# Wind Energy Update

Larry Flowers
National Renewable Energy Laboratory






Anchorage, AK

July 20, 2005

# Sizes and Applications

## Small (≤10 kW)

- Homes (Grid connected)
- Farms
- Remote Applications

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

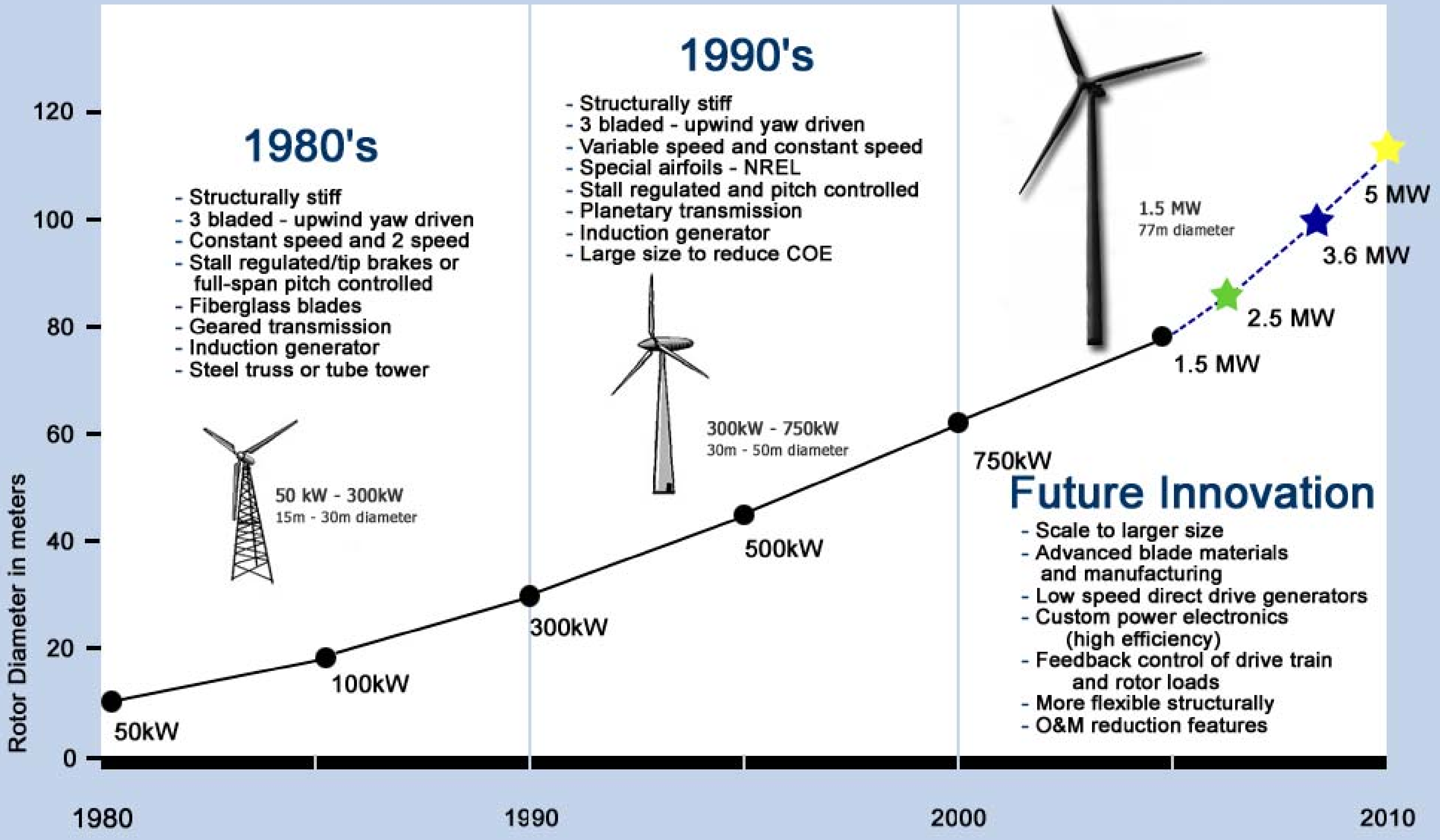
## Intermediate (10-500 kW)

- Village Power
- Hybrid Systems
- Distributed Power

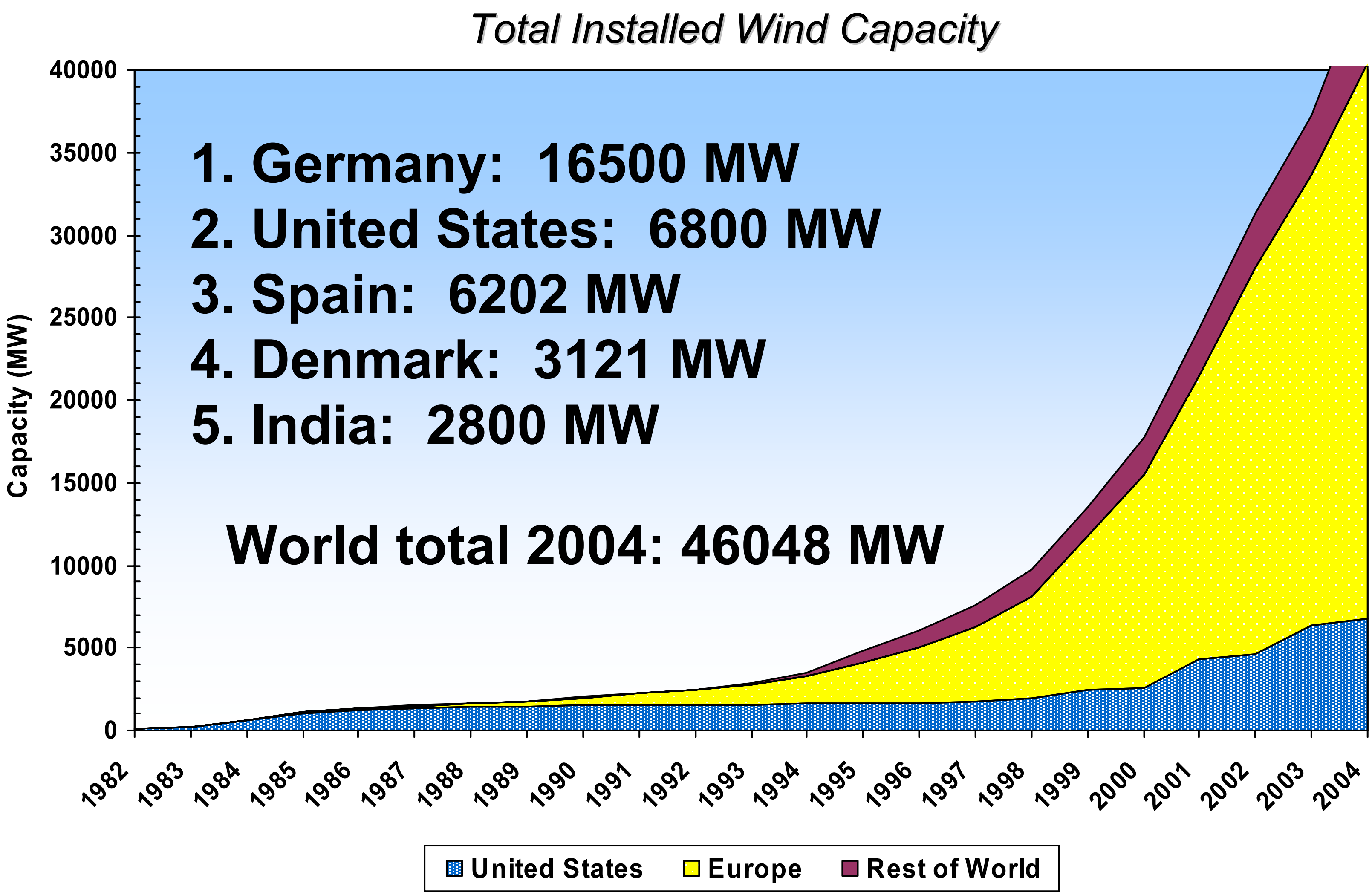
## Large (500 kW – 6 MW)

- Central Station Wind Farms
- Distributed Power
- Offshore Wind Generation Stations

