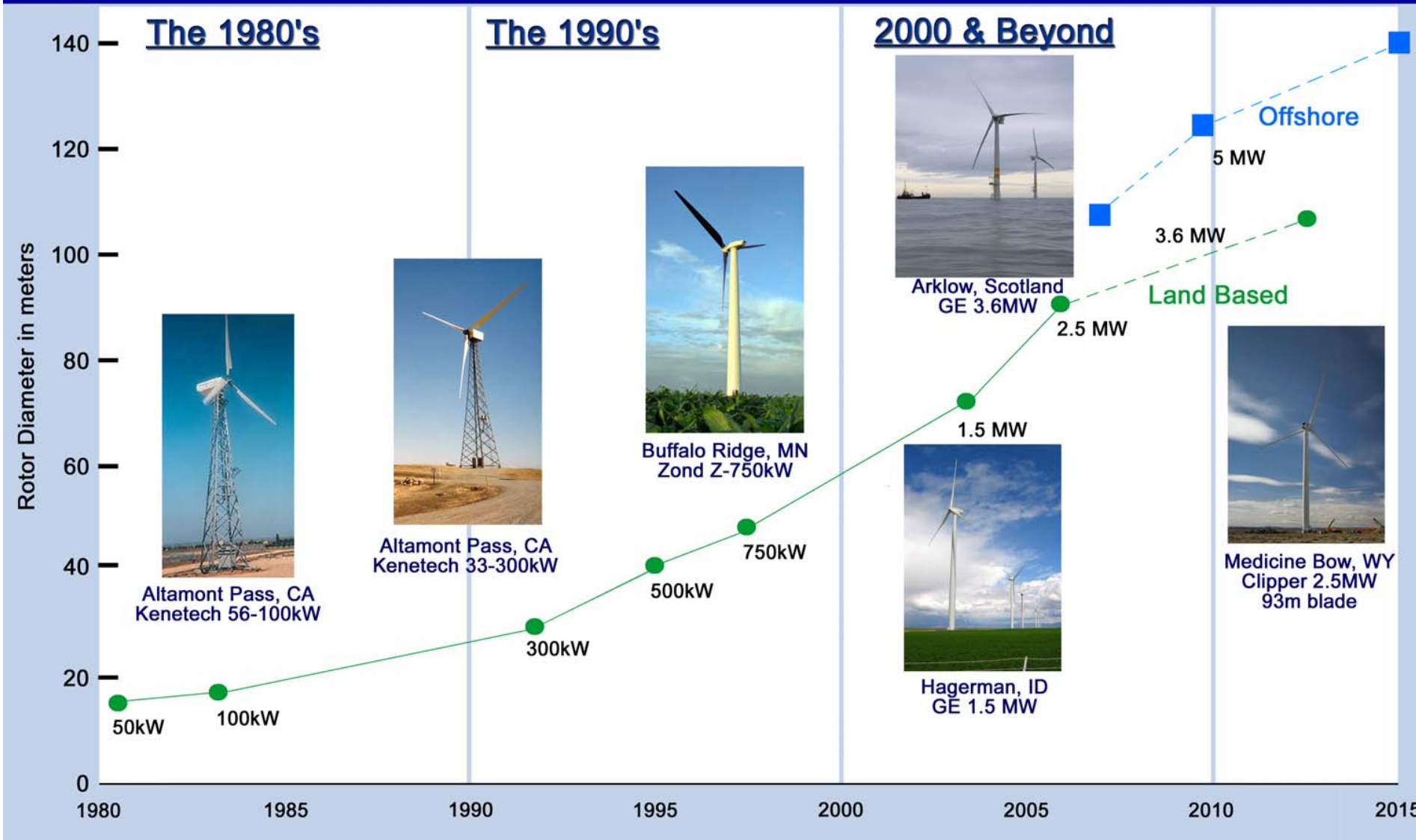
Wind Energy Update

Larry Flowers

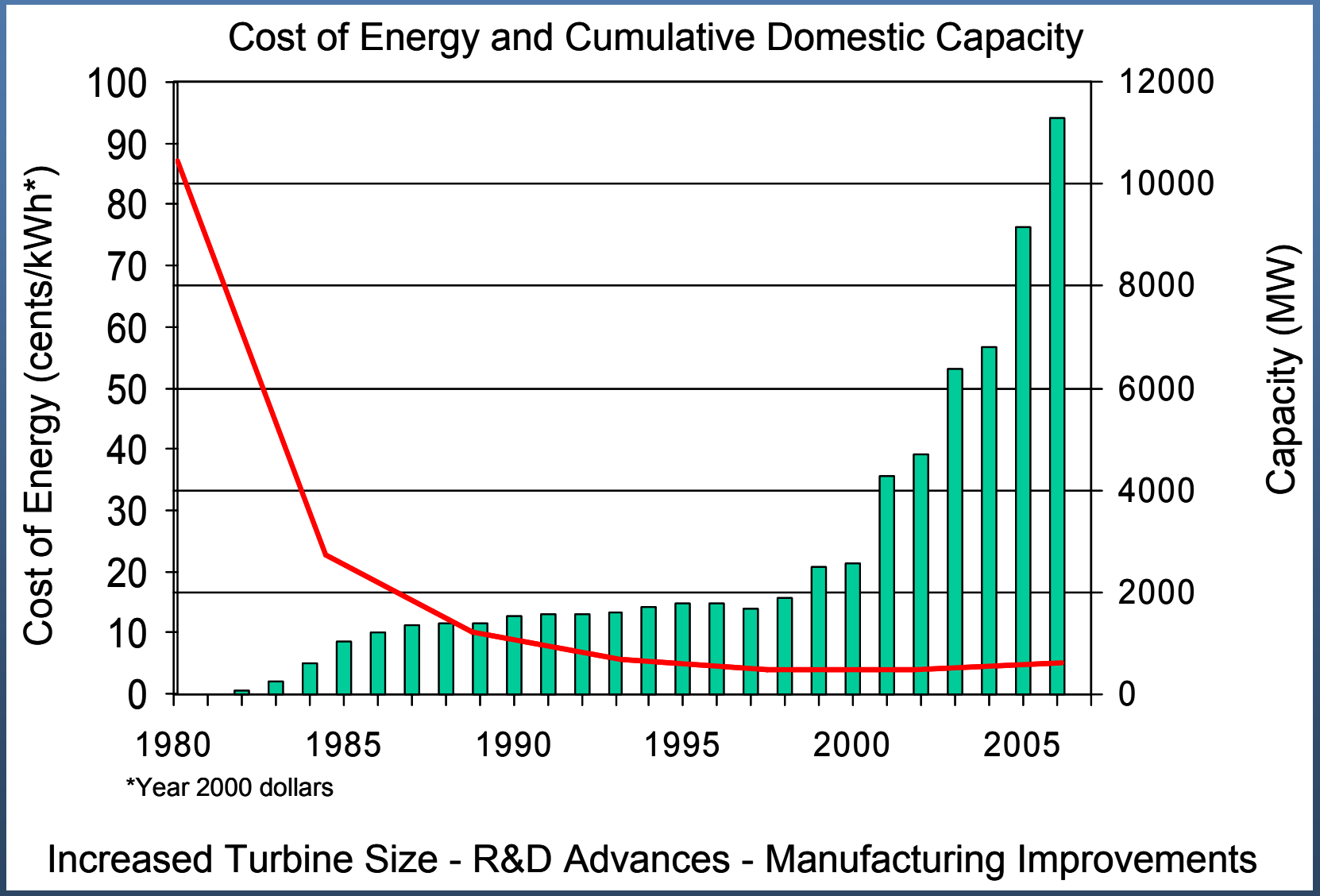
National Renewable Energy Laboratory

November 2007

Evolution of U.S. Commercial Wind Technology



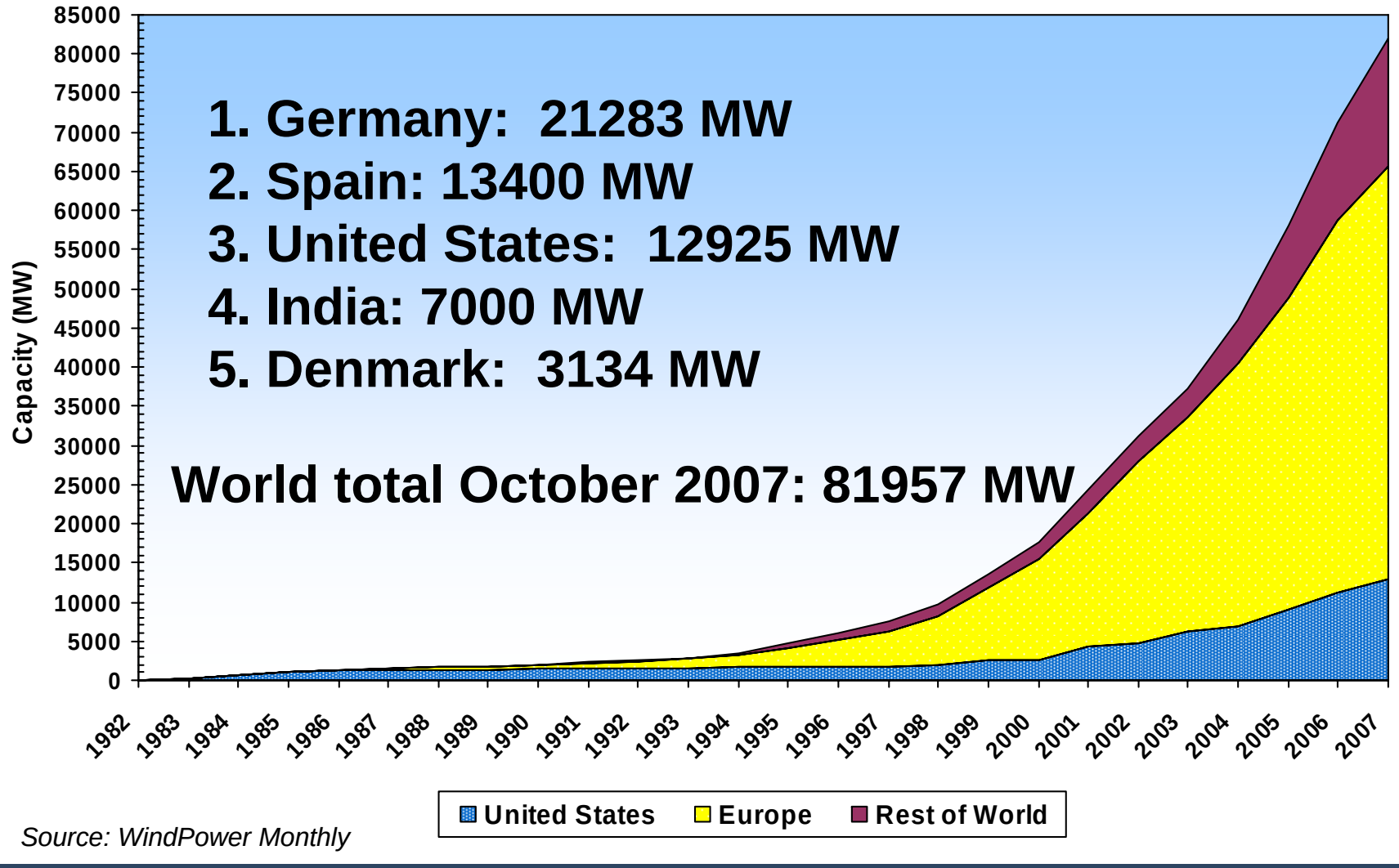
Capacity & Cost Trends



Increased Turbine Size - R&D Advances - Manufacturing Improvements

People Want Renewable Energy!

Total Installed Wind Capacity



Source: WindPower Monthly

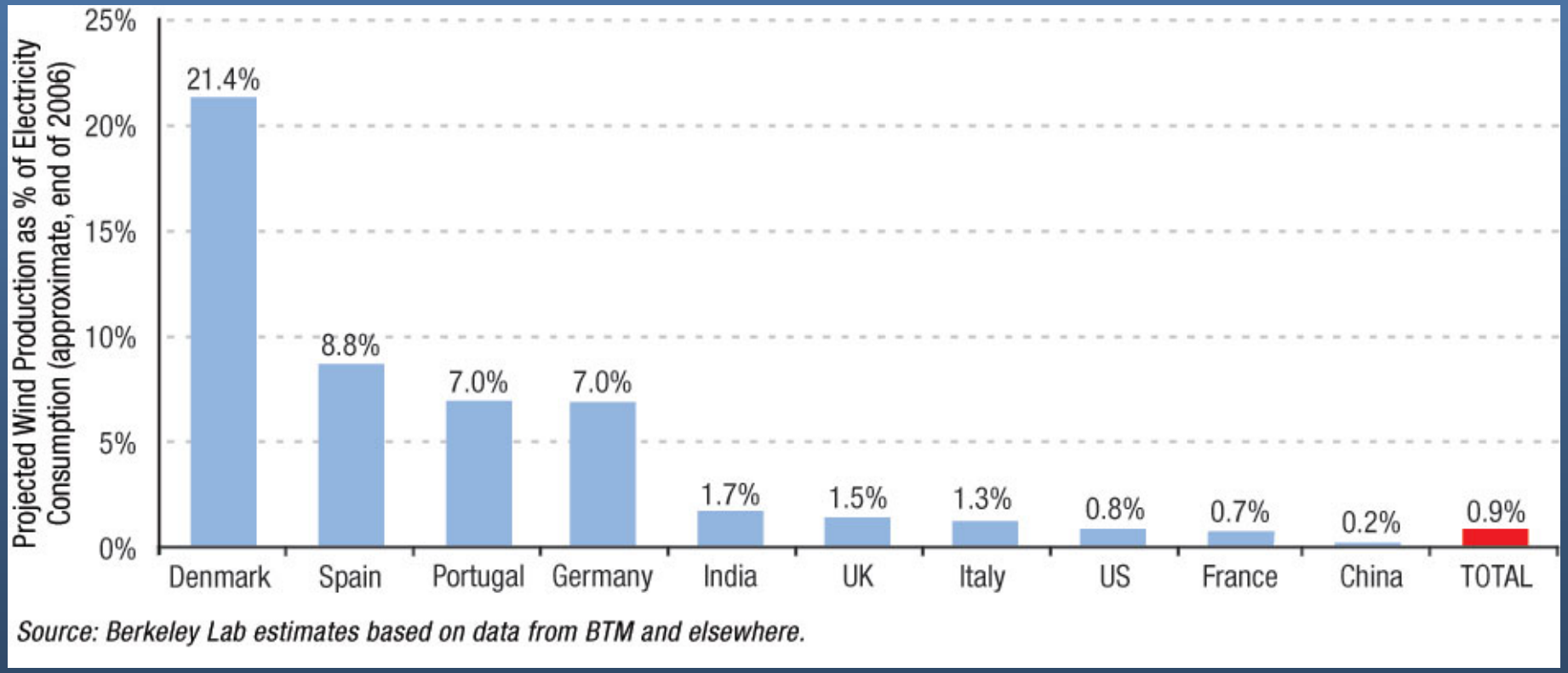
U.S. Leads World in Annual Wind Capacity Additions; Third in Cumulative Capacity

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**

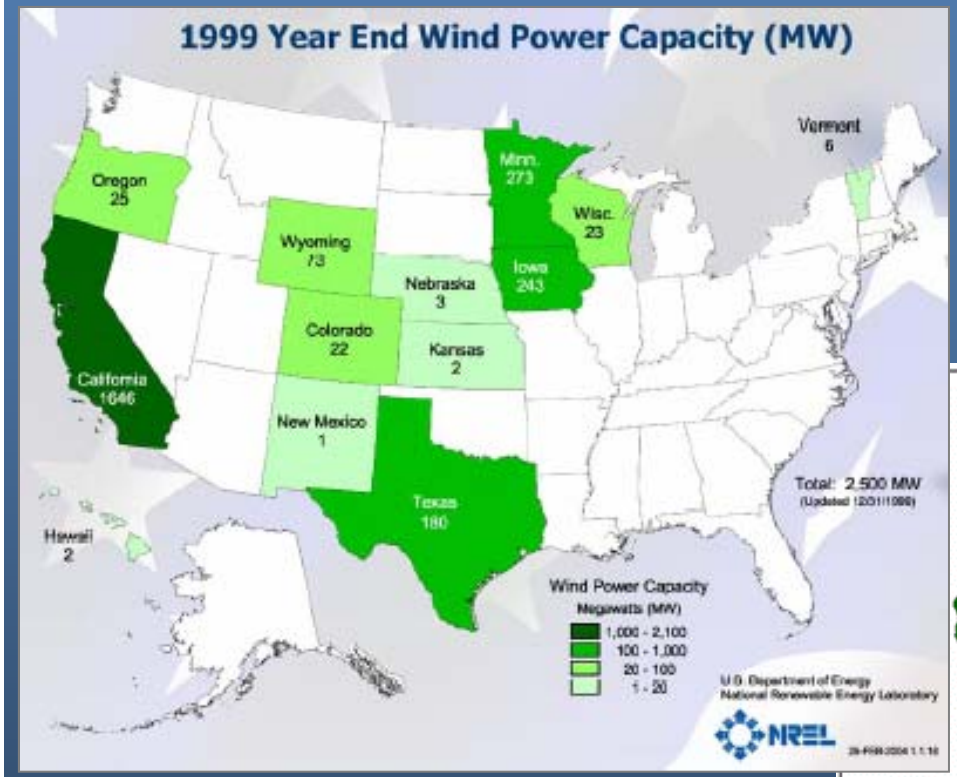
Source: BTM, 2007; AWEA/GEC dataset for U.S. cumulative capacity.

