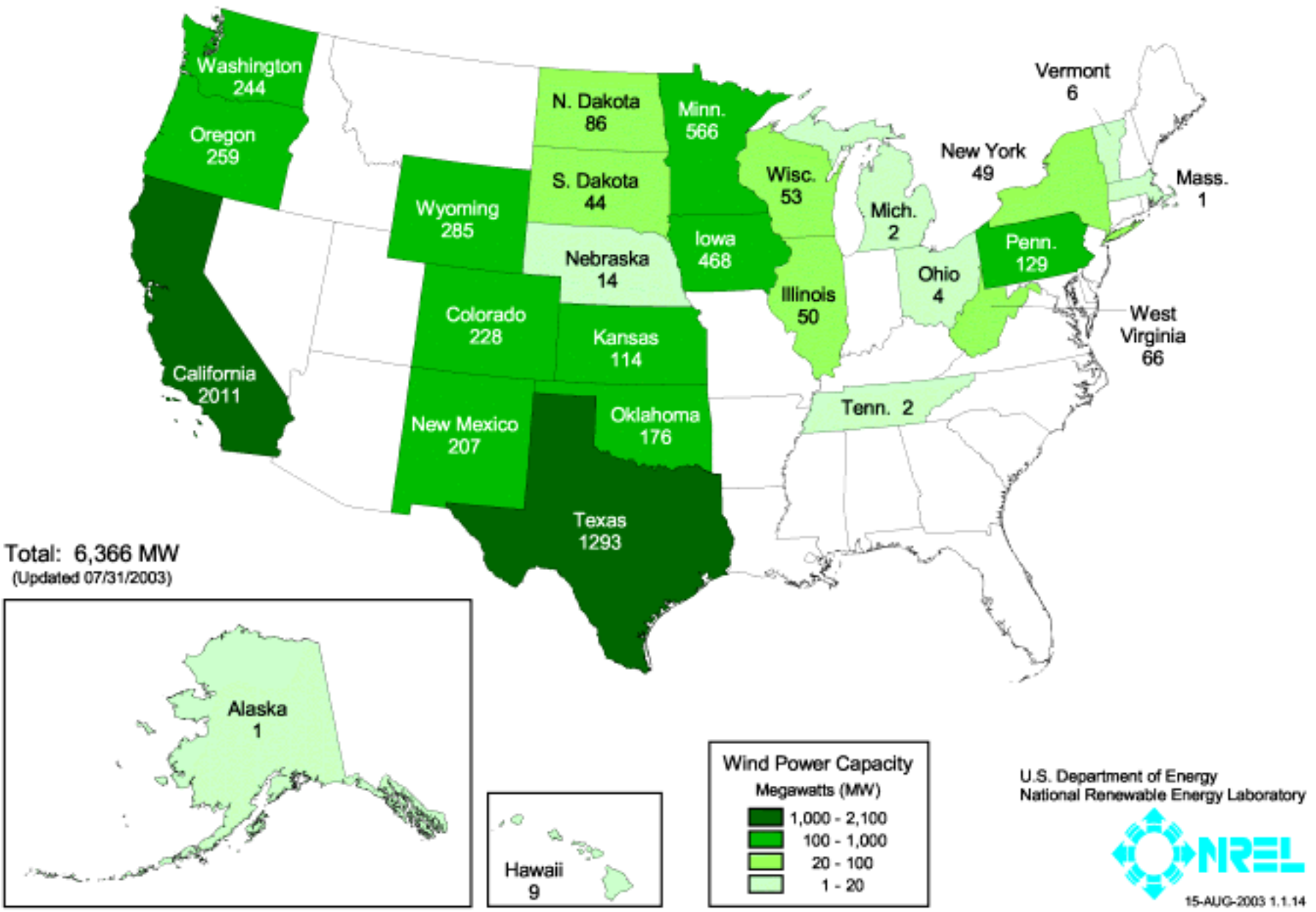
United States - 2003 Expected Year End Wind Power Capacity (MW)

