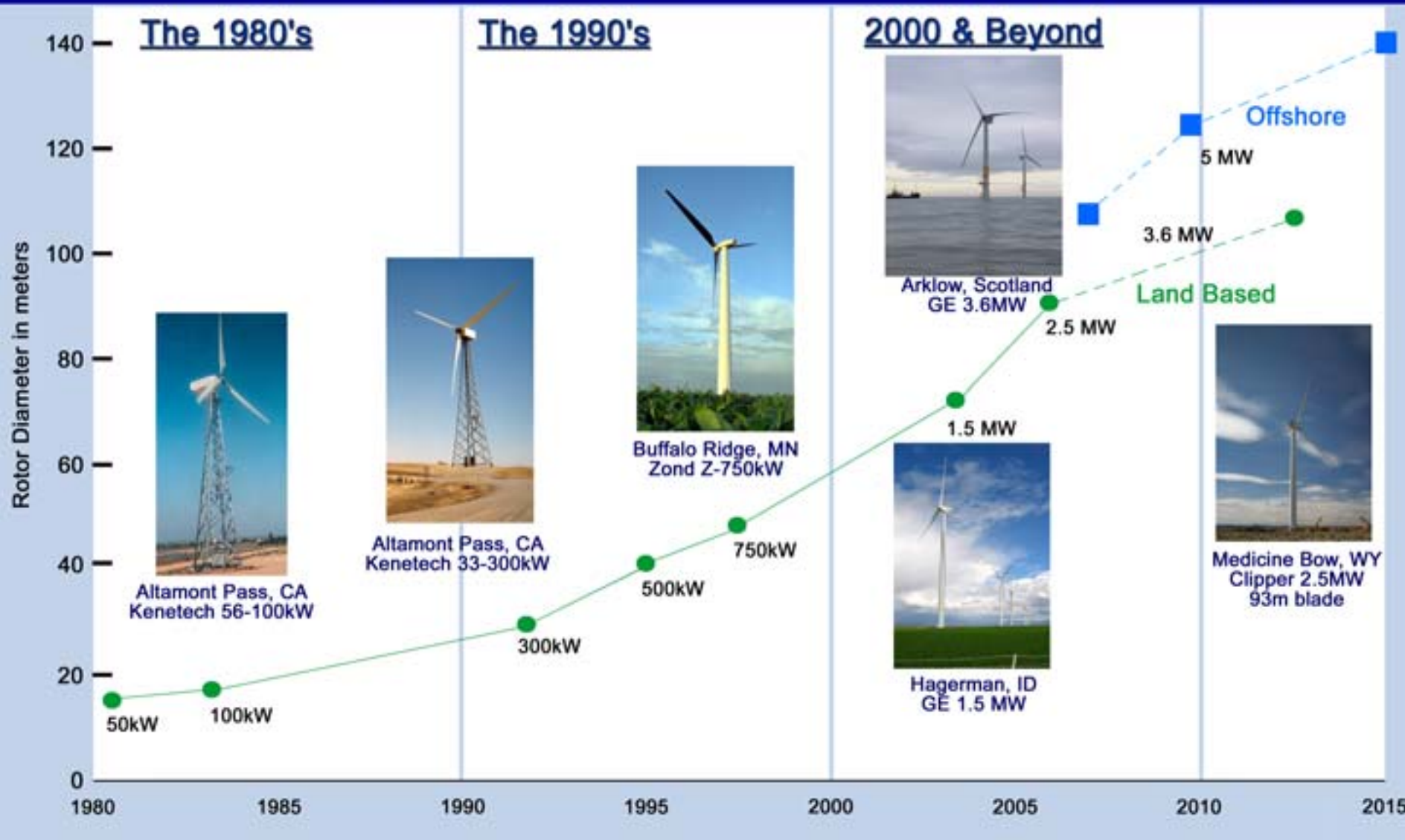
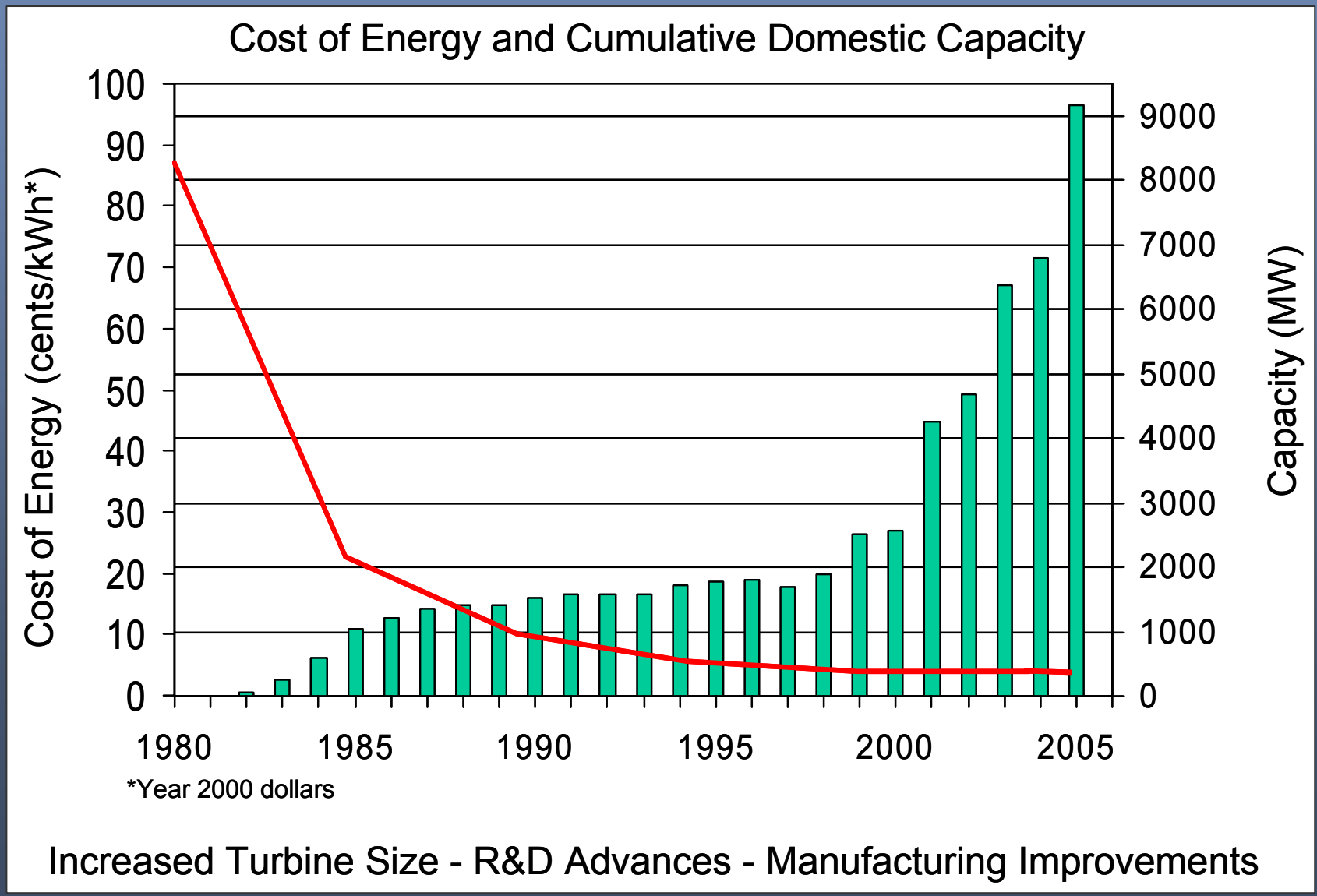
# Wind Energy Update