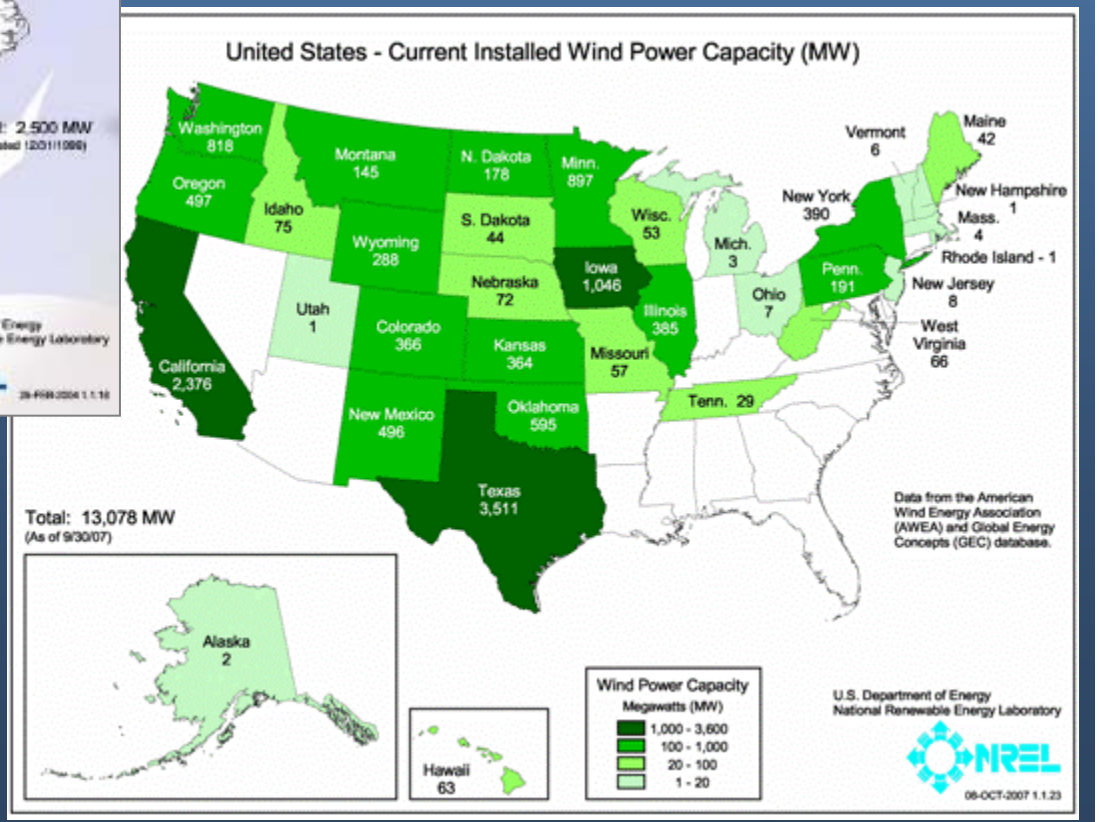
U.S Lagging Other Countries for Wind As a Percentage of Electricity Consumption



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

Installed Wind Capacities ('99 – Sept 07)

