Wind Energy Update

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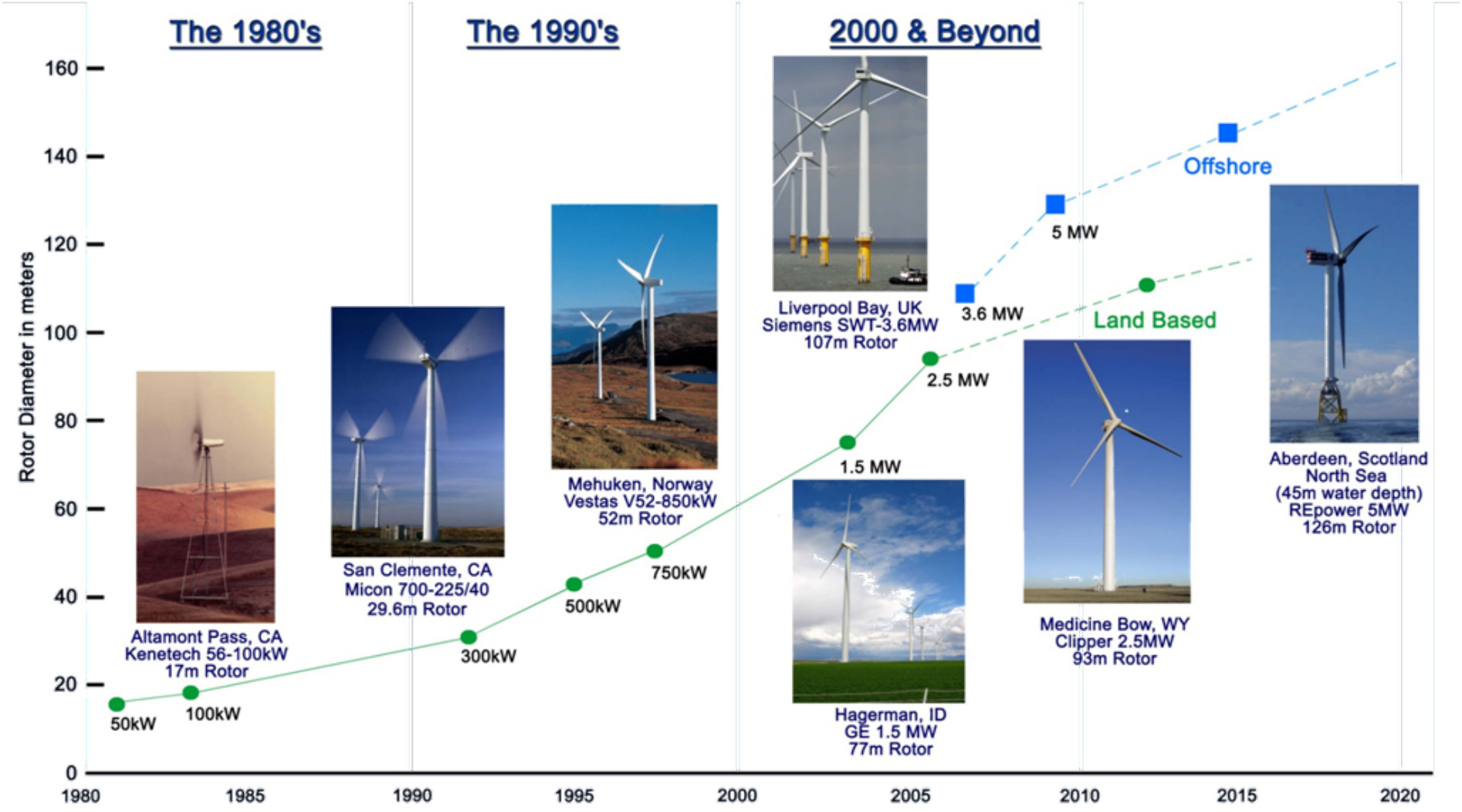