Larry Flowers
National Renewable Energy Laboratory
August 09, 2006
WEATS

# Evolution of U.S. Commercial Wind Technology

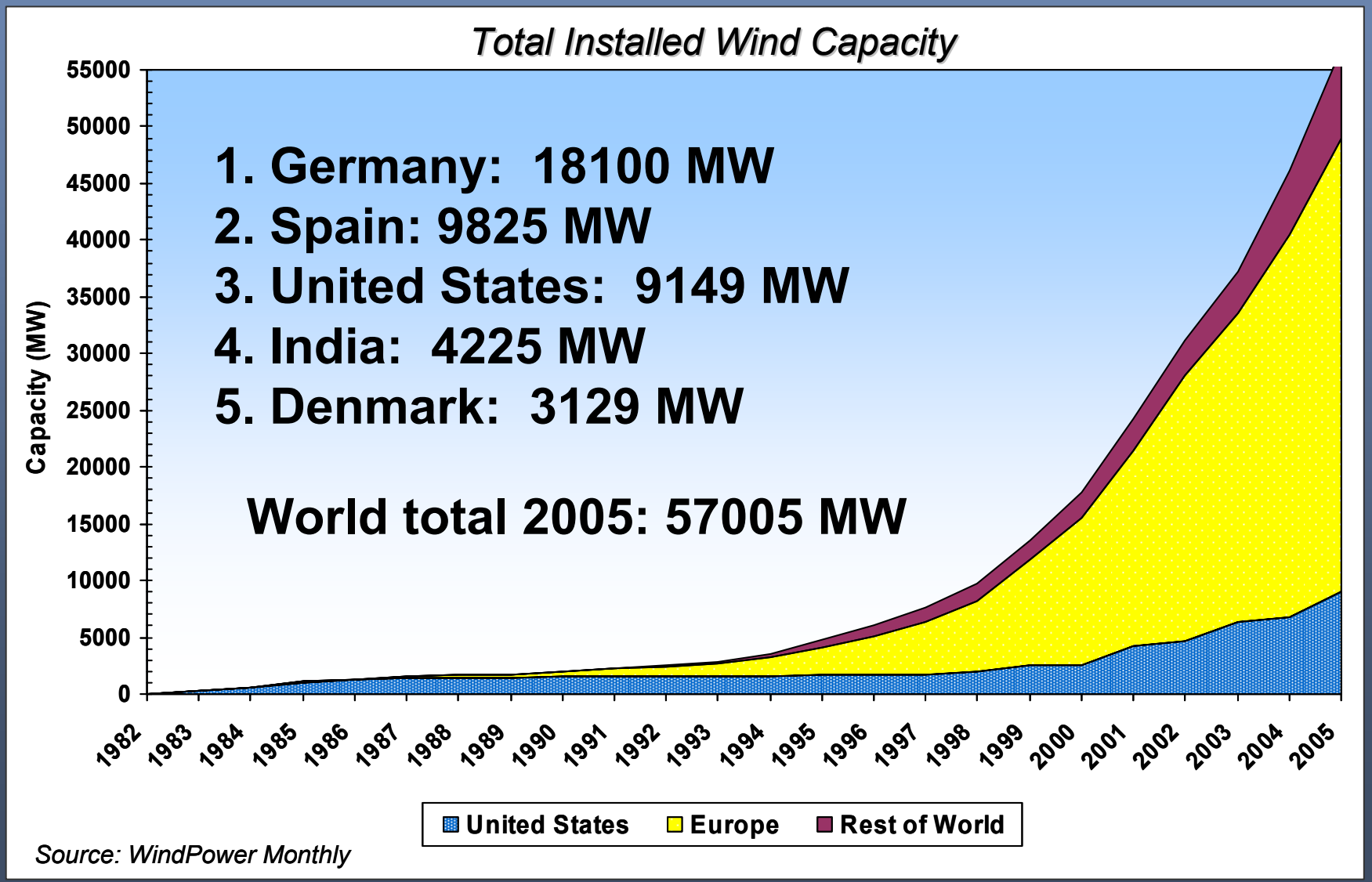


# Capacity & Cost Trends



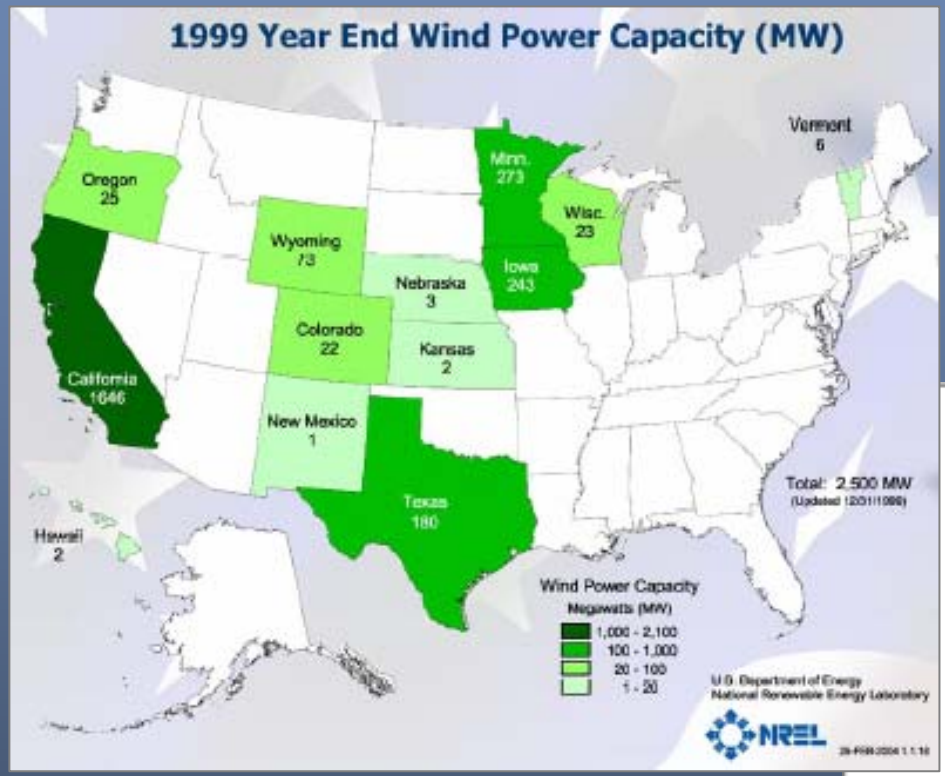

Increased Turbine Size - R&D Advances - Manufacturing Improvements

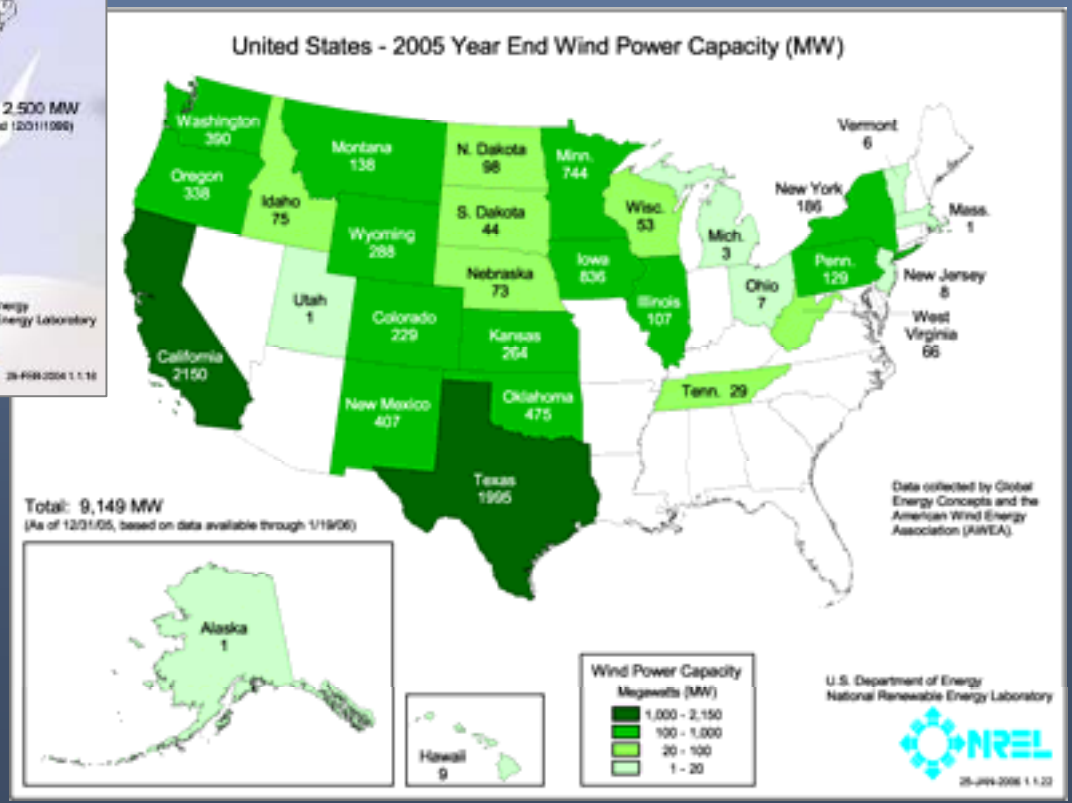
# People Want Renewable Energy!




*Source: WindPower Monthly*

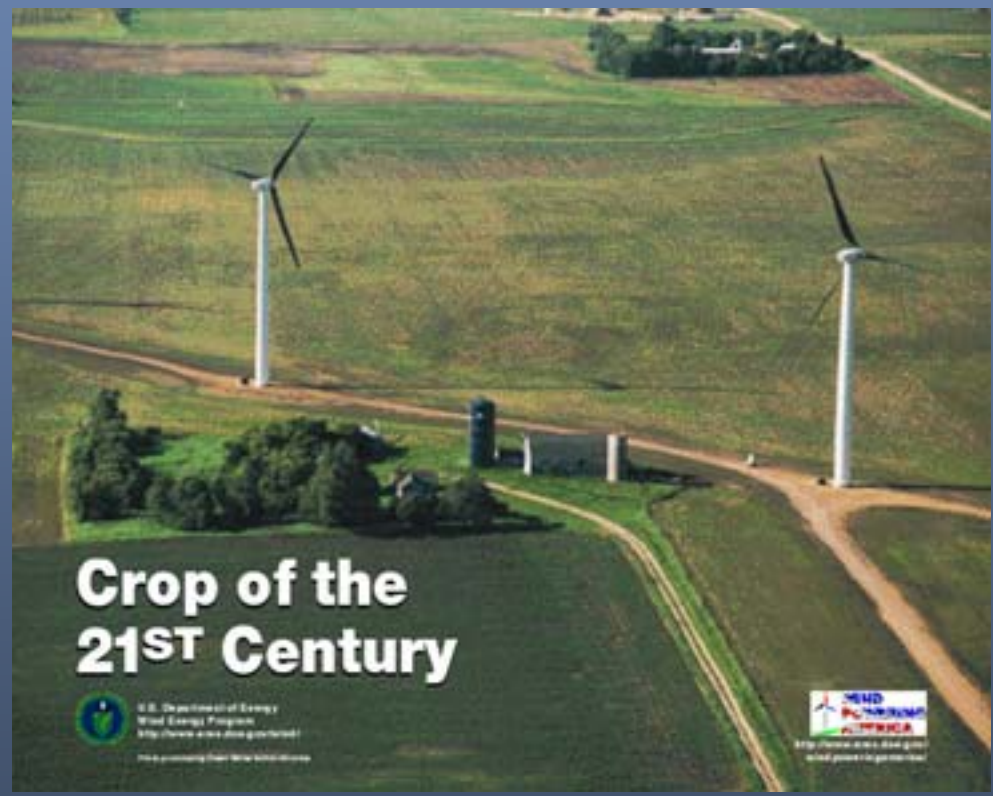
# Installed Wind Capacities (99-05)