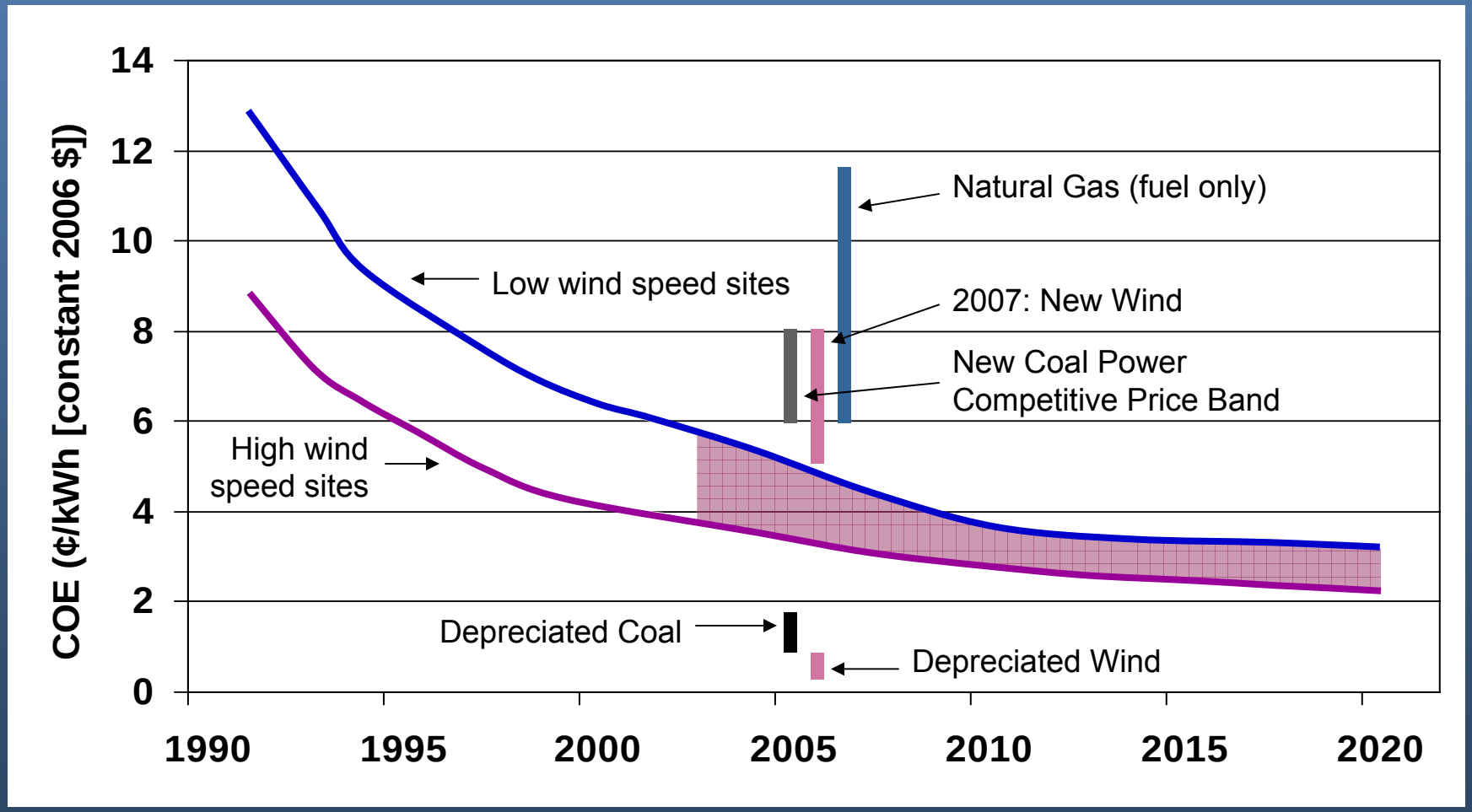




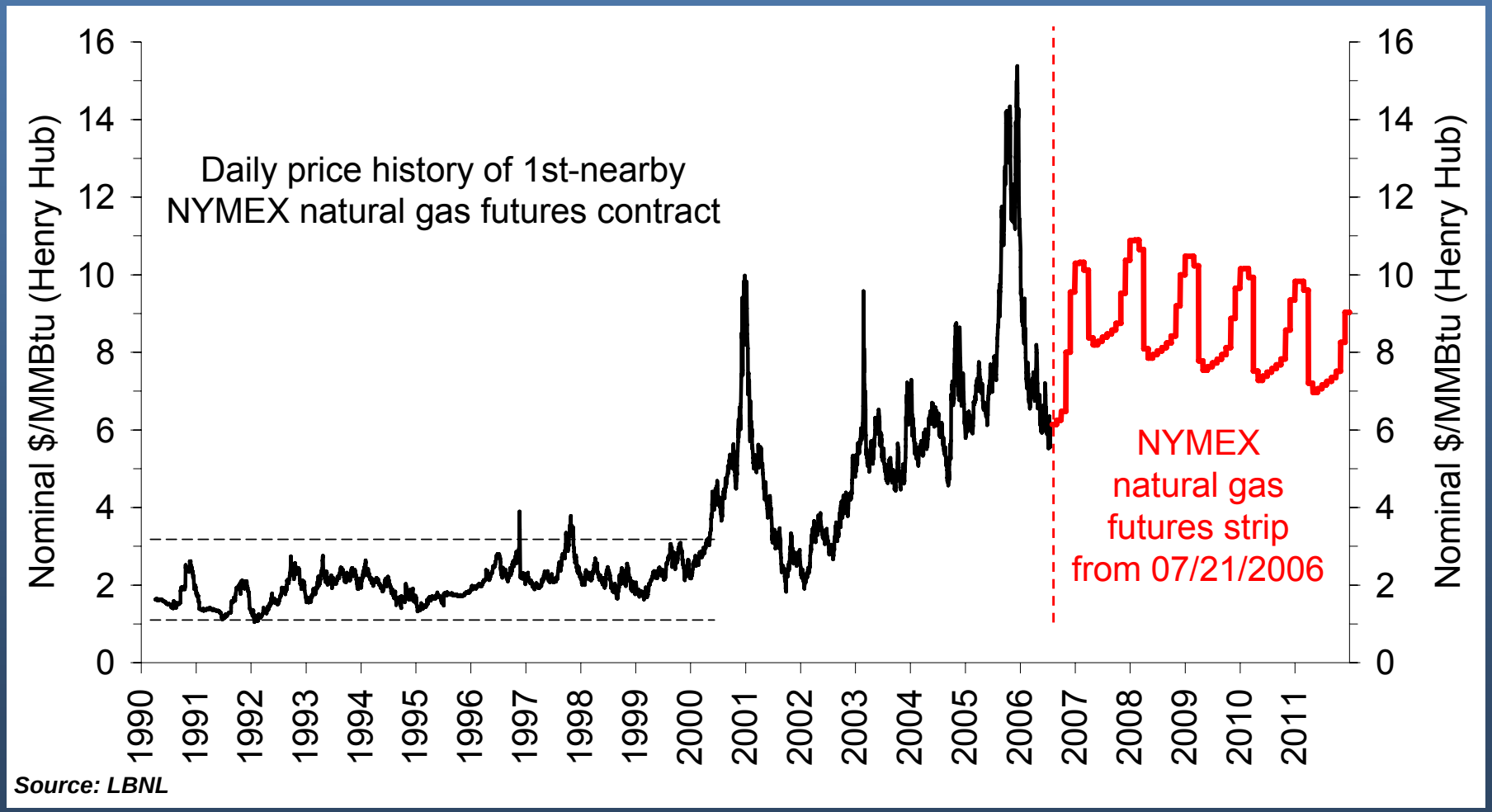
Drivers for Wind Power

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

Wind Cost of Energy

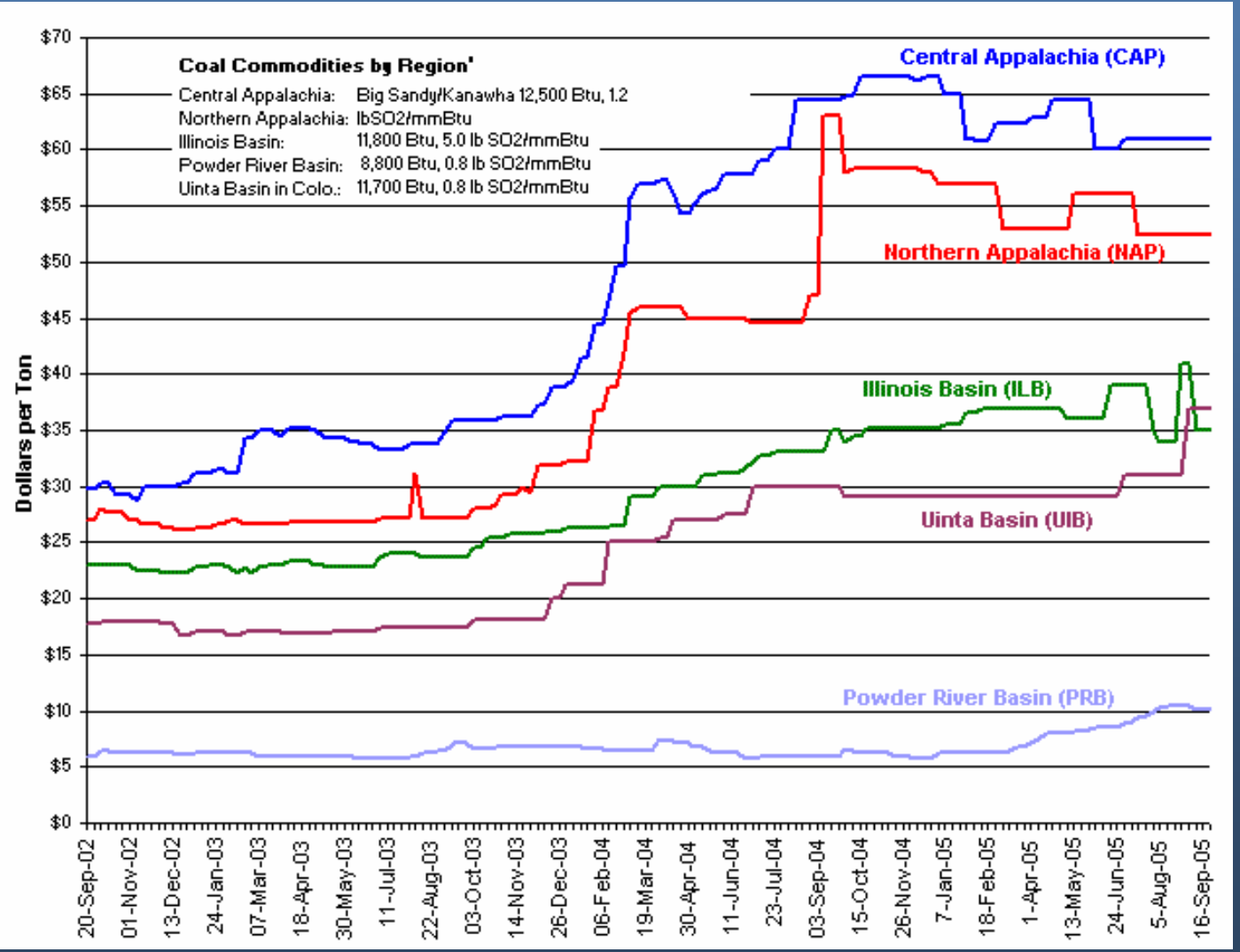


Natural Gas – Historic Prices



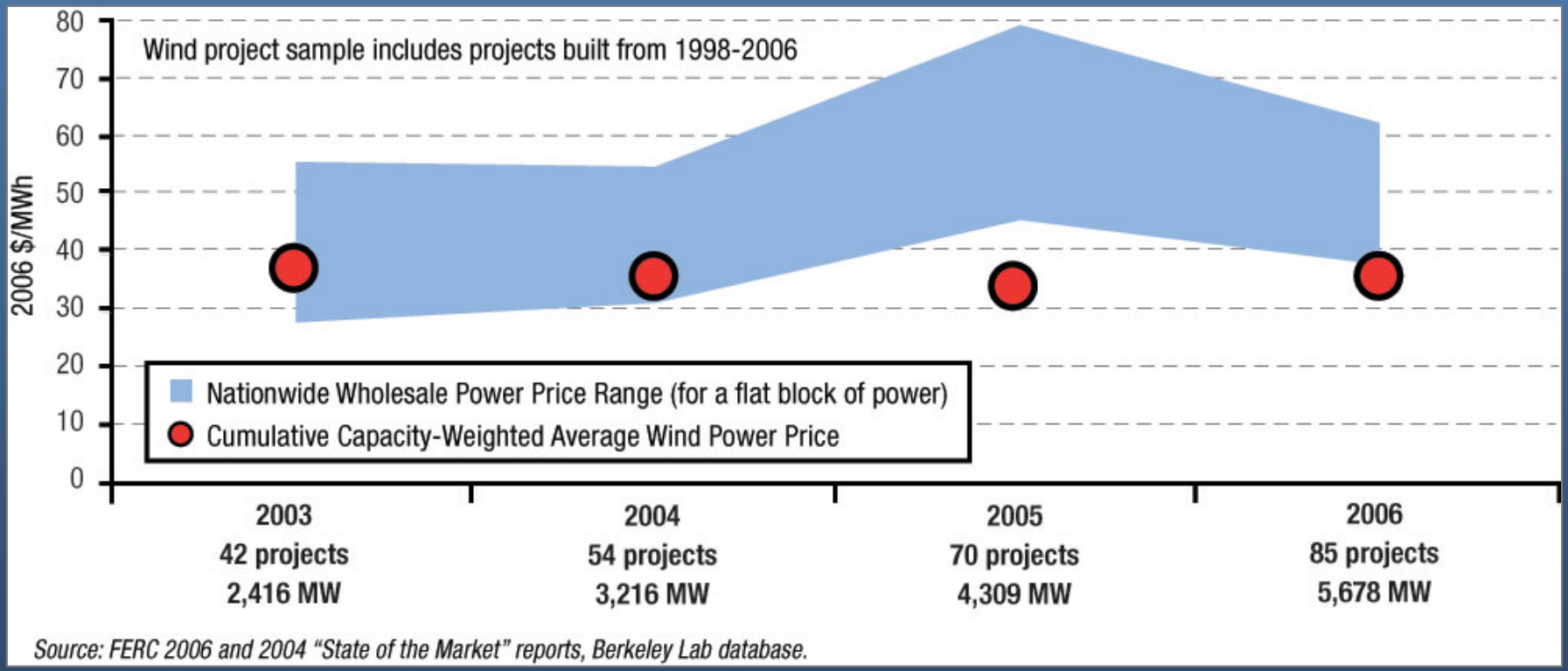
Source: LBNL

Historical Coal Prices



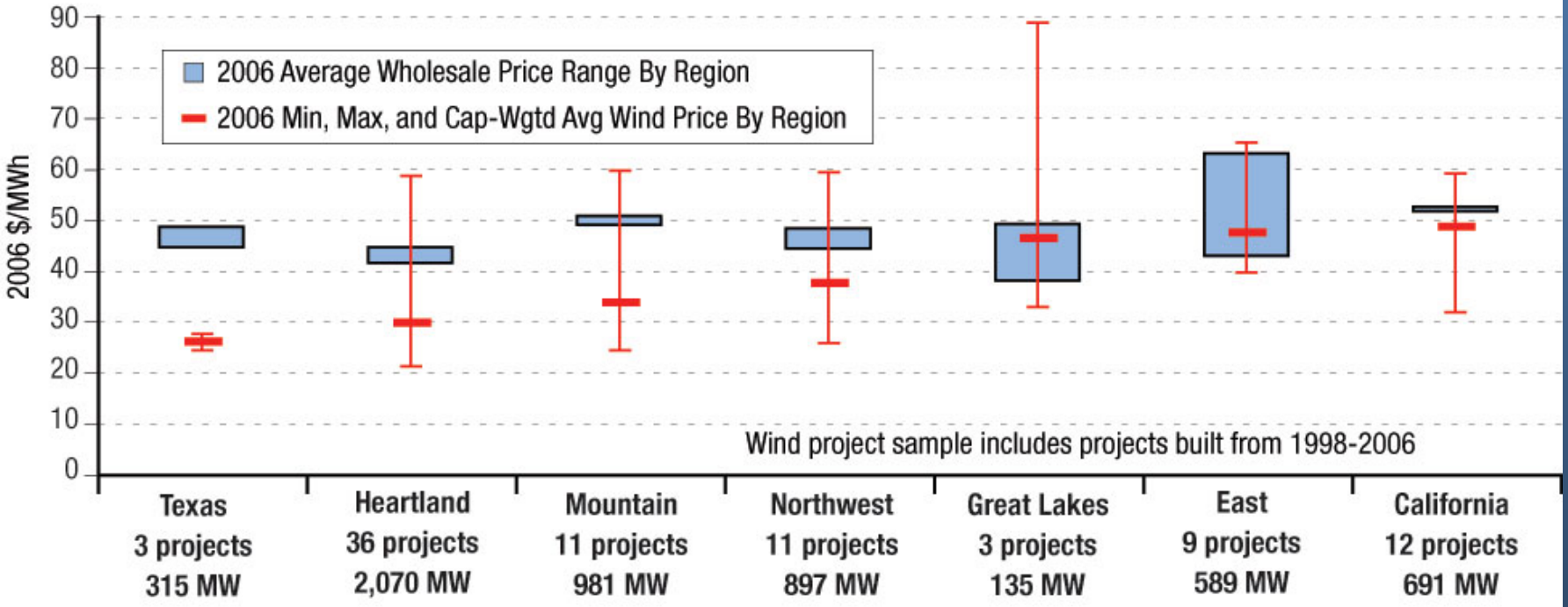
Source: EIA

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



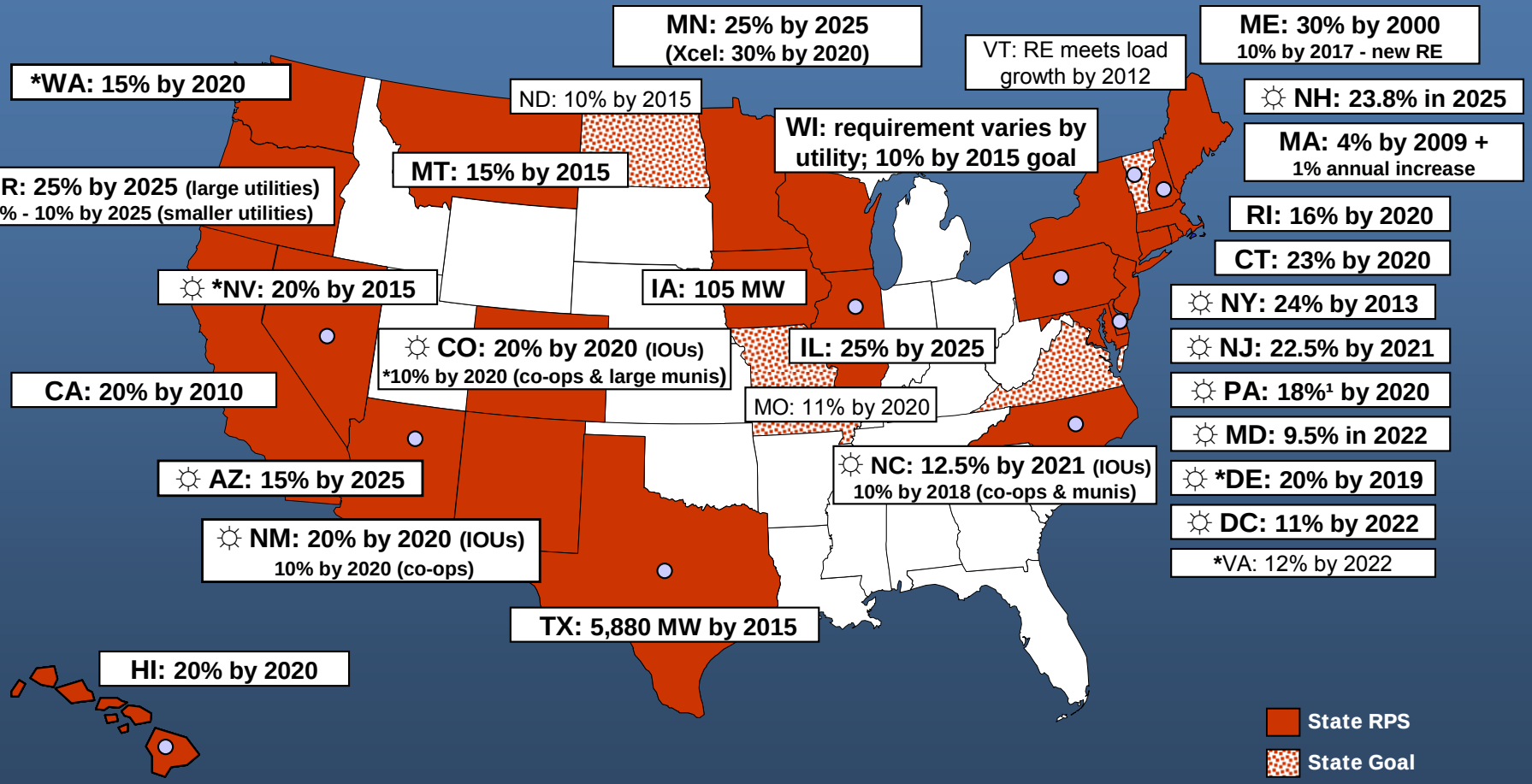
Source: FERC 2006 and 2004 "State of the Market" reports, Berkeley Lab database.

In 2006, Wind Projects Built Since 1997 Were Competitive with Wholesale Power Prices in Most Regions



Source: FERC 2006 "State of the Market" report, Berkeley Lab database.

Renewables Portfolio Standards



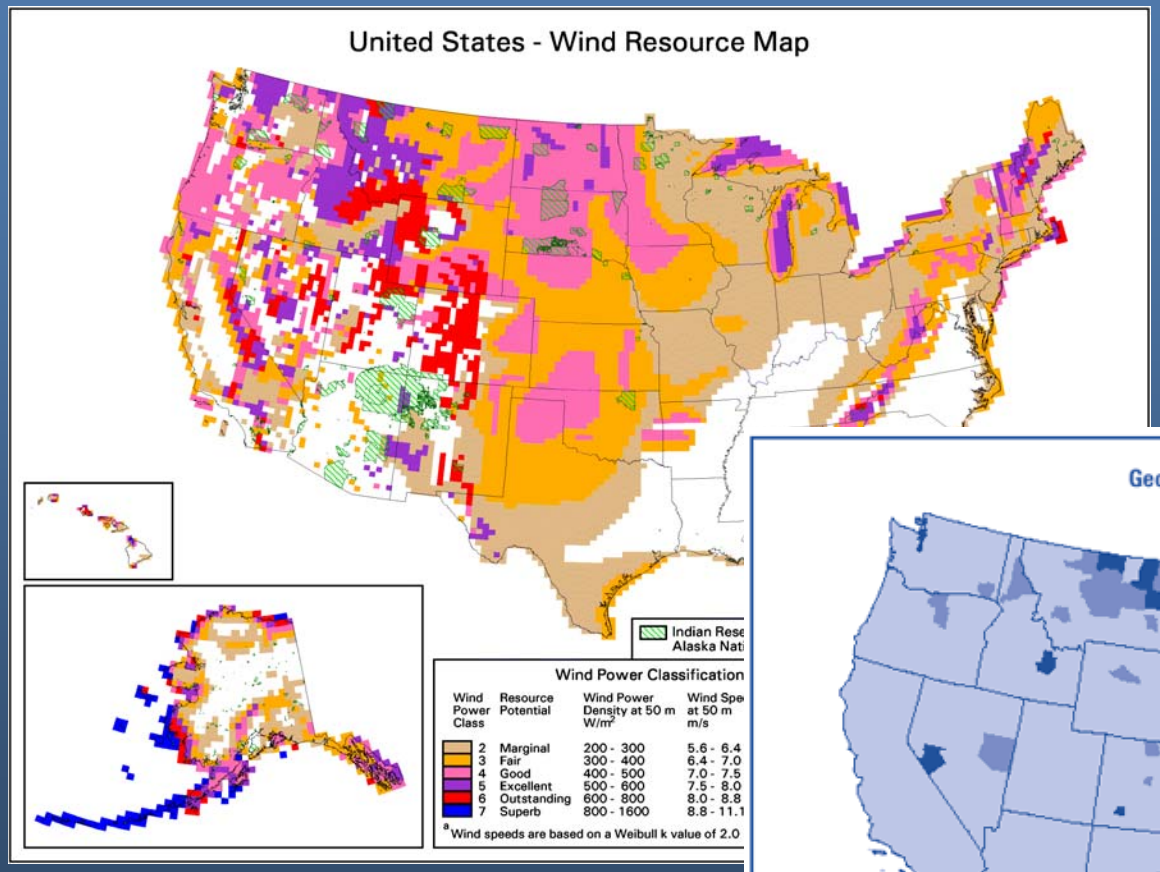
☼ Minimum solar or customer-sited RE requirement
* Increased credit for solar or customer-sited RE
¹PA: 8% Tier I / 10% Tier II (includes non-renewables); SWH is a Tier II resource