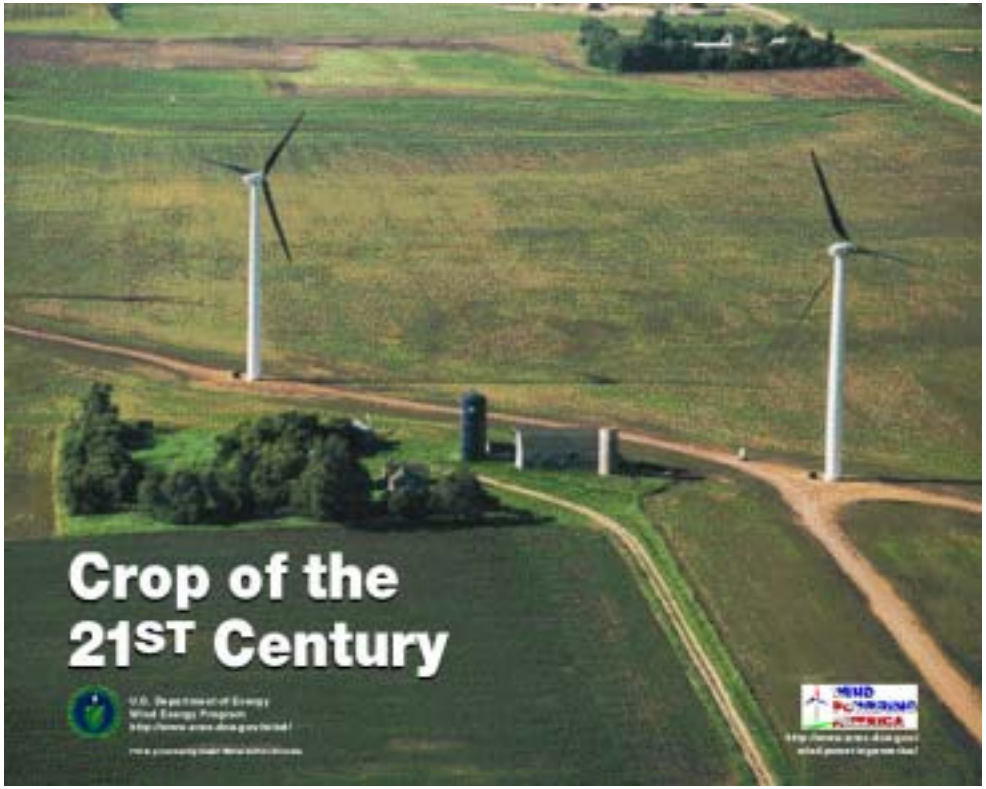


Maturing Wind Technology

- Technology has matured over 25 years of learning experiences
- Availabilities reported of 98-99%
- Certification to international standards helps to avoid “show stoppers”
- Performance and cost have dramatically improved
- New hardware is being developed on multiple fronts:
  - higher productivity and lower costs
  - larger sized for both land and off-shore installations
  - tailored designs for high capacity factor, low wind speed and extreme weather conditions

Drivers for Wind Power

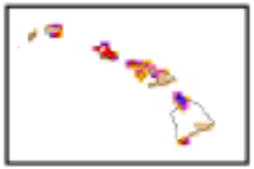
- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Green Power
- Energy Security

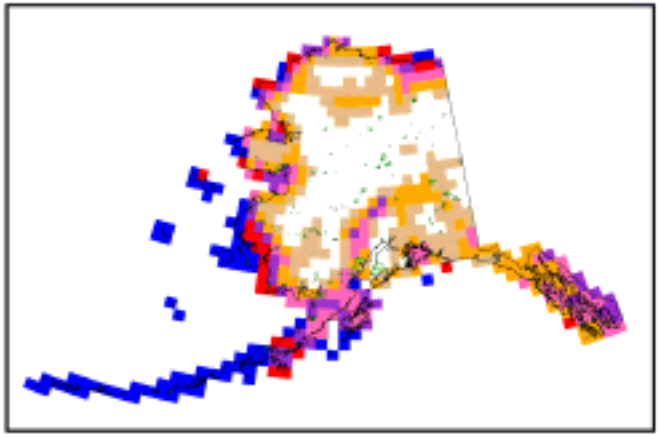


Wind Economics - Determining Factors

- Wind Resource
- Financing and Ownership Structure
- Taxes and Policy Incentives
- Plant Size: equipment, installation and O&M economies of scale
- Turbine size, model, and tower height
- Green field or site expansion
- What is included: land, transmission, ancillary services