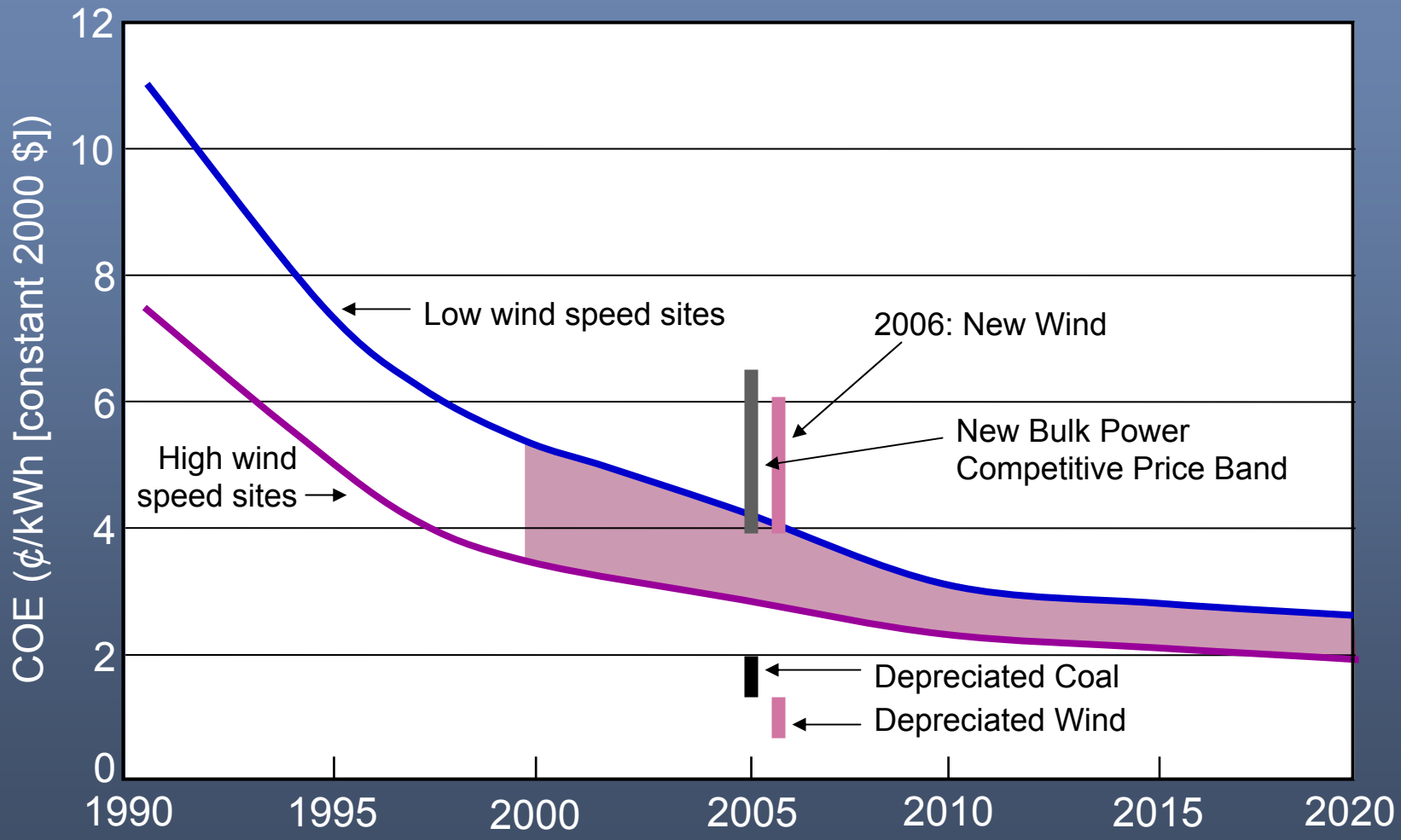



# Drivers for Wind Power

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

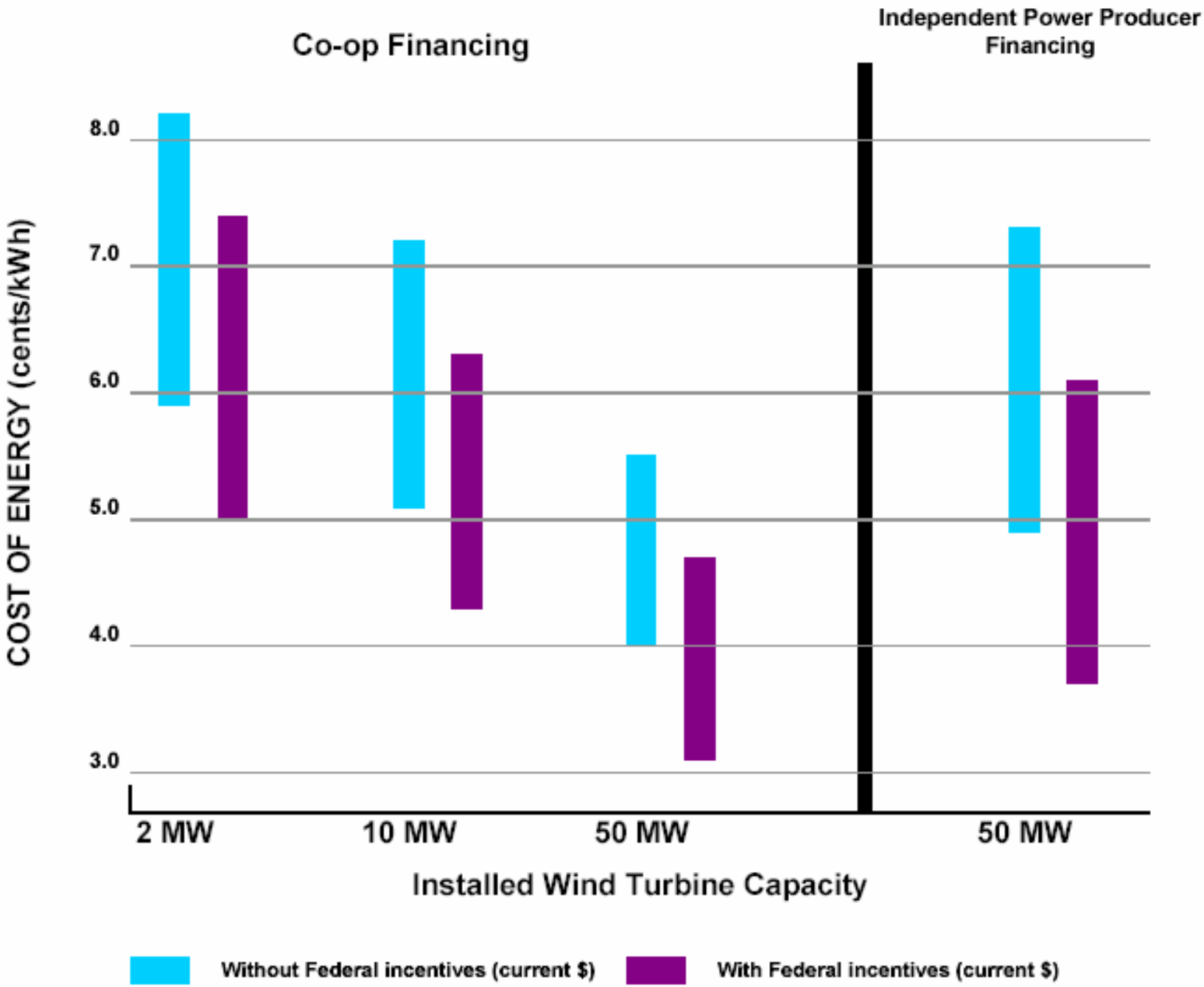


# Wind Cost of Energy

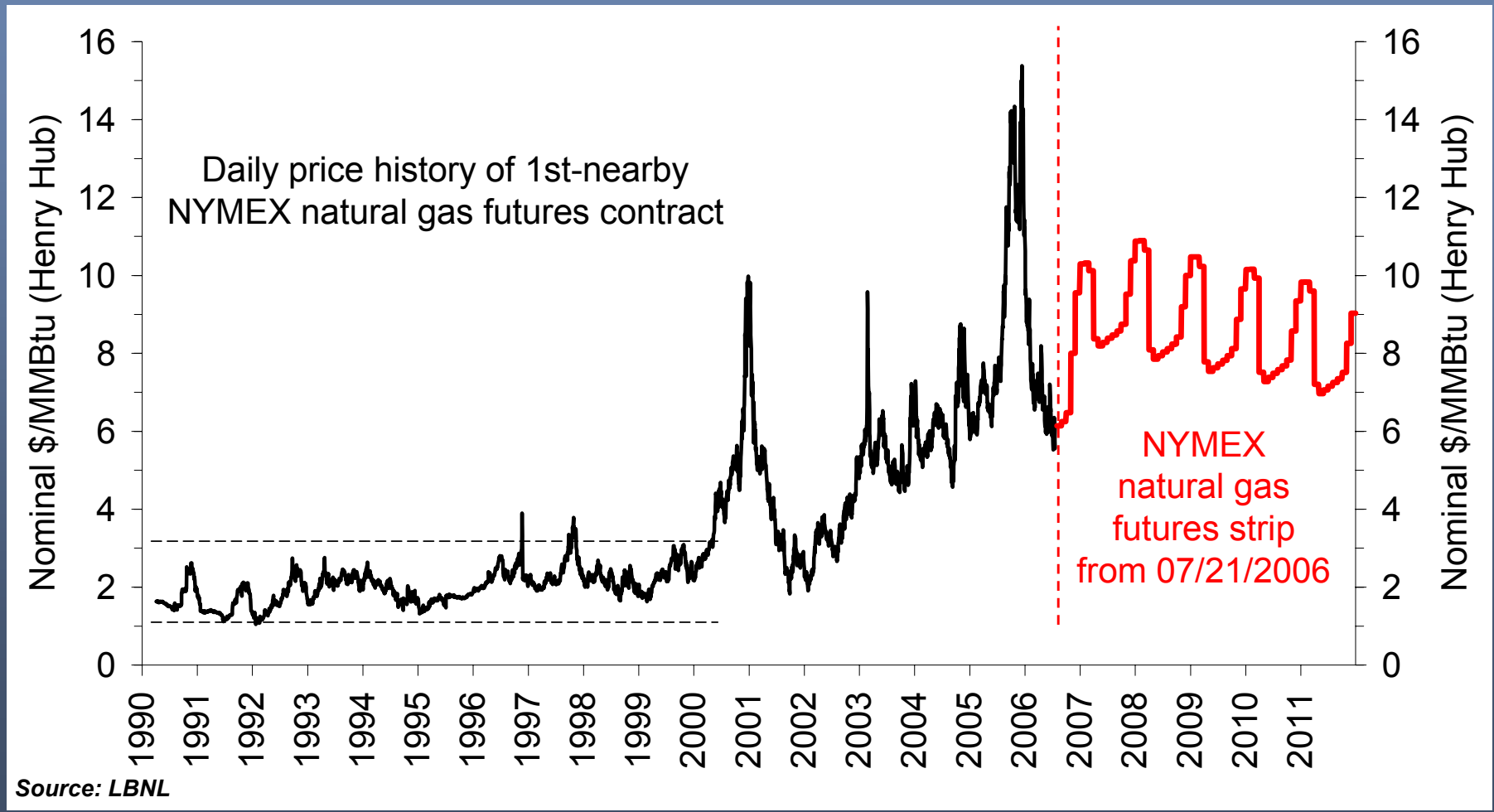


# Wind Economics – Determining Factors

- 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

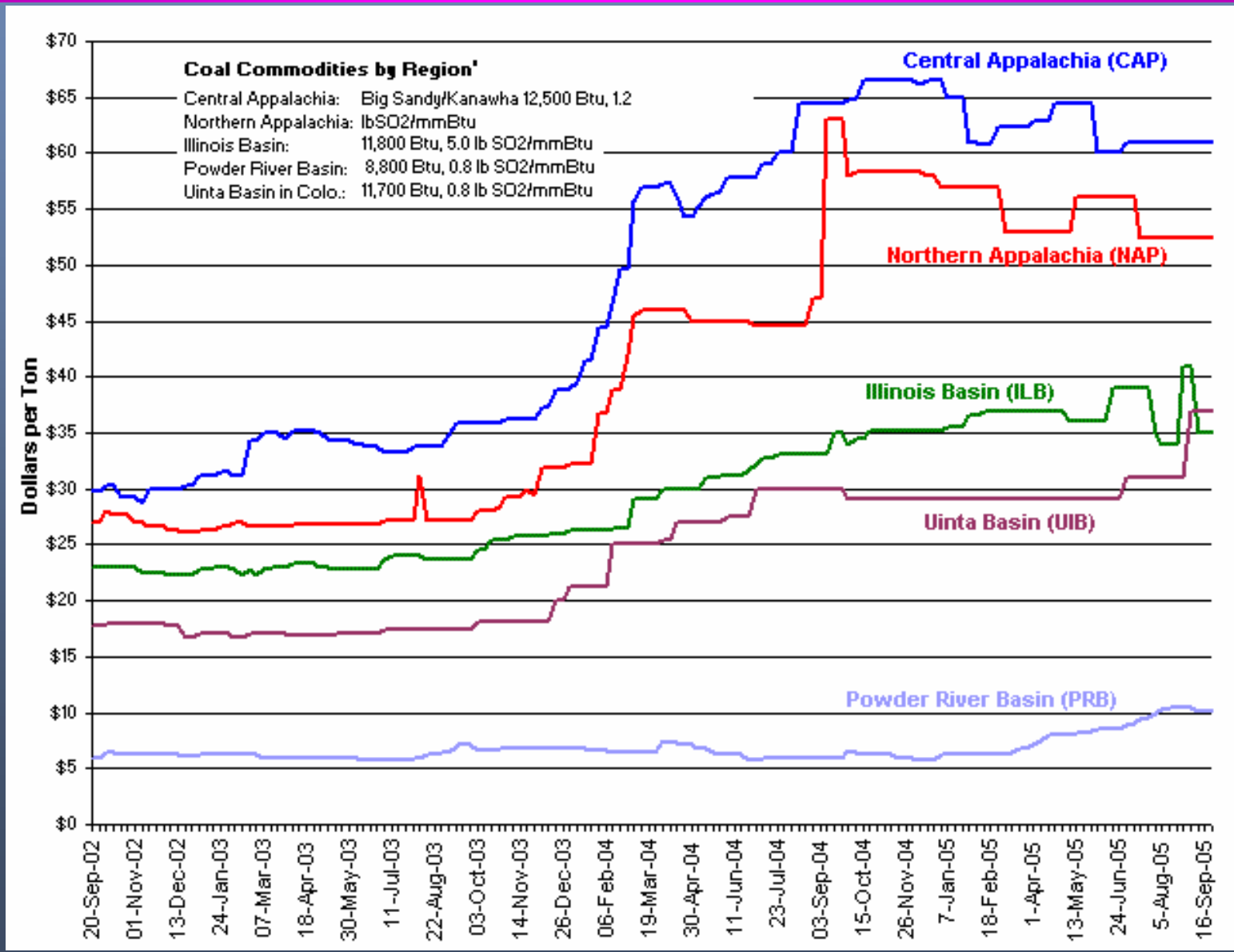

Co-op Financing
Independent Power Producer Financing
COST OF ENERGY (cents/kWh)
8.0
7.0
6.0
5.0
4.0
3.0
2 MW
10 MW
50 MW
50 MW