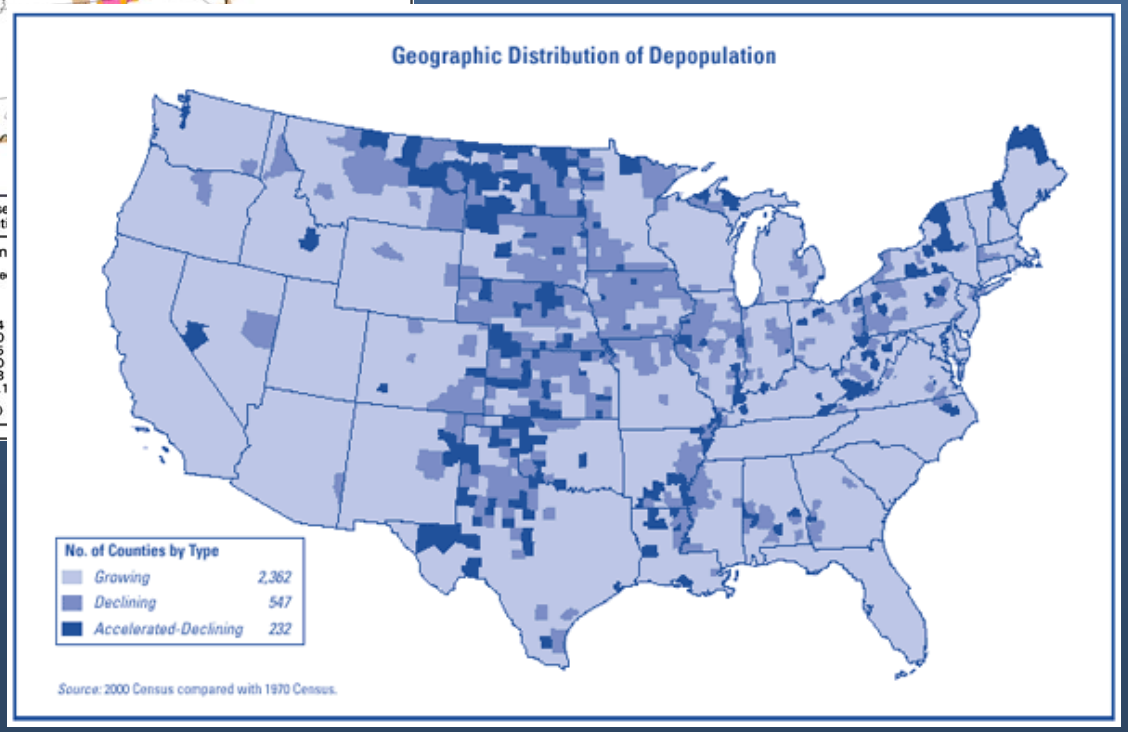
DSIRE: www.dsireusa.org

September 2007

Wind Energy Investors

Windy Rural Areas Need Economic Development





Economic Development Impacts

- **Land Lease Payments**: 2-3% of gross revenue $2500-4000/MW/year
- **Local property tax** revenue: ranges widely - $300K-1700K/yr per 100MW
- 100-200 **jobs**/100MW during construction
- 6-10 permanent O&M **jobs** per 100 MW
- Local construction and service industry: concrete, towers usually done locally

Case Study: Texas

Utilities and wind companies invested $1B in 2001 to build 912 MW of new wind power, resulting in:

- **2,500 quality jobs with a payroll of $75M**
- $13.3M in tax revenues for schools and counties
- $2.5M in 2002 royalty income to landowners
- Another 2,900 indirect jobs as a result of the multiplier effect
- $4.6M increase in Pecos County property tax revenue in 2002

Case Study: Minnesota

107-MW Minnesota wind project

- **$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)

Case Study: Iowa

240-MW Iowa wind project

- $640,000/yr in lease payments to farmers ($2,000/turbine/yr)
- $2M/yr in property taxes
- $5.5M/yr in O&M income
- **40 long-term O&M jobs**
- **200 short-term construction jobs**
- Doesn't include multiplier effect

Case Study: New Mexico

- 204-MW wind project built in 2003 in DeBaca and Quay counties for PNM
- 150 construction jobs
- 12 permanent jobs and $550,000/yr in salaries for operation and maintenance
- $550,000/year in lease payments to landowners
- **$450,000/year in payments in lieu of taxes to county and school districts**
- Over $40M in economic benefits for area over 25 years

Photo: PNM

Source: PNM, New Mexico Wind Energy Center Quick Facts, 2003.

Case Study: Hyde County, South Dakota

40-MW wind project in South Dakota creates $400,000 - $450,000/yr for Hyde County, including:

- More than $100,000/yr in annual lease payments to farmers ($3,000 - $4,000/turbine/yr)
- $250,000/yr in property taxes (25% of Highmore's education budget)
- 75 -100 construction jobs for 6 months
- 5 permanent O&M jobs
- Sales taxes up more than 40%
- Doesn't include multiplier effect

Case Study: Prowers County, Colorado

- 162-MW Colorado Green Wind Farm (108 turbines)
- $200M+ investment
- 400 construction workers
- 14-20 full-time jobs
- Land lease payments $3000-$6000 per turbine
- **Prowers County 2002 assessed value $94M; 2004 assessed value +33% (+$32M)**
- **Local district will receive 12 mil tax reduction**
- Piggyback model

"Converting the wind into a much-needed commodity while providing good jobs, the Colorado Green Wind Farm is a boost to our local economy and tax base."

John Stulp, county commissioner, Prowers County, Colorado

Colorado – Economic Impacts

from 1000 MW of new wind development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $2.7 million/year

Local Property Tax Revenue:
- $11 million/year

Construction Phase:
- 1405 new OH construction jobs
- $188.5 M to local economies

Operational Phase:
- 223 new long-term jobs
- $21.2 M/yr to local economies

Indirect & Induced Impacts

Construction Phase:
- 1225 new jobs
- $130.2 M to local economies

Operational Phase:
- 181 local jobs
- $20.1 M/yr to local economies

Totals (construction + 20yrs)

Total economic benefit = $1.14 billion

New local jobs during construction = 2630

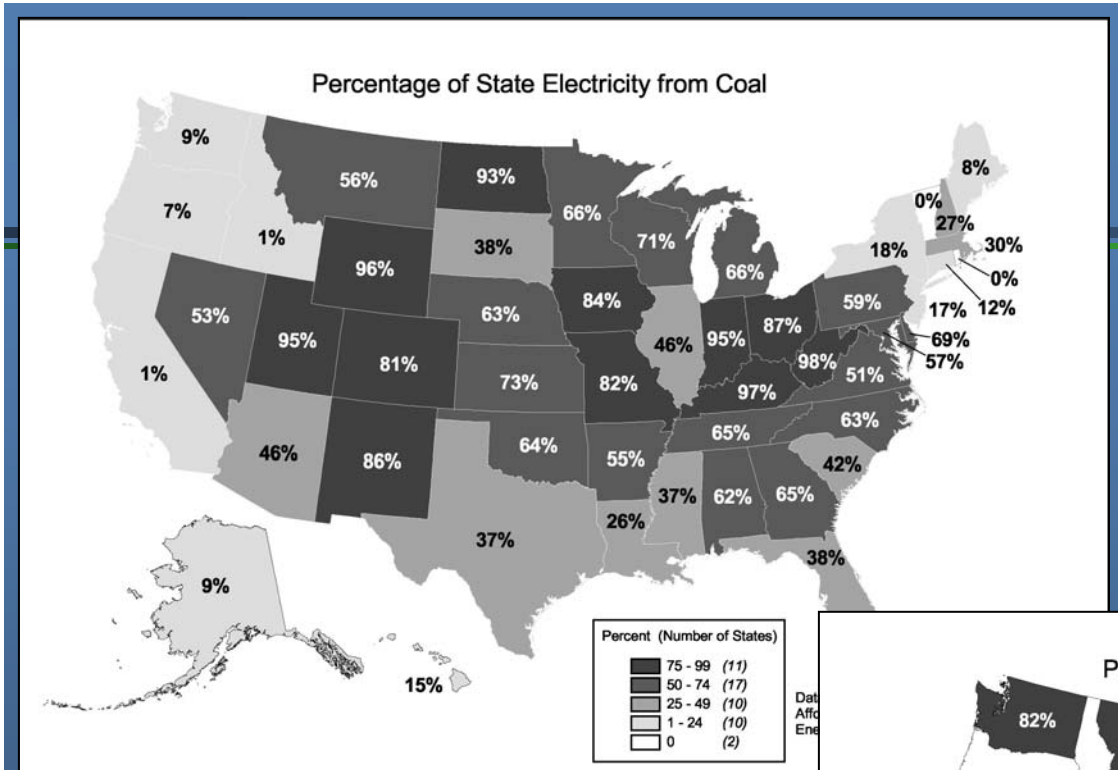
New local long-term jobs = 404

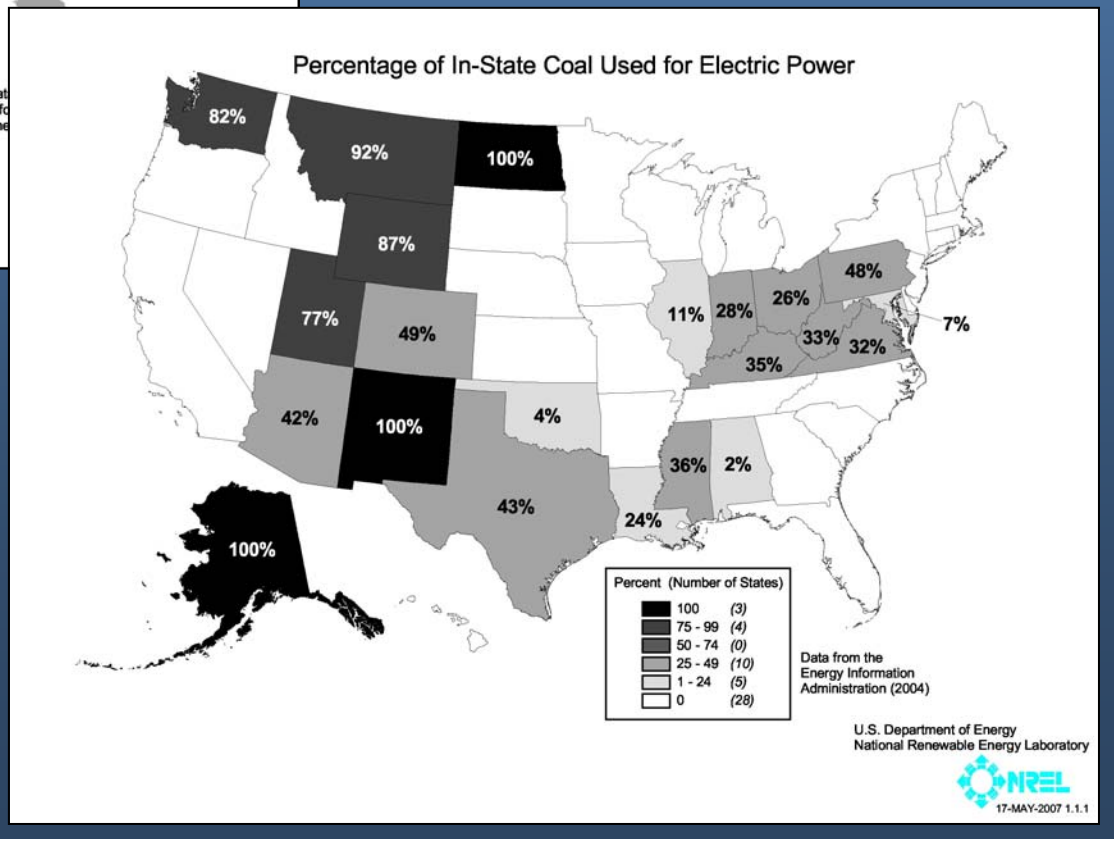
Construction Phase = 1-2 years
Operational Phase = 20+ years

Local Ownership Models

- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale

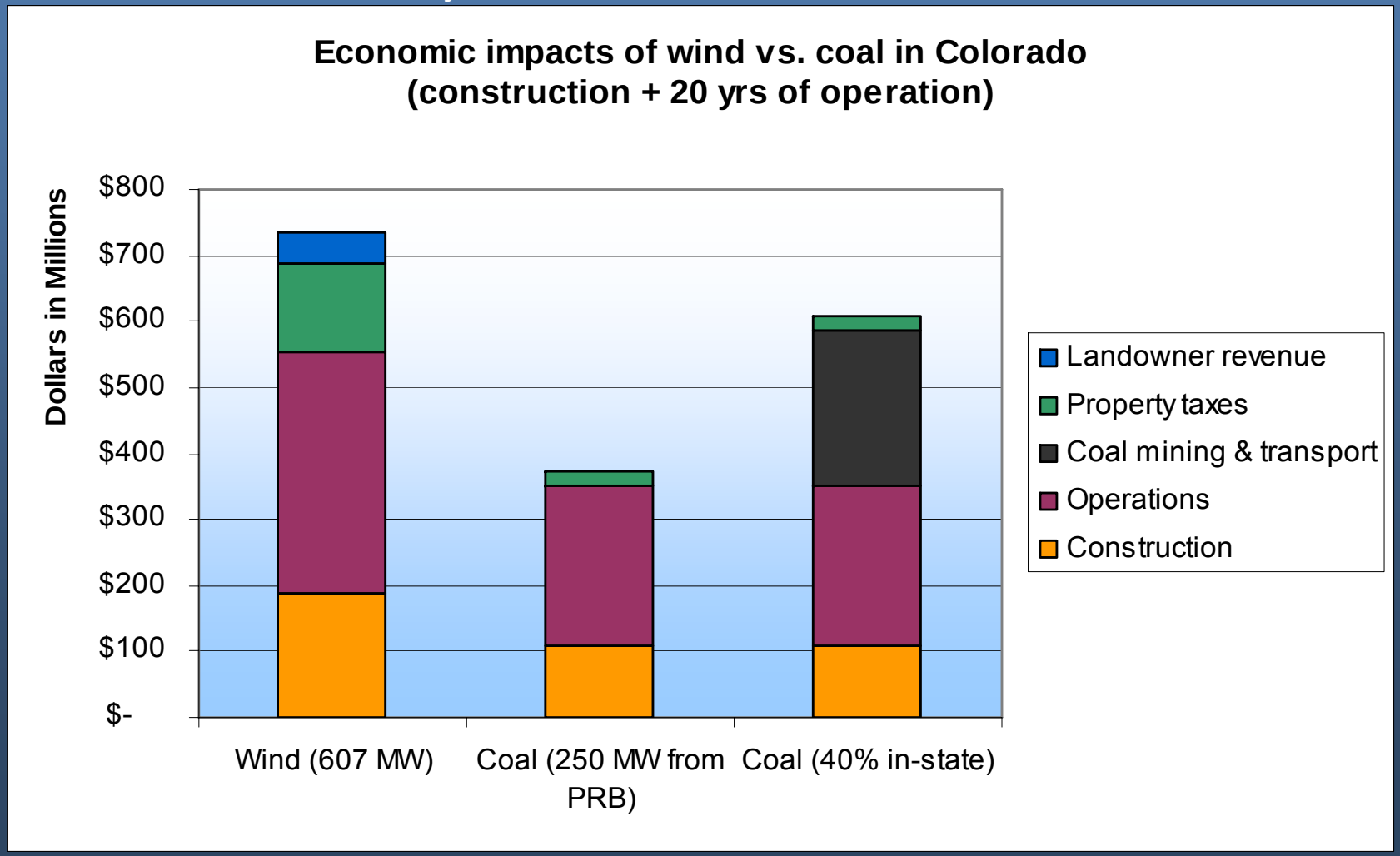
© L. Kennedy


Percentage of State Electricity from Coal
9%
56%
93%
66%
8%
7%
1%
38%
71%
0%
27%
30%
96%
66%
18%
0%
53%
84%
59%
17%
12%
95%
81%
63%
46%
95%
87%
69%
1%
73%
82%
98%
51%
57%
97%
46%
86%
64%
55%
65%
63%
42%
37%
62%
65%
26%
37%
38%
9%
15%
Percent (Number of States)
75 - 99 (11)
50 - 74 (17)
25 - 49 (10)
1 - 24 (10)
0 (2)