# THE EVOLUTION OF COMMERICAL U.S. WIND TECHNOLOGY

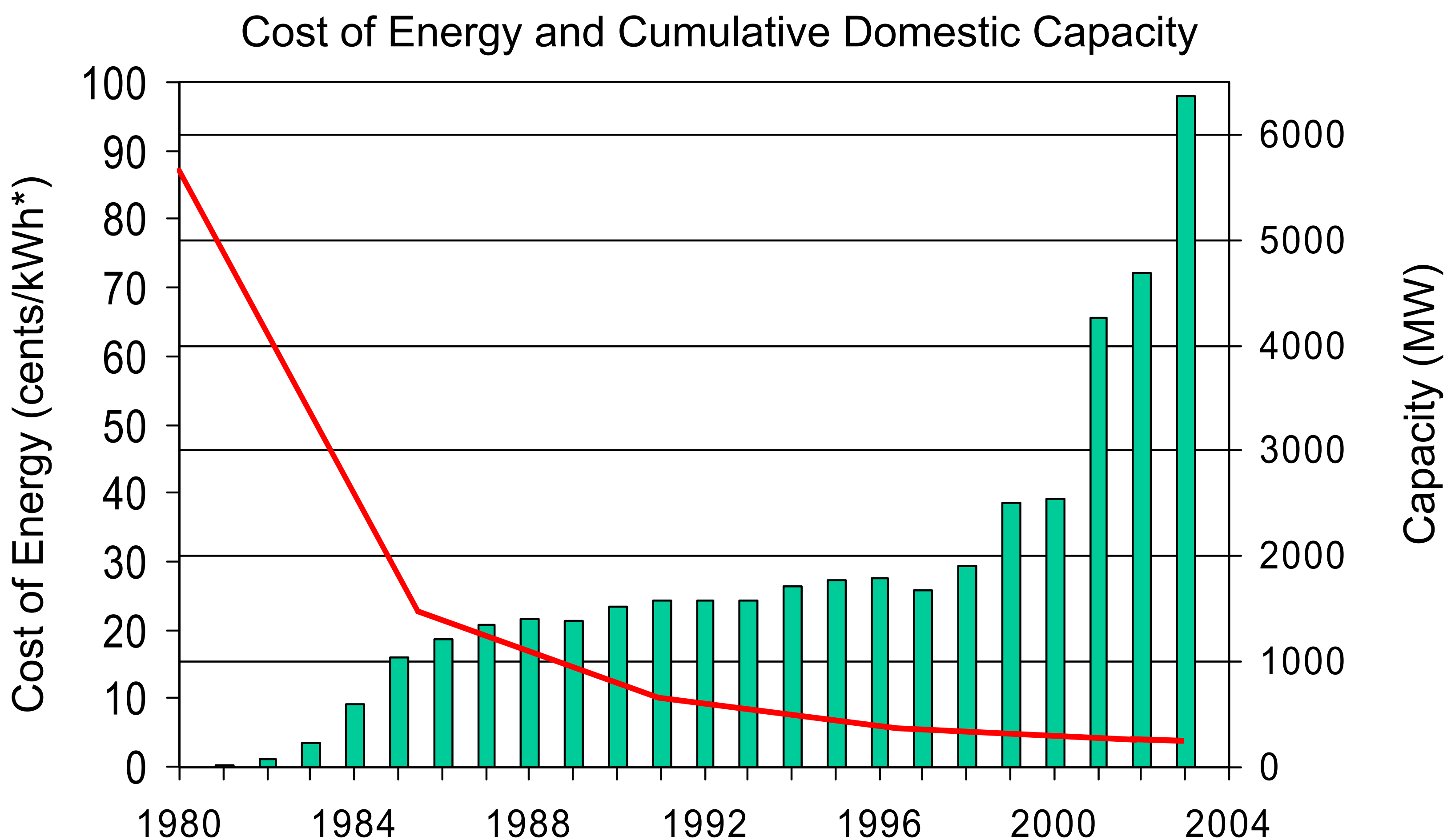


# World Growth Market



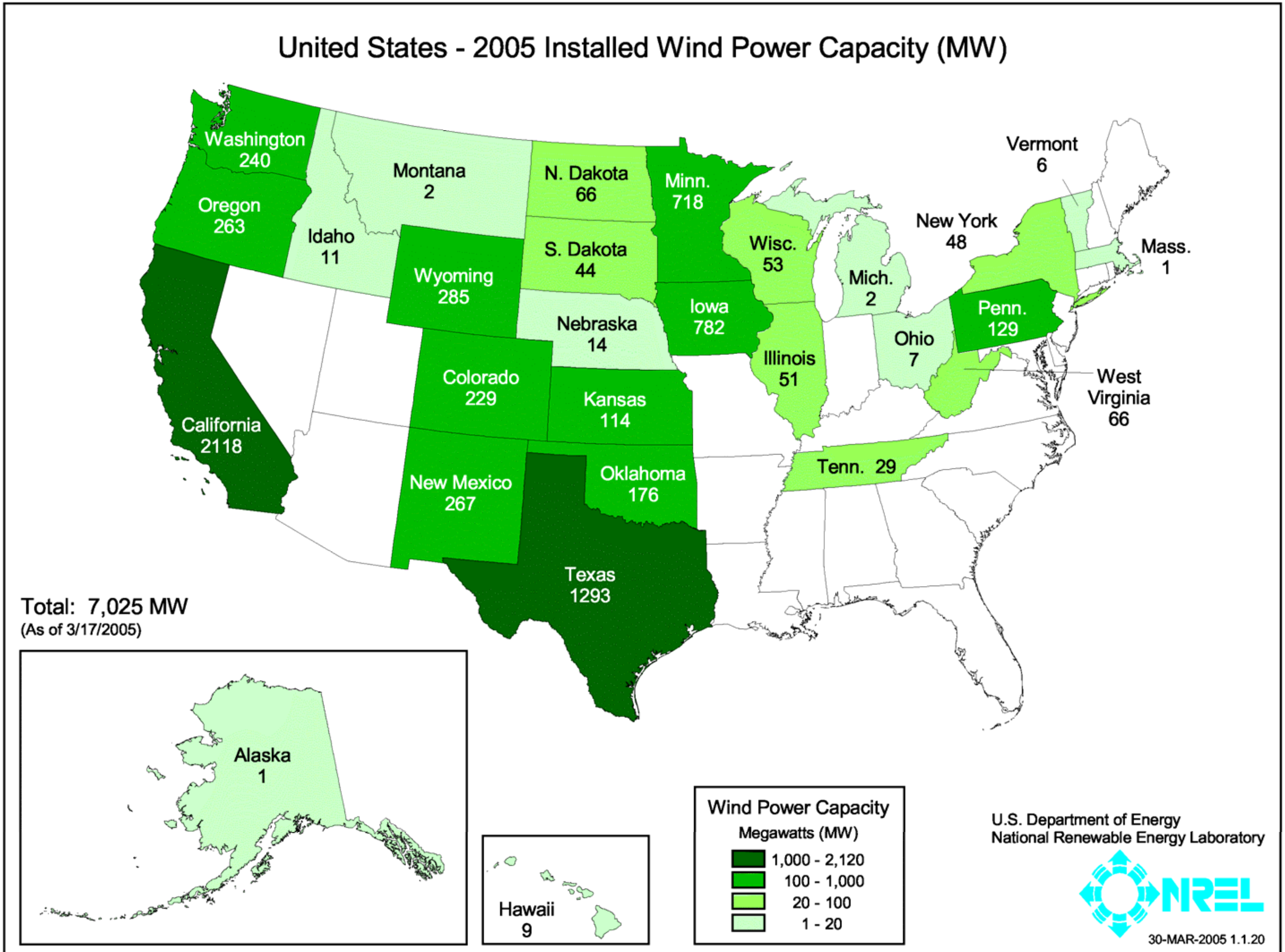

*Source: WindPower Monthly*

# Capacity & Cost Trends



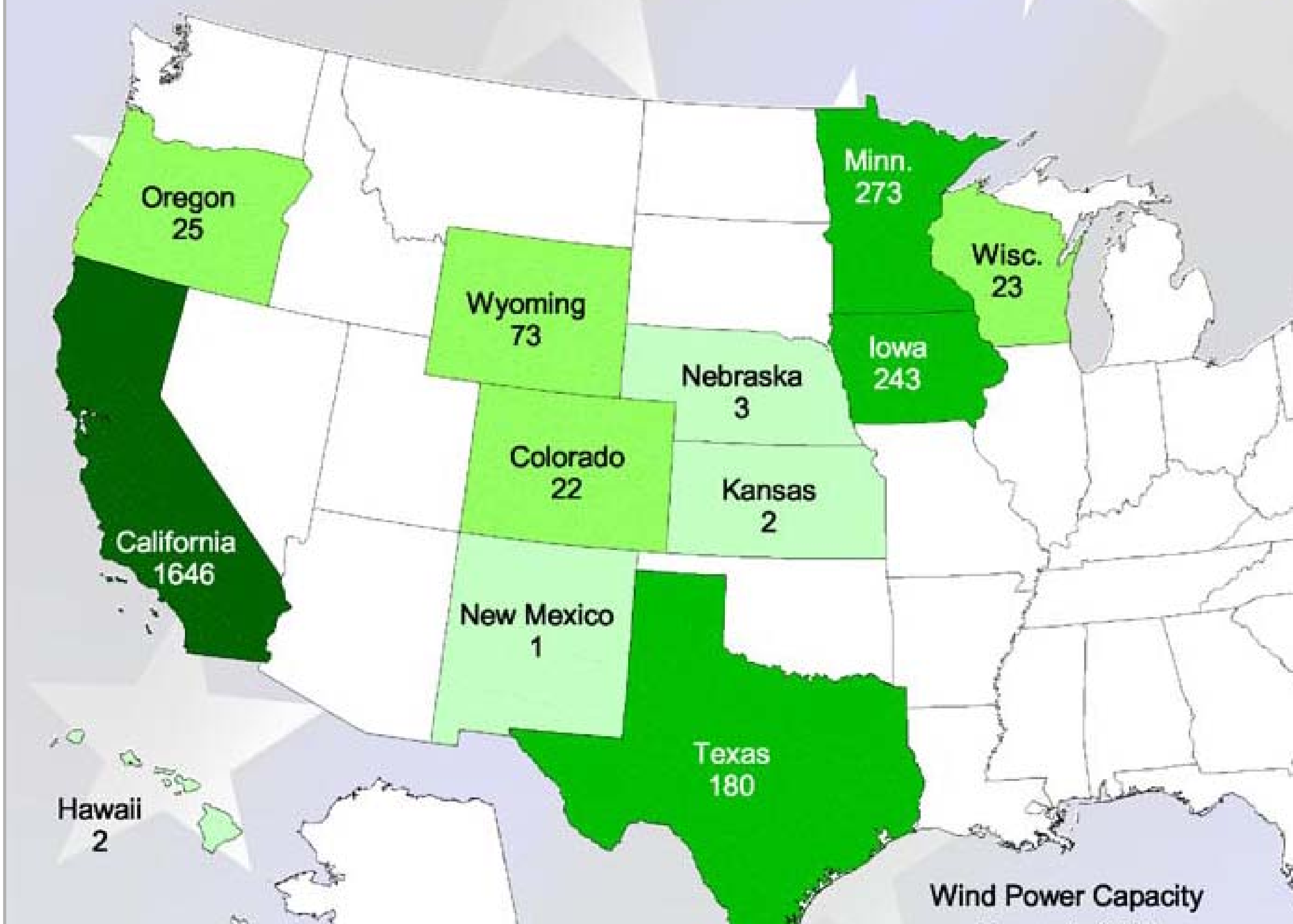

*Year 2000 dollars

Increased Turbine Size - R&D Advances - Manufacturing Improvements



United States - 2005 Installed Wind Power Capacity (MW)
Washington 240
Oregon 263
California 2118
Idaho 11
Montana 2
Wyoming 285
N. Dakota 66
S. Dakota 44
Nebraska 14
Colorado 229
Kansas 114
New Mexico 267
Oklahoma 176
Texas 1293
Minn. 718
Iowa 782
Wisc. 53
Illinois 51
Mich. 2
Ohio 7
Tenn. 29
Penn. 129
West Virginia 66
New York 48
Vermont 6
Mass. 1
Total: 7,025 MW
(As of 3/17/2005)
Alaska 1
Hawaii 9
Wind Power Capacity
Megawatts (MW)
1,000 - 2,120
100 - 1,000
20 - 100
1 - 20
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
30-MAR-2005 1.1.20

