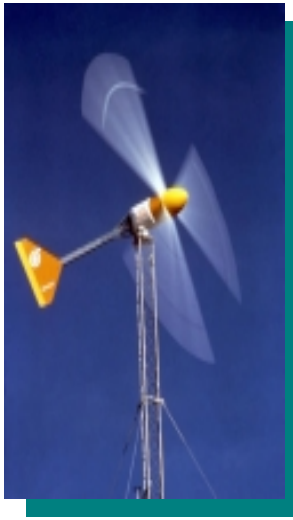
Wind Power Update

Larry Flowers – NREL

October 24-25, 2001

Sizes and Applications



Small (≤10 kW)

- Homes
- Farms
- Remote Applications

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

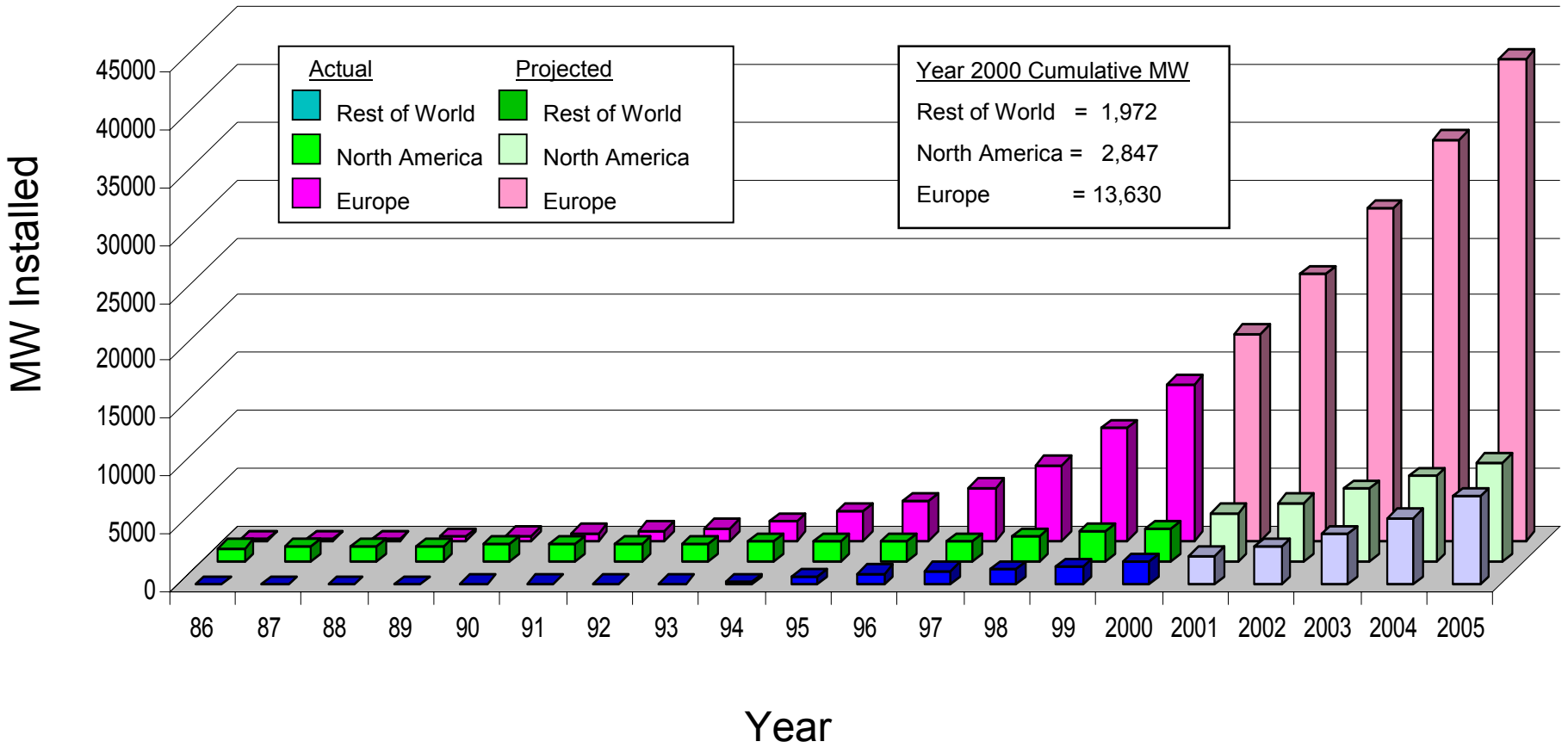
Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Distributed Power

Large (250 kW - 2+MW)