Percentage of In-State Coal Used for Electric Power
82%
92%
100%
87%
48%
77%
49%
11%
28%
26%
7%
33%
32%
35%
42%
100%
4%
36%
2%
43%
24%
100%
Percent (Number of States)
100 (3)
75 - 99 (4)
50 - 74 (0)
25 - 49 (10)
1 - 24 (5)
0 (28)
Data from the Energy Information Administration (2004)
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
17-MAY-2007 1.1.1

Economic Impacts of Alternative Generation

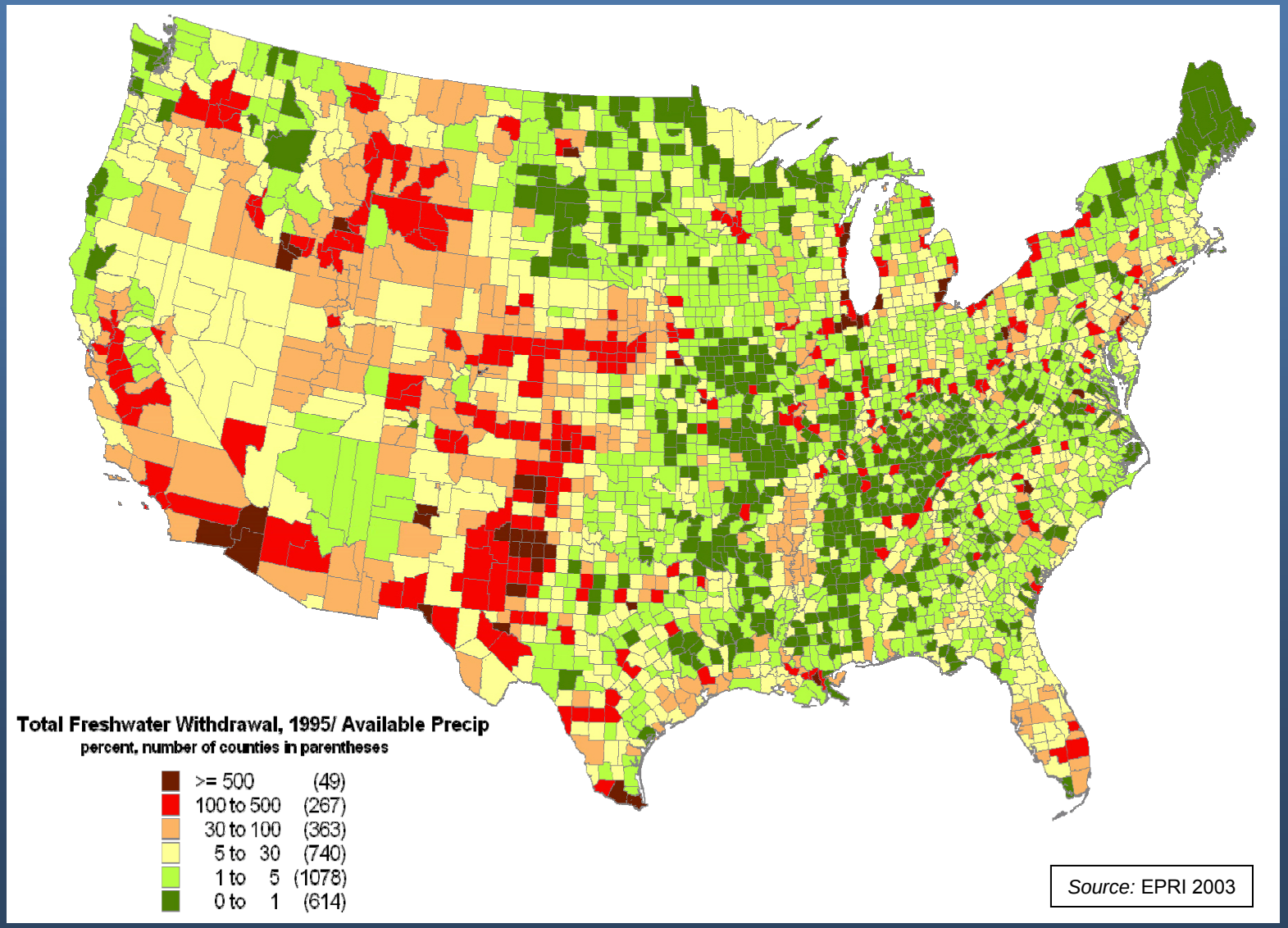
Colorado uses mostly out-of-state coal. But even with in-state coal…



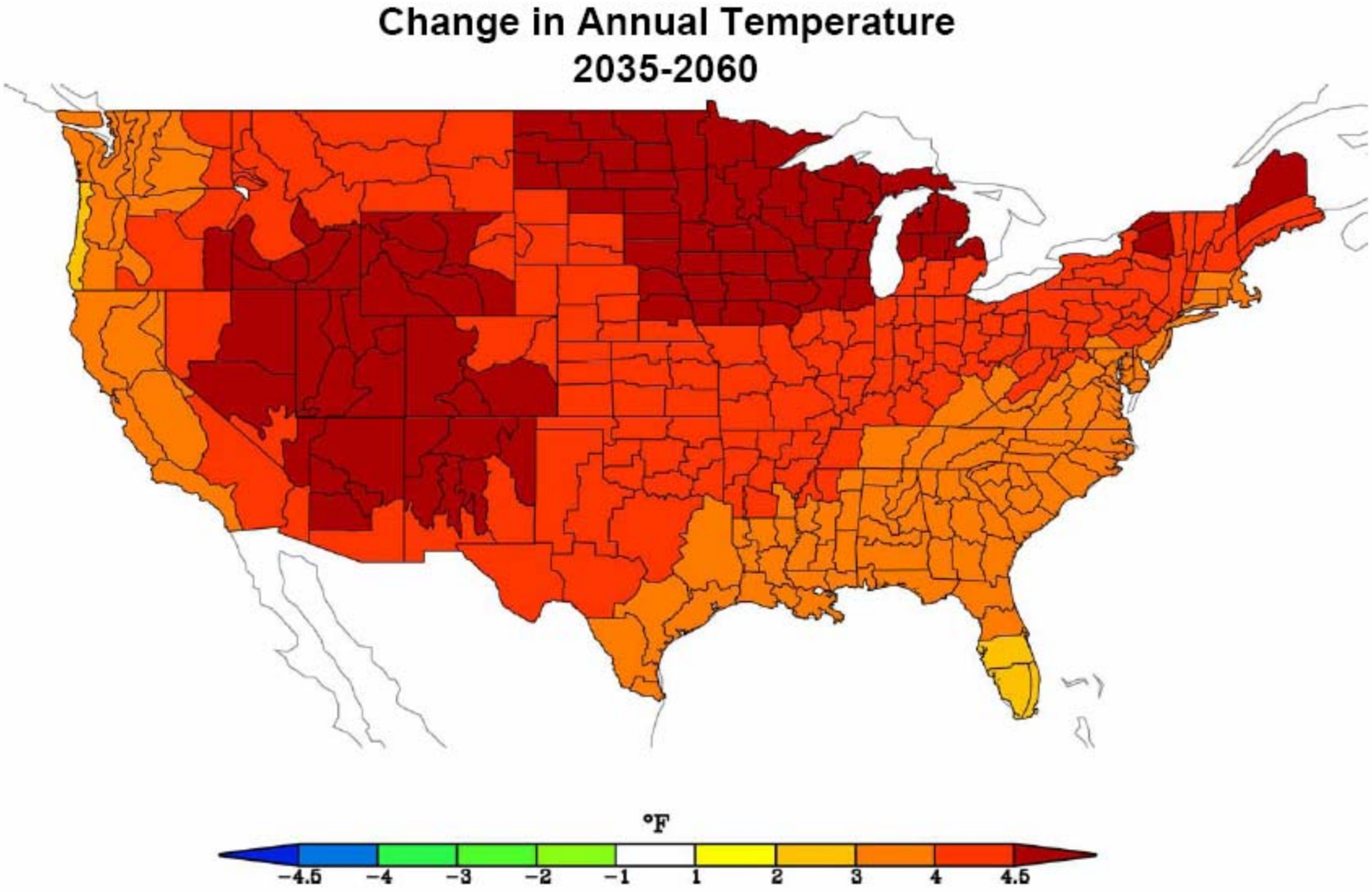
Environmental Benefits

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

Sustainable Withdrawal of Freshwater is National Issue

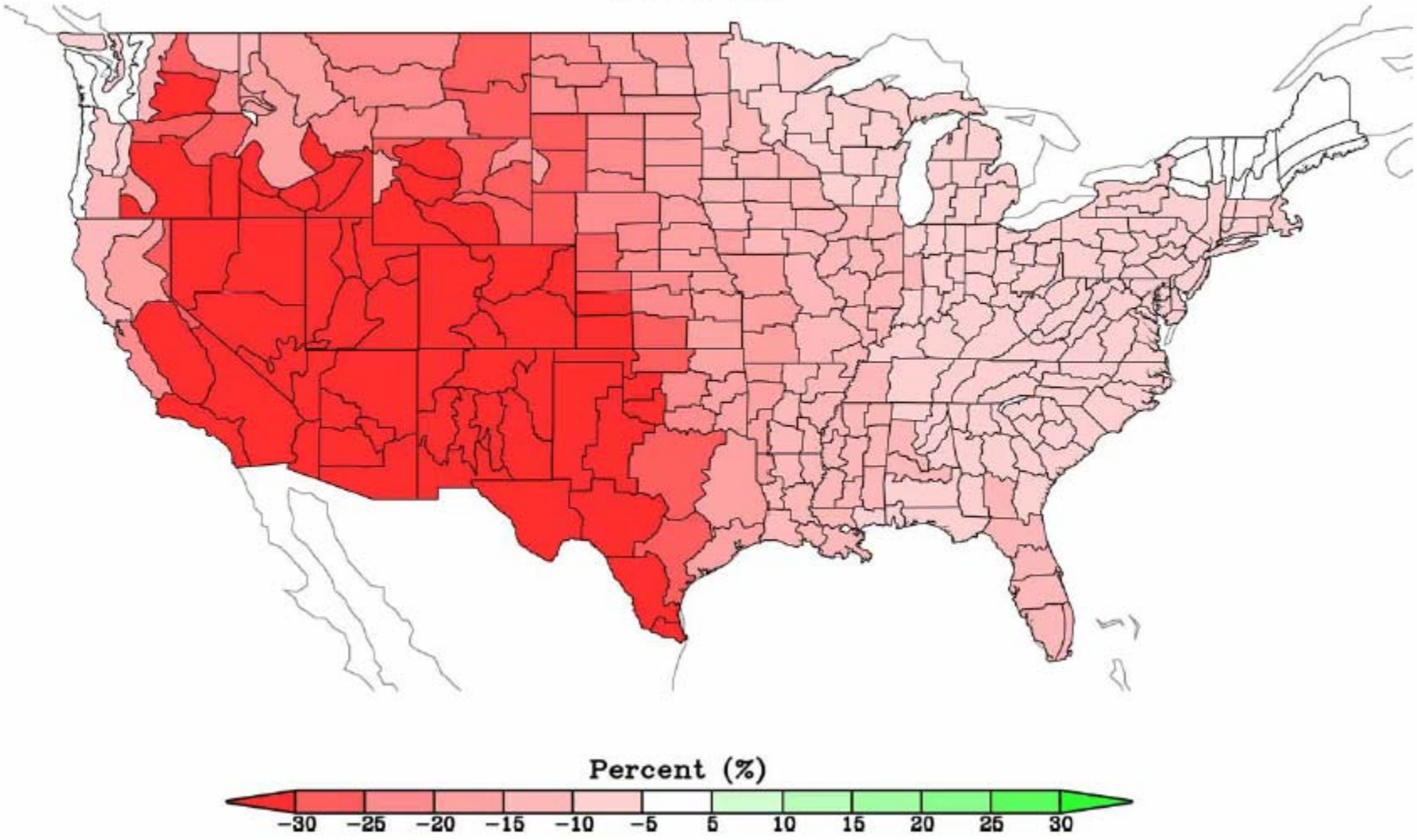


Source: EPRI 2003



Source: NOAA

Change in Annual (PCPN-Potential Evapotranspiration) 2035-2060



Source: NOAA

Energy-Water Nexus

Key Issues for Wind Power

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

A New Vision
For Wind Energy in the U.S.

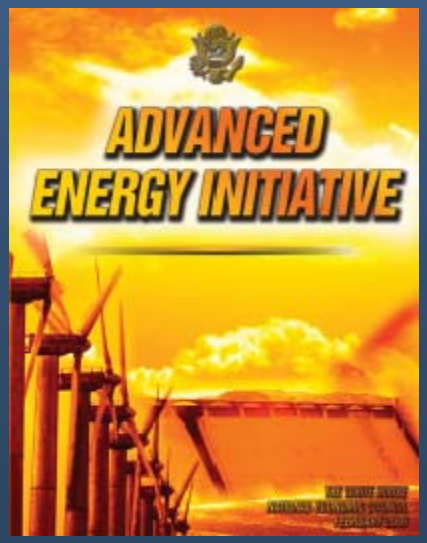

White House photo by Eric Draper

State of the Union Address

"…We will invest more in … **revolutionary** and…**wind technologies**"

Advanced Energy Initiative

"Areas with good wind resources have the potential to **supply up to 20% of the electricity** consumption of the United States."