# 1999 Year End Wind Power Capacity (



GE

SIEMENS

bp

BP Solar

JOHN DEERE

FPL

Vestas

AEP

AMERICAN ELECTRIC POWER

Gamesa

Xcel Energy

Windsource®

AES

MIDAMERICAN

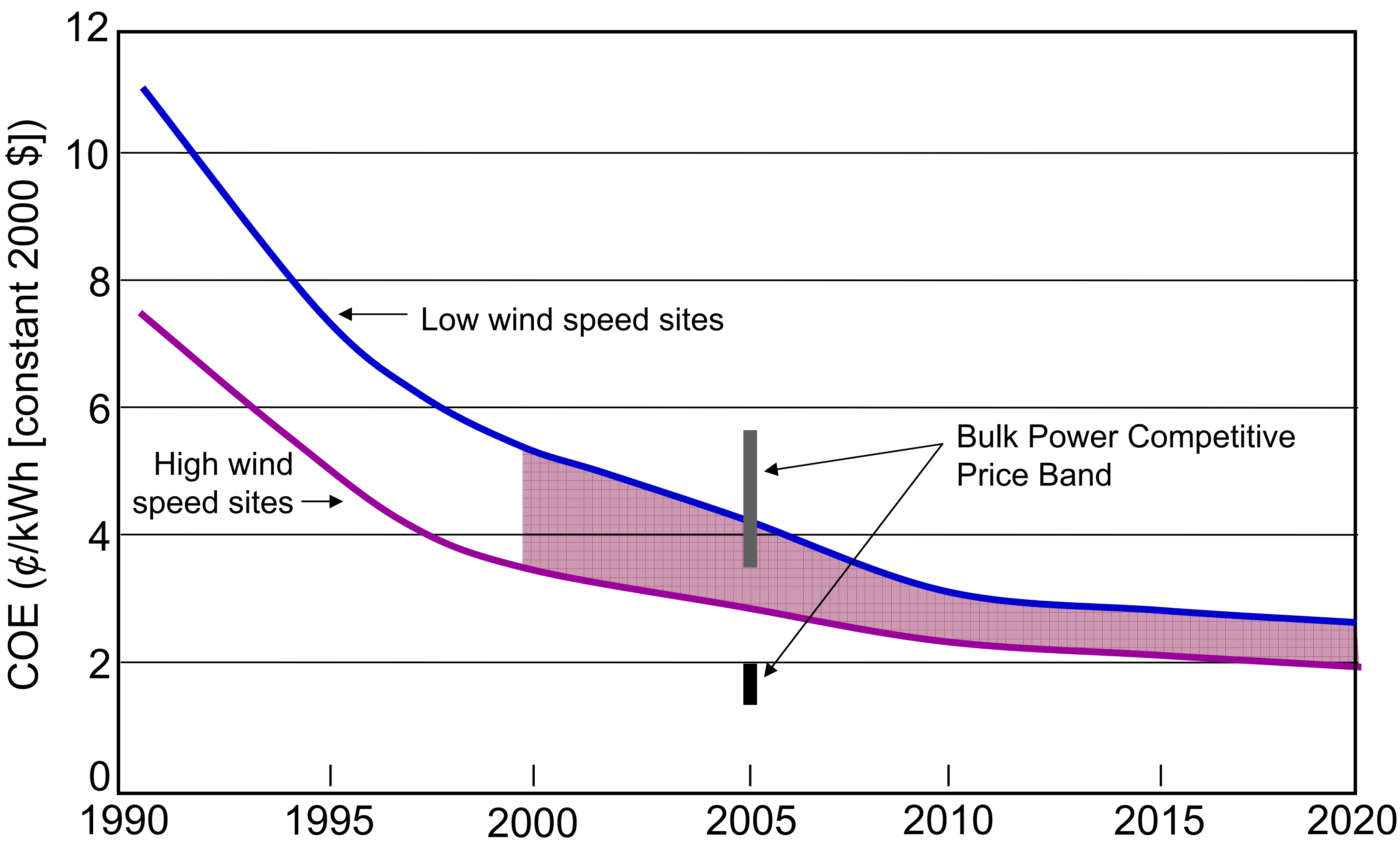
ENERGY HOLDINGS COMPANY

Goldman Sachs

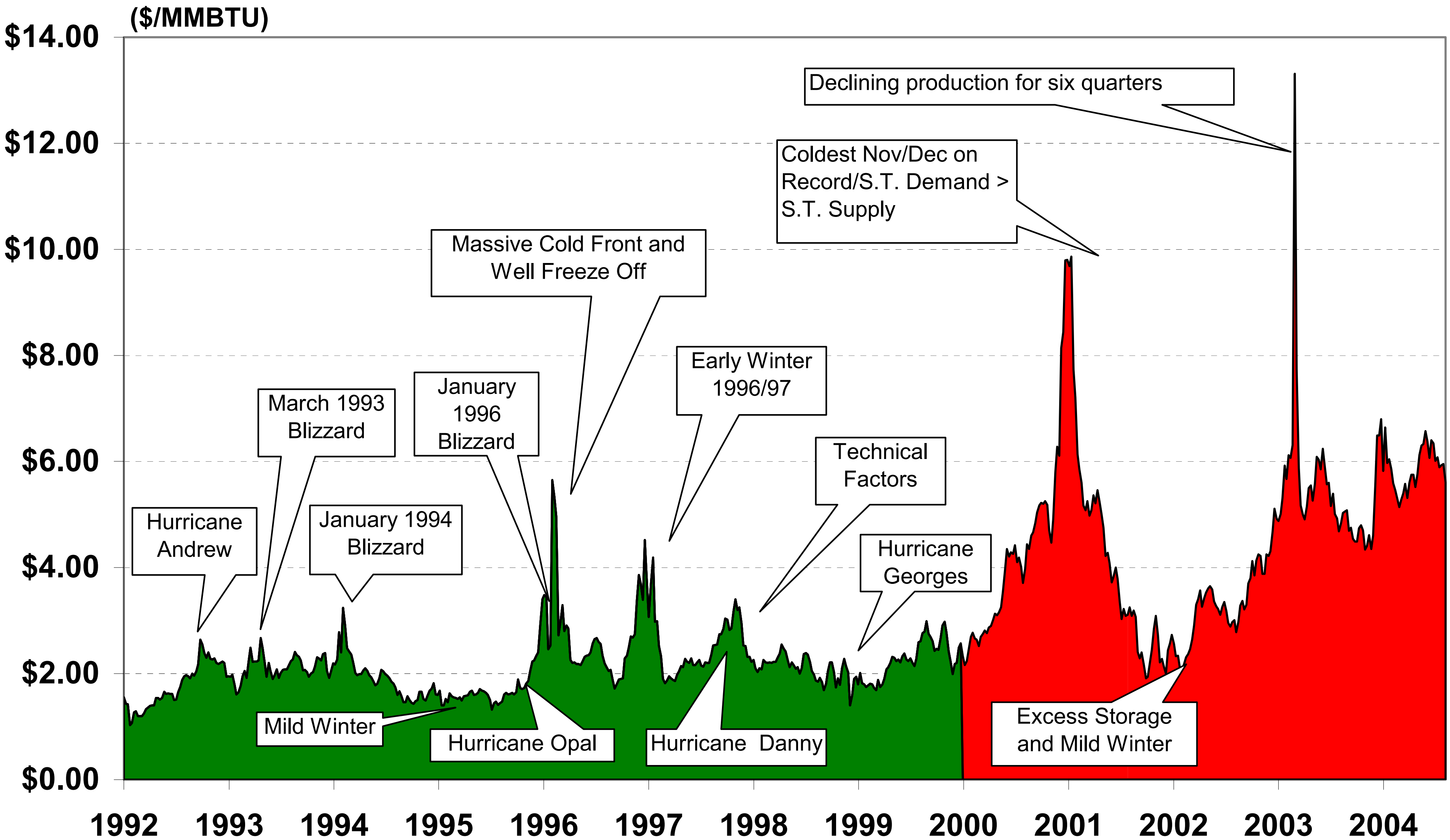