United States - Wind Resource Map





Source: "Wind Energy Resource Atlas of the United States", 1987

Indian Reservations and Alaska Native Village Areas

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory

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Cost of Energy Trend

1979: 40 cents/kWh

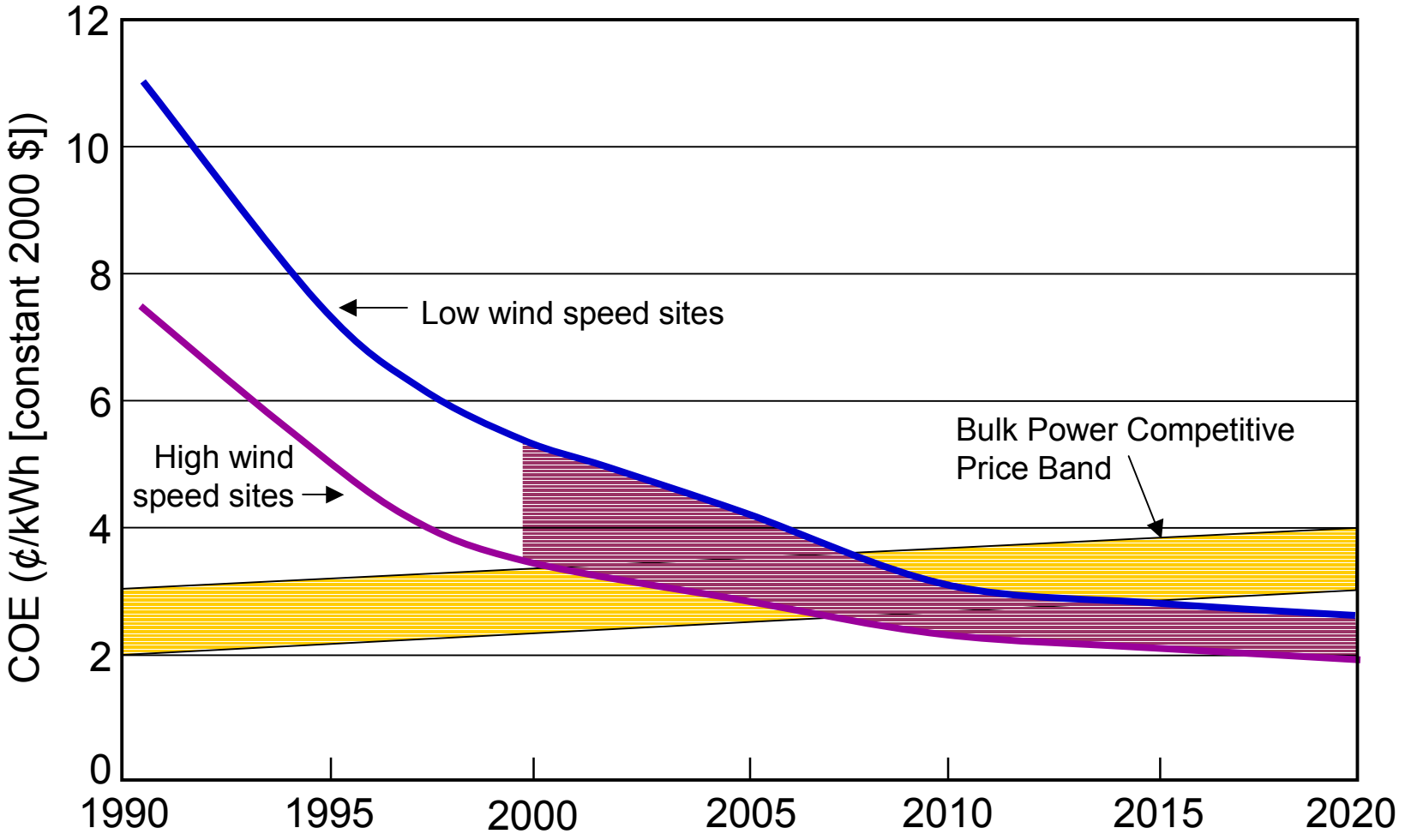
2000:
4 - 6 cents/kWh

NSP 107 MW Lake Benton wind farm
4 cents/kWh (unsubsidized)

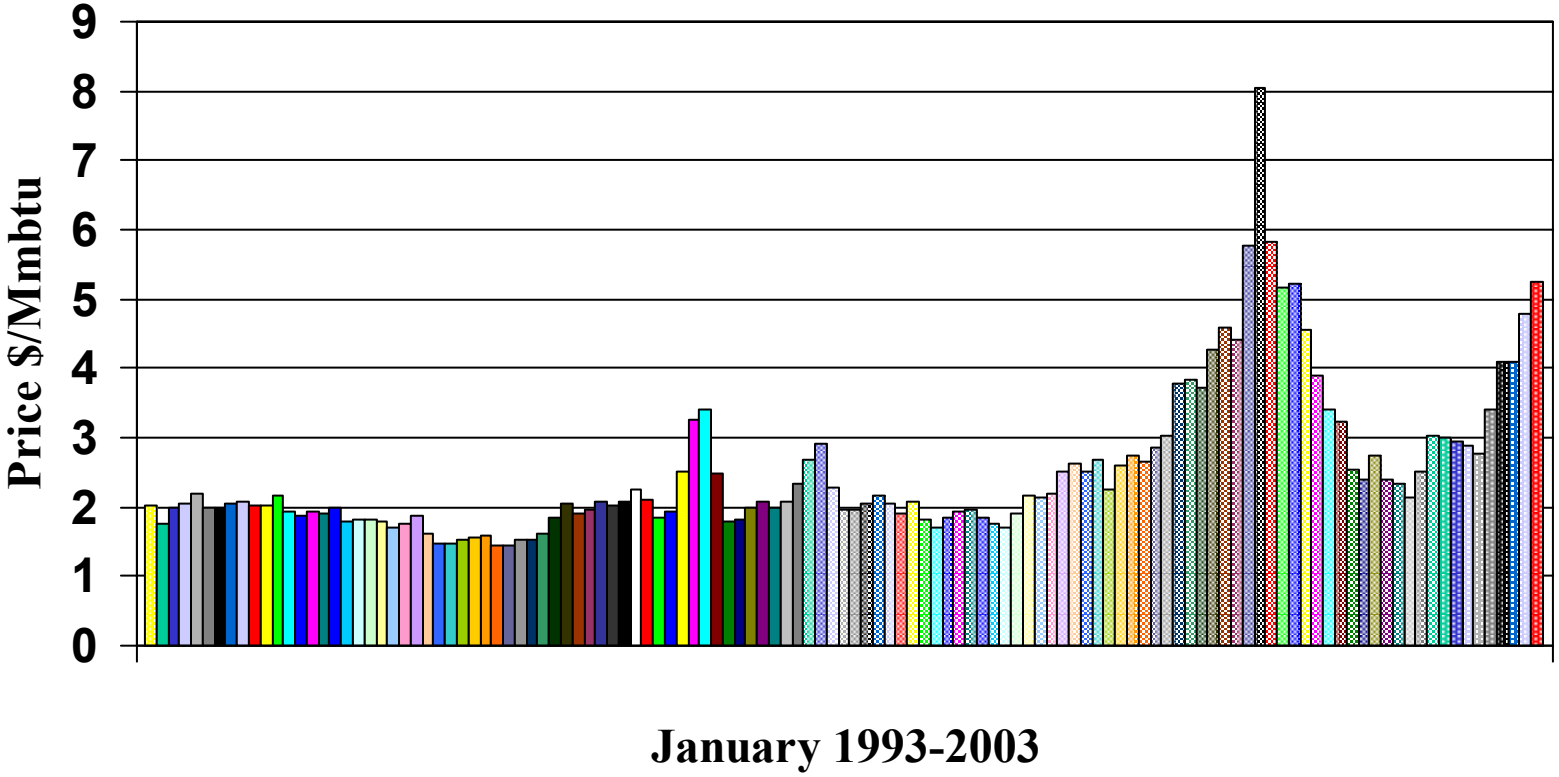
- Increased Turbine Size
- R&D Advances
- Manufacturing Improvements