- Central Station Wind Farms
- Distributed Power

Growth of Wind Energy Capacity Worldwide



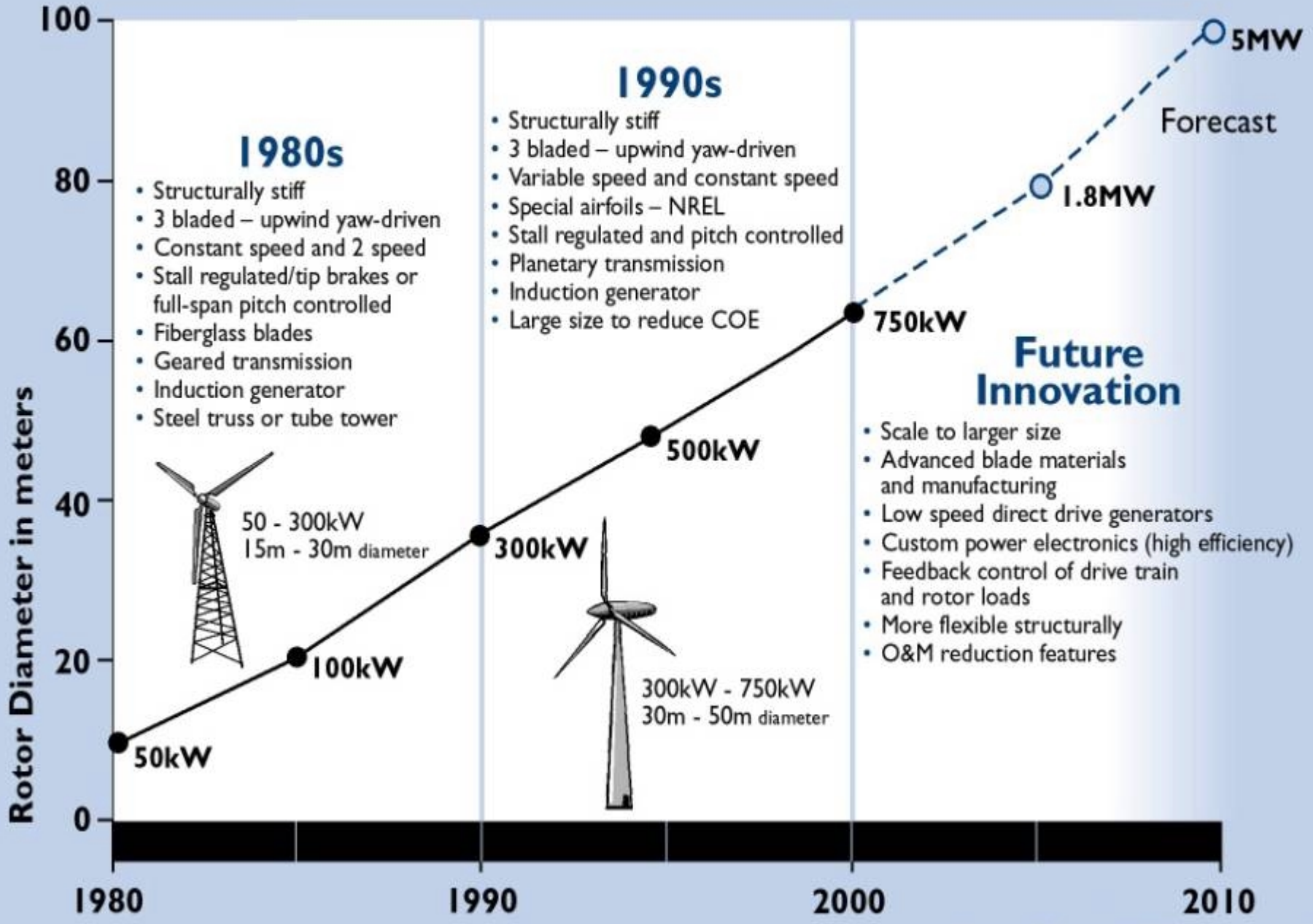
Source: BTM Consult Aps - March 2001

International Market Trends

- $5 billion/year in sales
- Fastest growing electric technology: 29% worldwide
- 45% world market from Danish companies
- European future in off-shore open installations
  - **86 MW in 2000**
  - **Growing to 2400 MW's in 2005***