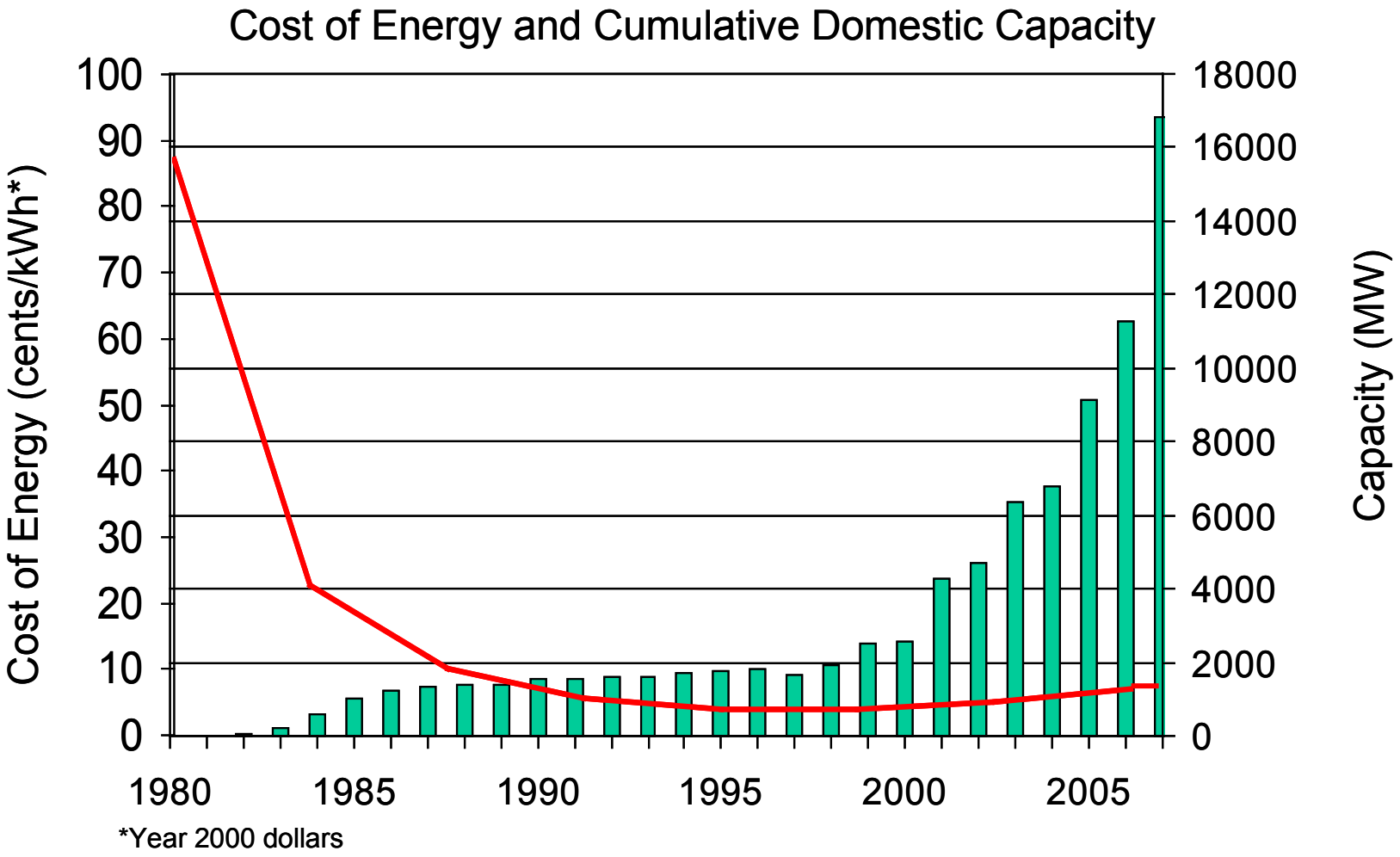
National Renewable Energy Laboratory