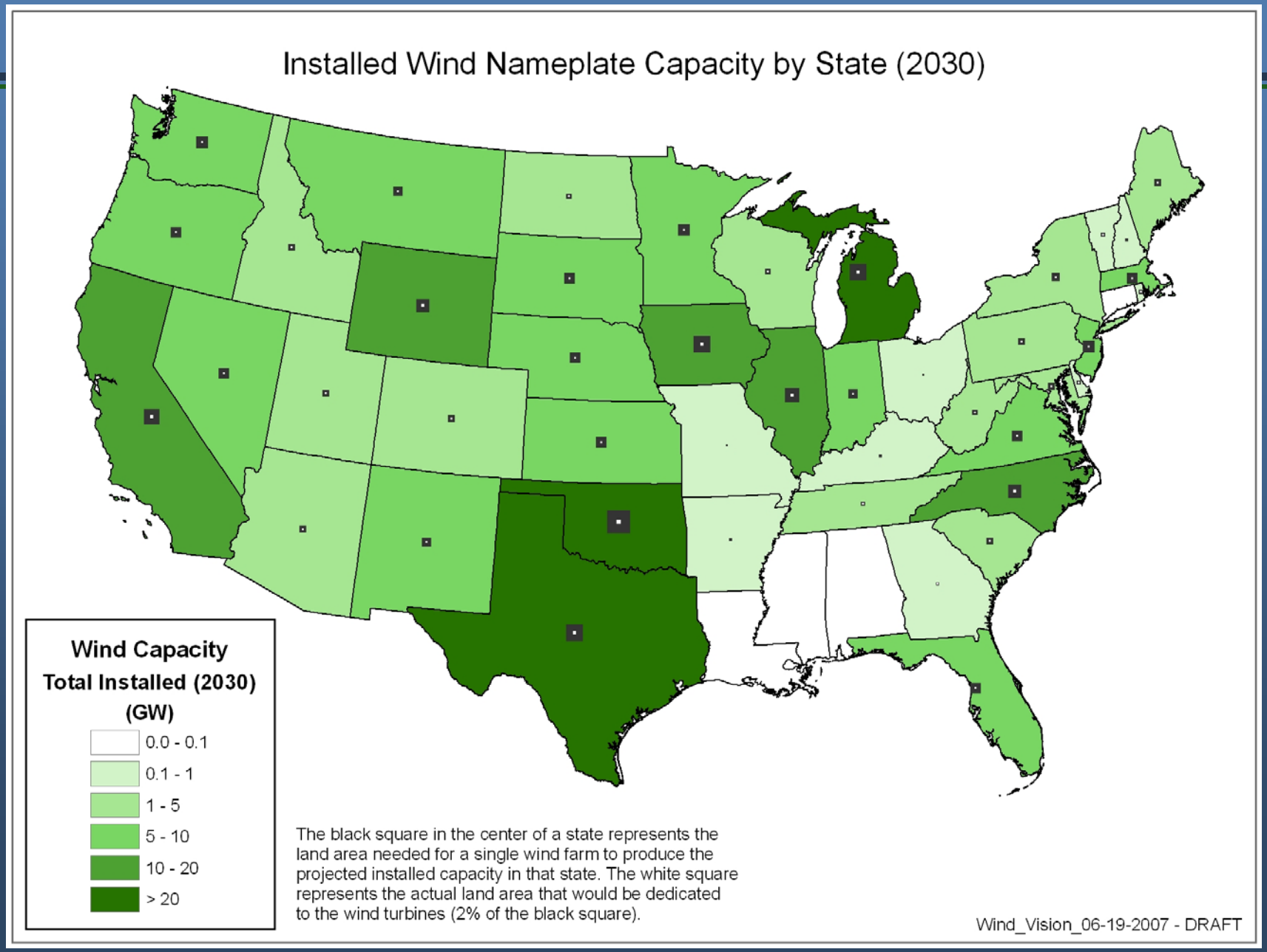


20% Wind-Electricity Vision

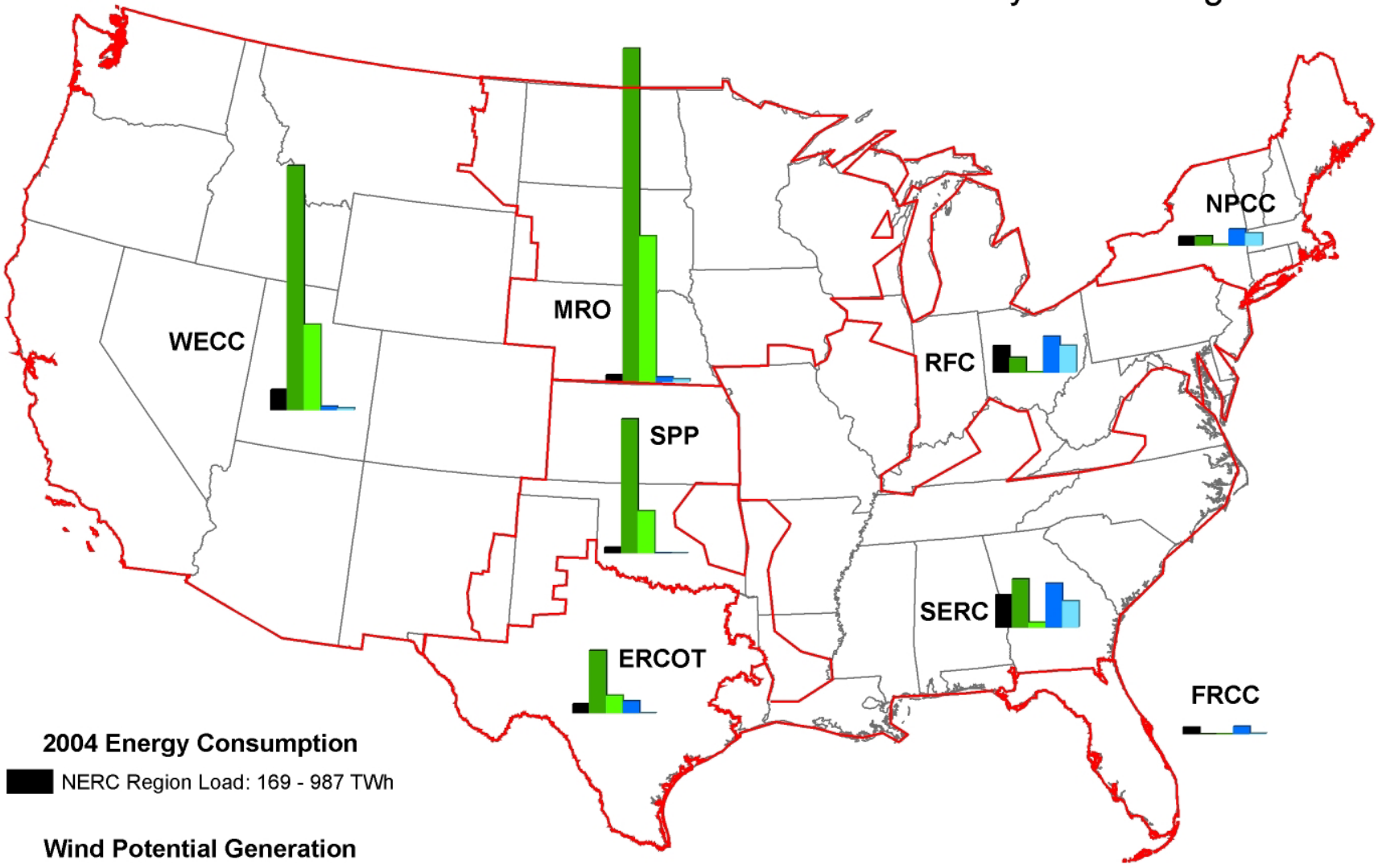
Wind energy will provide 20% of U.S. electricity needs by 2030, securing America's leadership in reliable, clean energy technology. As an inexhaustible and affordable domestic resource, wind strengthens our energy security, improves the quality of the air we breathe, slows climate change, and revitalizes rural communities.

awea

american wind energy association


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

Onshore and Offshore Wind Generation Potential by NERC Region



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

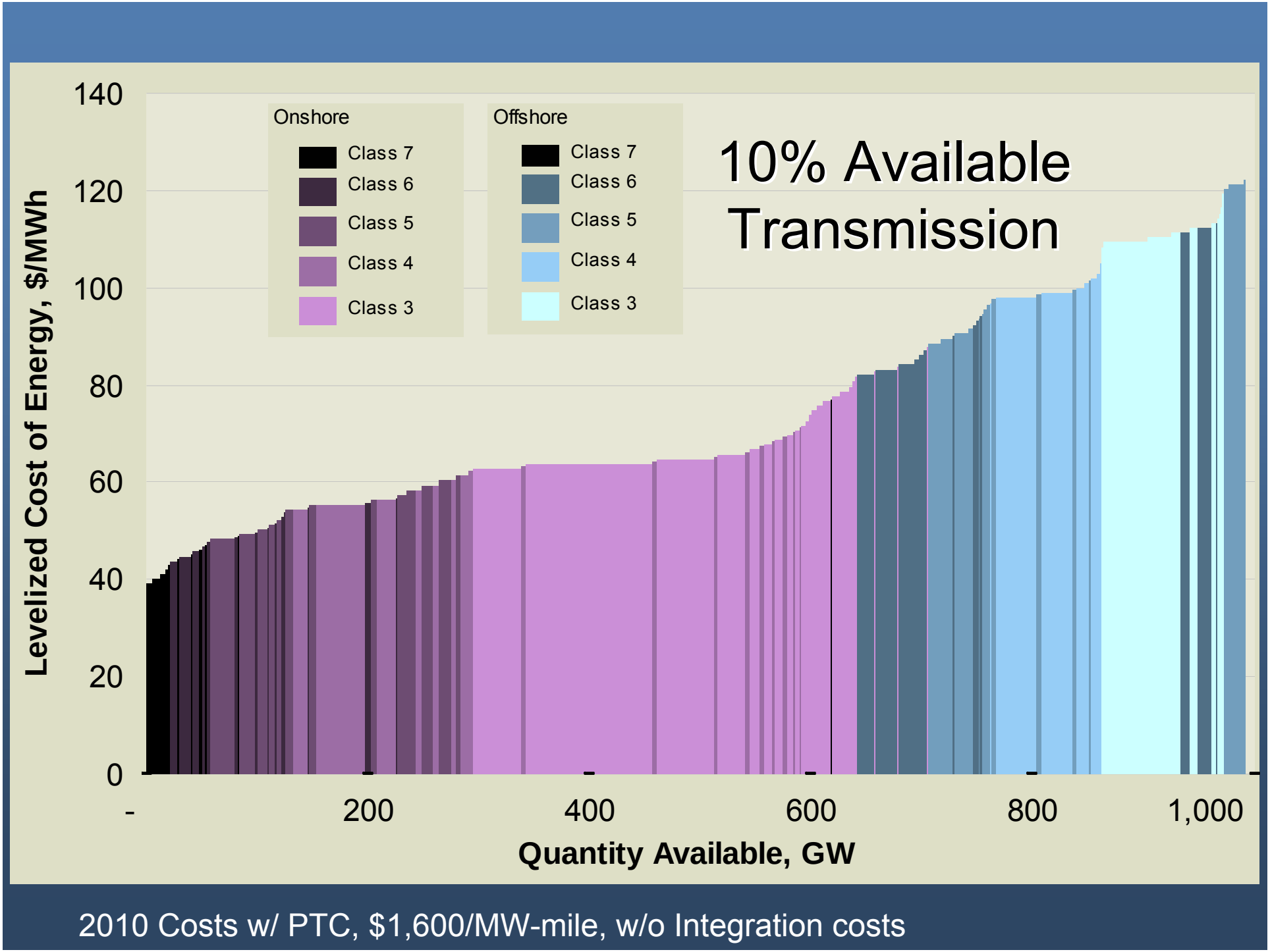
Offshore, Class 5 and greater: 0 - 803 TWh