**Source BTM Consult ApS - March 2001*

The Evolution of Commercial U.S. Wind Technology



Source: Thresher & Dodge, Wind Energy Journal 1998

Cost of Energy Trend

1979: 40 cents/kWh

2000:
4 - 6 cents/kWh

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

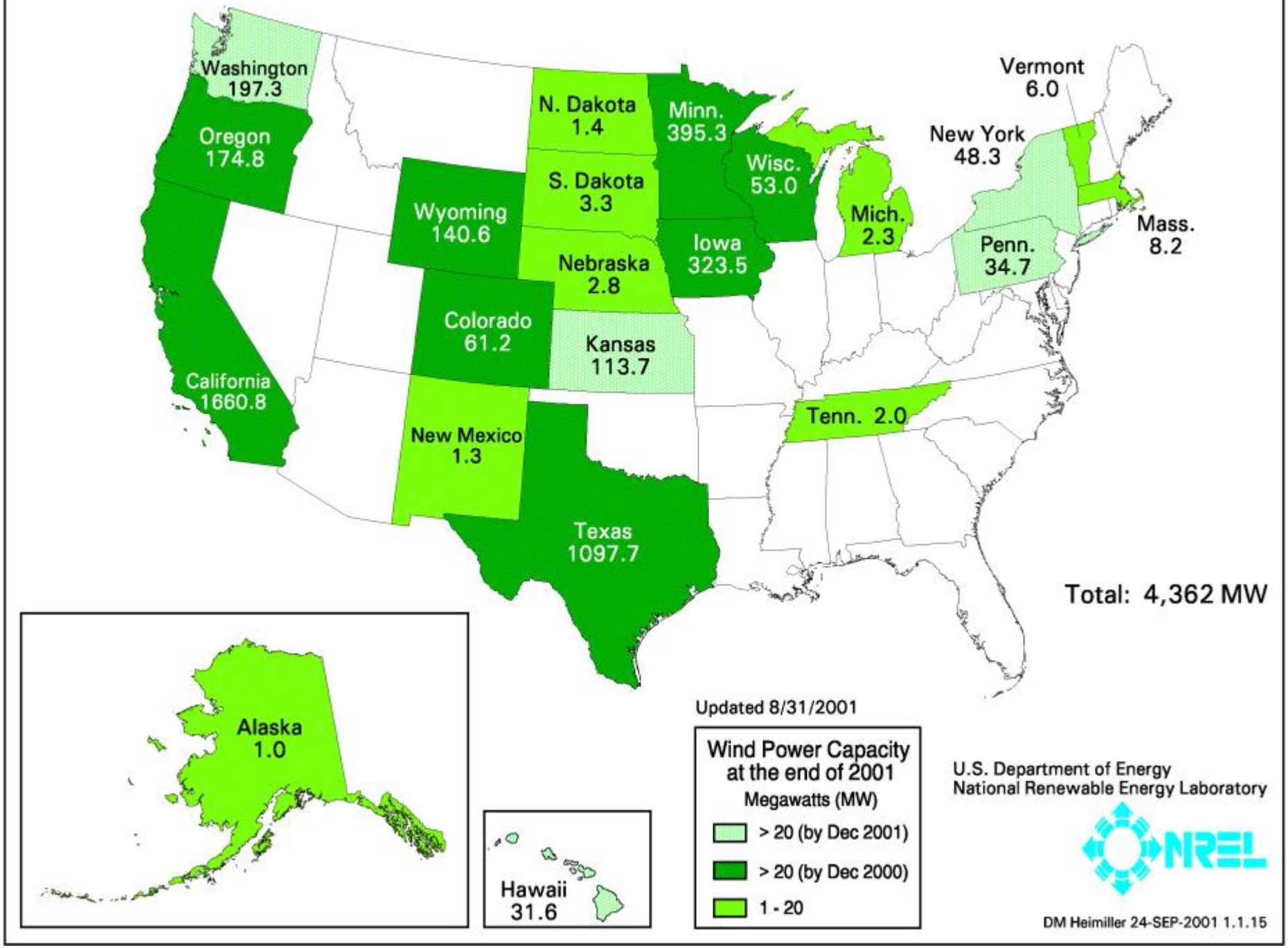
2004:
3 - 5 cents/kWh

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

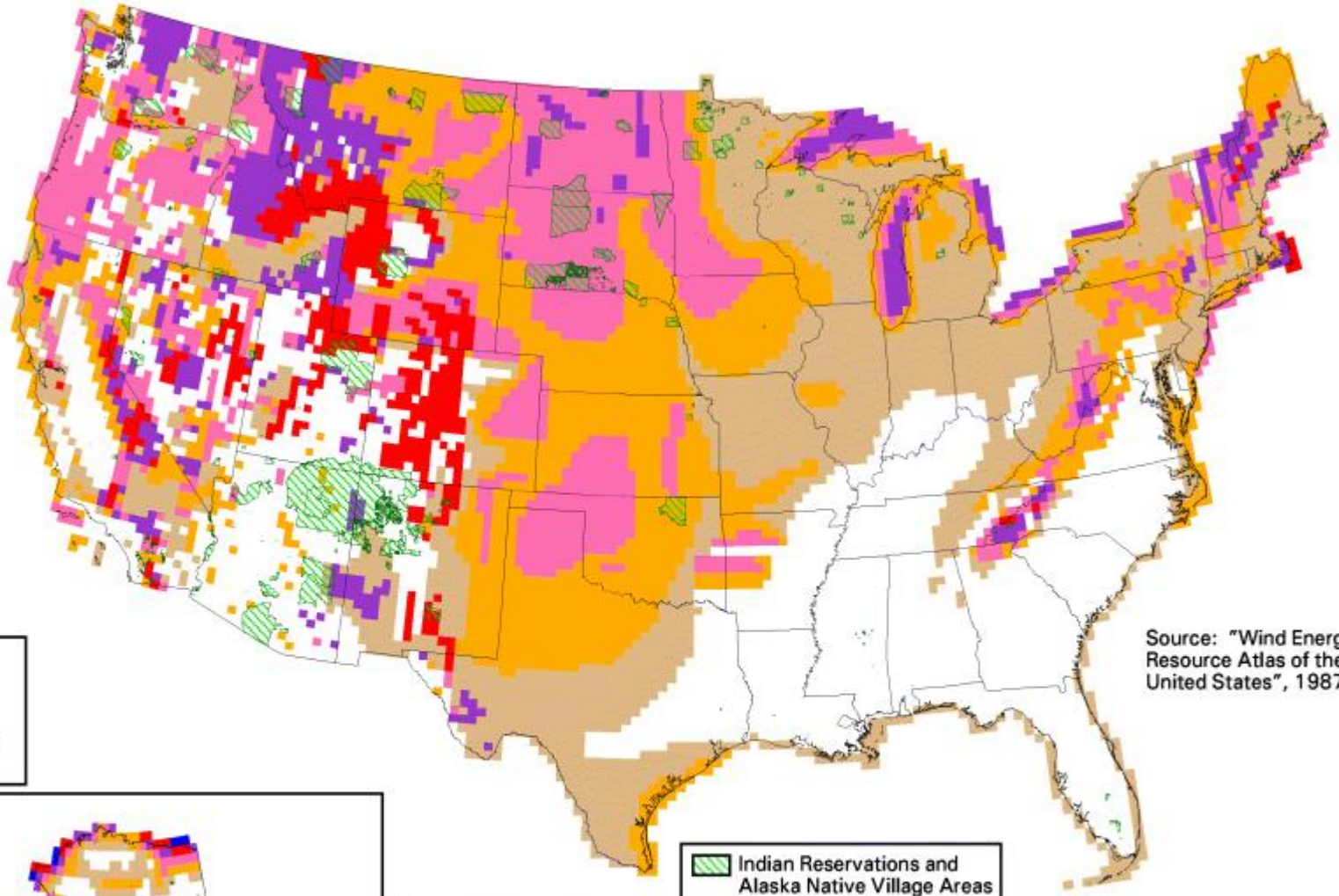
A Maturing Wind Technology

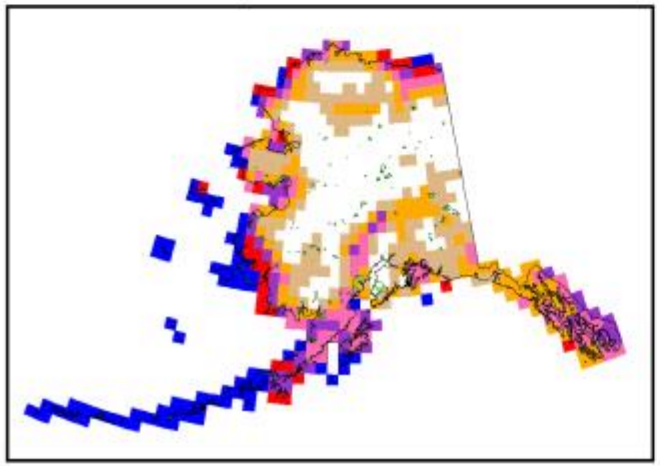
- Technology has matured over 25 years of learning experiences
- Availabilities reported of 98-99%
- Certification to international standards helps to avoid “show stoppers”
- Performance and cost have dramatically improved
  - hardware issues are being promptly addressed
- New hardware is being developed 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

United States - Wind Power Capacity Expected by Year-End 2001 (MW)