# Drivers for Wind Power

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

# Wind Cost of Energy

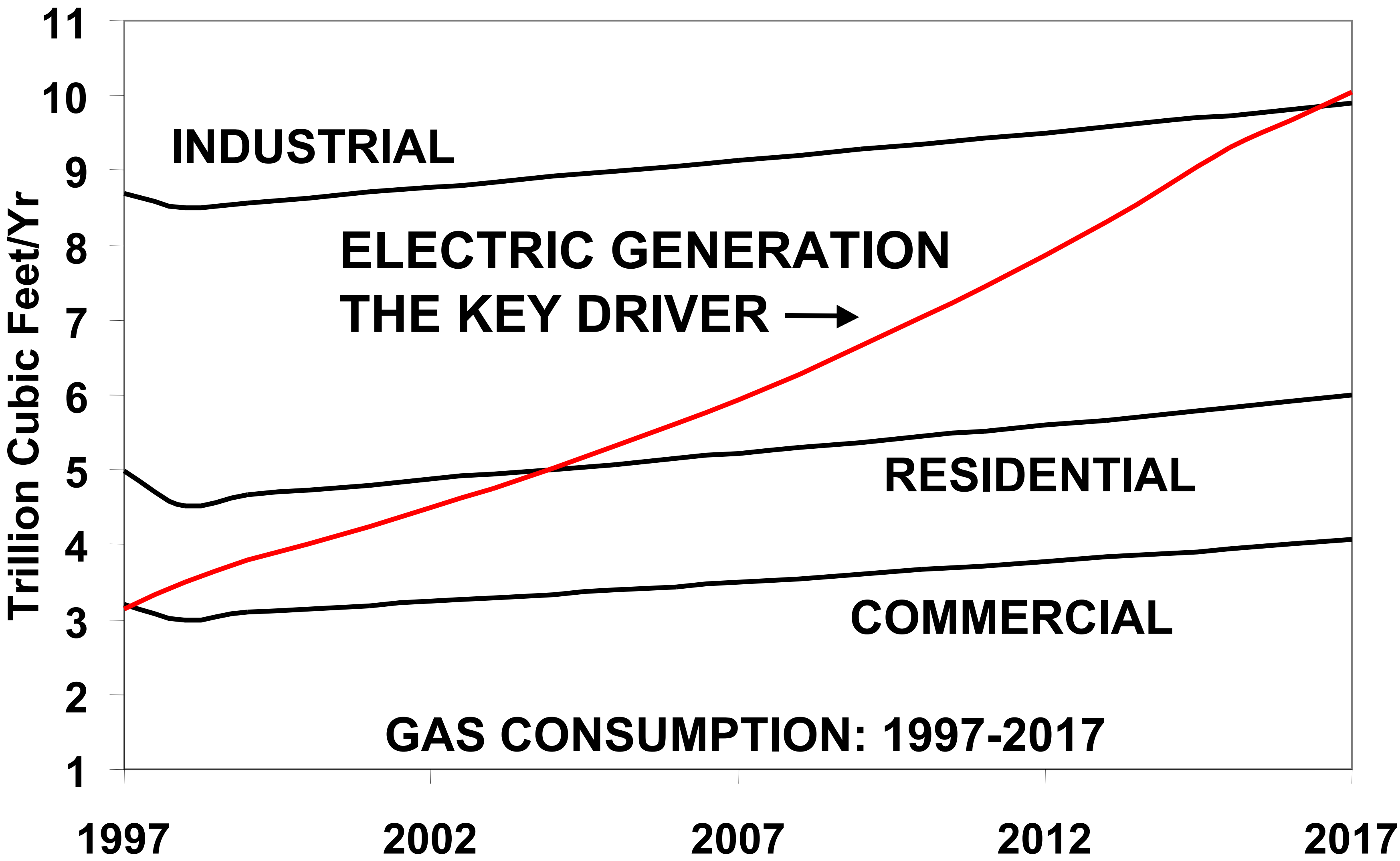


# Historical Gas Prices At The Henry Hub




Source: NGW and EVA, Inc.

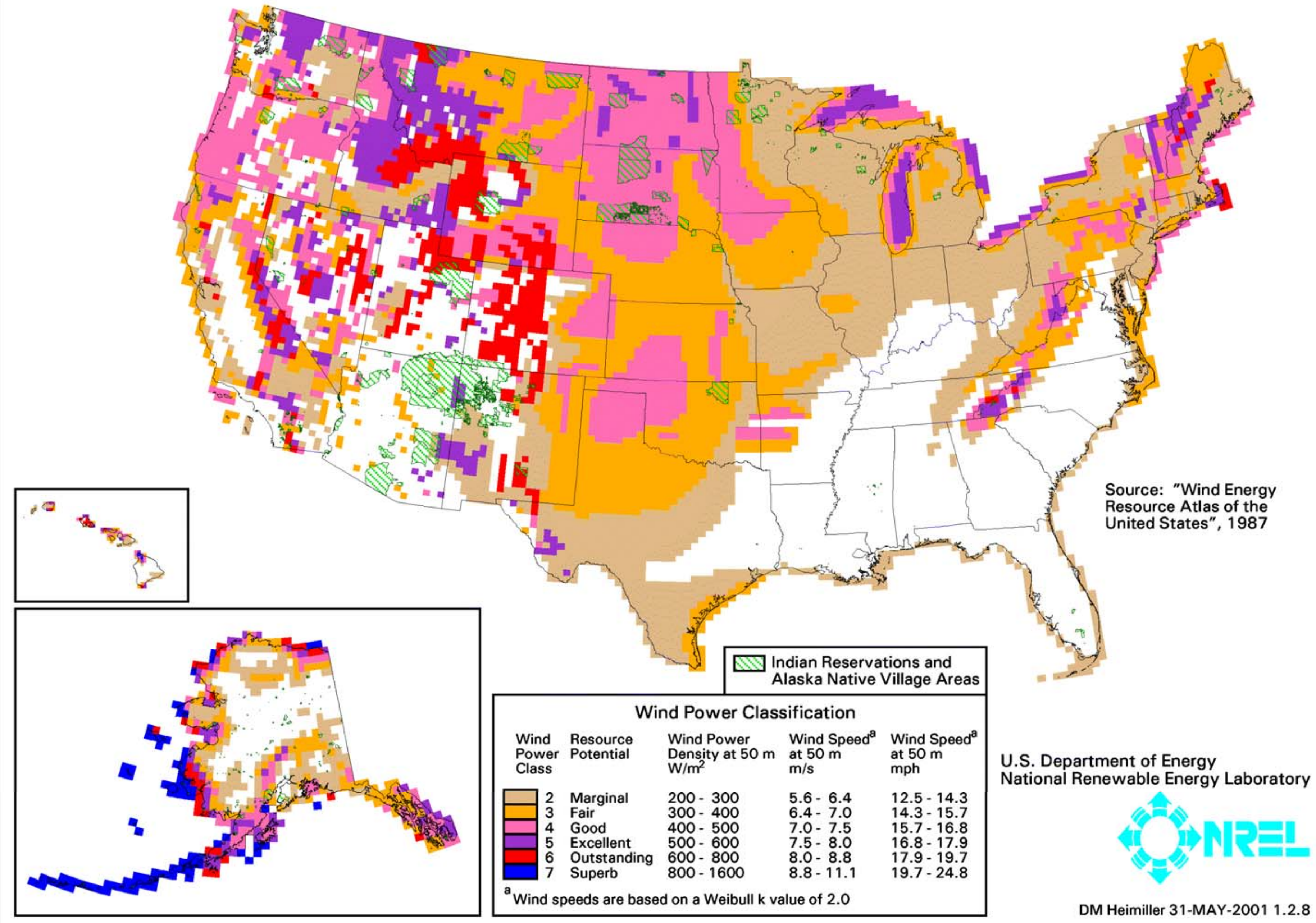
# The “Dash to Gas”