Installed Wind Turbine Capacity
Without Federal incentives (current $)
With Federal incentives (current $)

# Natural Gas – Historic Prices




***Source: LBNL***

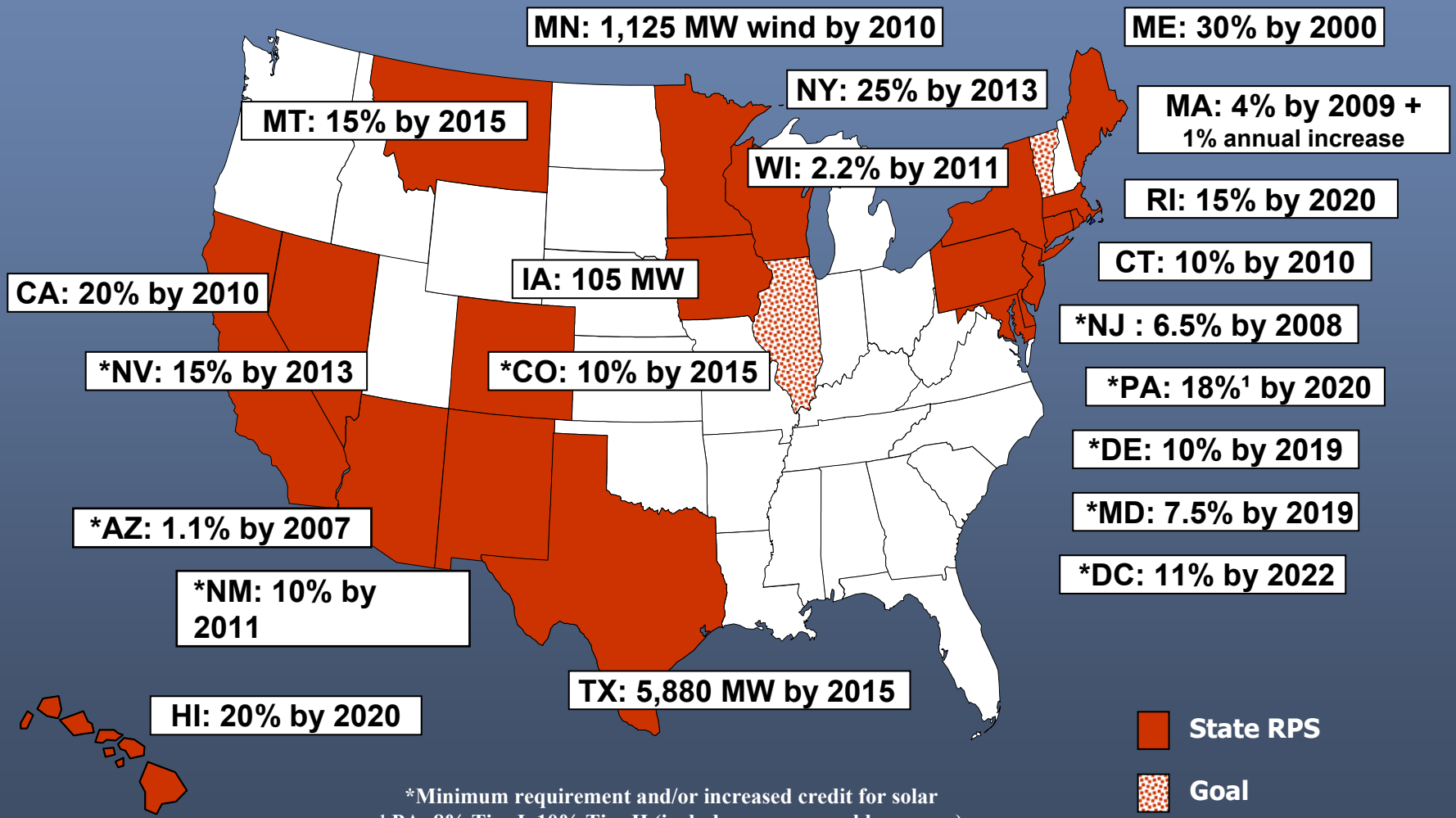
# Historical Coal Prices



"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*

# People want renewable energy (Renewables Portfolio Standards)



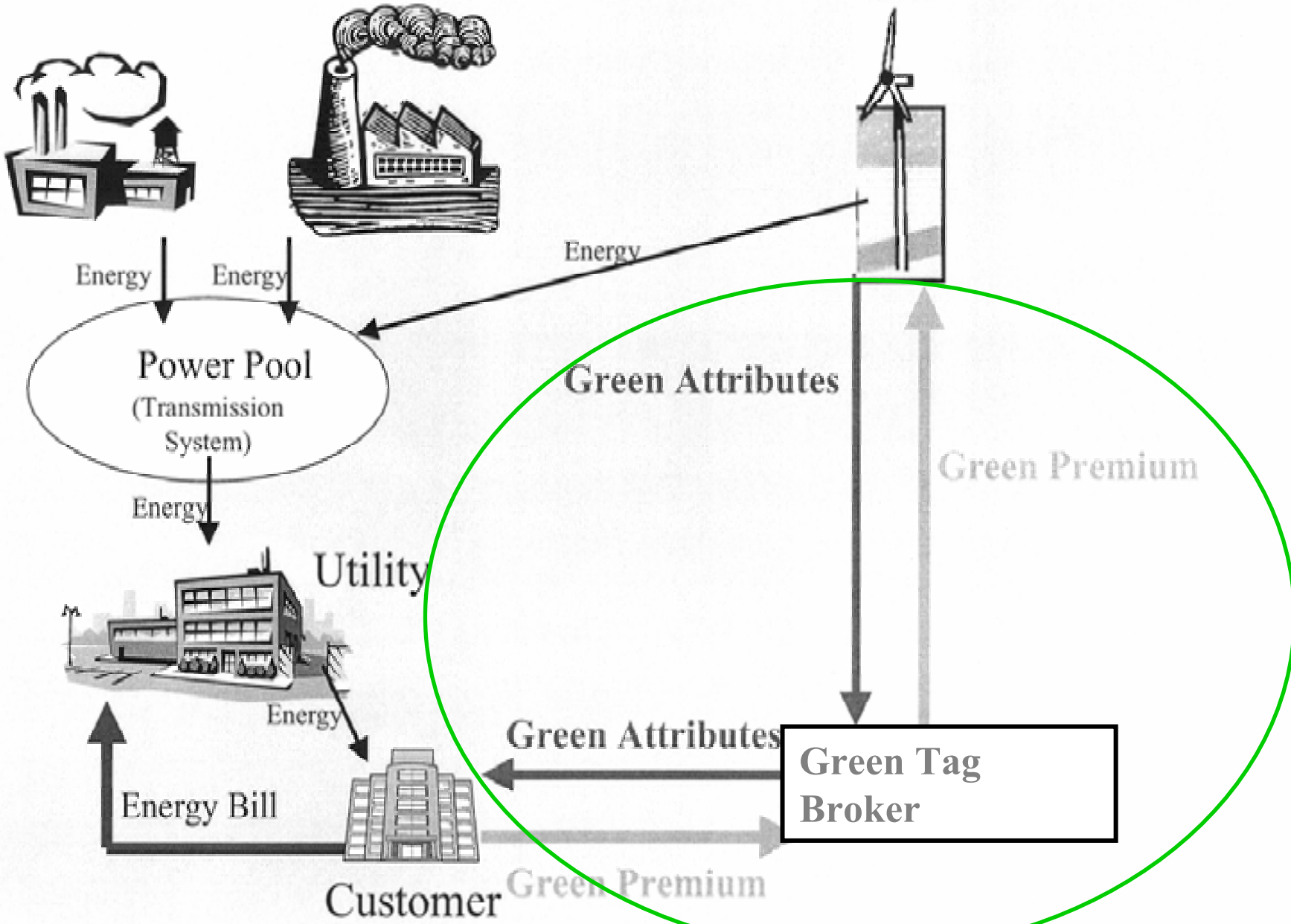

*Minimum requirement and/or increased credit for solar

[1] PA: 8% Tier I, 10% Tier II (includes non-renewable sources)