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

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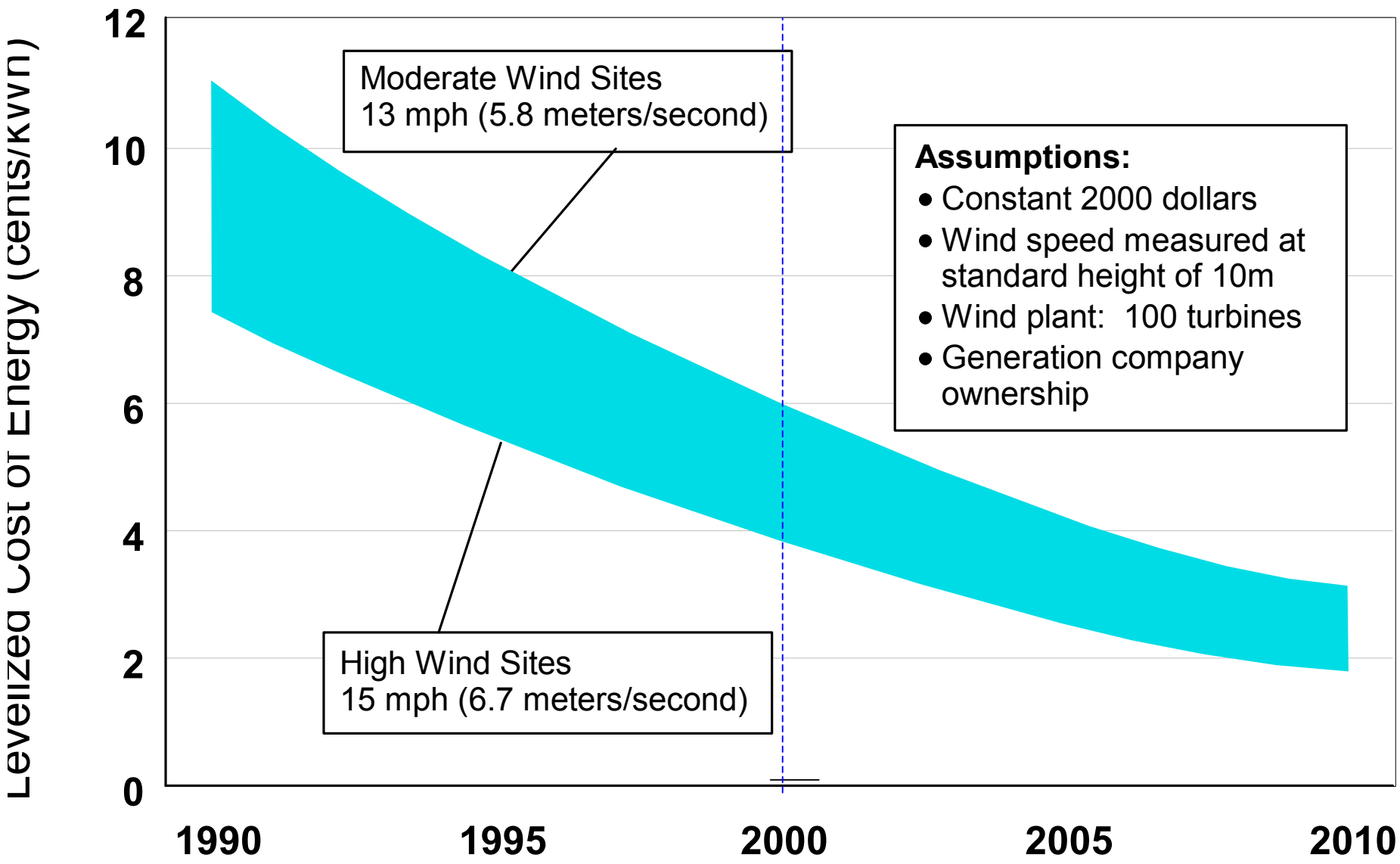
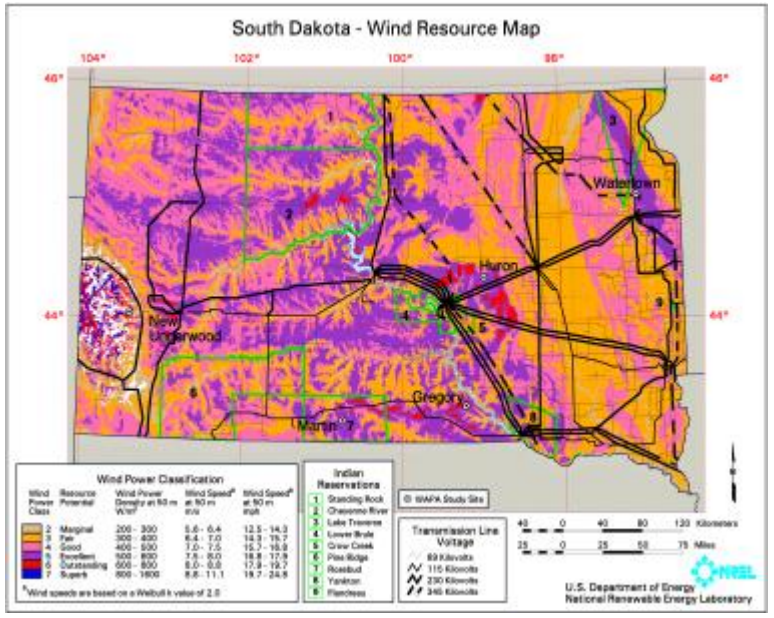
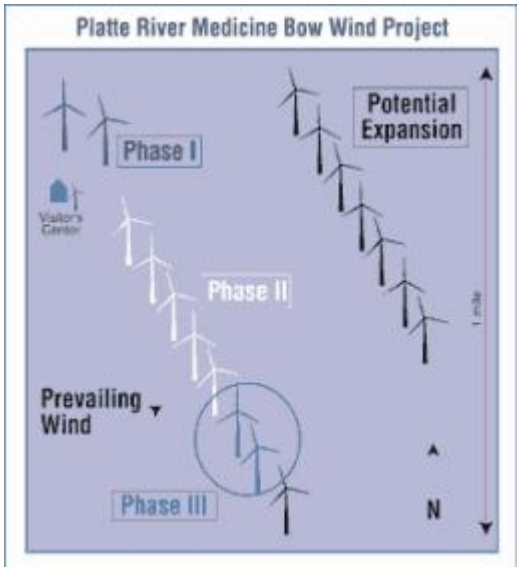

Levelized Cost of Energy (cents/kWh)
12
10
8
6
4
2
0
1990
1995
2000
2005
2010
Moderate Wind Sites
13 mph (5.8 meters/second)
High Wind Sites
15 mph (6.7 meters/second)
Assumptions:
• Constant 2000 dollars
• Wind speed measured at standard height of 10m
• Wind plant: 100 turbines
• Generation company ownership

But… *It really depends*

Location, Location, Location

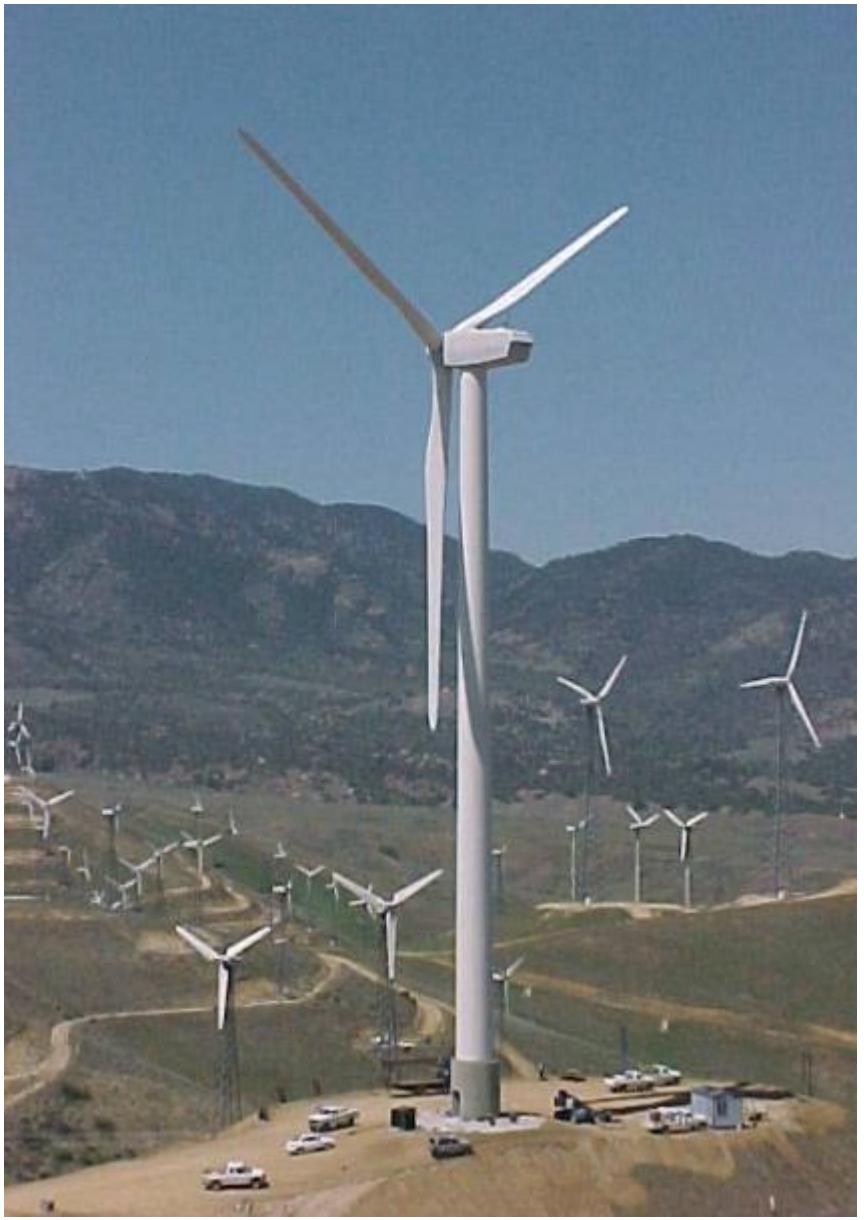
- Resource
  - 1 mph in average speed is ~ 0.5 cents/kWh
  - Raising tower from 50 to 100m increases kWh ~15% or more in class 4-5
  - Coincidence of wind with load increases value
- Permitting
  - private vs. public land
  - state and local regulations
- Existing site expansion
  - quick, low cost option
- What is included
  - transmission, land