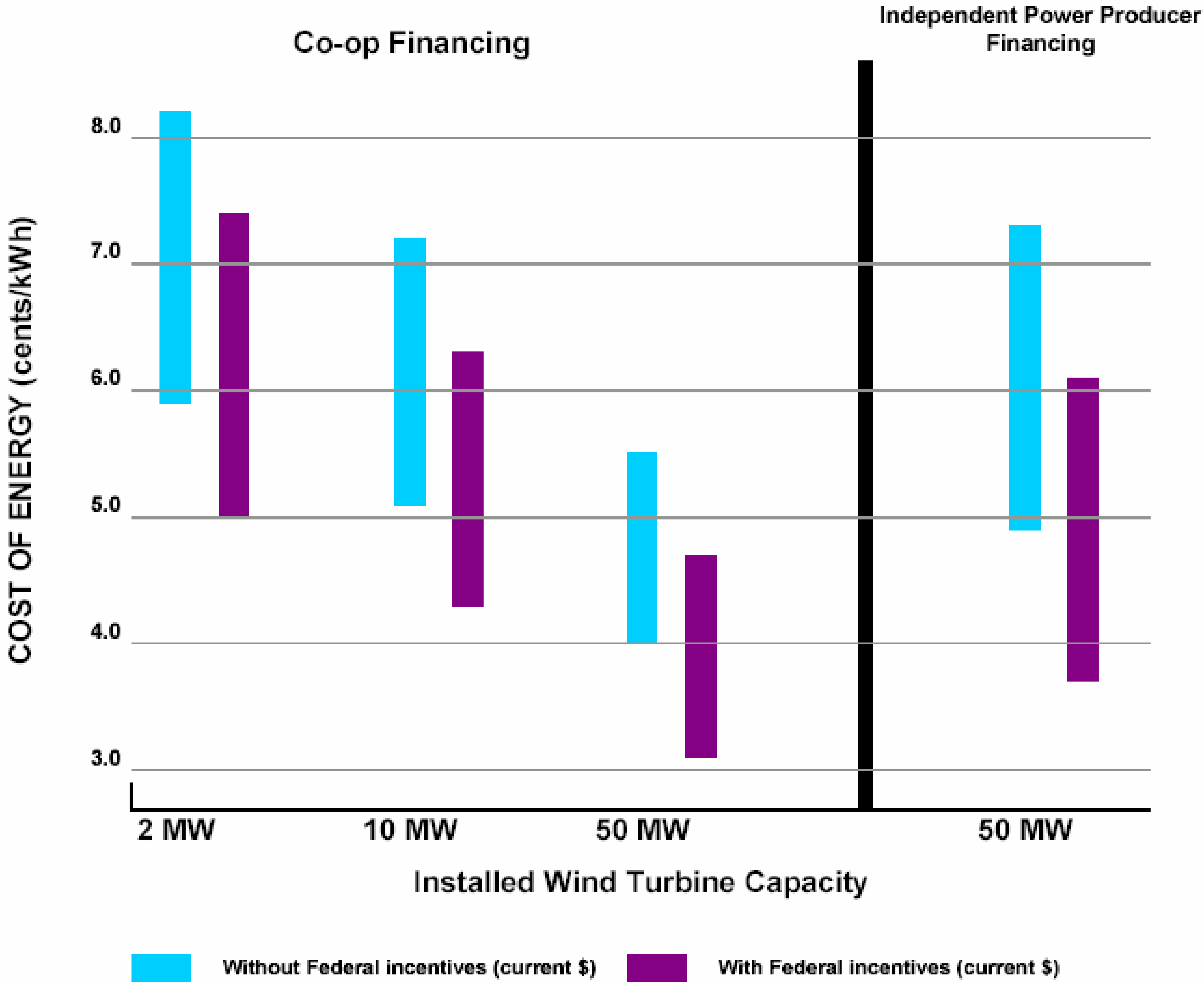


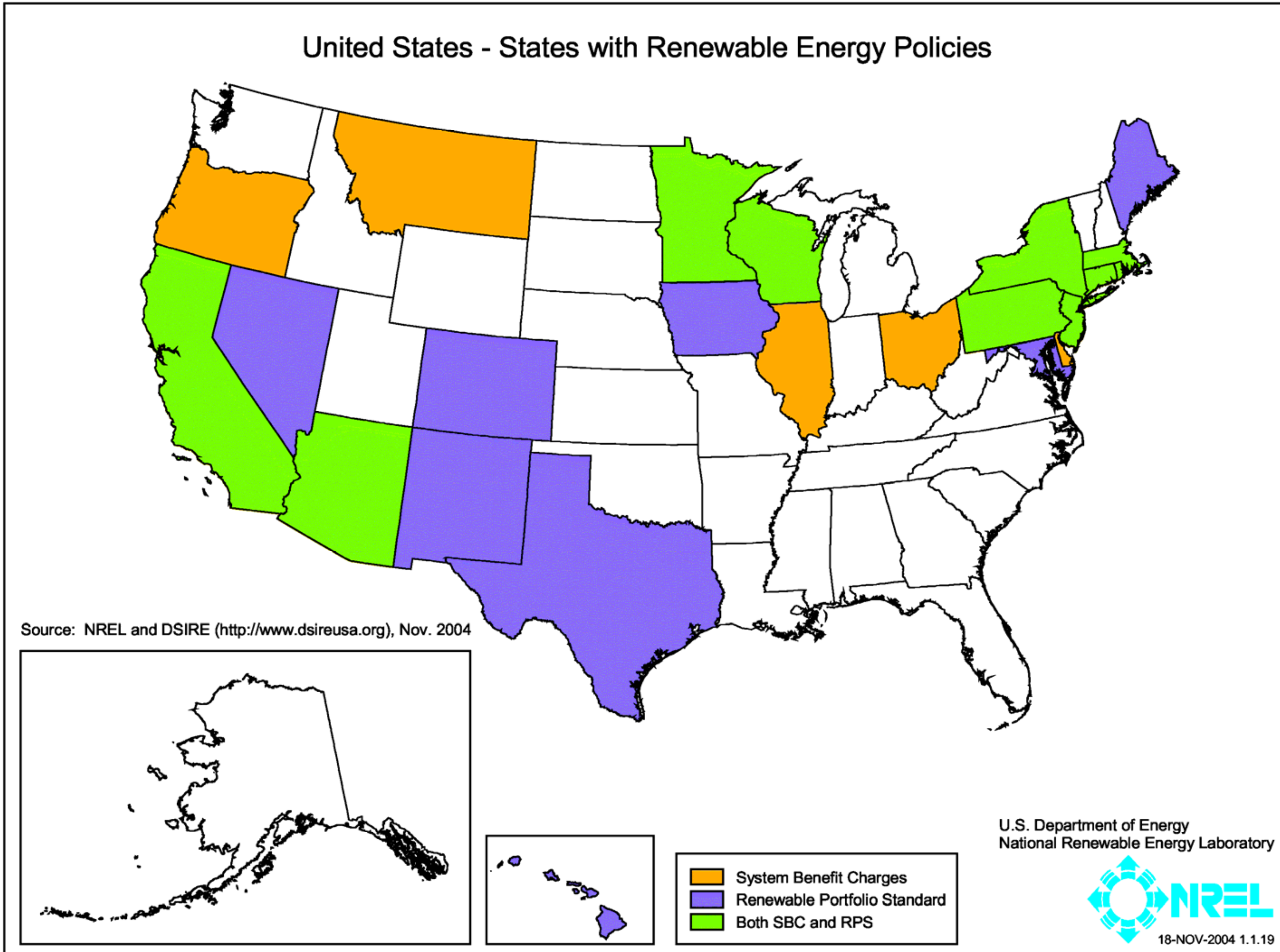
# Wind Economics - Determining Factors

- 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

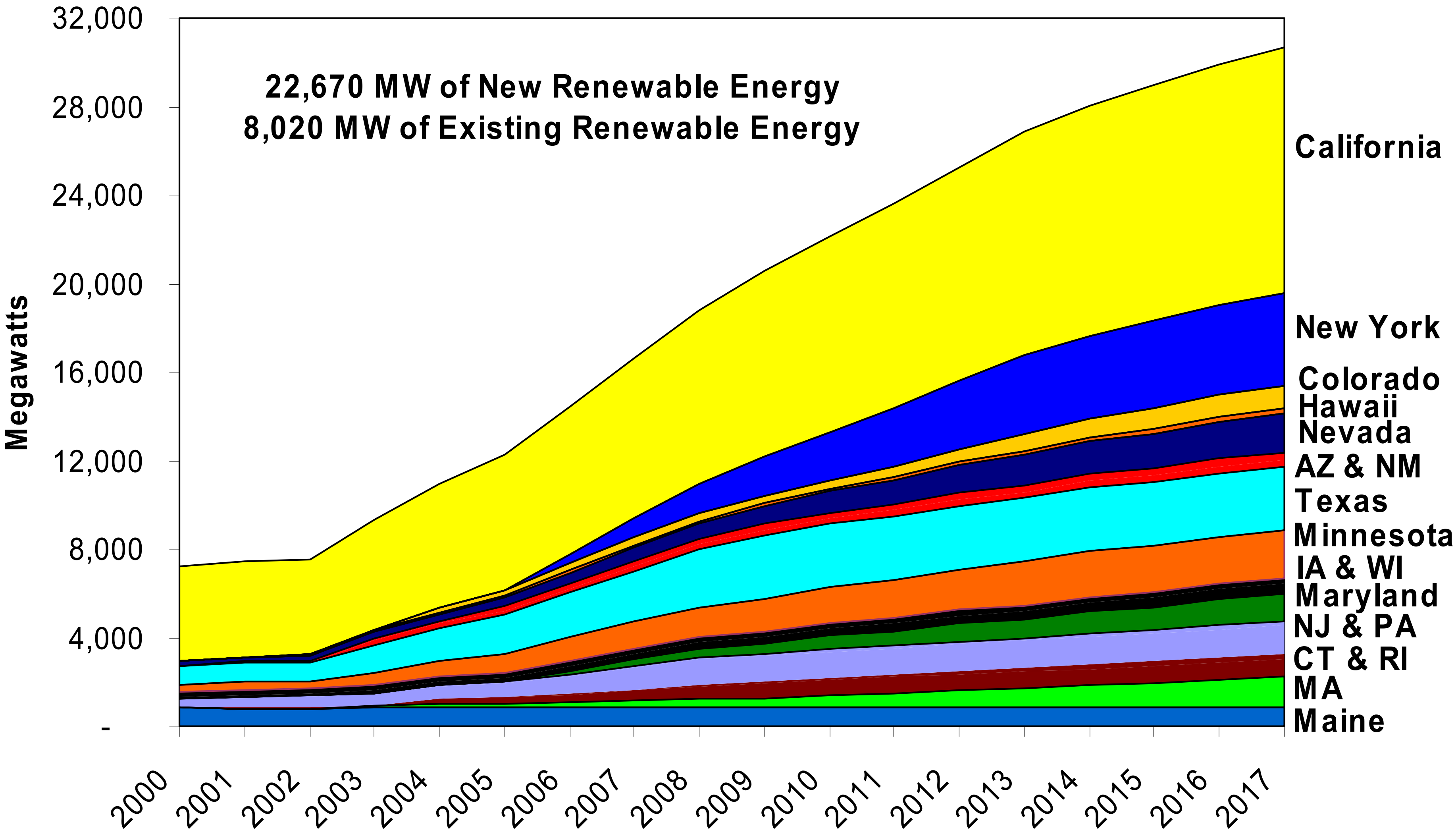
# United States - Wind Resource Map




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 $)


United States - States with Renewable Energy Policies
Source: NREL and DSIRE (http://www.dsireusa.org), Nov. 2004
System Benefit Charges
Renewable Portfolio Standard
Both SBC and RPS
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
18-NOV-2004 1.1.19

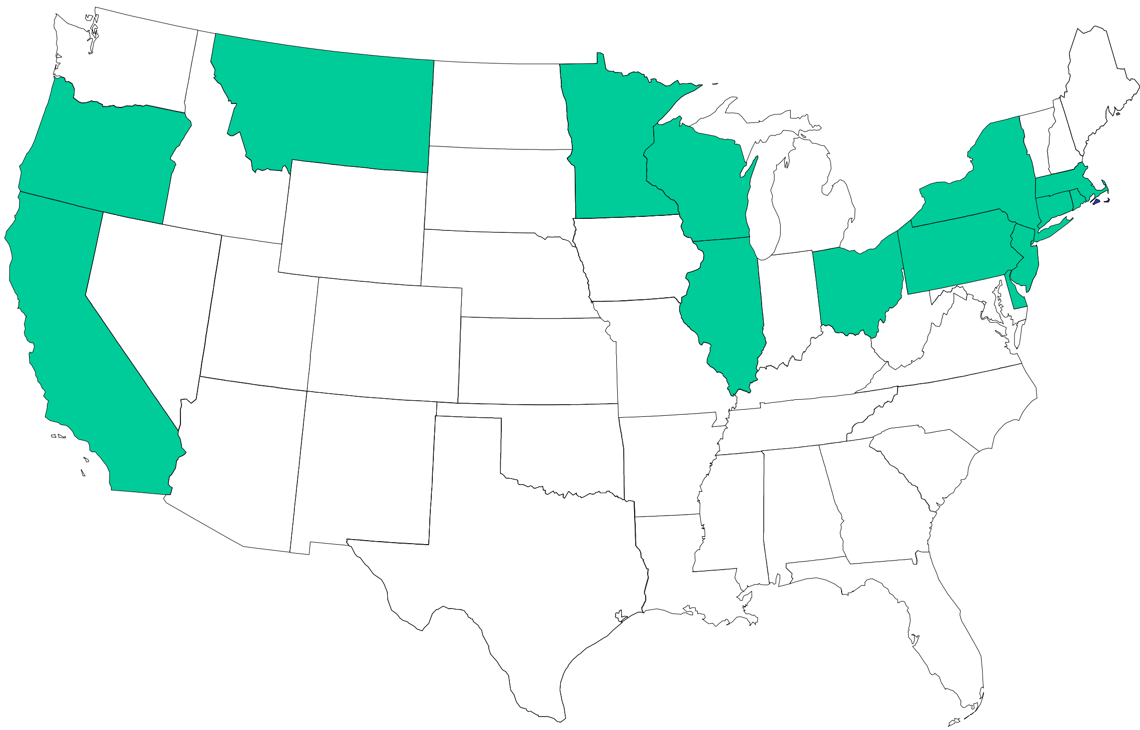
# Renewable Energy Expected From State Standards*




* Projected development assuming states achieve annual RES targets.