November 2010

Evolution of Commercial Wind Technology



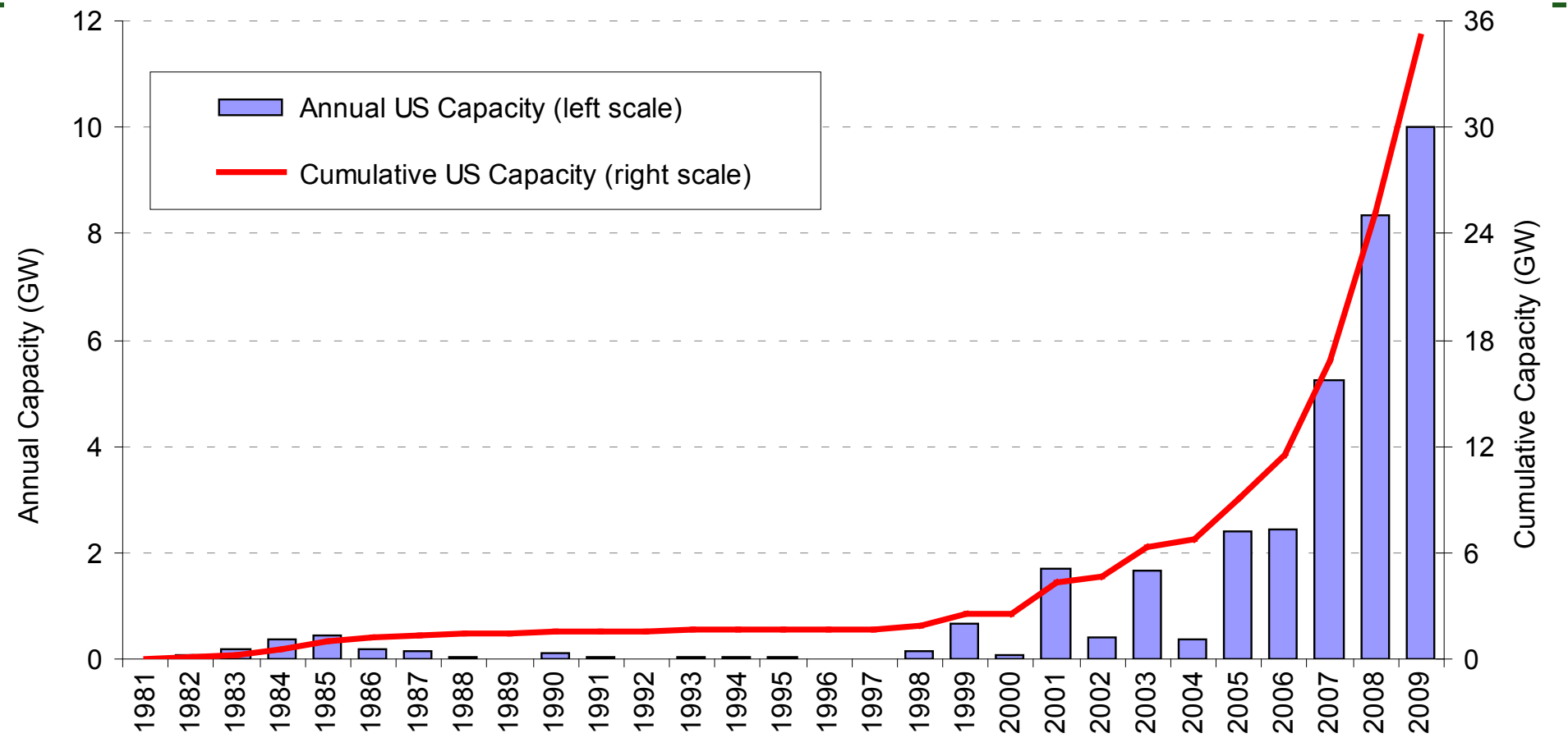
Capacity & Cost Trends



Increased Turbine Size - R&D Advances - Manufacturing Improvements

Five Years of Strong Growth:

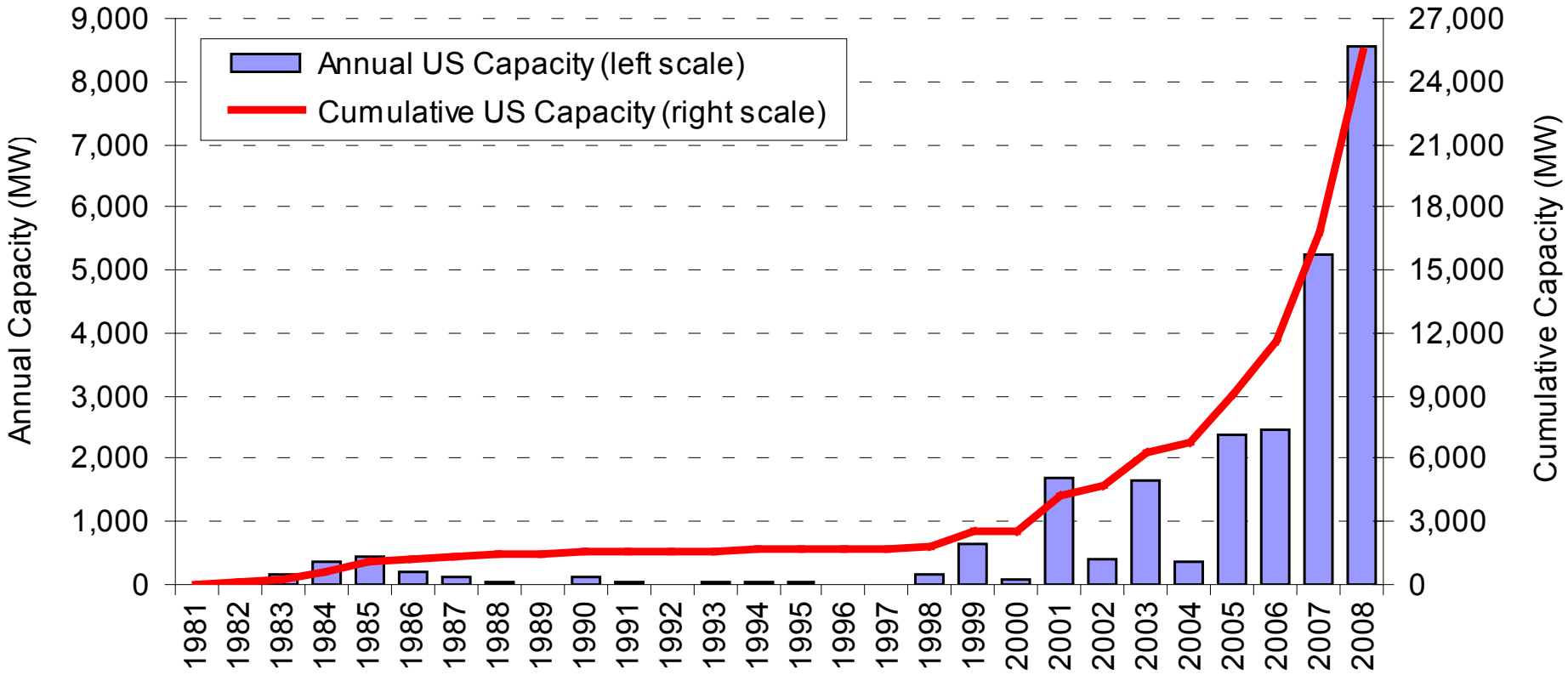
2009: 9,994 MW Added; $21 billion Investment