Plant and Turbine Size

- Spread “nearly fixed” costs: permitting, crane, legal and other soft costs
- Volume discount from manufacturer
- Economies of scale may bring O&M to under 0.2 cents/kWh
- Next generation of 1.2-2.0 MW machines are 10-15% cheaper/kW



Finances and Incentives

- Production Tax Credit
  - 1.7 cents/kWh (escalating) for 10 years equates to around 1.1 cents/kWh reduction in contract price
  - deadline pressure *increases* costs
- State and Local tax, etc. can be significant
  +/- 0.5 cents/kWh impact
- Public Power (100% debt at tax free rates)
  60% of GenCo or IPP cents/kWh
- Renewable Energy Production Incentive
  annual appropriations problem leads to little impact

Wind Energy Value

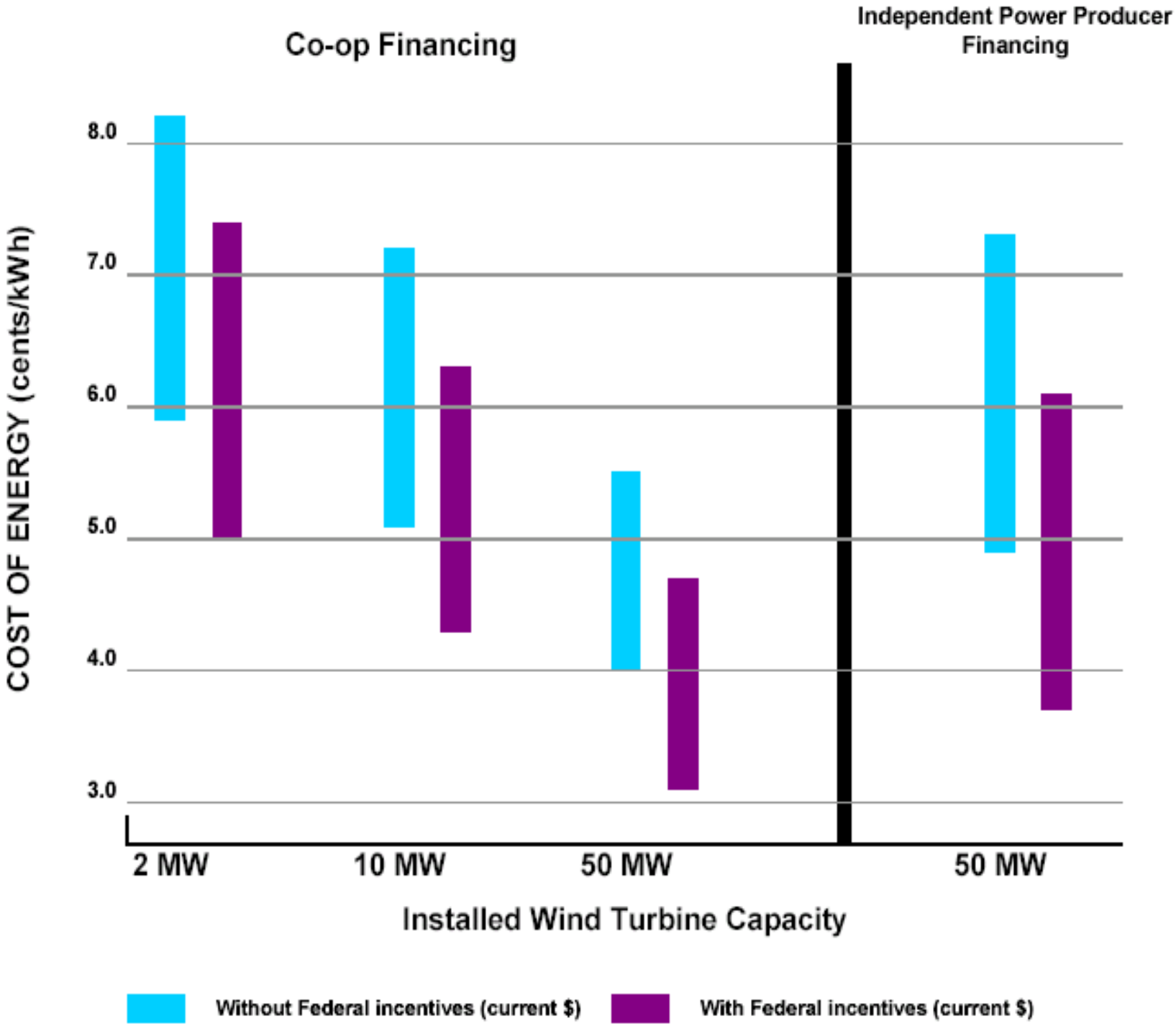
- Emissions free power beginning to have additional value
  - green markets
  - emissions credits
- Reliability/capacity value
- Fuel/Resource diversity and risk
- Intermittency
  - non-dispatchable (different types of kWh)
  - ancillary service costs ??