# State Clean Energy Funds

- **14 states, funded through system-benefits charges or other means**
- **More than $4 billion through 2012**
  - **CA: >$200 M/yr**
  - **OR: ~$10 M/yr**
  - **MT: ~$2 M/yr**



# Common Programs

**Clean Energy Funds are more flexible than an RPS, and allow states to target multiple technologies and programs**

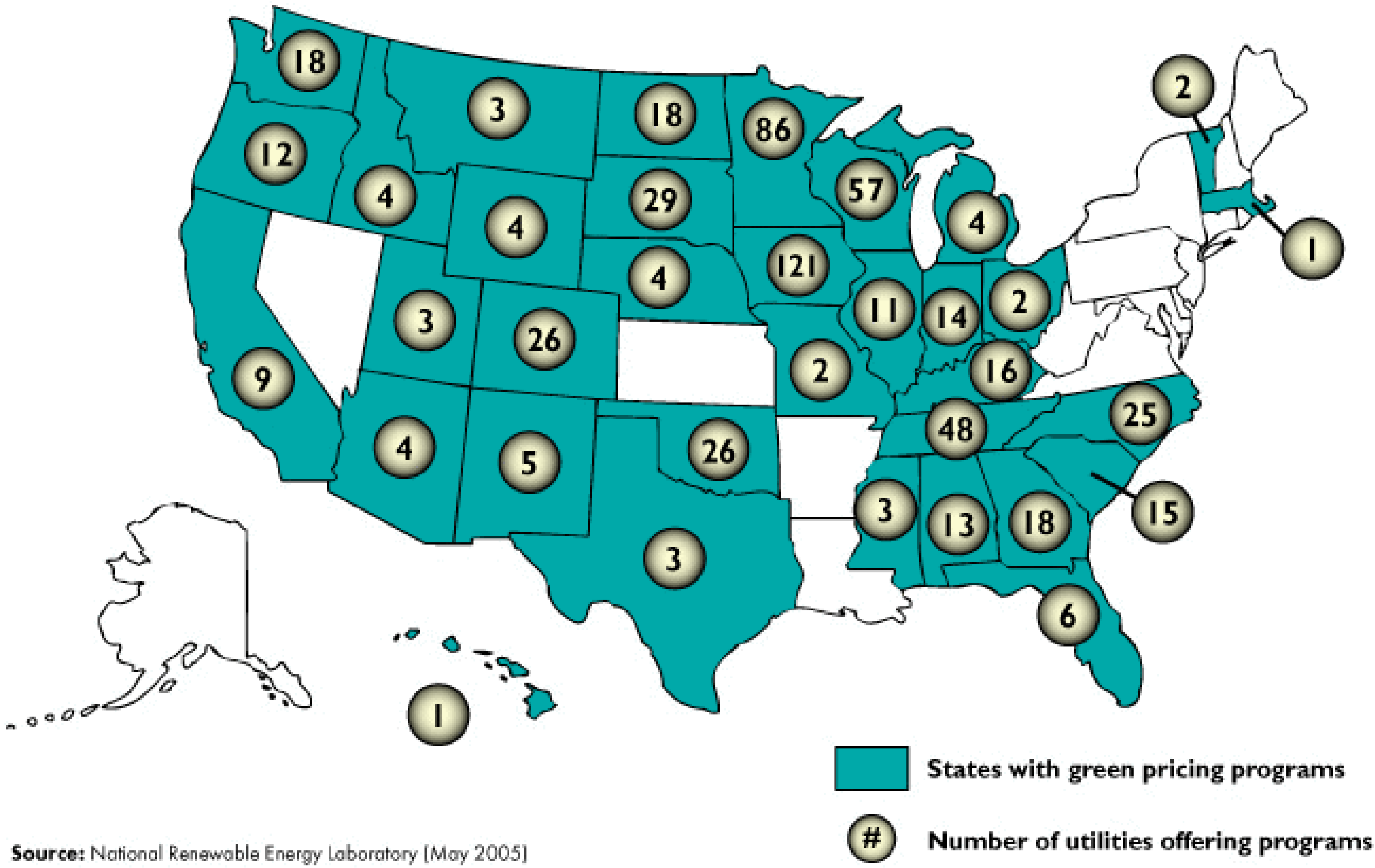
- Financial incentives for utility-scale RE projects
- Distributed generation buy-down incentives
- Distributed generation competitive solicitations
- Consumer financing programs
- Project and company financing
- Support for green power marketers
- Consumer education
- Small grants for business development, studies