2nd largest market (behind China) in 2009 capacity additions; largest market in terms of cumulative capacity

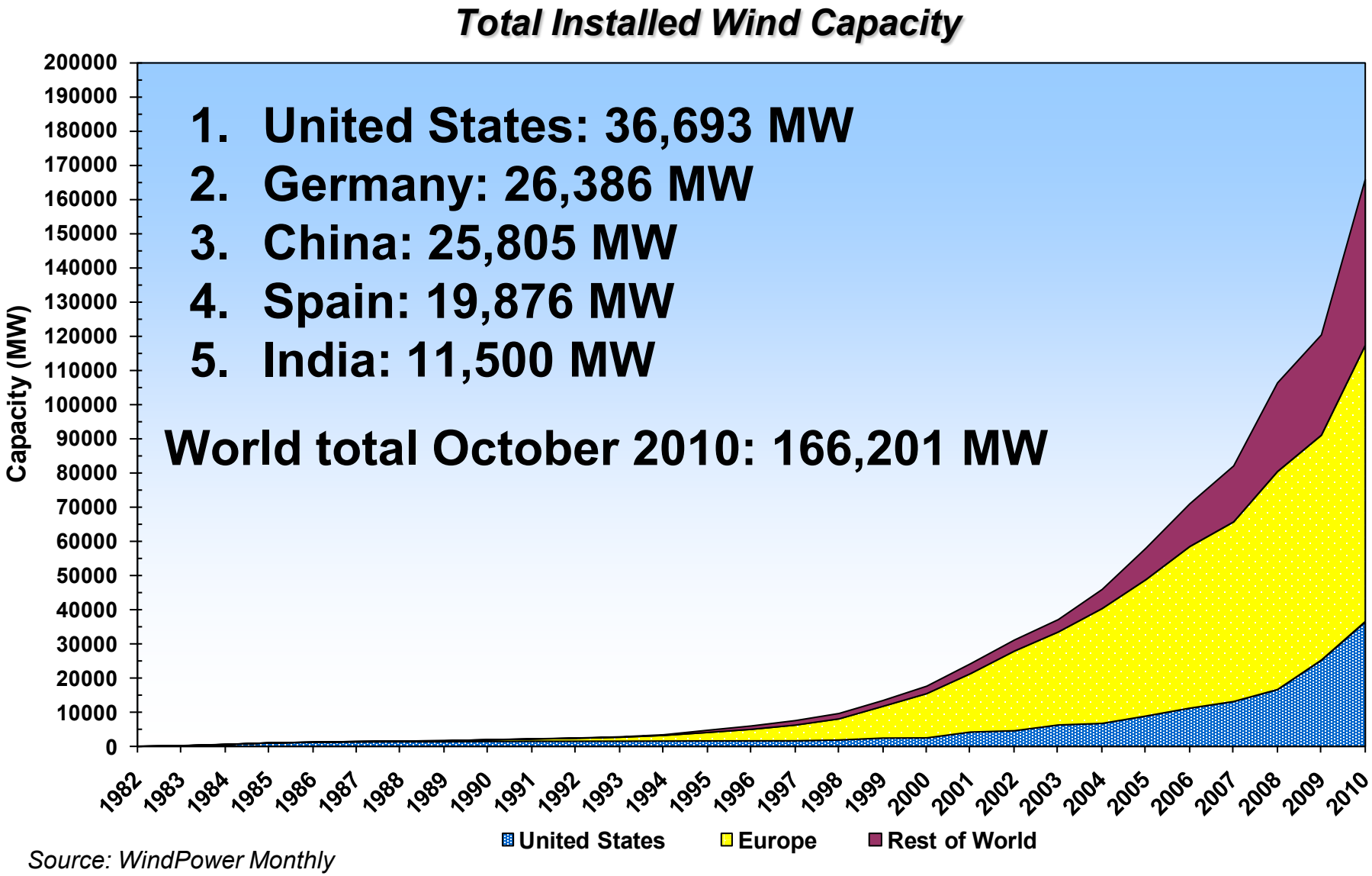
Four Years of Strong Growth:

2008: 8,558 MW Added; $16 billion Investment



2008 Wind Market Report; LBL

People Want Renewable Energy!