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

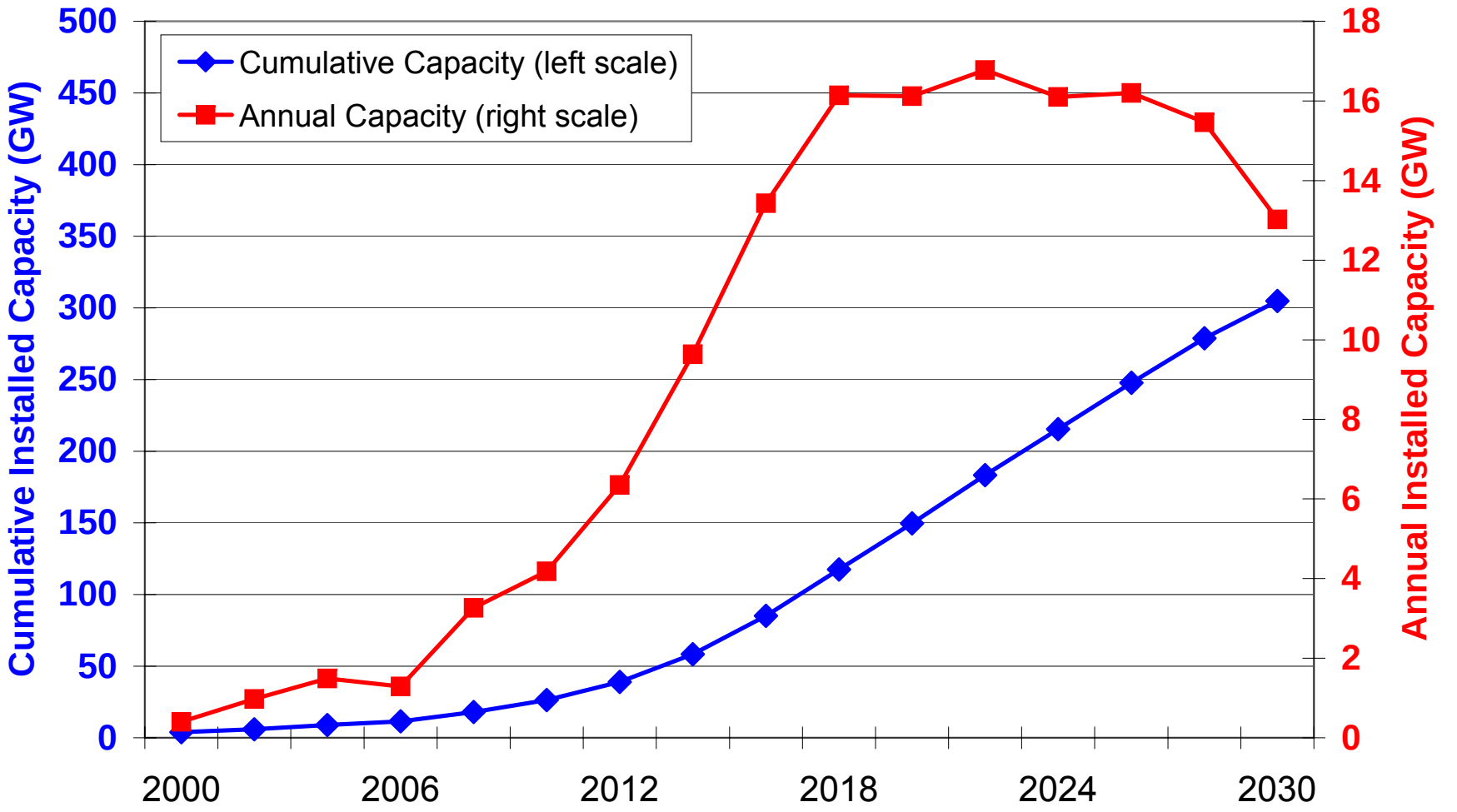
NREL

02-JUN-2006



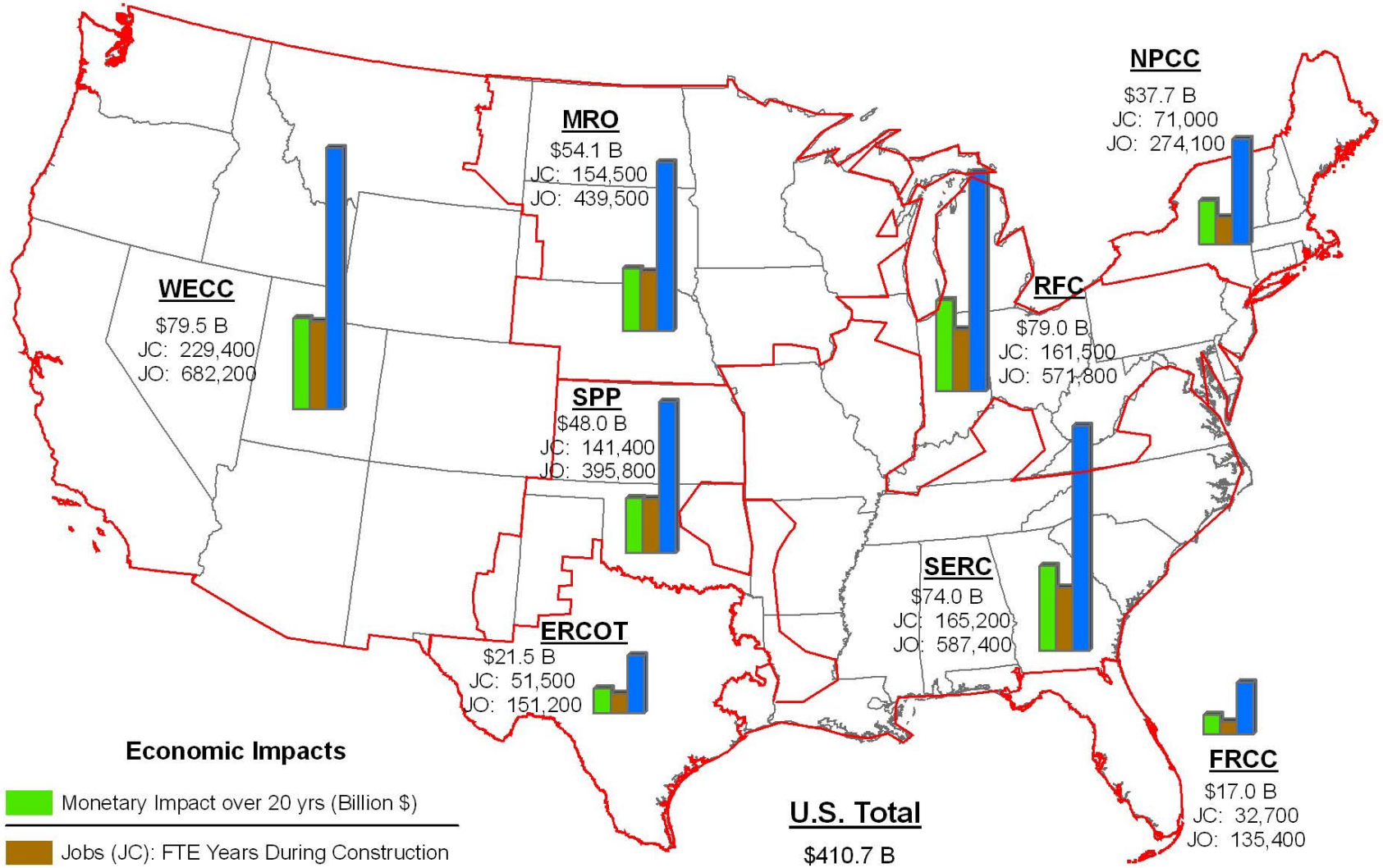
2010 Costs w/ PTC, $1,600/MW-mile, w/o Integration costs

What does 20% Wind look like?



Source: AWEA 20% Vision

20% Wind Electricity by 2030 - Economic Impacts by NERC Region



Economic Impacts

Monetary Impact over 20 yrs (Billion $)

Jobs (JC): FTE Years During Construction

Jobs (JO): FTE Years over 20 yrs Operation

Wind Vision case = 304 GW of wind capacity.
All job values rounded to the nearest 100.

U.S. Total

$410.7 B
JC: 1,007,200
JO: 3,237,400

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

Wind_Vision_06-19-2007 - DRAFT

Economic Impacts to Kansas

from 7158 MW of new wind development by 2030

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:
- $20.8 million/year

Local Property Tax Revenue:
- $19 million/year

Construction Phase:
- 11,133 new construction jobs
- $1.35B to local economies

Operational Phase:
- 1805 new long-term jobs
- $152M/yr to local economies

Indirect Impacts

Construction Phase:
- 5,000 new jobs
- $424M to local economies

Operational Phase:
- 438 local jobs
- $43 M/yr to local economies

Induced Impacts

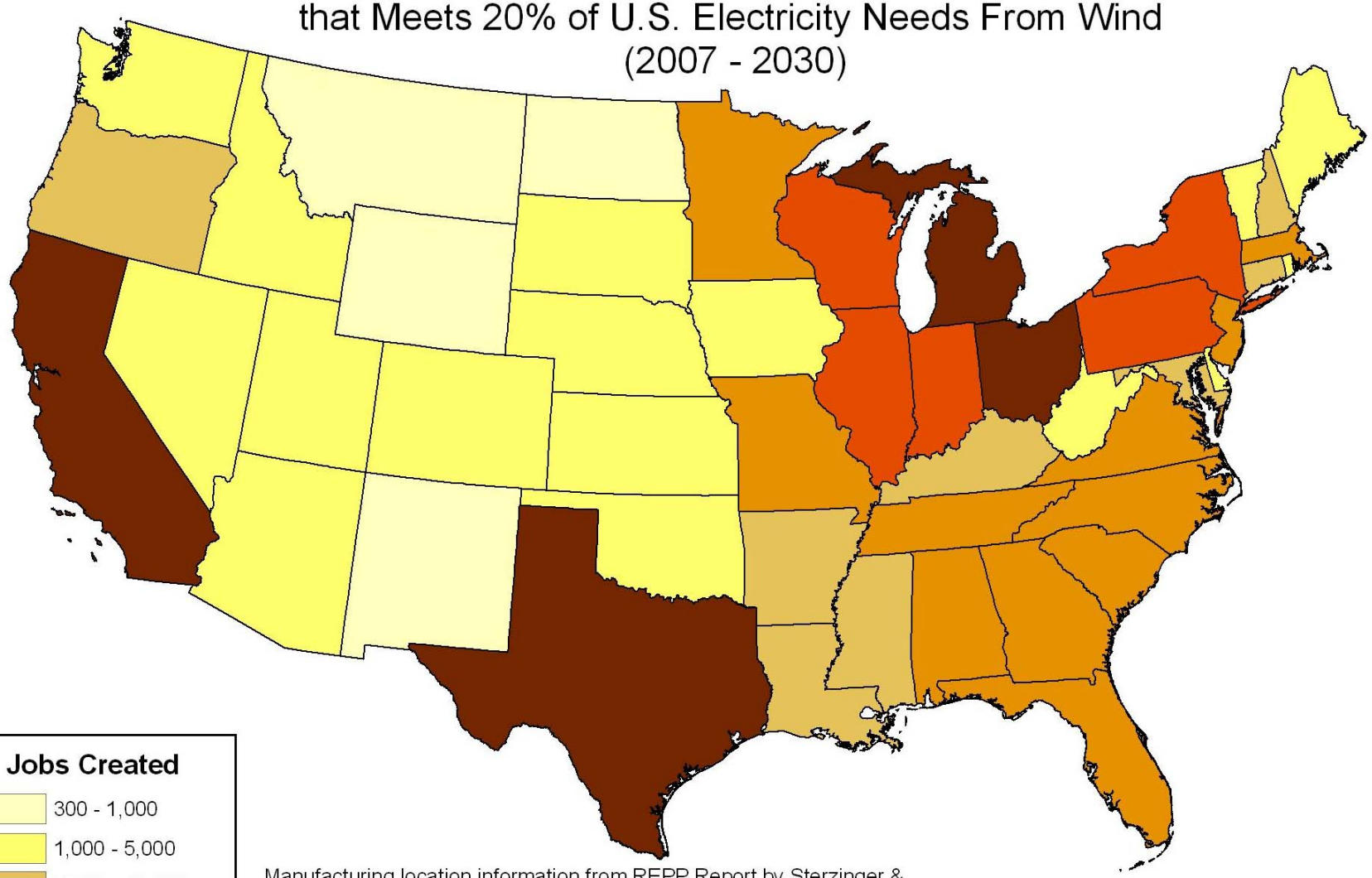
Construction Phase:
- 6,223 new jobs
- $559 M to local economies

Operational Phase:
- 850 local jobs
- $76 M/yr to local economies

Totals (construction + 20 yrs)
Total economic benefit to Kansas = $7.8 billion
New local jobs during construction = over 23,000
New long-term jobs for Kansans = over 3,000

Construction Phase = 1-2 years
Operational Phase = 20+ years

Total Cumulative Manufacturing Jobs Created by Scenario that Meets 20% of U.S. Electricity Needs From Wind (2007 - 2030)

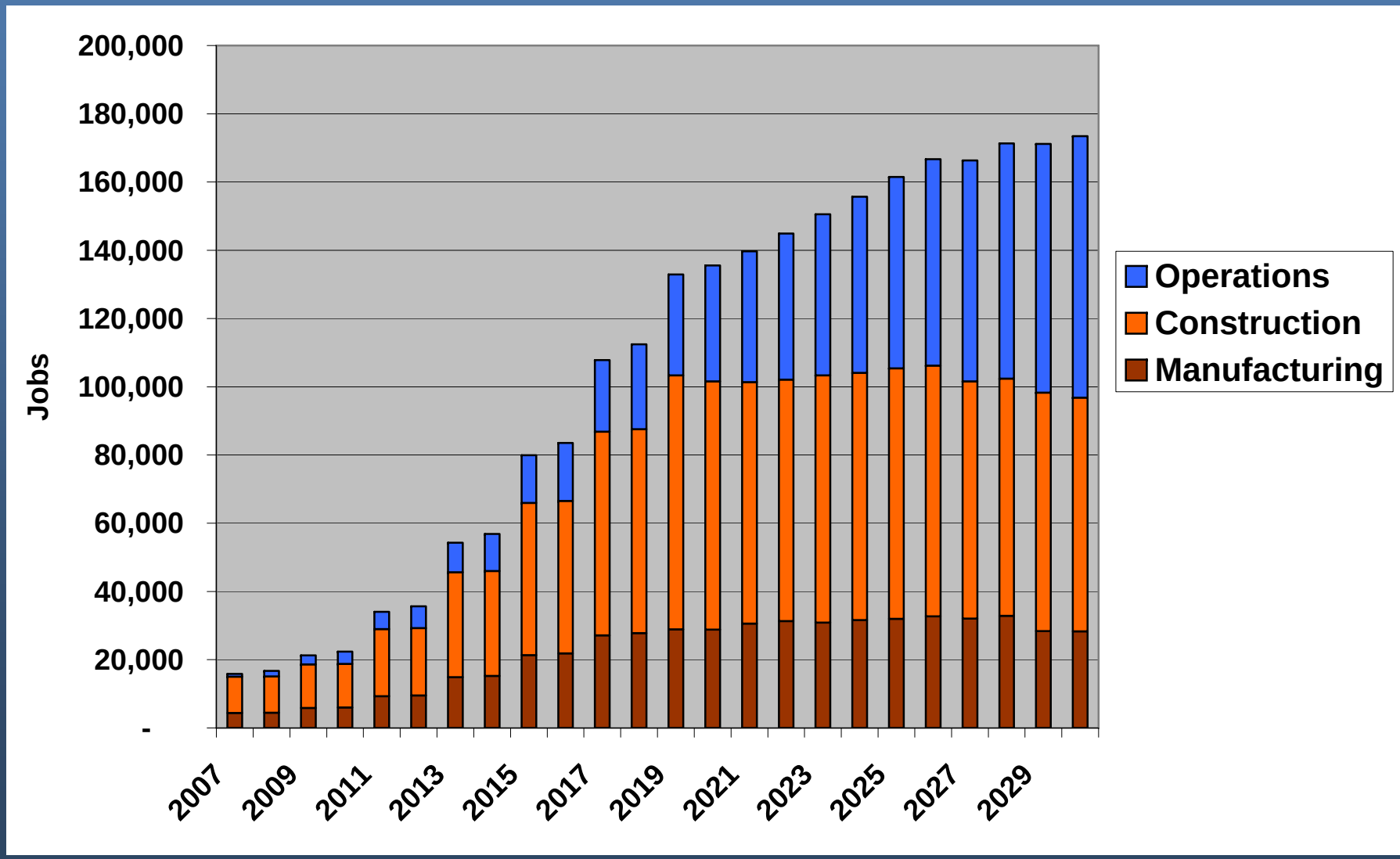


Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

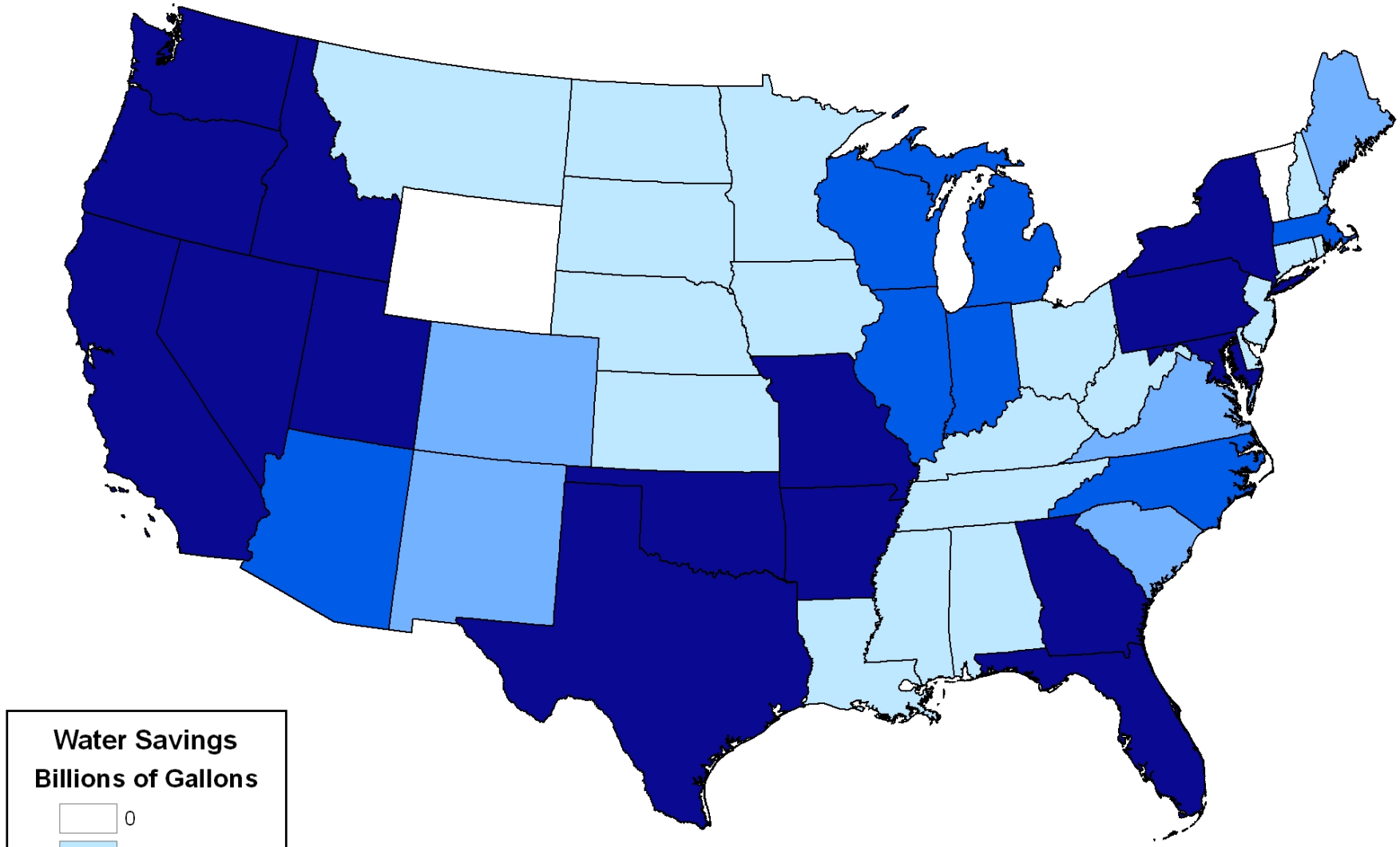
Major component assumptions: 50% of blades are manufactured in U.S. in 2004 increasing to 80% in 2030, 26% of towers are from the U.S. in 2004 increasing to 50% in 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.