# Consideration of Carbon Risk in Western IRPs is Becoming More Common

- **PacifiCorp:** multiple carbon scenarios, with base case of $8 per ton of $CO_2$ beginning in 2009
- **Idaho Power:** multiple carbon scenarios, with base-case of $12.30 per ton of $CO_2$ beginning in 2008
- **Xcel/PSCo:** scenarios of $6 and $12 per ton of $CO_2$ beginning in 2009
- **PGE:** scenario of $10 per ton of $CO_2$
- **Avista:** scenario of $1.32 - $11 per ton of $CO_2$, beginning in 2004
- **California:** CPUC now requires that utilities consider carbon costs at $8 - $25 per ton of $CO_2$

**Can amount to a ~$5/MWh adder to a gas plant, and more for coal**

# Utility Green Pricing Activities




**Source:** National Renewable Energy Laboratory (May 2005)

# Key Deployment Issues for Wind Power

- Permitting and Siting (visual, noise, avian, land use)
- Transmission: capacity allocation, RTO formation, new line builds/planning
- Power Variability: impact on utility operations
- Green power markets
- Policy environment – PTC, RPS, state tax provisions

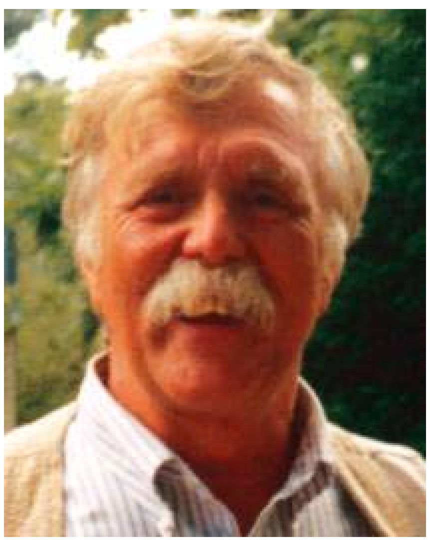
"Wind energy adds diversity to our generation fleet and provides a hedge against fossil fuel price increases.  In addition, the development of renewable energy resources is widely supported by the public and our customers."

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

“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*

WIND POWERING AMERICA



"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*

"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*

# Kotzebue Electric Association, Alaska

*Brad Reeve, General Manager, Kotzebue Electric Association*

"It is becoming clear that wind energy will play a major role in the national generation mix. In Kotzebue, Alaska, wind energy provides between 5%-7% of the total energy needs and we plan to add more. There are potentially 70 to 90 communities that could reduce their energy costs by adding wind energy. This makes it extremely important for utilities to learn all they can about wind's ability to provide safe, reliable, cost-effective electricity to their members."

# Kotzebue, Alaska

- Application:  Village power system
- 11 MW diesel power plant
- Operating with 10 turbines since 1999
- 2MW average load, min load 700kW. Peak wind penetration level ~ 35%
- Local utility plans expansion to 2-3 MW

of wind
turbine
capacity

# Wales Alaska Wind Diesel System

**High penetration system**

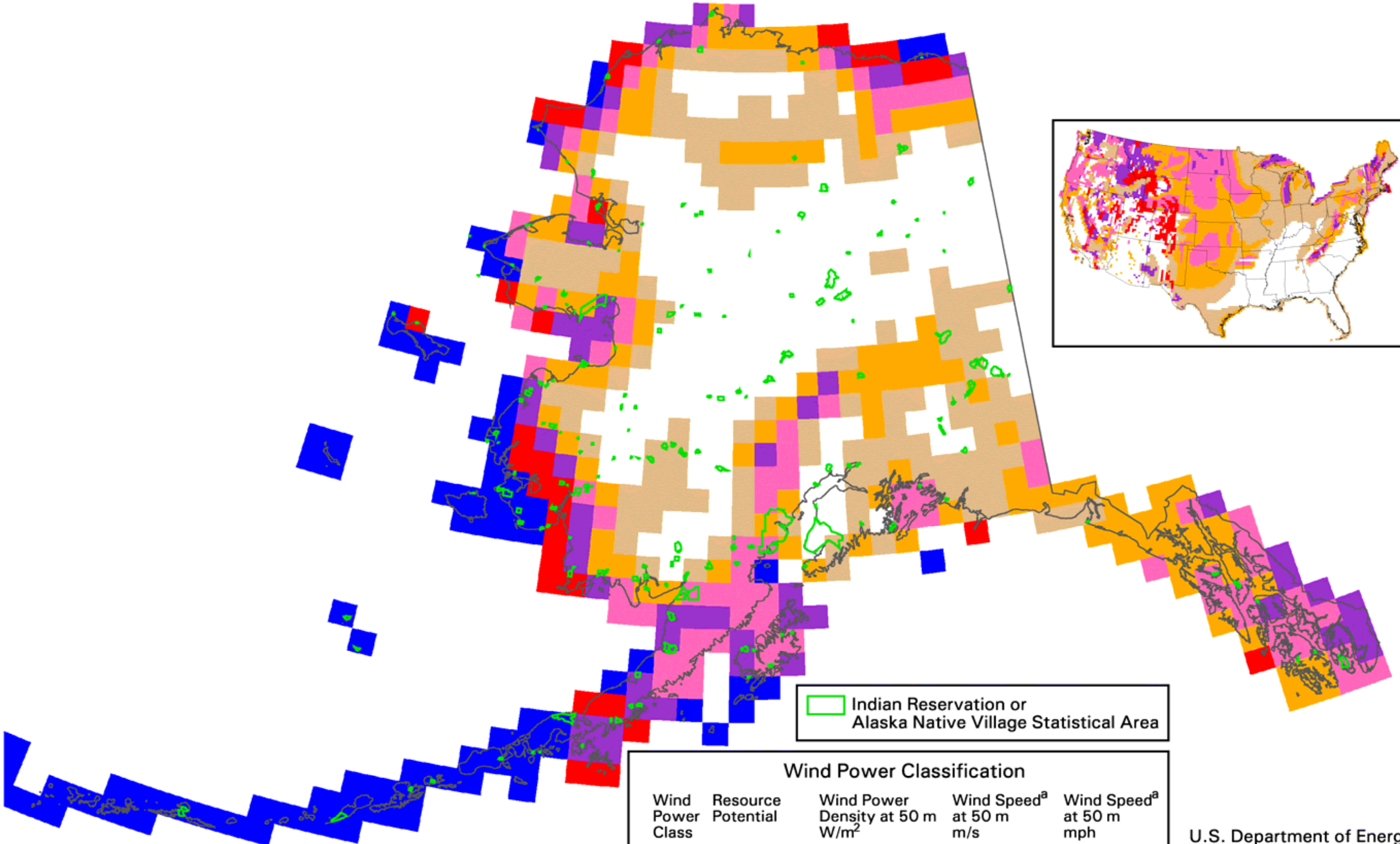
- 80kW average load with 130kW of wind power
- Short term battery storage
- Resistive loads used for heating and hot water

# St. Paul High Penetration Wind-Diesel Power System Without Storage

Provide electrical and thermal loads to the industrial/airport facility

- Owned and financed by the TDX corporation
- 225-kW Vestas and two 150-kW Volvo diesels
- 6000-gal. hot water tank and distribution
- Peak plant output 160 kW, current load ~85 kW
- Average penetration ~100%, peak >400%
- COE ~$.21/kWh (current diesel grid $.34/kWh)

# Alaska - Wind Resource Map





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

Source: Pacific Northwest National Laboratory - DOE, 1987.