Recent Developments

- The wind industry is delivering ~3 cent/kWh contracts, including PTC for large projects
- Several large projects under developments
  - 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

Conclusions

- The wind industry is delivering ~ 3 cent/kWh contracts, including PTC for large projects
- This price will likely be higher for small projects in new locations
- Value side important: but cost dominates in domestic markets today

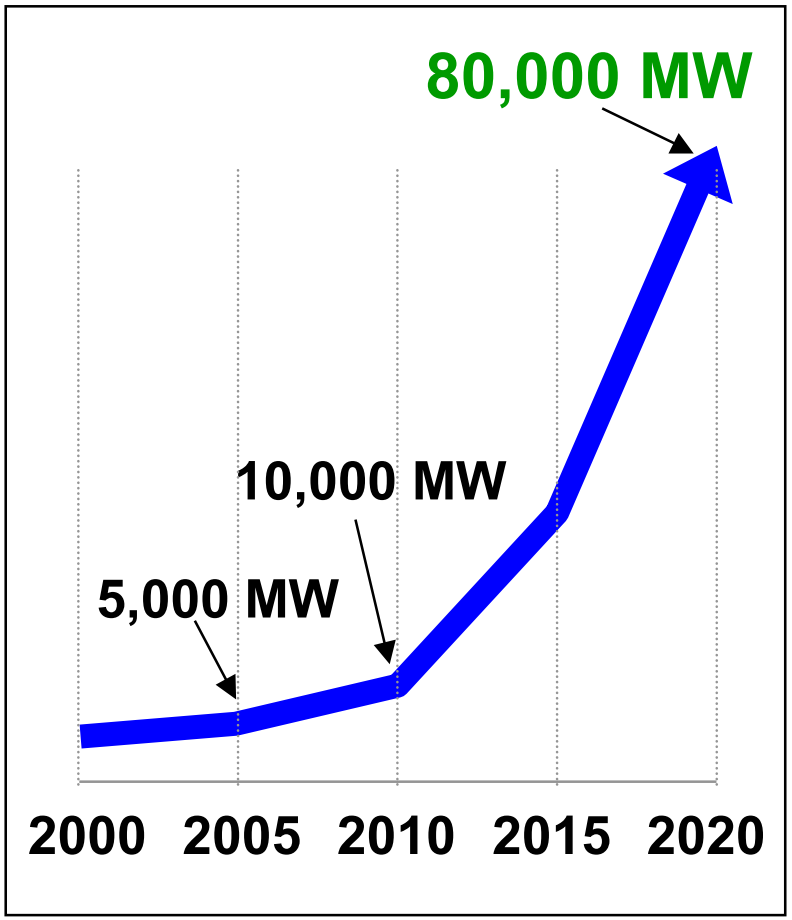

Co-op Financing
Independent Power Producer Financing
COST OF ENERGY (cents/kWh)
8.0
7.0
6.0
5.0
4.0
3.0
2 MW
10 MW
50 MW
50 MW
Installed Wind Turbine Capacity
Without Federal incentives (current $)
With Federal incentives (current $)

Economic Development Opportunities

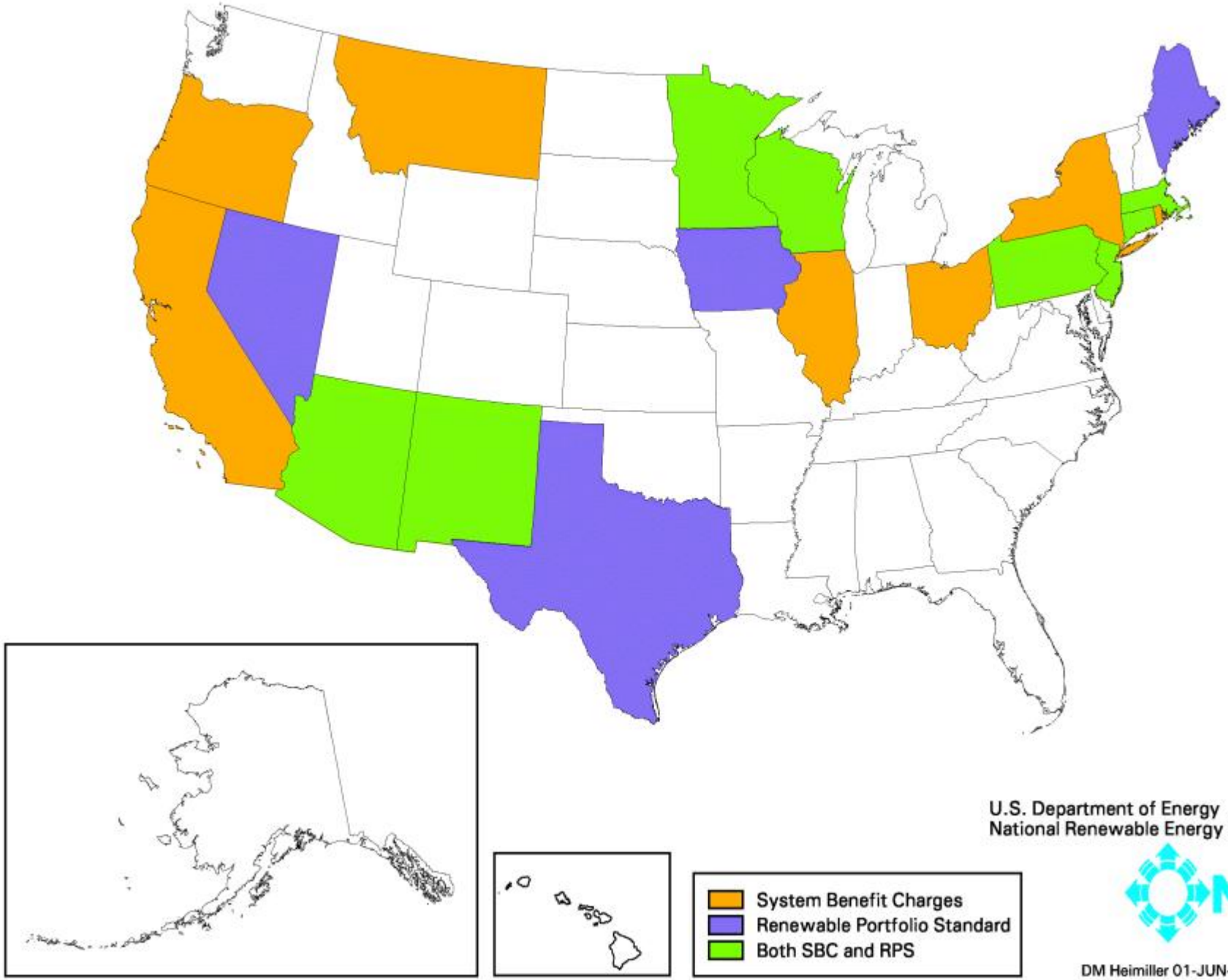
- Land Lease Payments: 2-3% of gross revenue $2500-4000/MW/year
- Local property tax revenue: 100 MW brings in on the order of $1 million/yr
- 1-2 jobs/MW during construction
- 2-5 permanent O&M jobs per 50-100 MW,
- Local construction and service industry: concrete, towers usually done locally
- Investment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