Wind_Vision_Jobs_06-19-2007 - DRAFT

20% Wind Vision Employment

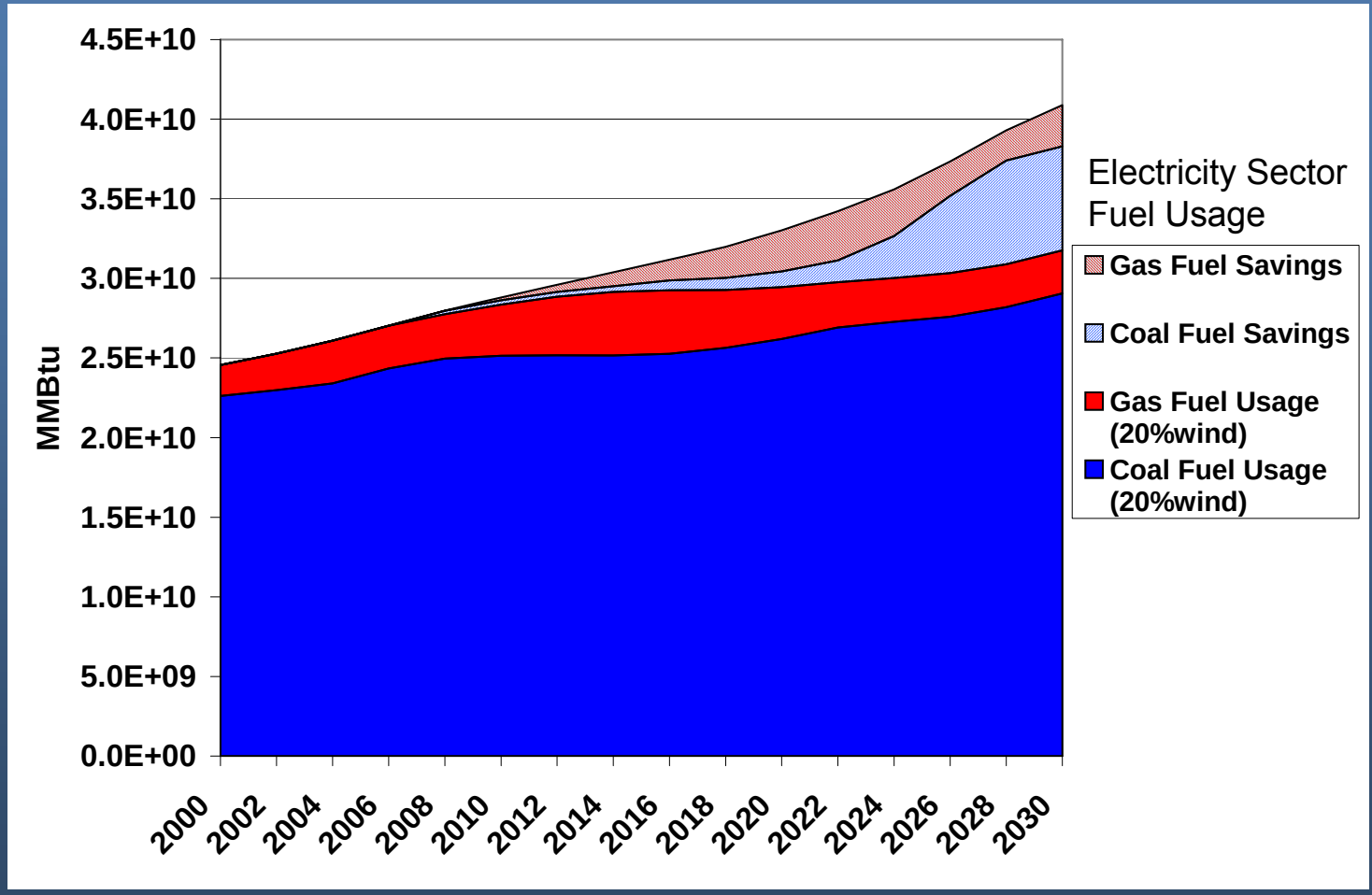


Cumulative Water Savings Due to Deployment of Wind Energy (2008 - 2030)



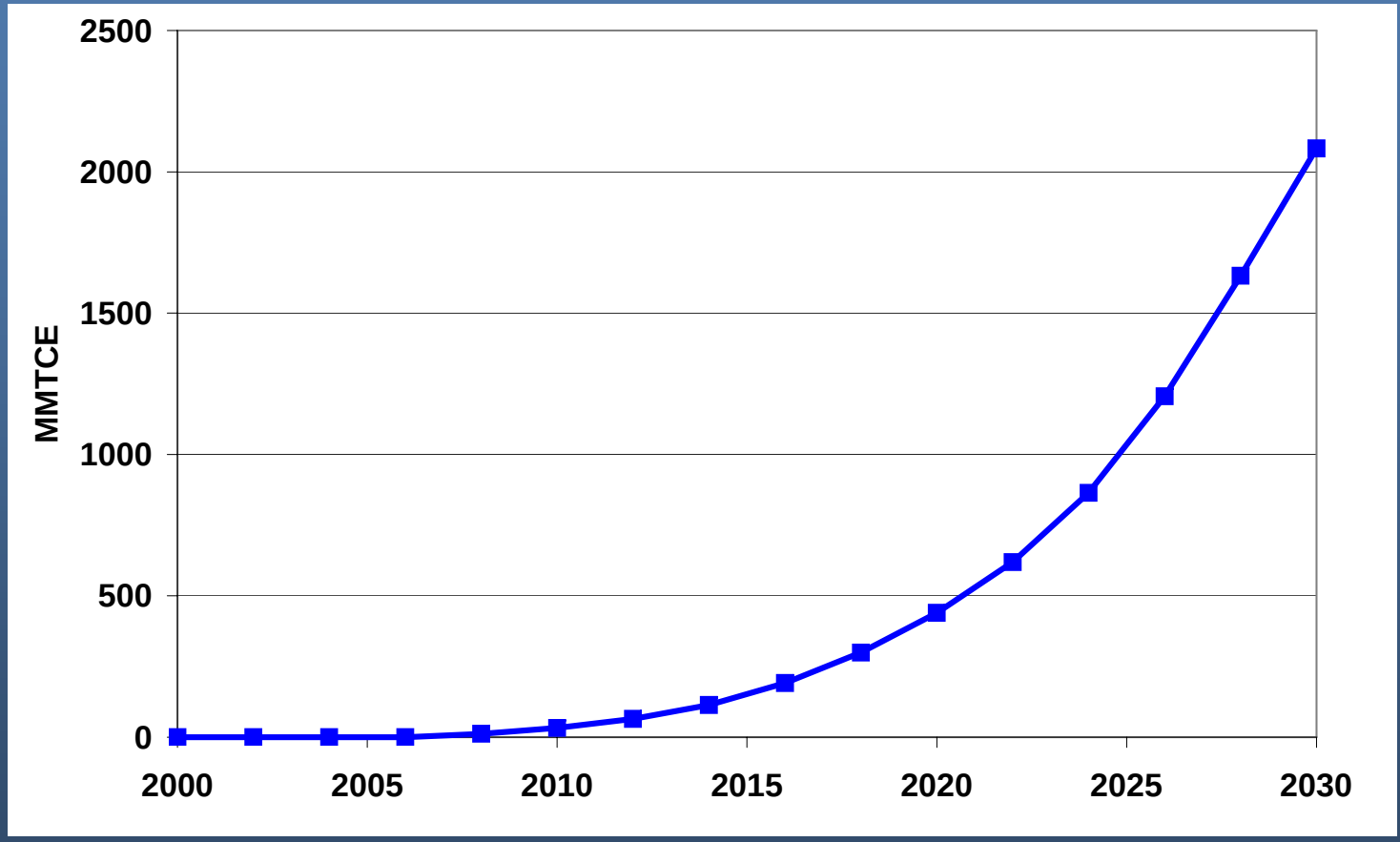
Wind_Vision_Water_06-19-2007 - DRAFT

Fuel Savings From Wind



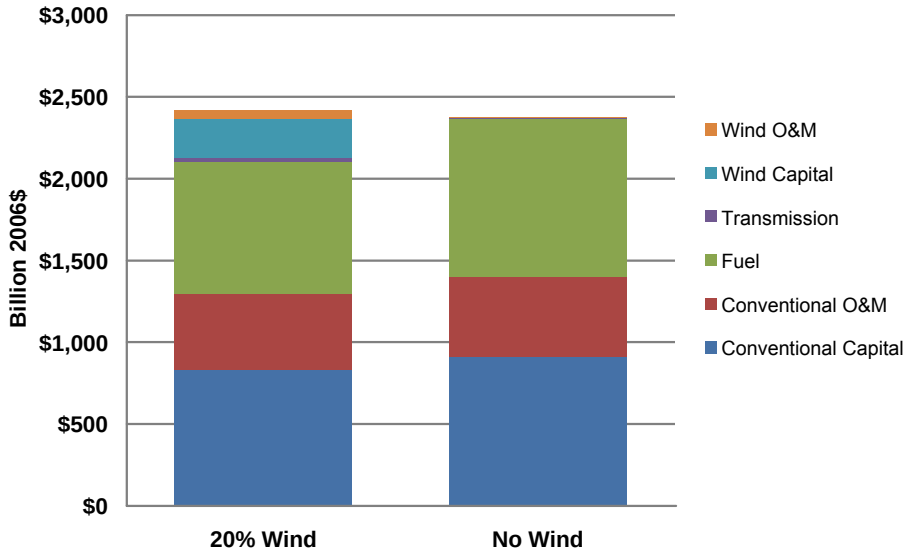
Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006$/MMBtu)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh)
11%	0.6 -**1.1**- 1.5	86 - **150** - 214	16.6 - **29** - 41.6

Cumulative Carbon Savings



Cumulative Carbon Savings (2007-2050, MMTCE)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh-wind)
4,182 MMTCE	$ 50 - $145	$ 9.7/MWh - $ 28.2/MWh

Incremental Cost of 20% Wind Vision



	Present Value Direct Costs (billion 2006$)*	Average Incremental Levelized Cost of Wind ($/MWh-Wind)*	Average Incremental Levelized Rate Impact ($/MWh-Total)*	Impact on Average Household Customer ($/month)**
Vision Scenario	$43 billion	$8.6/MWh	$0.6/MWh	$0.5/month

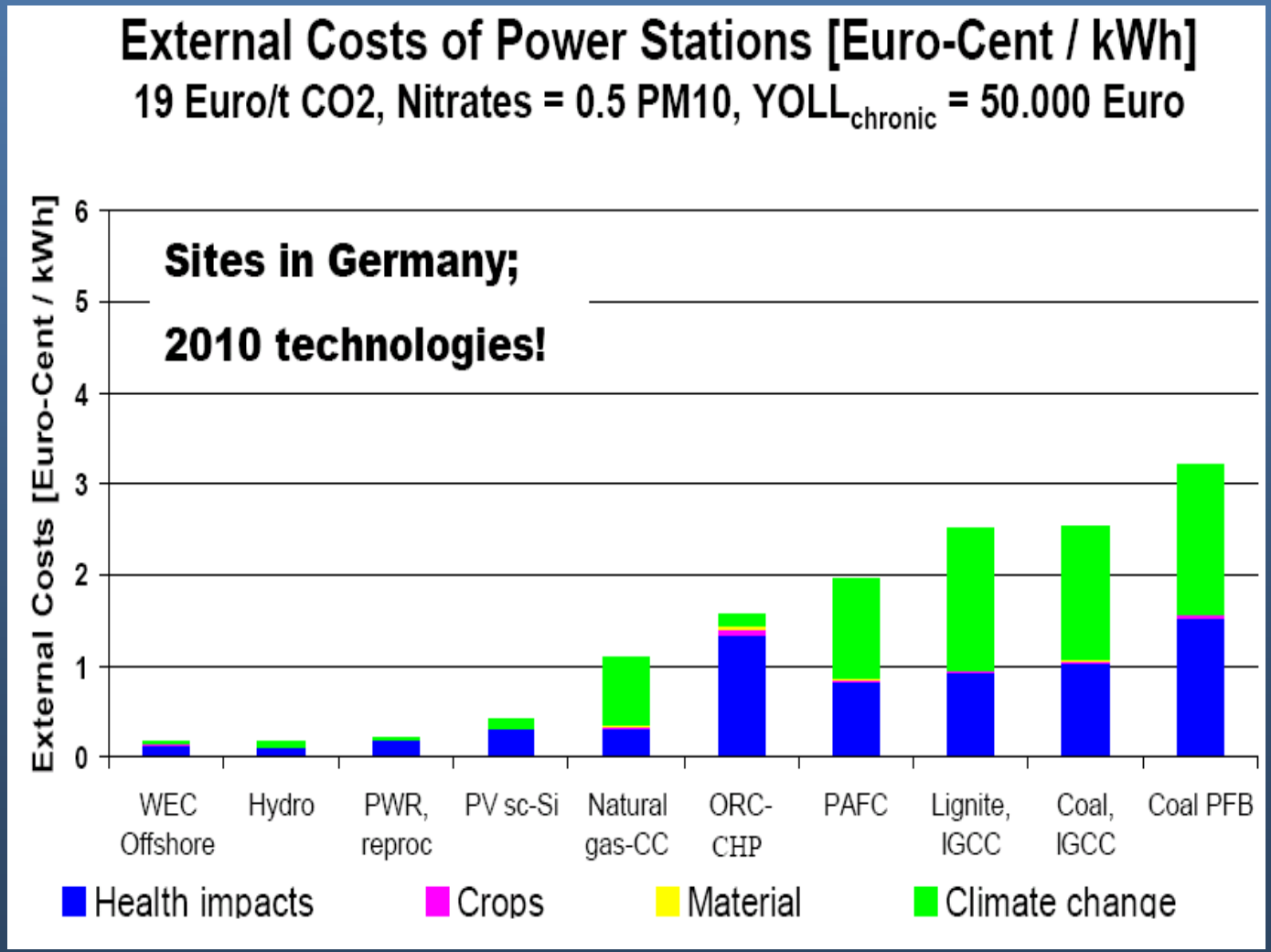
* 7% real discount rate is used, as per OMB guidance; the time period of analysis is 2007-2050, withWinDS modeling used through 2030, and extrapolations used for 2030-2050.
** Assumes 11,000 kWh/year average consumption

Results: Costs and Benefits

• Incremental direct cost to society	**$43 billion**
• Reductions in emissions of greenhouse gases and other atmospheric pollutants	825 M tons (2030) **$98 billion**
• Reductions in water consumption	8% total electric 17% in 2030
• Jobs created and other economic benefits	140,000 direct $450 billion total
• Reductions in natural gas use and price pressure	11% **$150 billion**

Major Market Distortion: External Costs of Fossil Fuels not Reflected in Pricing

(The PTCs are a bargain)



"With public sentiment nothing can fail; without it, nothing can succeed."

- A. Lincoln

Conclusions

- 20% wind energy penetration is possible
- 20% penetration is not going to happen under business as usual scenario
- Policy choices will have a large impact on assessing the timing and rate of achieving a 20% goal
- Key Issues: market transformation, transmission, project diversity, technology development, policy, public acceptance
- 20% Vision action plan: December 2007

Source: AWEA 20% Vision

Humanity's Top Ten Problems for next 50 years

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population

2003: 6.3 Billion people

2050: 9-10 Billion people

Source: Nobel laureate, Richard Smalley

Carpe Ventem











www.windpoweringamerica.gov