Source: WindPower Monthly

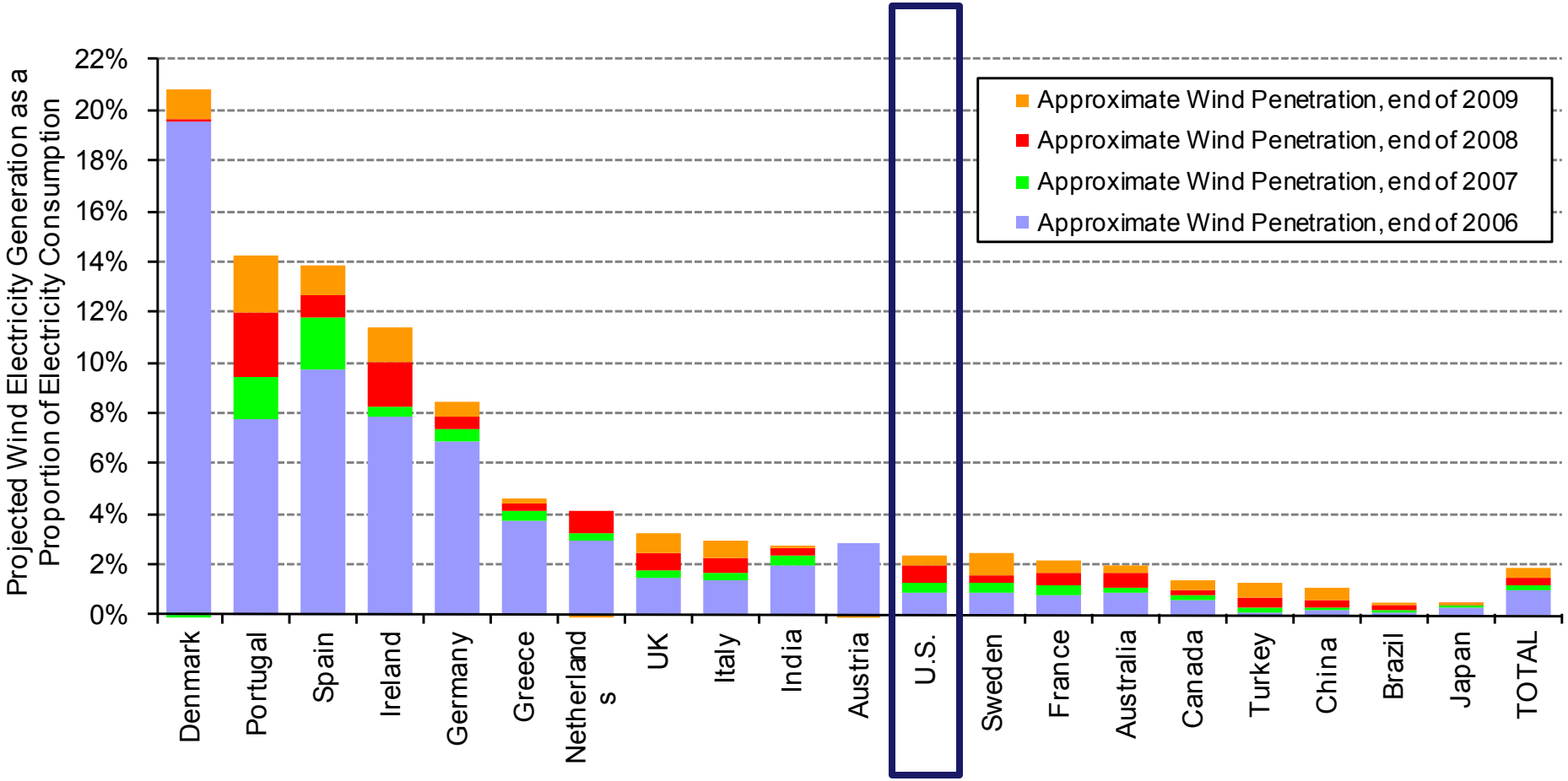
Four States Have Achieved > 10% Wind; Texas Continues to Lead in Capacity

Annual Capacity (2009, MW)		Cumulative Capacity (end of 2009, MW)		Estimated Percentage of In-State Generation	
Texas	2,292	Texas	9,410	Iowa	18.8%
Indiana	905	Iowa	3,670	South Dakota	13.6%
Iowa	879	California	2,798	North Dakota	11.5%
Oregon	754	Washington	1,908	Minnesota	10.0%
Illinois	632	Oregon	1,821	Oregon	8.7%
New York	568	Minnesota	1,810	Kansas	7.2%
Washington	542	Illinois	1,547	Colorado	7.0%
North Dakota	488	New York	1,274	Wyoming	6.9%
Wyoming	425	Colorado	1,246	Texas	6.3%
Pennsylvania	388	North Dakota	1,203	Oklahoma	5.0%
Oklahoma	299	Oklahoma	1,130	Montana	4.8%
California	281	Wyoming	1,101	Washington	4.5%
Utah	204	Indiana	1,036	New Mexico	4.4%
Kansas	199	Kansas	1,014	California	3.1%
Colorado	178	Pennsylvania	748	Maine	3.1%
Missouri	146	New Mexico	597	Idaho	2.9%
Maine	128	Wisconsin	449	Indiana	2.7%
South Dakota	126	Montana	375	Hawaii	2.2%
Montana	104	West Virginia	330	Illinois	2.1%
New Mexico	100	South Dakota	313	New York	2.0%
Rest of U.S.	358	*Rest of U.S.*	1,376	*Rest of U.S.*	0.25%
TOTAL	**9,994**	**TOTAL**	**35,155**	**TOTAL**	**2.4%**