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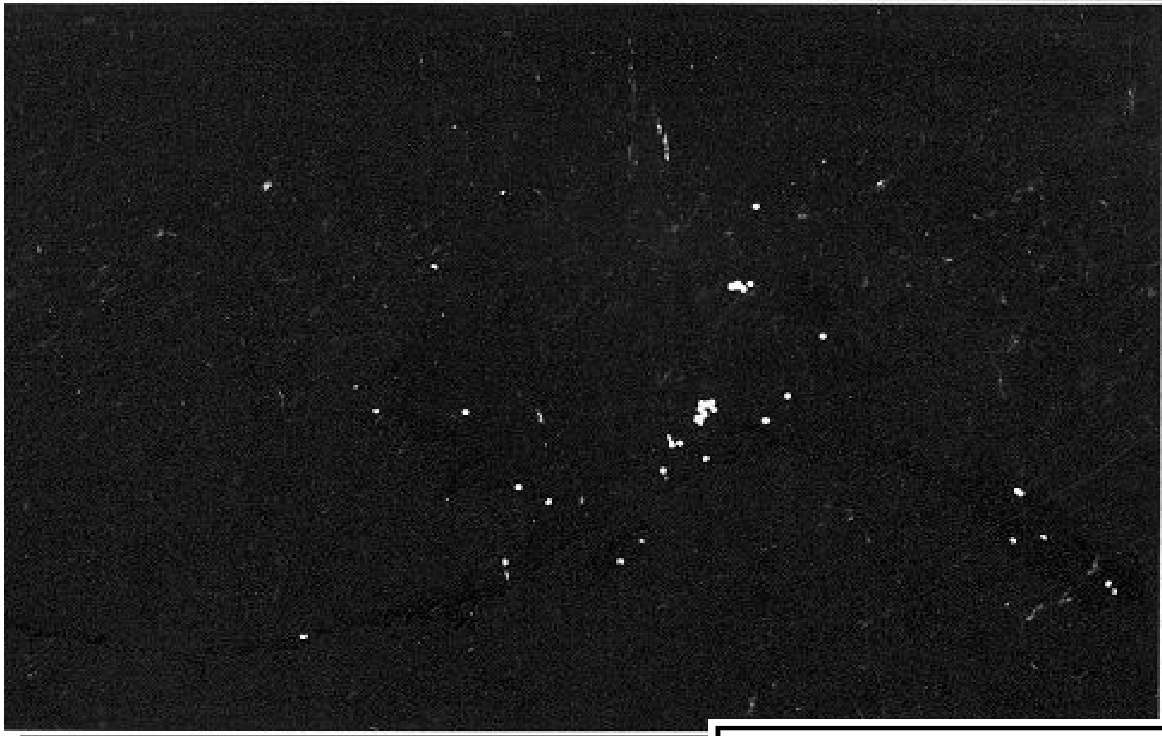
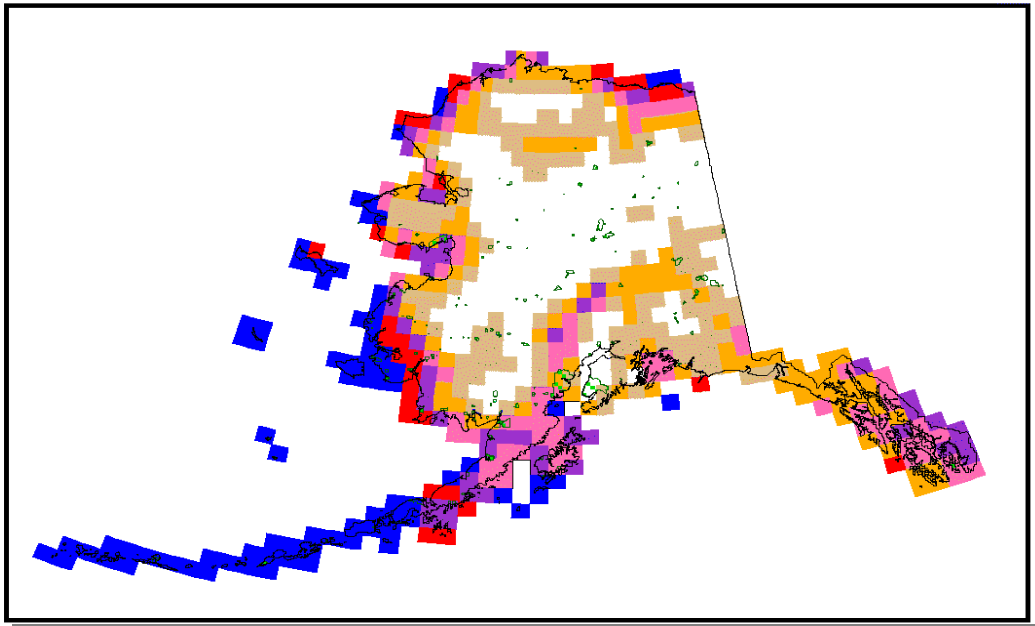
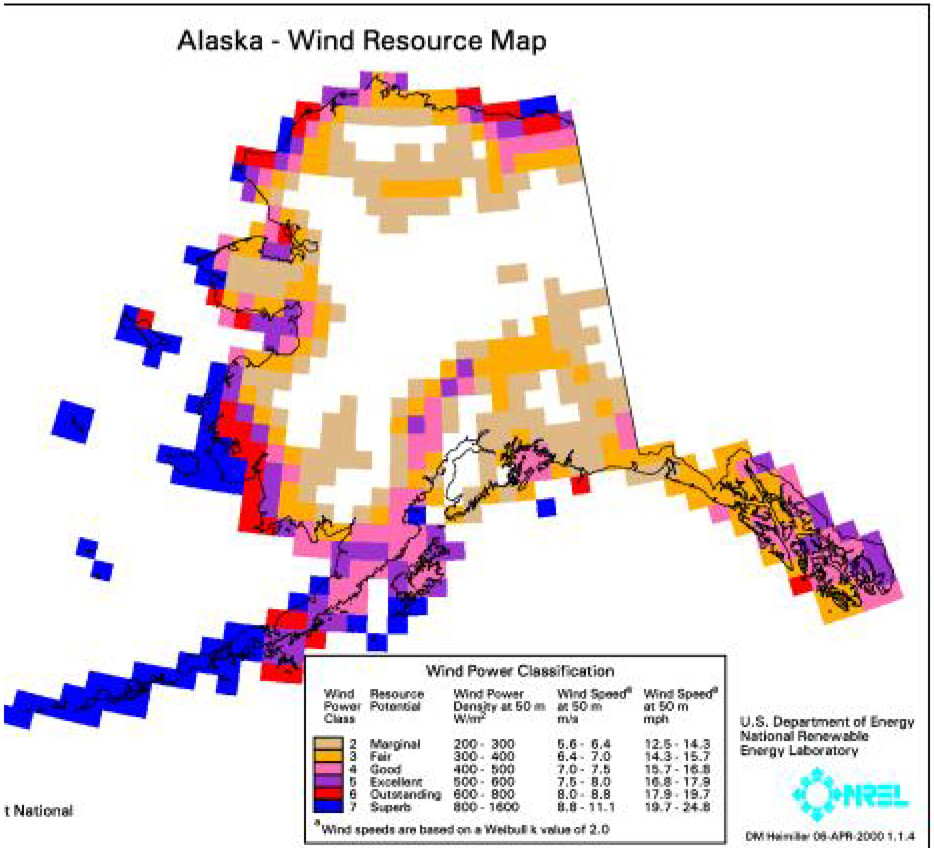
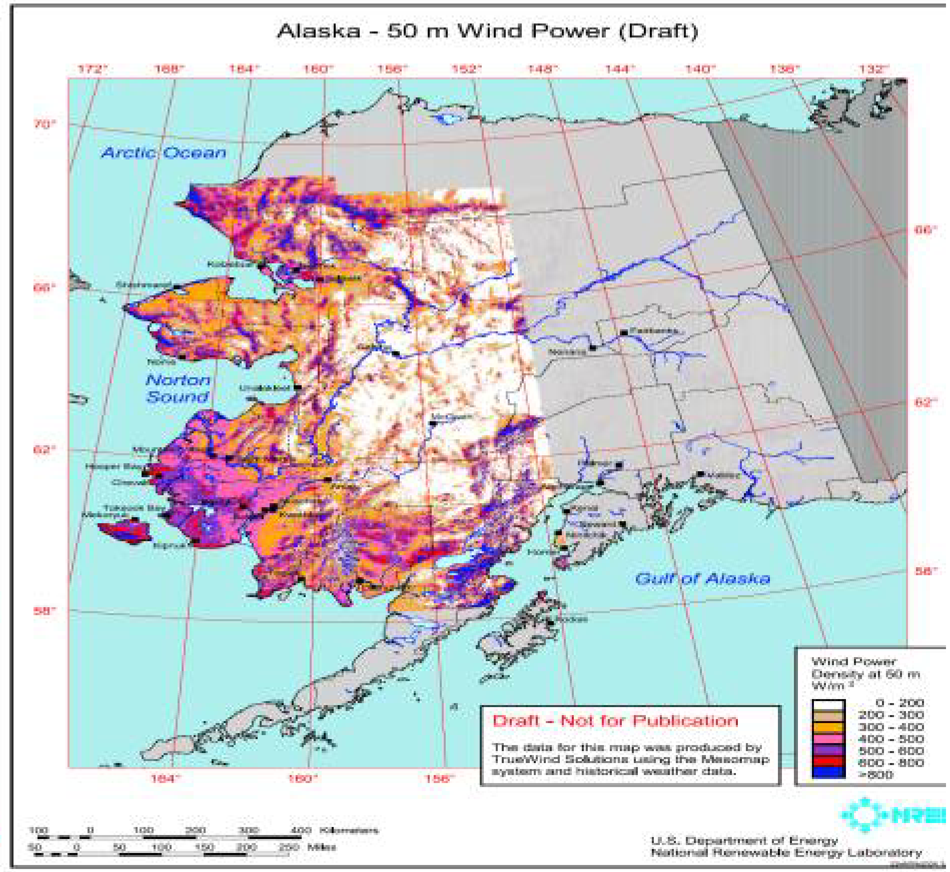




# Comparison of Digital Wind Map from 1987 U.S. Wind Atlas and New (2004) High-Resolution (200-m$^2$) Alaska Wind Map




1987




2004

**Wind Power Classification**

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

# Wind Energy Economic Security Benefits

Wind energy is an **indigenous**, homegrown, energy resource that contributes to national security.

Wind energy is **inexhaustible** and infinitely renewable.

Wind displaces electricity that would otherwise be produced by burning natural gas, thus helping to **reduce gas demand** and limit gas price hikes.

Wind energy is the **least cost** new energy source.

Wind energy boosts rural **economic development**.

Unlike most other electricity generation sources, wind turbines **don't consume water**.

Wind energy has many **environmental benefits**.

Wind energy can be used in a **variety of applications**.

Wind energy is the fuel of **today and tomorrow**.

September 28-30, 2004
Anchorage, Alaska

www.windpoweringamerica.gov/wkshp_2004_wind_diesel.html

Check in often for more details, agenda and registration

# SAVE THE DATES!

## *Wind-Diesel Workshop 2004*

Photo: Selawik, Alaska

**Topics:**

- Operating Experience
- Comparative Economics
- Project Development
- System Integration
- Institutional Approaches
- Lessons Learned
- Markets
- Emerging Concepts
- Component Development
- Test Center Reports
- Environmental Benefits

# *Carpe Ventem*

www.windpoweringamerica.gov