DSIRE: www.dsireusa.org

March 2006

# Green Tag Transaction

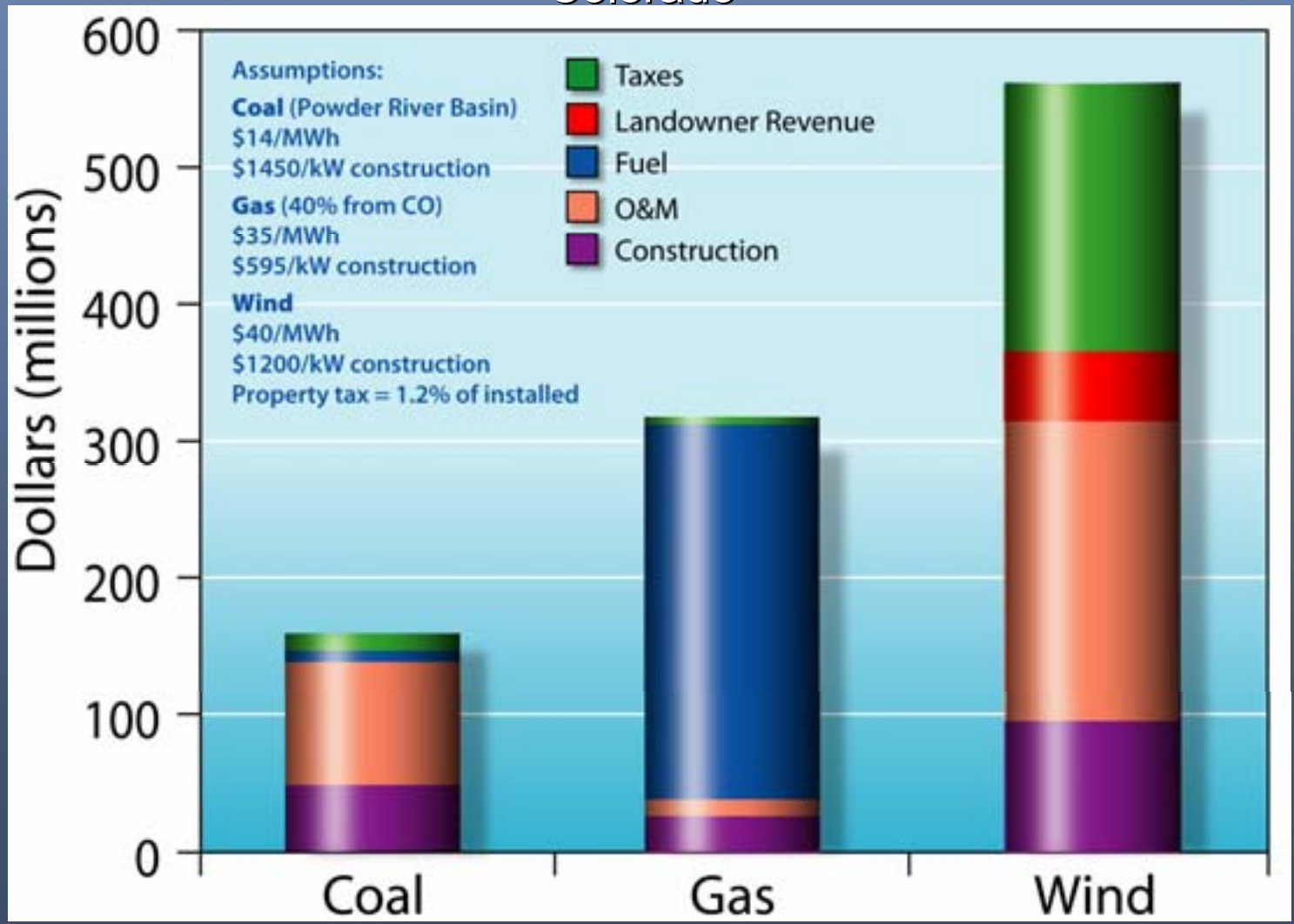


# Economic Development Impacts

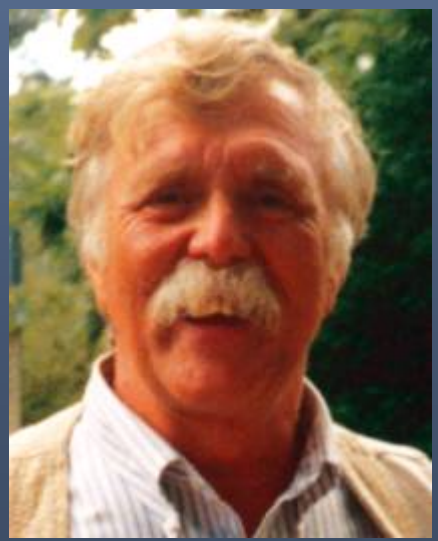
- Land Lease Payments: 2-3% of gross revenue $2500-4000/MW/year
- Local property tax revenue: 100 MW generates $500K-$1 million/yr
- 100-200 jobs/100 MW during construction
- 2-6 permanent O&M jobs per 50-100 MW
- Local industry:  concrete, towers, electrical services
- Manufacturing and Assembly plants expanding in U.S. (e.g. IL, CA, ND, PA)

# Comparative Economic Development Impacts

## Colorado




Source: Tegen, Suzanne - Windpower2005



"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*

# Wind Energy Investors







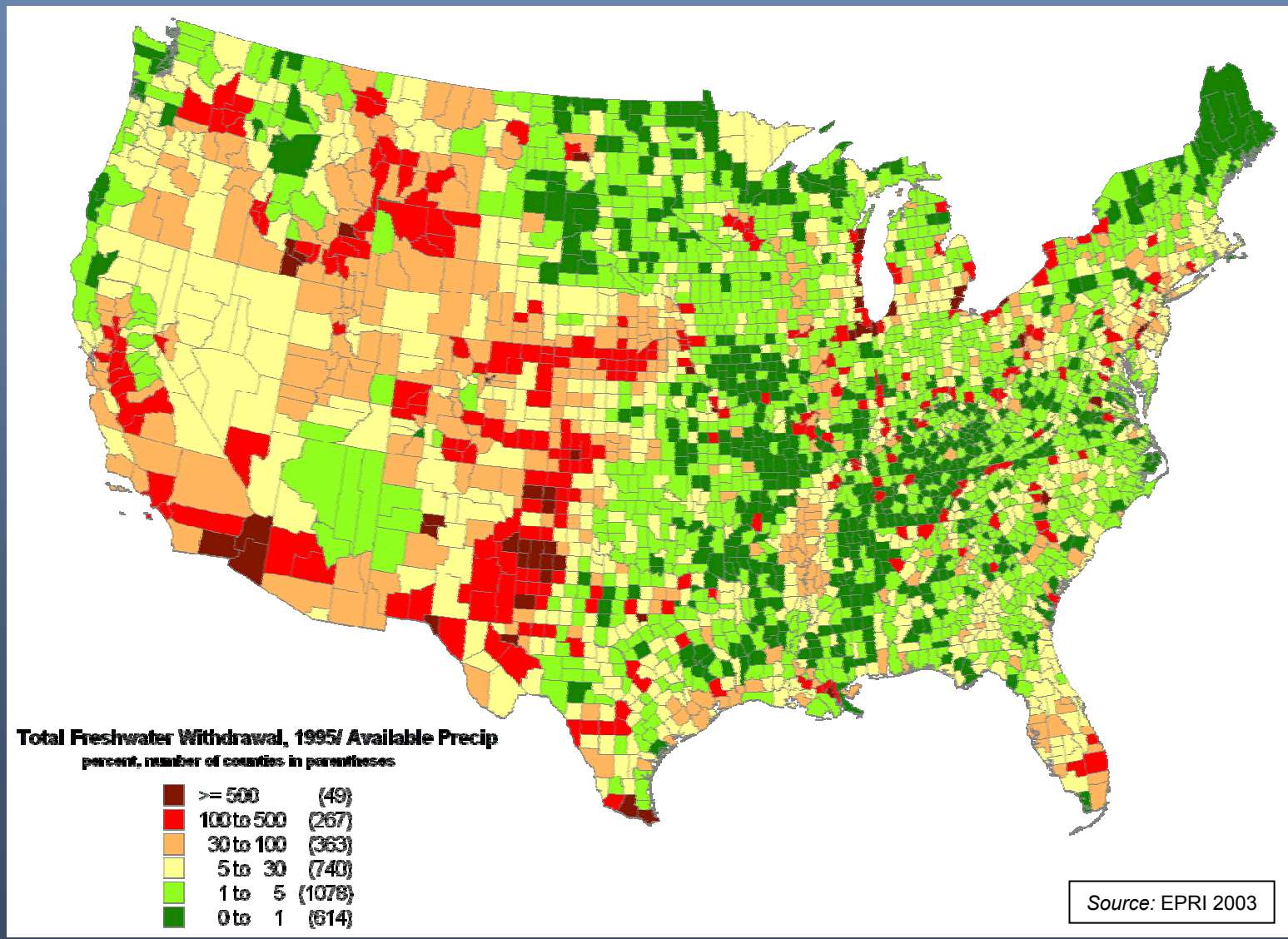





# Environmental Benefits

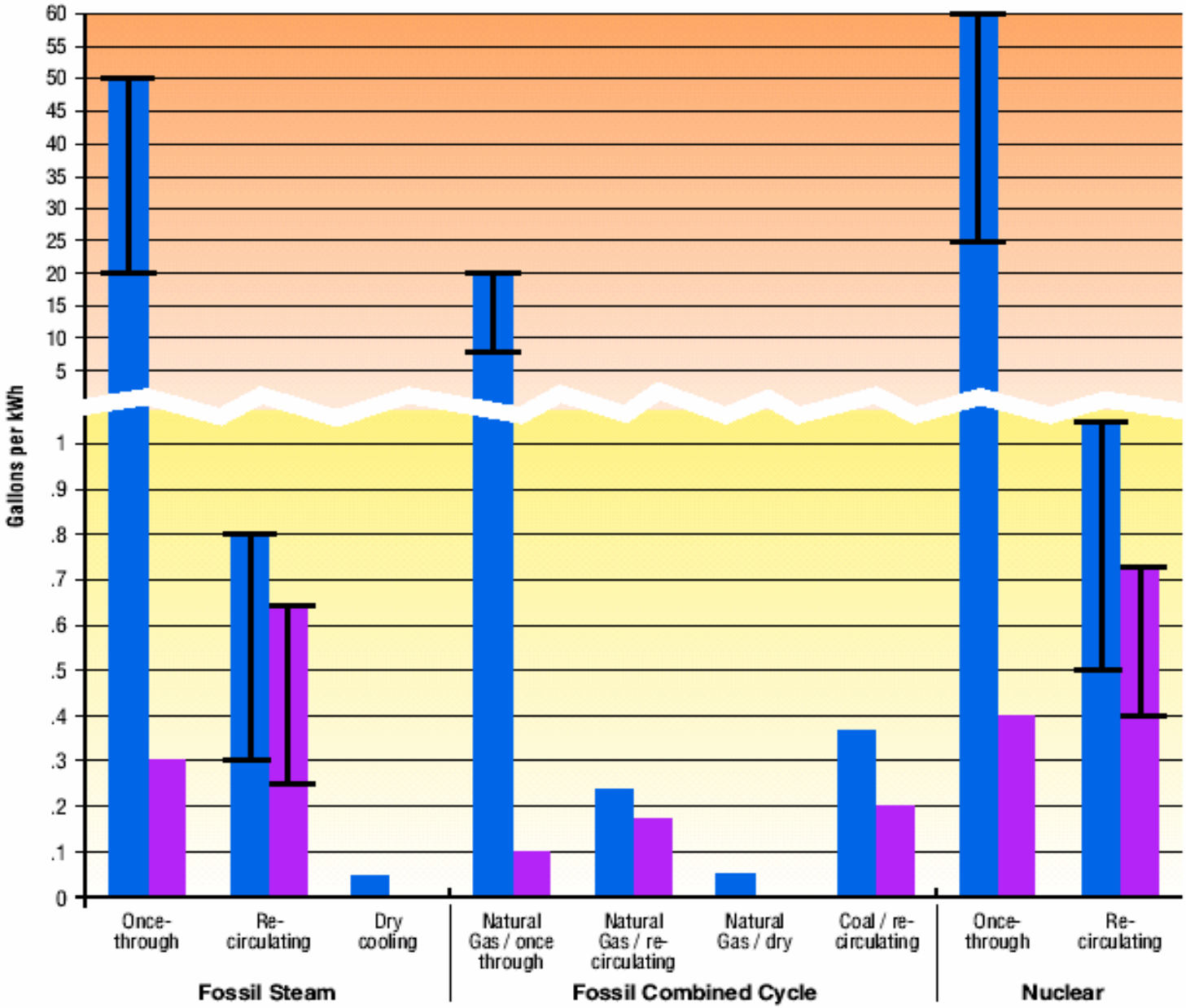
- No SOx or NOx
- No particulates
- No mercury
- No CO2
- No water