Source: AWEA project database, EIA, Berkeley Lab estimates

2009 Wind Market Report, LBNL

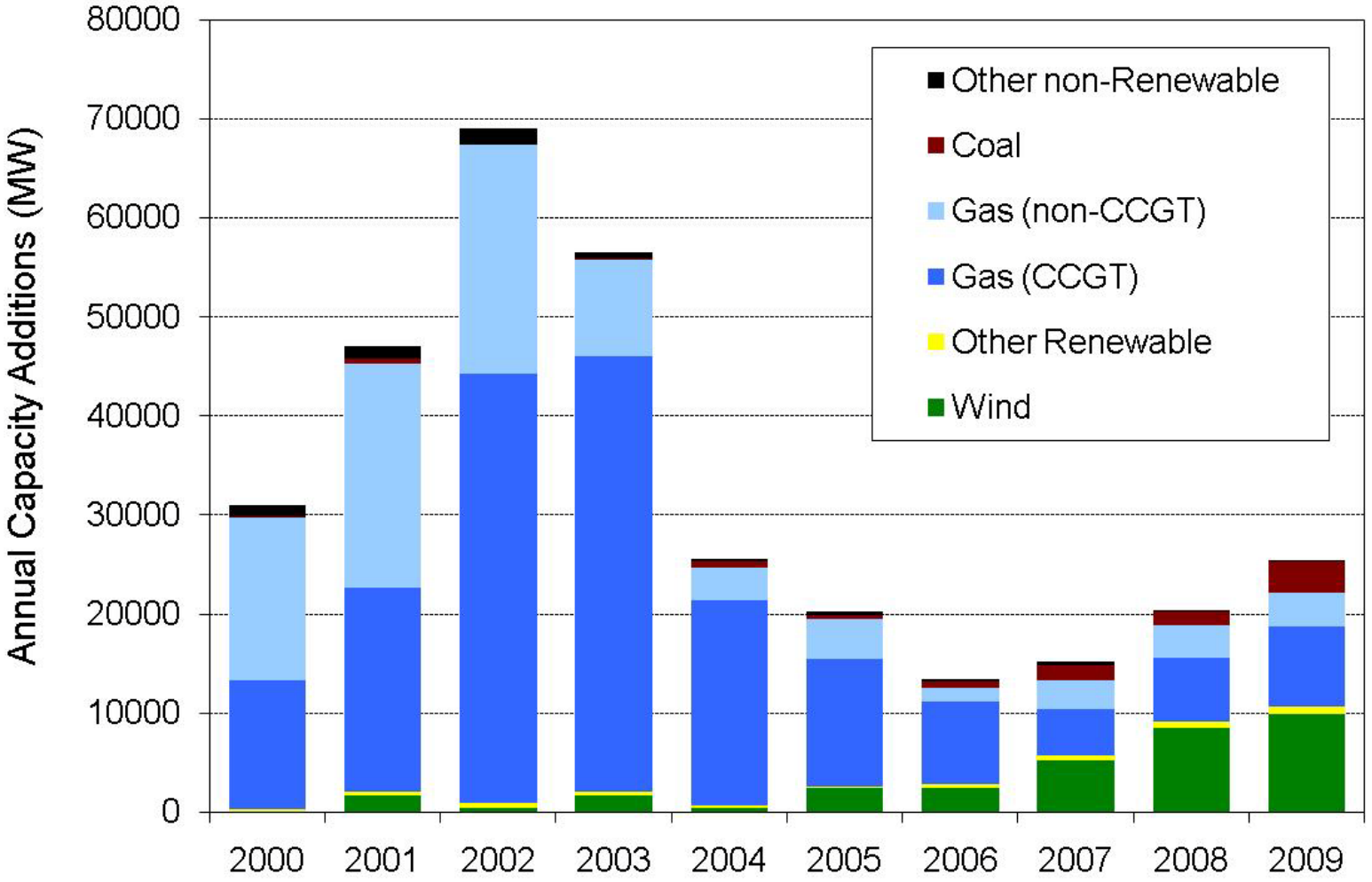
Wind Capacity at End of 2009 Could Deliver 2.4% of US Electricity Supply



Note: Figure only includes the 20 countries with the most installed wind capacity at the end of 2009