2004:
3 – 4.5 cents/kWh

Wind Cost of Energy



U.S. Average Natural Gas Prices

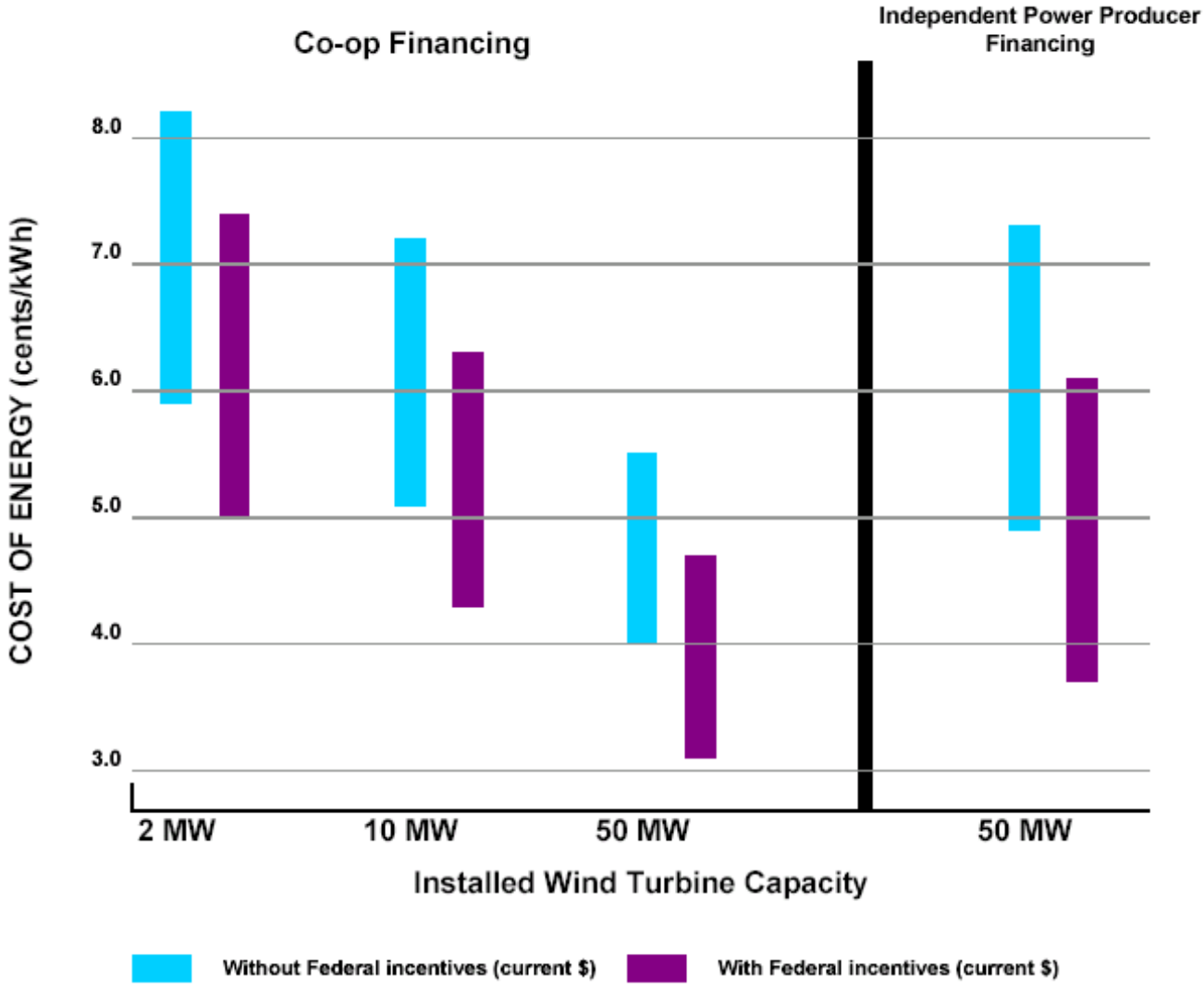


"Wind energy adds diversity to our generation fleet and provides a hedge against fossil fuel price increases. In addition, the development of renewable energy resources is widely supported by the public and our customers."

Rick Walker, director, Renewable Energy Business Development, AEP Energy Services, Inc., Dallas, TX