# Sustainable Withdrawal Of Freshwater Is National Issue




*Source:* EPRI 2003

## Cooling Water Withdrawal and Consumption, by fuel and technology in gal/kWh[a, b, c]




a Myhre, R. 2002. Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century, EPRI, Palo Alto, CA: 1006786.

b EIA, 2002 and 2000. Form 767. Steam-Electric Plant Operation and Design Report. Schedule V. Cooling System Information. Section A. Annual Operations.

c Afonso, Rui. Dry- vs. Wet-Cooling Technologies, prepared for the Clean Air Task Force by Energy and Environmental Strategies, October, 2001.

# Thermoelectric Power Plants – Water Usage

In 2002, nationwide:

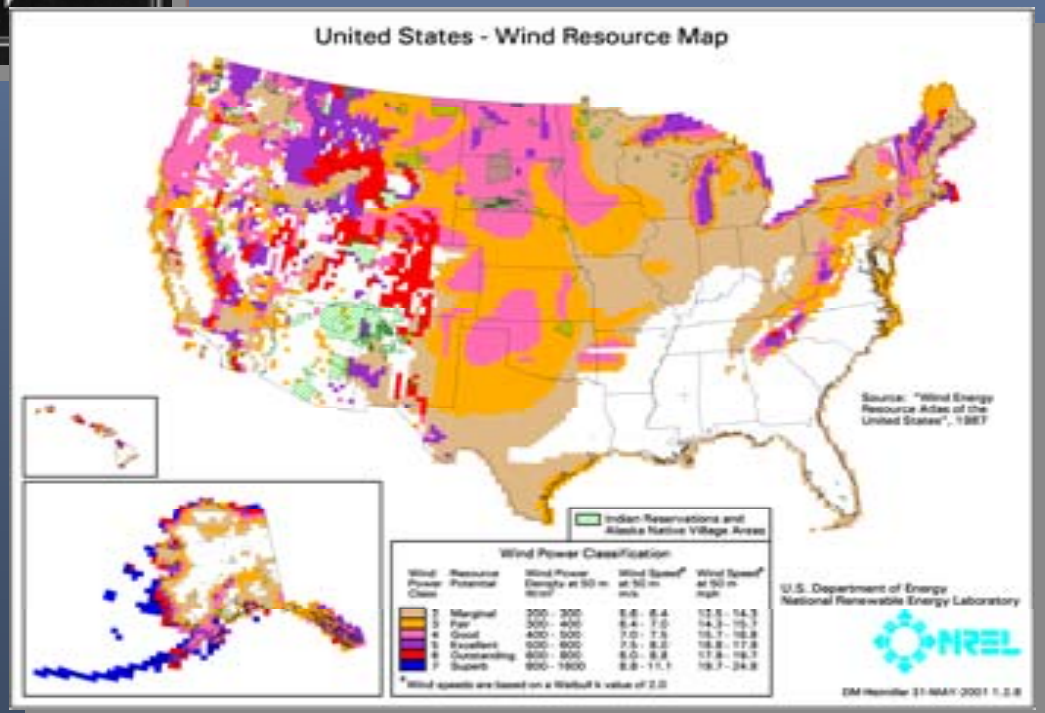
- Withdrawals of water at all thermoelectric power plants = 225 billion gallons/day
- = 252 million acre-feet
- ~ ¾ size of Lake Erie