2009 Wind Market Report, LBNL

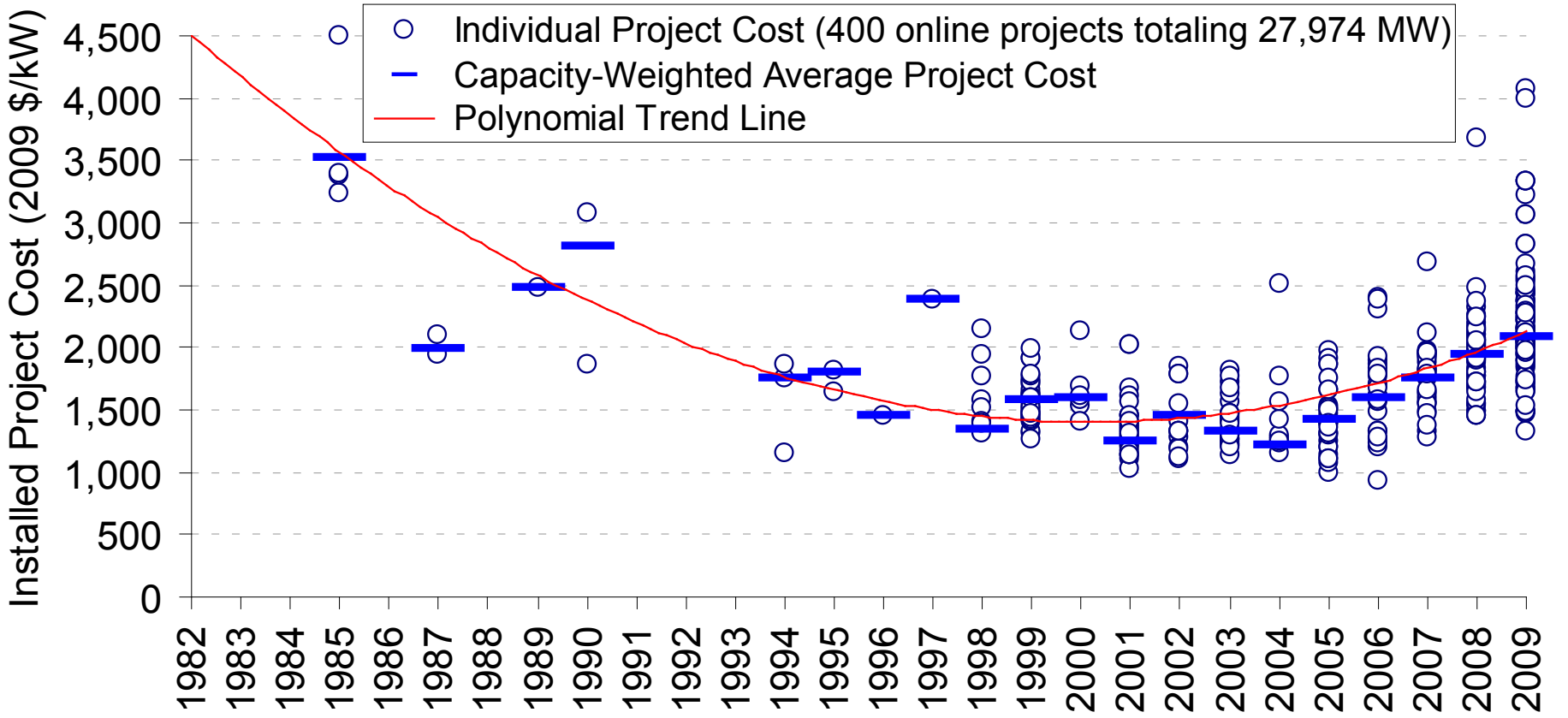
Wind Is a Major Source of New Capacity Additions: 39% in 2009



Source: EIA, Ventyx, AWEA, IREC, Berkeley Lab

2009 Wind Market Report, LBNL

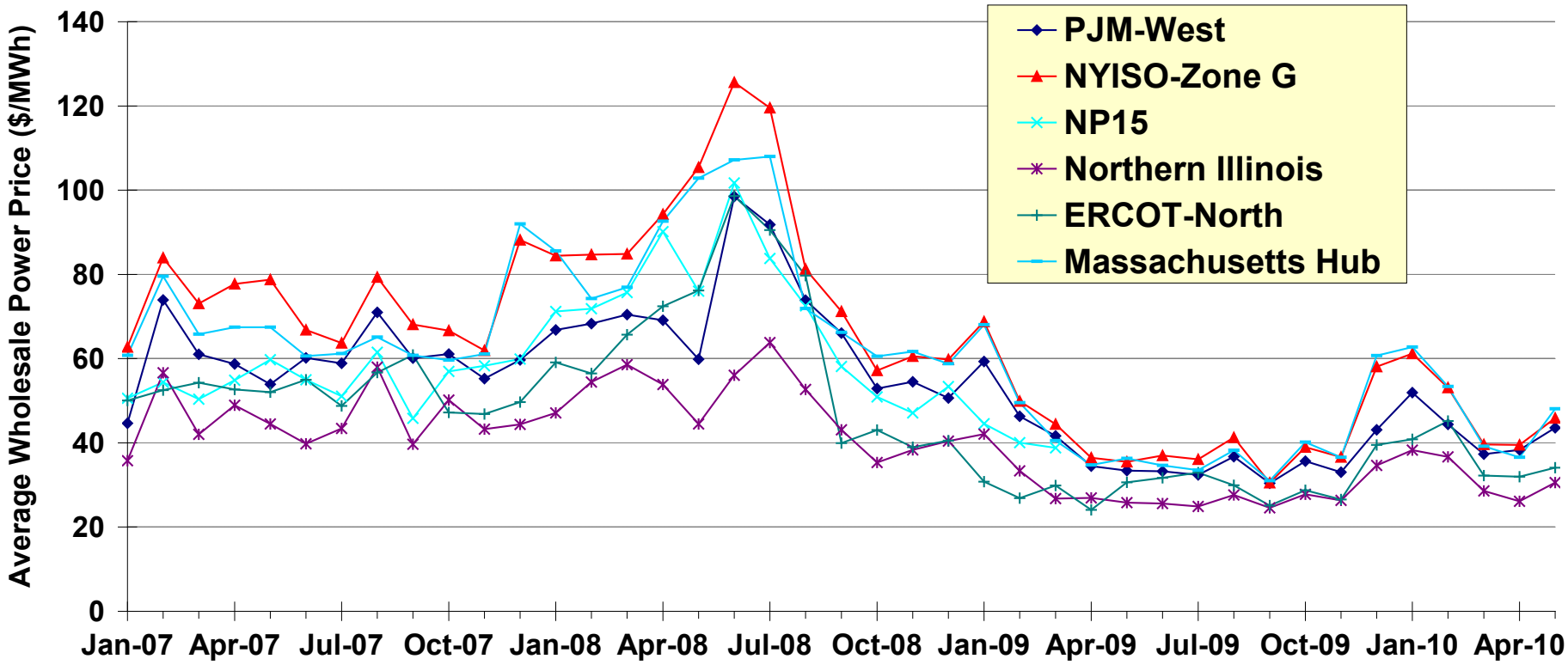
Wind Project Installed Costs in 2009 Continued to Rise, on Average