COOP vs. IPP Financing

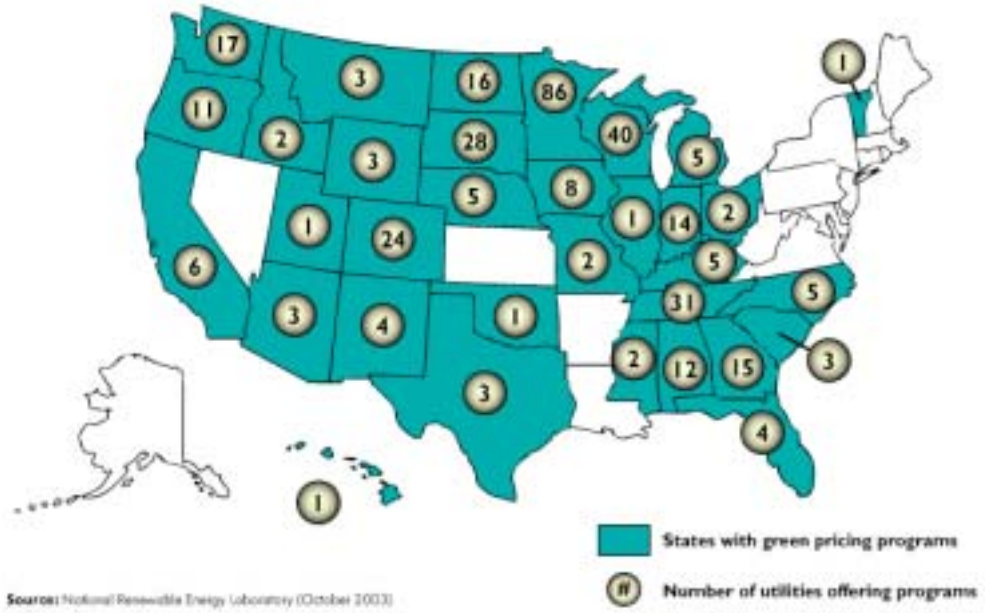
- Larger plants are significantly less expensive per kWh
- Public power can own/ install smaller plants at comparable cost to large IPP projects
- Aggregation of demand reduces costs



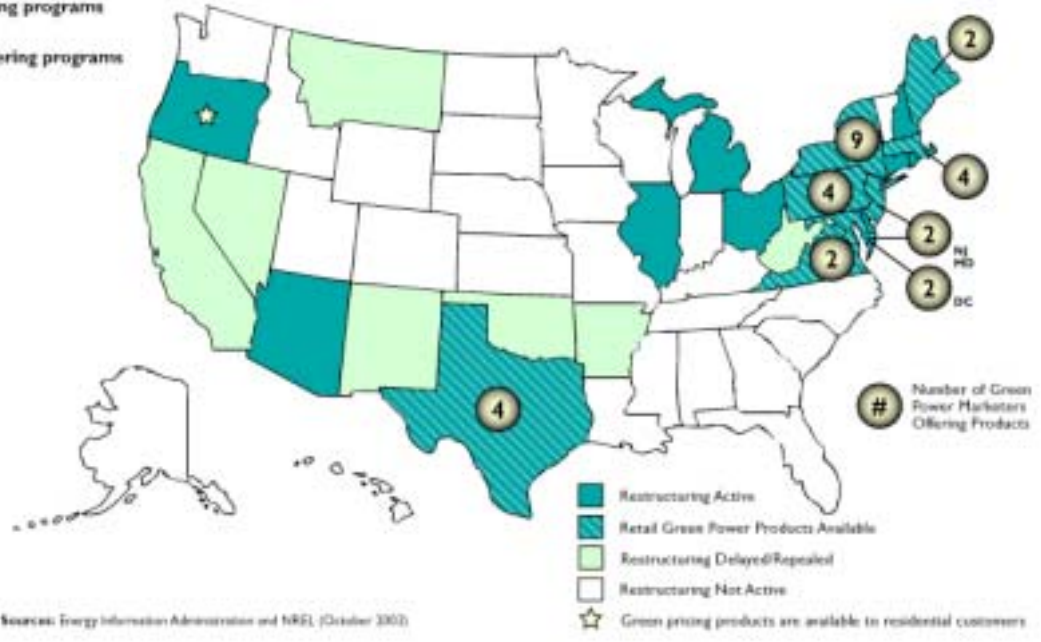
Recent Developments

- The wind industry is delivering ~3 cent/kWh contracts, including PTC for large projects
- Several large projects under development
  - 300 MW Stateline (WA/OR)
  - 109 MW Utilicorp (KS)
  - 4>100 MW under development in West Texas
- Gas price increases and the power crisis
  - CO: 162 MW of wind wins all-source bid on economics alone
  - “wind is the lowest cost resource”
  - serious consideration of GW (BPA, Austin)
  - transmission and grid impacts to the forefront
- RUS loan to Basin Electric for Green Pricing program in S. Dakota
- NPPD RFP for 20 MW

Green Power & Customer Choice



Source: National Renewable Energy Laboratory (October 2003)