Source: Western Resource Advocates

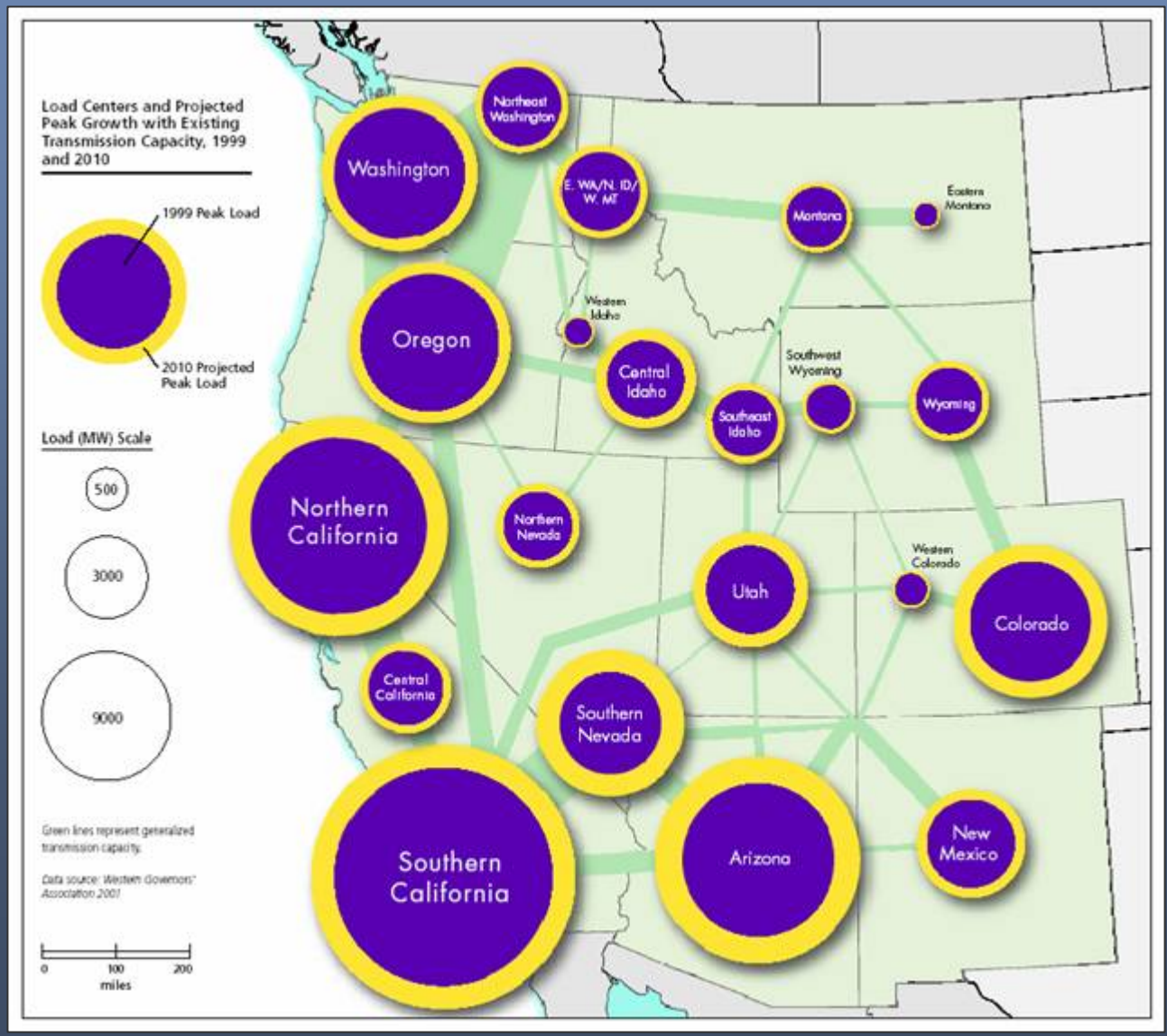
# Key Issues for Wind Power

- 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

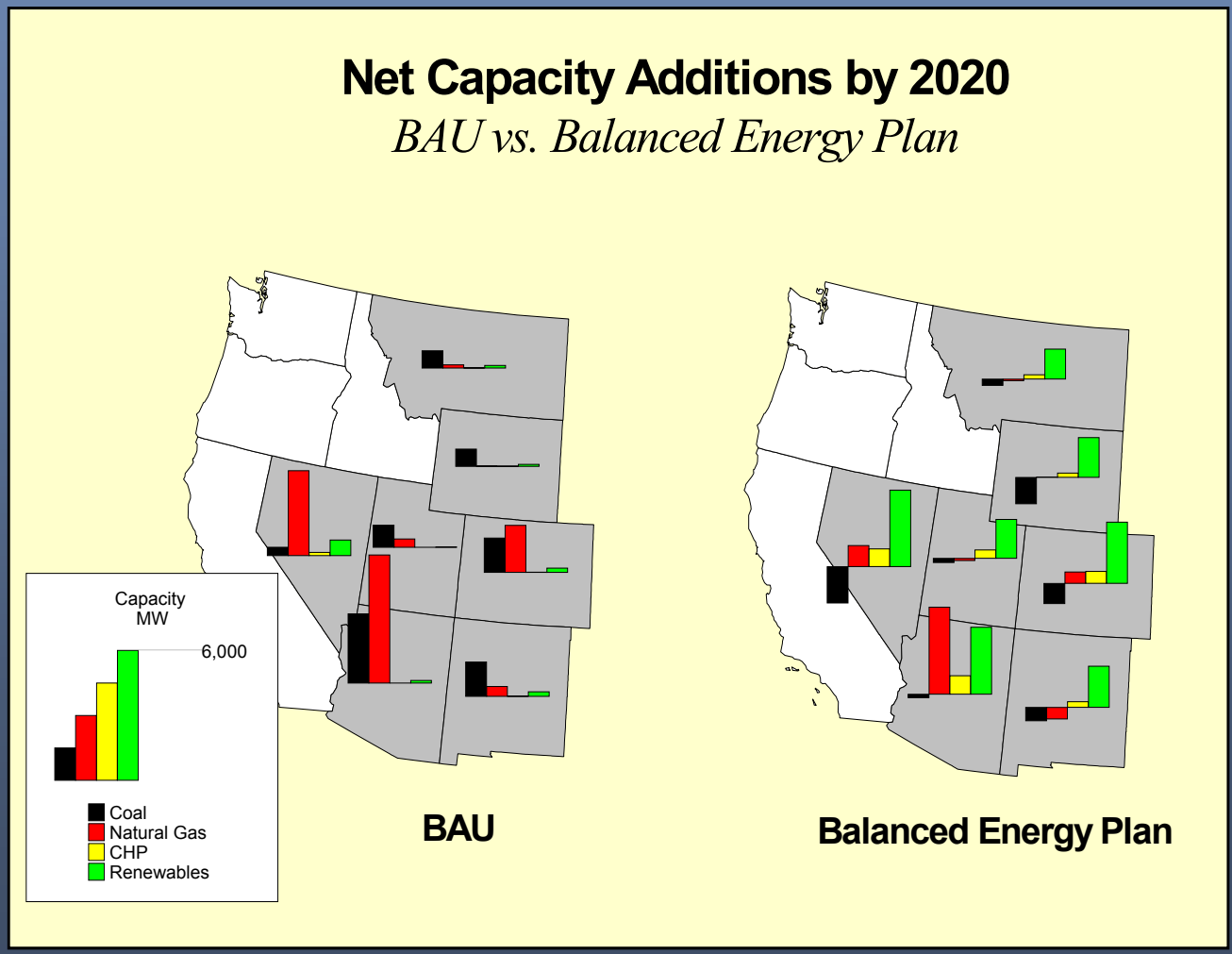

2000 POPULATION DISTRIBUTION IN THE UNITED STATES
One dot = 7500 people


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
U.S. Department of Energy
National Renewable Energy Laboratory
NREL

# Load Growth


Load Centers and Projected Peak Growth with Existing Transmission Capacity, 1999 and 2010
1999 Peak Load
2010 Projected Peak Load
Load (MW) Scale
500
3000
9000
Green lines represent generalized transmission capacity.
Data source: Western Governors' Association 2001
0
100
200
miles
Washington
Northeast Washington
E. WA/N. ID/ W. MT
Montana
Eastern Montana
Oregon
Western Idaho
Central Idaho
Southwest Wyoming
Southeast Idaho
Wyoming
Northern California
Northern Nevada
Utah
Western Colorado
Colorado
Central California
Southern Nevada
Southern California
Arizona
New Mexico

# Interior West Capacity Additions




Balanced Plan:

- 15,400 MW renewables
- 3000 MW CHP
- 7800 MW natural gas
- Retires 5000 MW of coal

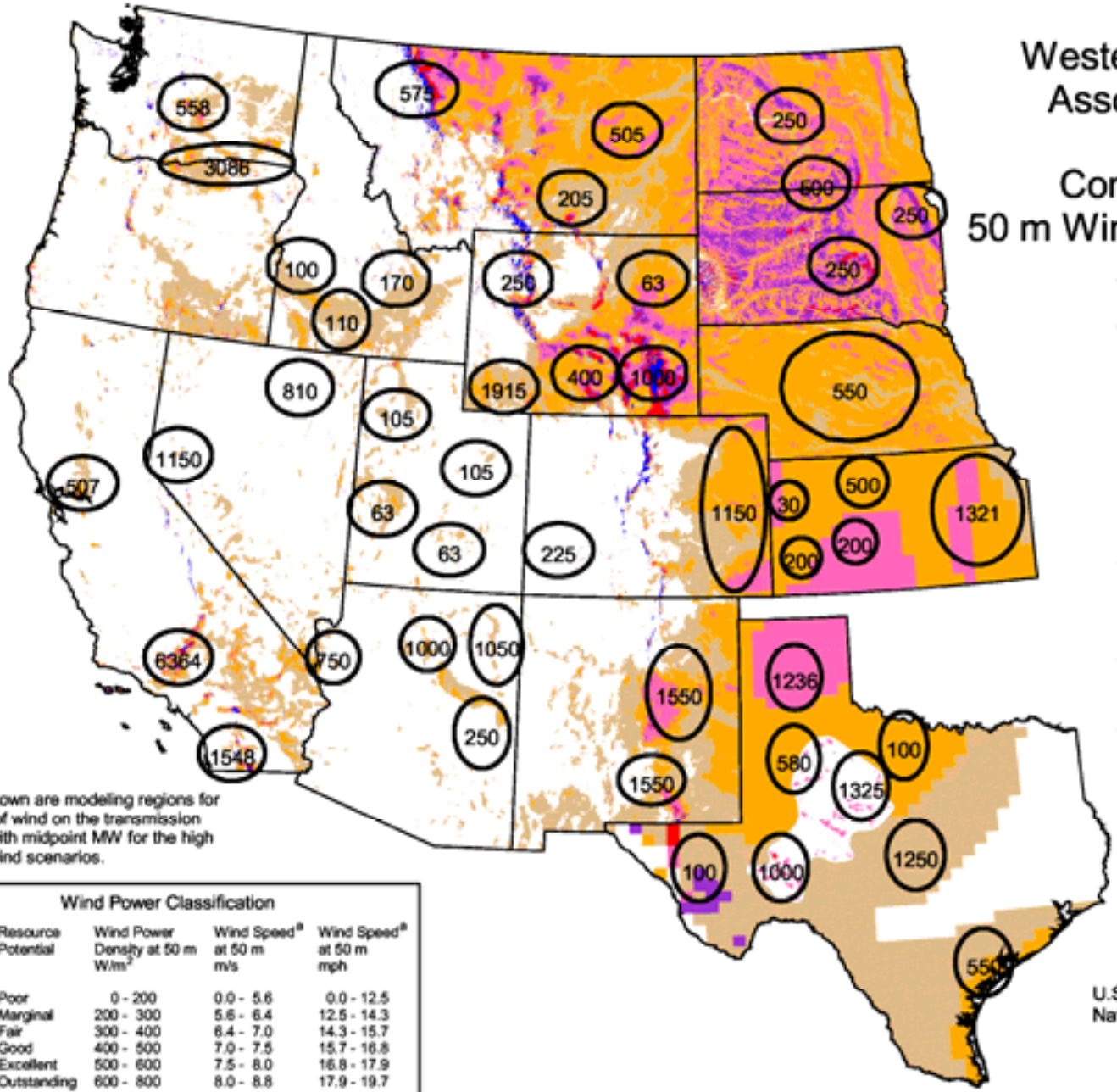
BAU

- 16,000 MW natural gas
- 10,000 MW coal
- 1500 MW renewables
- 150 MW CHP

Source: Western Resource Advocates

# Western Governor's Association Area

## Combined Data
## 50 m Wind Resource Data




Circles shown are modeling regions for insertion of wind on the transmission system, with midpoint MW for the high and low wind scenarios.

The wind resource information shown for Kansas and most of Texas is from the 1987 "Wind Energy Resource Atlas of the United States". Wind resource is shown for every 1/3 degree of longitude by 1/4 degree of latitude. As little as 5% of the area shown in each area may be well-exposed to the power class displayed.

The remaining wind resource assessments were conducted on a state-by-state basis from 1999 to 2004. Over that time, the methodology and resolution of the data varied due to changes in the assessment process. Also, the fine resolution of these assessments may prevent many good resource areas from appearing when viewed at this scale.

### Wind Power Classification

| Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m² | Wind Speed[a] at 50 m m/s | Wind Speed[a] at 50 m mph |
|---|---|---|---|---|
| 1 | Poor | 0 - 200 | 0.0 - 5.6 | 0.0 - 12.5 |
| 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 |

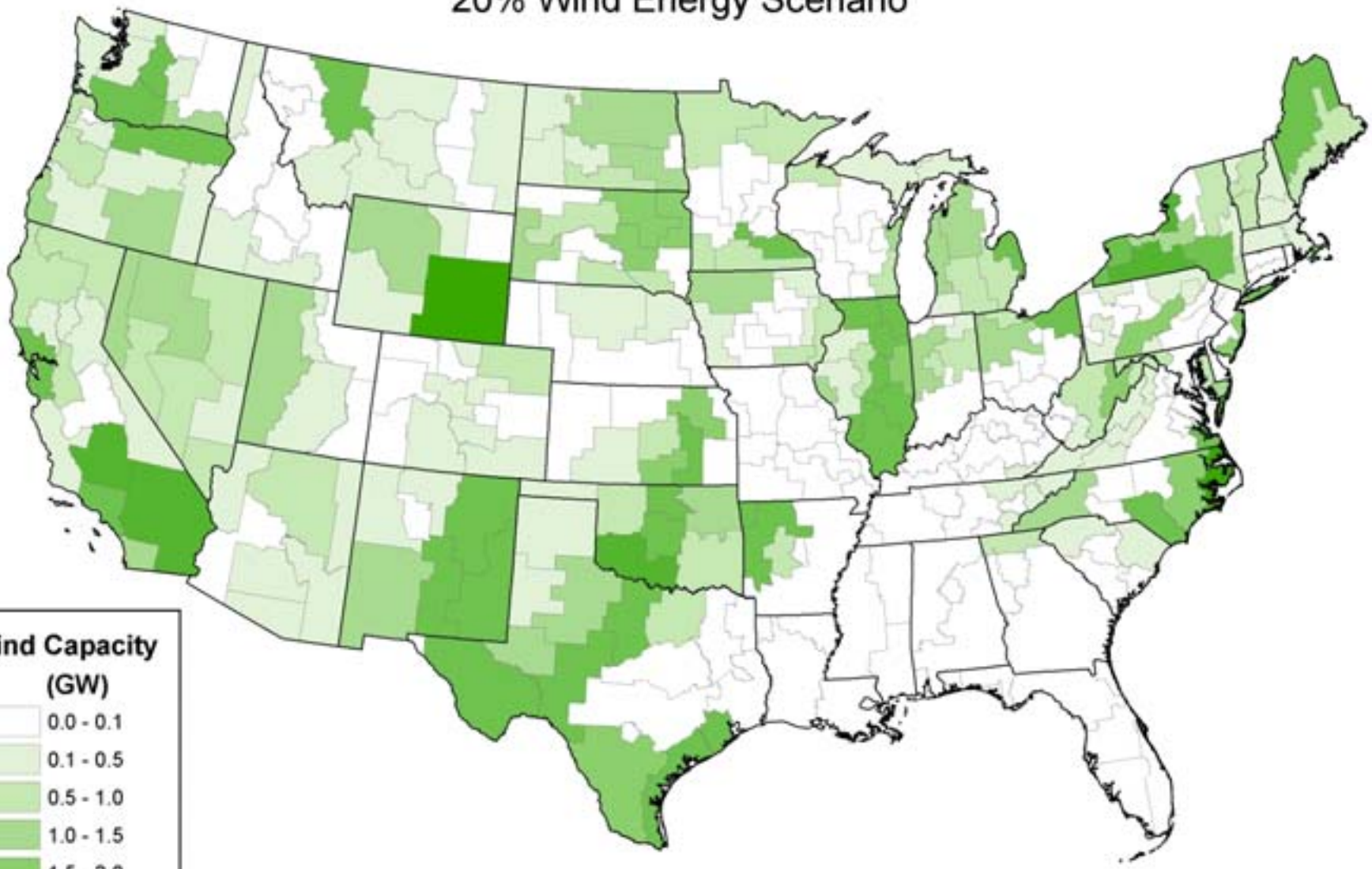
[a] Wind speeds are based on a Weibull k value of 2.0