Goals

- Provide at least 5% of the nation's electricity with wind by 2020
  - Install more than 5000 MW by 2005
  - Have more than 10,000 MW on-line by 2010
- Double the number of states that have more than 20 MW of wind capacity to 16 by 2005, and triple the number to 24 by 2010
- Increase wind's contribution to federal electricity use to 5% by 2010
- Supplemental goals
  - Federal agencies-2.5% RE by 2005; 7 1/2% by 2010



United States - State with Renewable Energy Policies



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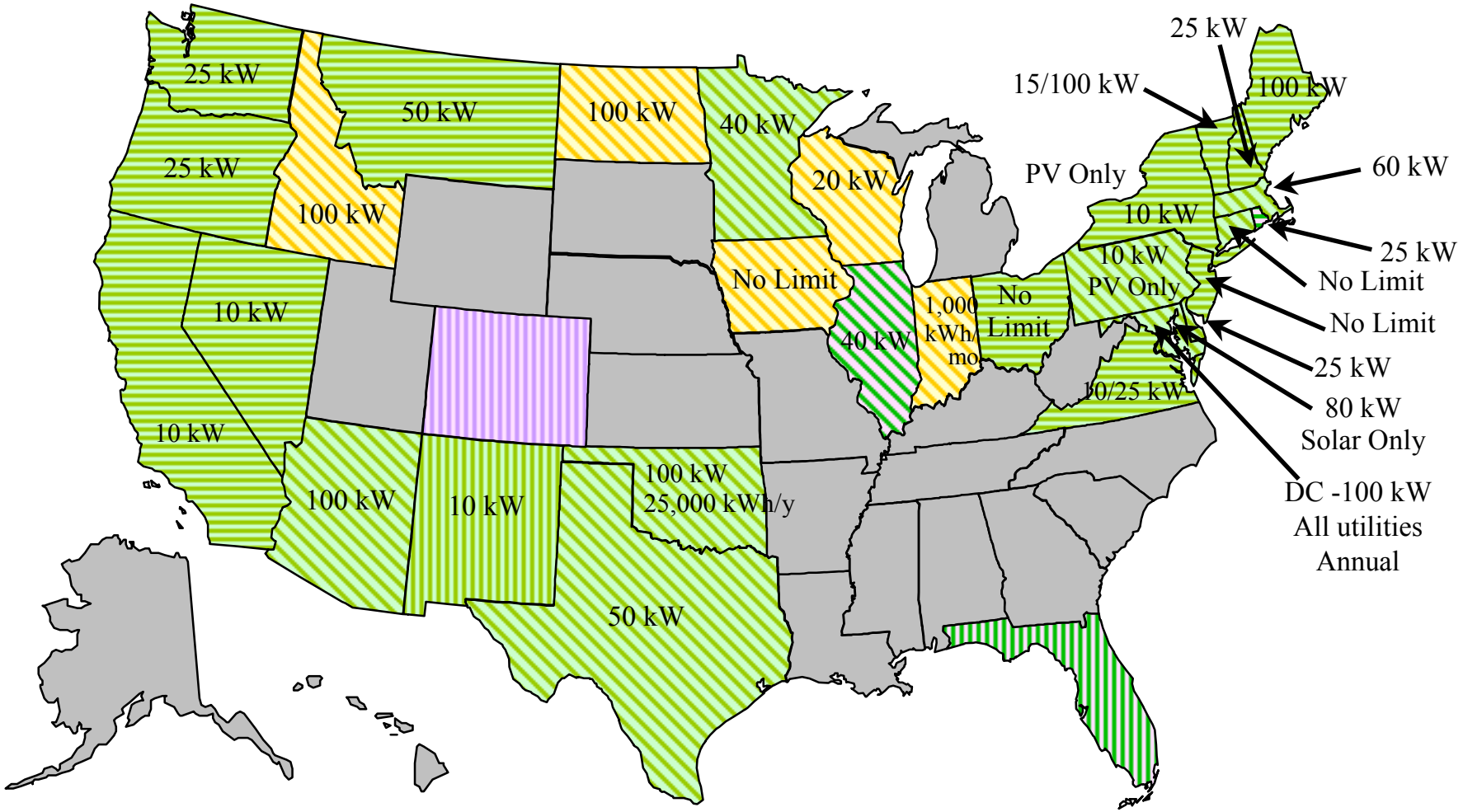
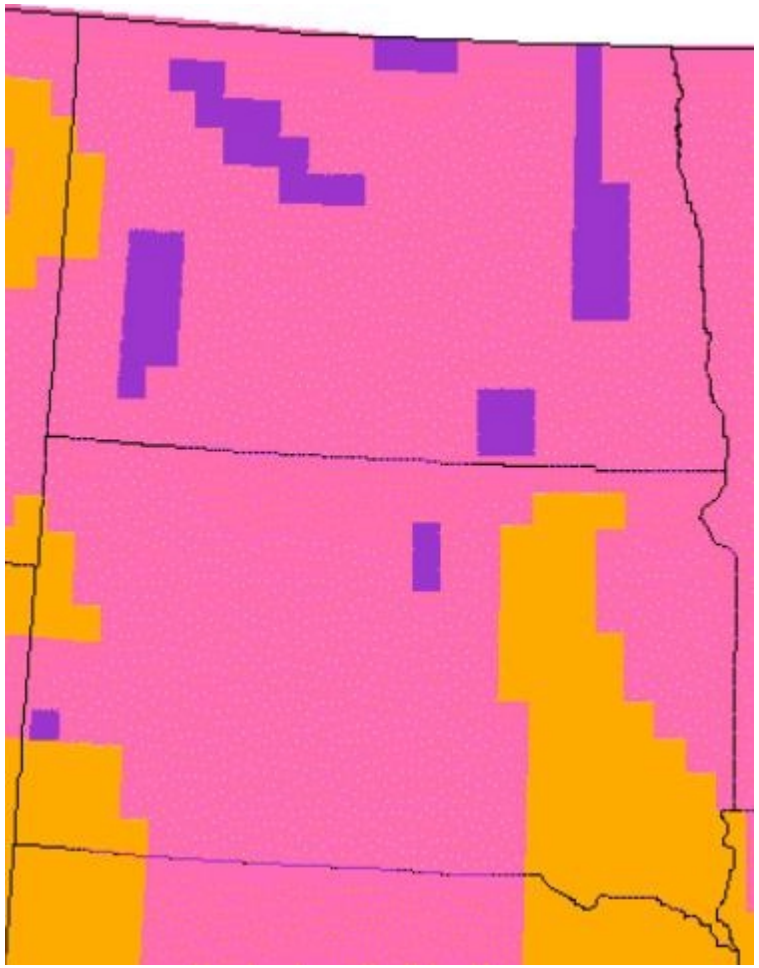
Net Metering By State