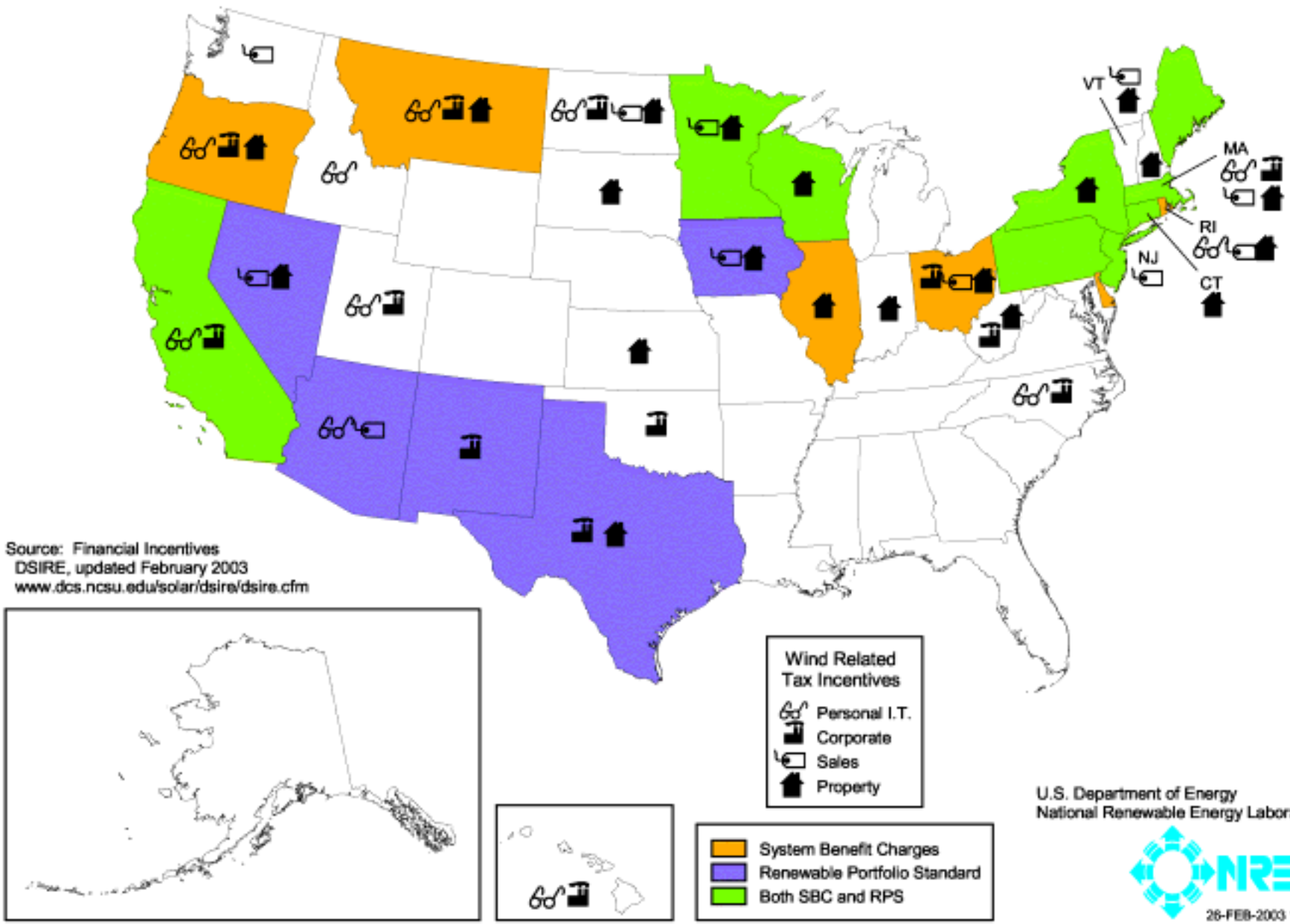
Sources: Energy Information Administration and NREL (October 2003)

WIND POWERING AMERICA

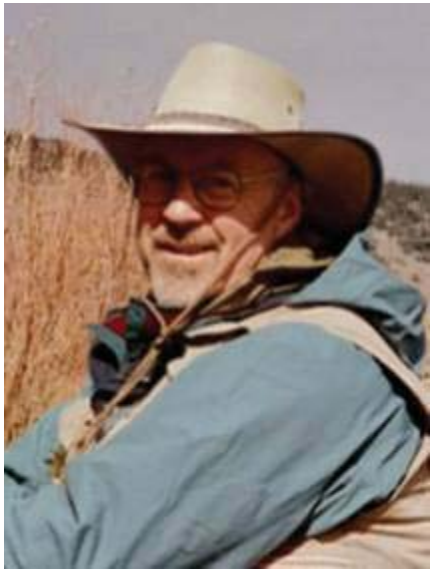
“Our customers wanted this wind program and it was our job to deliver it. It has turned out to be a huge source of community pride. The turbines are a visible landmark showing the Moorhead Community’s commitment to a better world for our children.”

Christopher Reed, Moorhead Public Service, Moorhead, Minnesota

United States - States with Renewable Energy Policies



WIND POWERING AMERICA



"You don't have to be a utility commissioner to see that we need better regulatory policies to achieve the diversity, economic development, and environmental benefits of wind power."

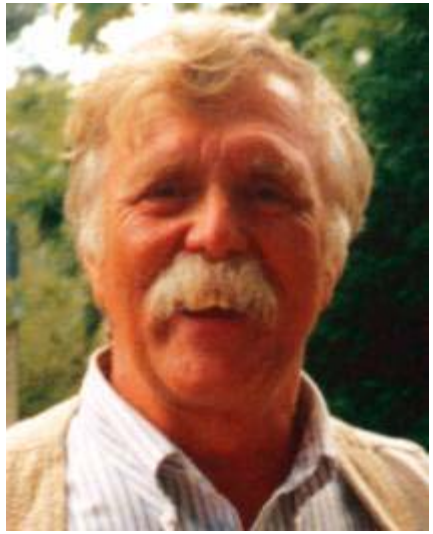
Bob Anderson, Montana Public Service Commission, Helena, Montana

Economic Development Opportunities

- Land Lease Payments: 2-3% of gross revenue $2500-4000/MW/year
- Local property tax revenue: 100 MW brings in on the order of $1 million/yr
- 1-2 jobs/MW during construction
- 2-5 permanent O&M jobs per 50-100 MW,
- Local construction and service industry: concrete, towers usually done locally
- Investment as Equity Owners: production tax credit, accelerated depreciation
- Manufacturing and Assembly plants expanding in U.S. (Micon in IL, LM Glasfiber in ND)