U.S. Department of Energy
National Renewable Energy Laboratory

NREL

24-JAN-2006 5.3.8

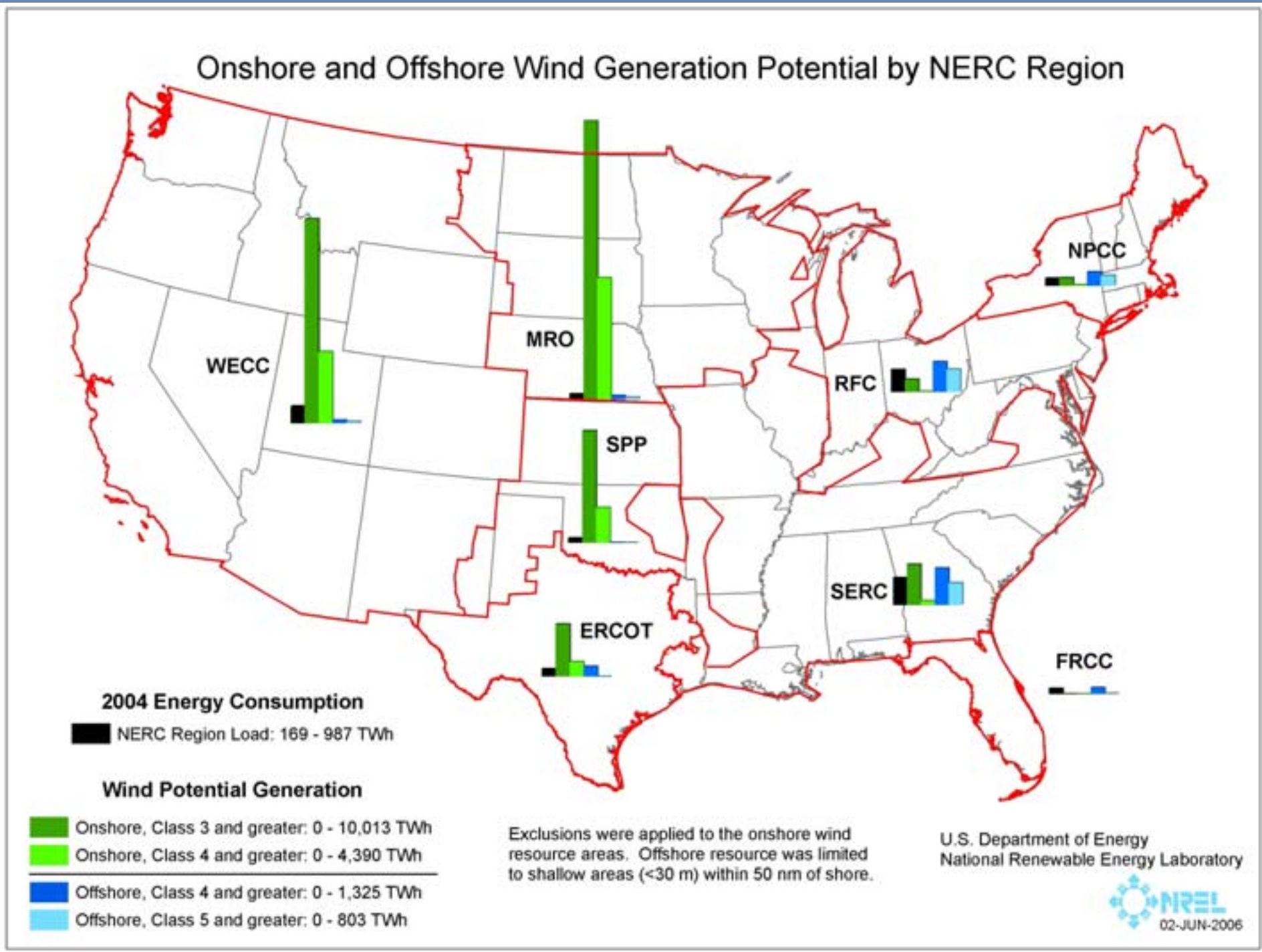
# 20% Wind Energy Scenario

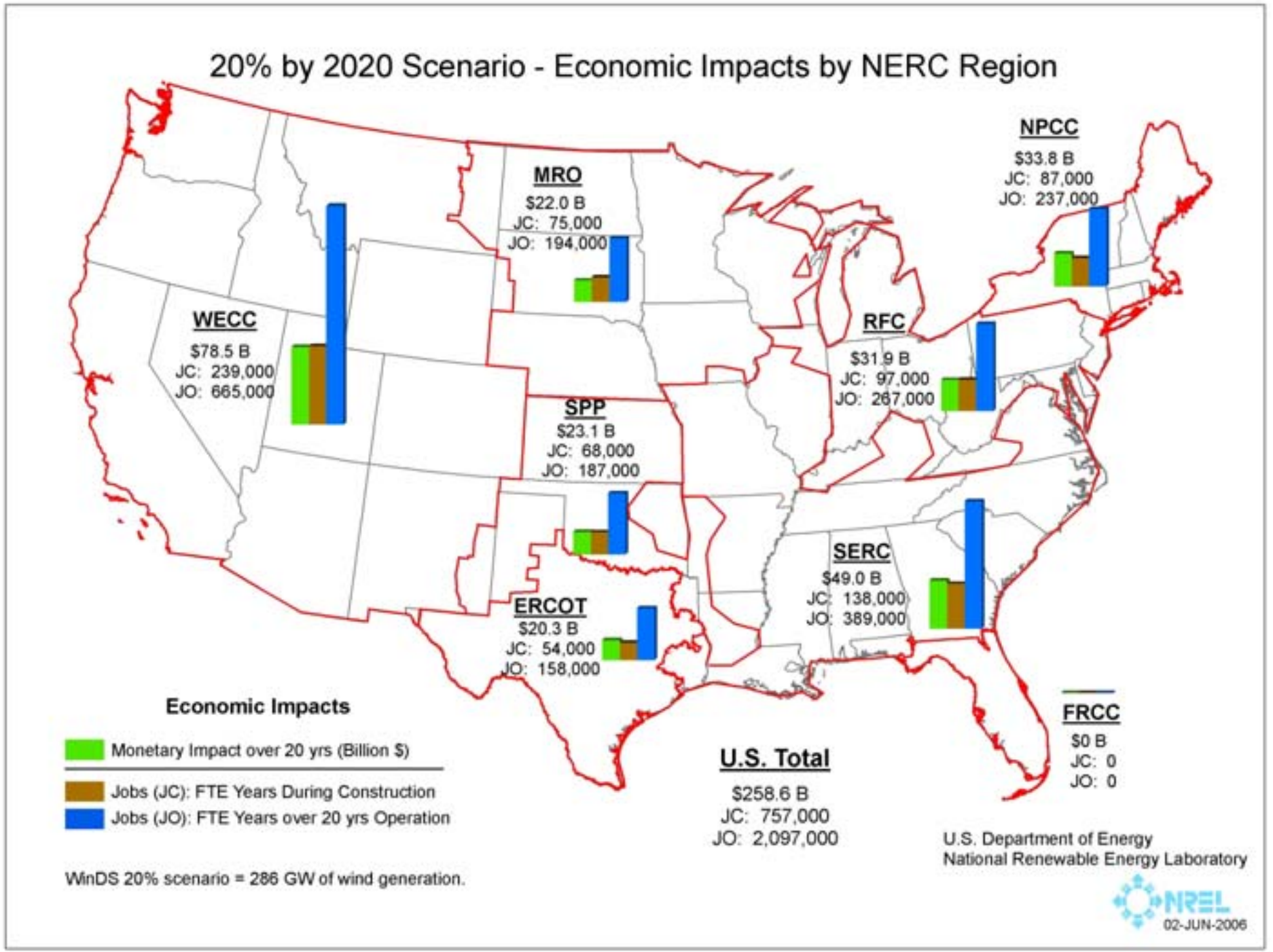



WinDS scenario: 20% of total energy generation; onshore and offshore; 2020

U.S. Department of Energy
National Renewable Energy Laboratory

NREL
01-JUN-2006


Onshore and Offshore Wind Generation Potential by NERC Region
WECC
MRO
SPP
ERCOT
RFC
SERC
FRCC
NPCC
2004 Energy Consumption
NERC Region Load: 169 - 987 TWh
Wind Potential Generation
Onshore, Class 3 and greater: 0 - 10,013 TWh
Onshore, Class 4 and greater: 0 - 4,390 TWh
Offshore, Class 4 and greater: 0 - 1,325 TWh
Offshore, Class 5 and greater: 0 - 803 TWh
Exclusions were applied to the onshore wind resource areas. Offshore resource was limited to shallow areas (<30 m) within 50 nm of shore.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
02-JUN-2006


20% by 2020 Scenario - Economic Impacts by NERC Region
NPCC
$33.8 B
JC: 87,000
JO: 237,000
MRO
$22.0 B
JC: 75,000
JO: 194,000
WECC
$78.5 B
JC: 239,000
JO: 665,000
RFC
$31.9 B
JC: 97,000
JO: 267,000
SPP
$23.1 B
JC: 68,000
JO: 187,000
SERC
$49.0 B
JC: 138,000
JO: 389,000
ERCOT
$20.3 B
JC: 54,000
JO: 158,000
FRCC
$0 B
JC: 0
JO: 0
Economic Impacts
Monetary Impact over 20 yrs (Billion $)
Jobs (JC): FTE Years During Construction
Jobs (JO): FTE Years over 20 yrs Operation
U.S. Total
$258.6 B
JC: 757,000
JO: 2,097,000
WinDS 20% scenario = 286 GW of wind generation.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
02-JUN-2006

# 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**.

# Wind Energy Benefits (EIEIO)

- Economic development (revenue, increased local tax base, jobs)
- Indigenous resource
- Environmental benefits (emission free, water-free generation)
- Inexhaustible supply
- On the Rez

"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*

# HUMANITY'S TOP TEN PROBLEMS FOR THE NEXT 50 YEARS

1. **ENERGY**
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

| | | |
|---|---|---|
| **2004** | **6.3** | **Billion People** |
| **2050** | **9-10** | **Billion People** |

*Carpe Ventem!*

www.windpoweringamerica.gov