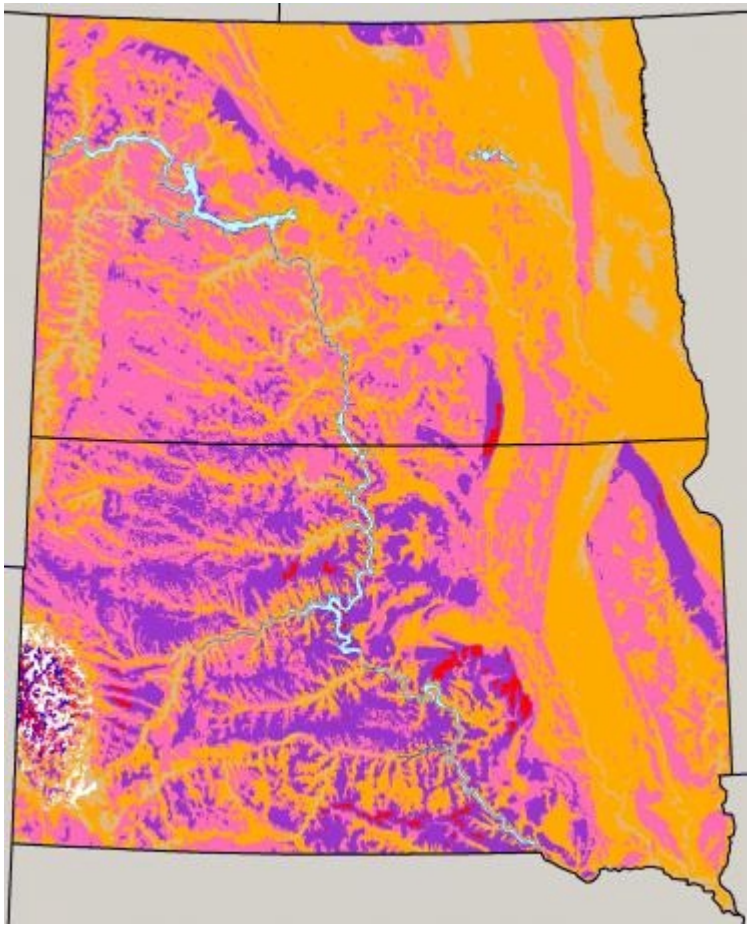
Revised: 31 Jan 01

IOU - Investor-Owned Utility
REC - Rural Electric Cooperative

Comparison of Digital Wind Map from 1987 U.S. Wind Atlas and New (2000) High-Resolution (1-km^2) Wind Map North and South Dakota



1987



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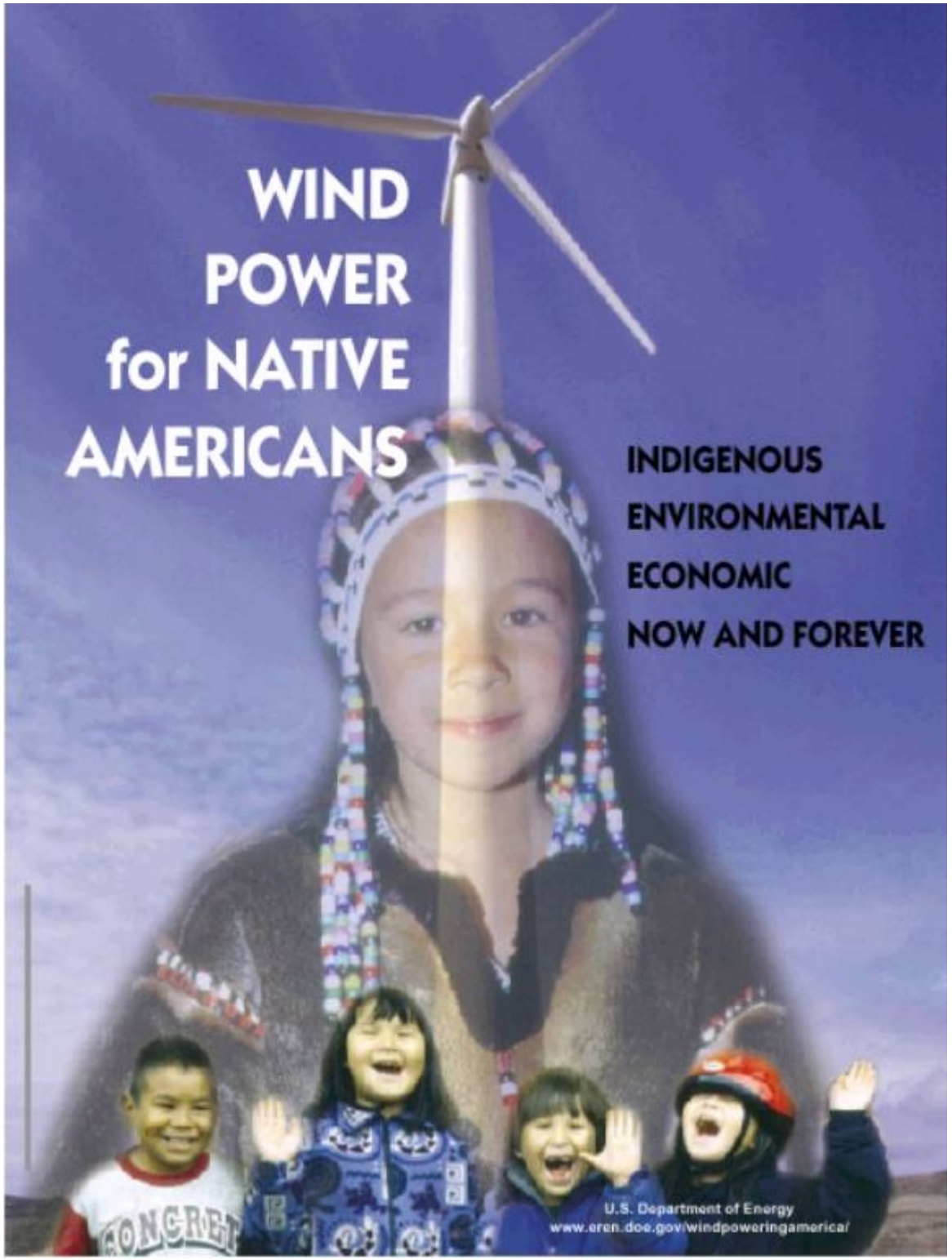
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