Wind Power Provides Rural Economic Benefits

- 240 MW of wind in Iowa
  - $640,000/yr in lease payments to farmers ($2,000/turbine/yr)
  - $2 million/yr in property taxes
  - $5.5 mil/yr in O&M income
  - 40 long-term O&M jobs
  - 200 short-term construction jobs
  - Doesn't include multiplier effect
- 107 MW wind project in MN
  - $500,000/yr in lease payments to farmers
  - $611,000 in property taxes in 2000 = 13% of total county taxes
  - 31 long-term local jobs and $909,000 in income from O&M (includes multiplier effect)

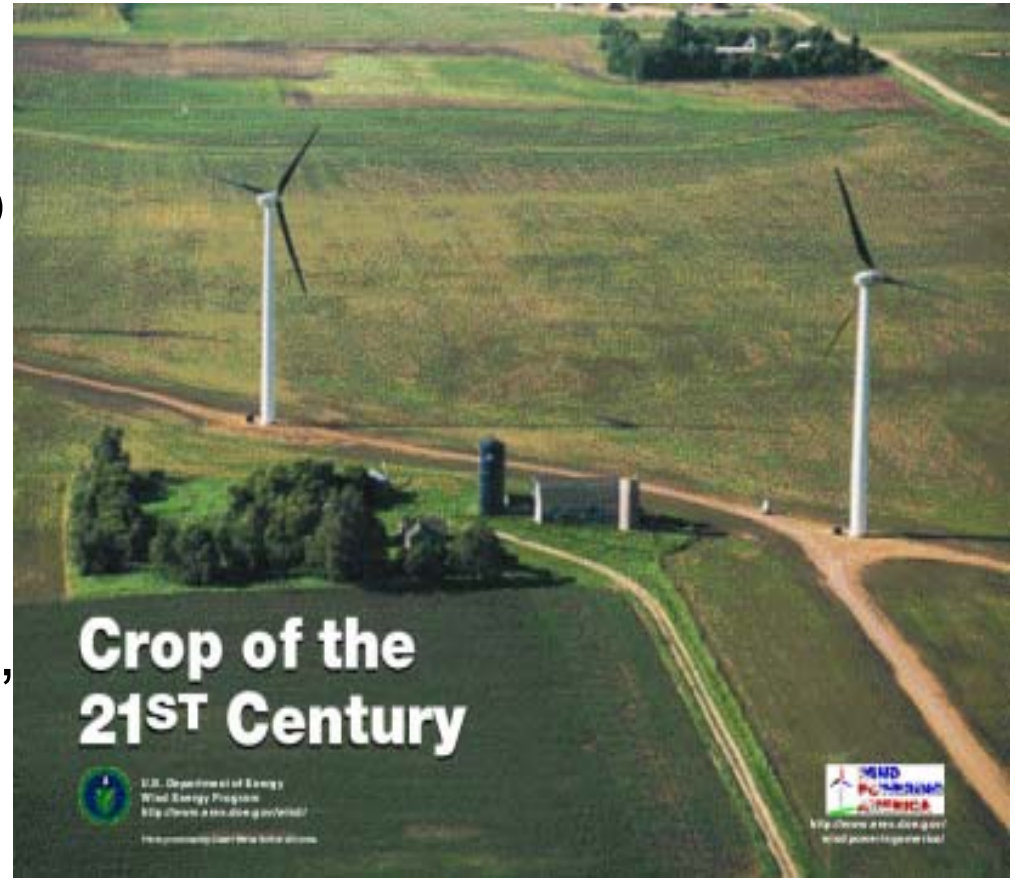


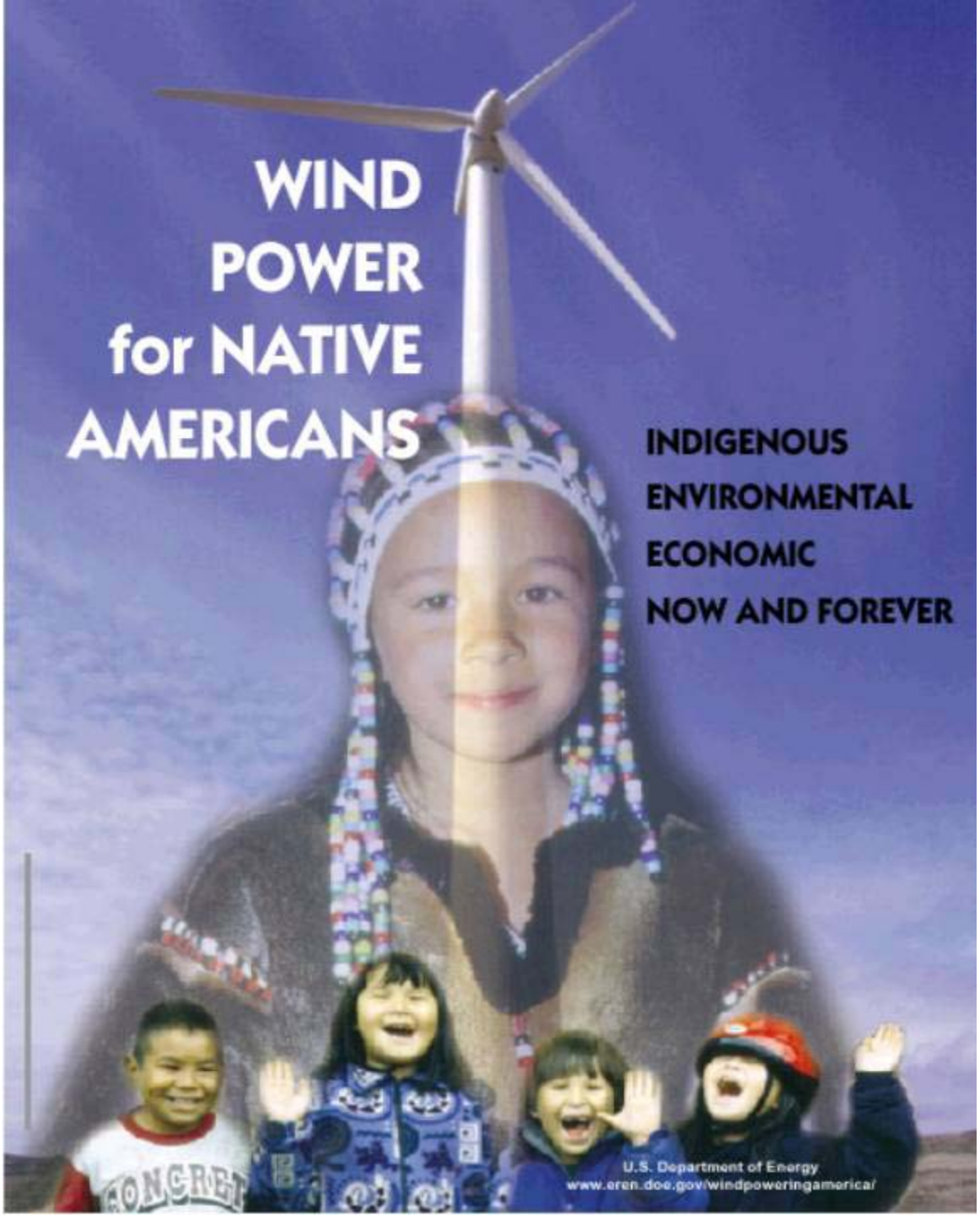
“Wind is a homegrown energy that we can harvest right along side our corn or soybeans or other crops. We can use the energy in our local communities or we can export it to other markets. We need to look carefully at wind energy as a source of economic growth for our region”

David Benson, Farmer and County Commissioner, Nobles County, Minnesota

Key Issues for Wind Power

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

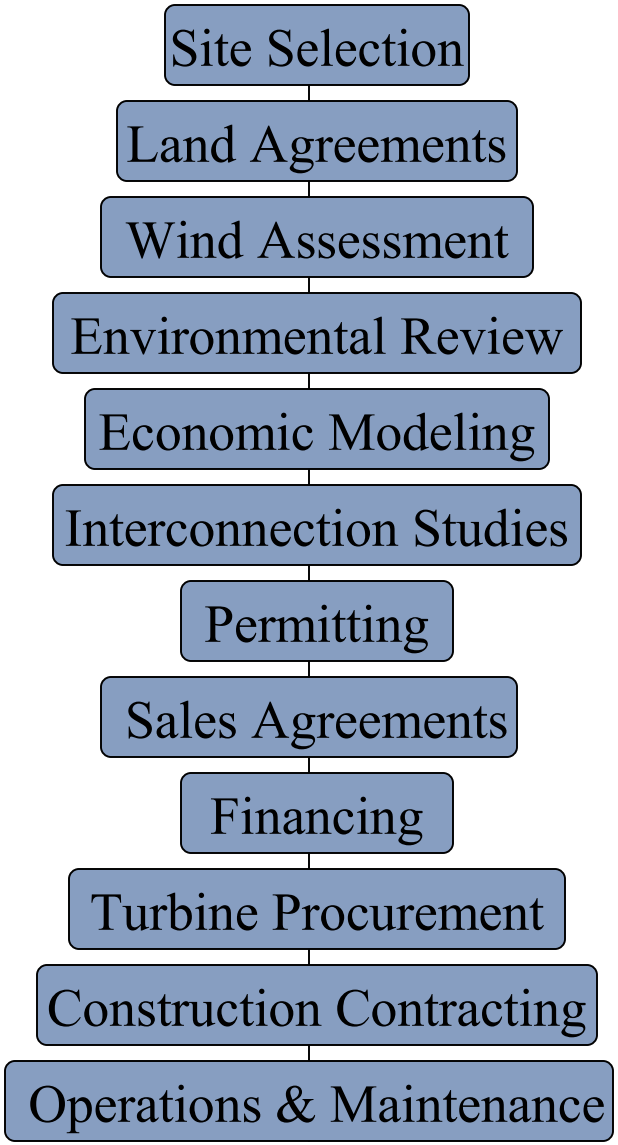



WIND
POWER
for NATIVE
AMERICANS
INDIGENOUS
ENVIRONMENTAL
ECONOMIC
NOW AND FOREVER
U.S. Department of Energy
www.eren.doe.gov/windpoweringamerica/

"In evaluating the potential of wind energy generation, Native Americans realize that wind power is not only consistent with our cultural values and spiritual beliefs, but can also be a means of achieving Native sustainable homeland economies."

Ronald Neiss, Rosebud Utility Commission President, Rosebud Sioux Reservation, South Dakota

The Wind Project Development Process



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