Project costs bottomed out in 2001-2004, and have risen by roughly $800/kW, on average, through 2009

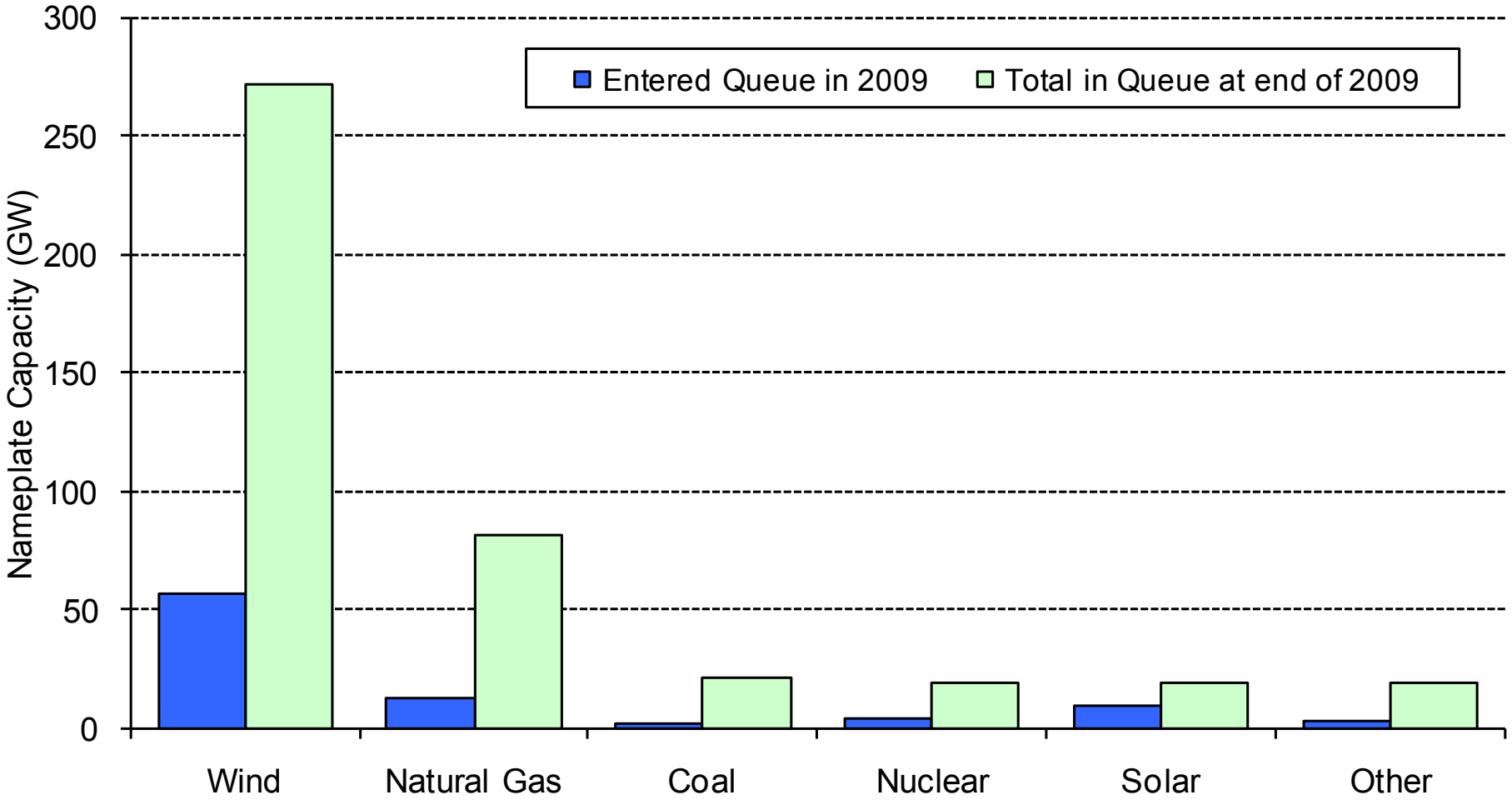
2009 Wind Market Report, LBNL

…While Wholesale Prices Have Recently Plummeted (with Natural Gas Prices)



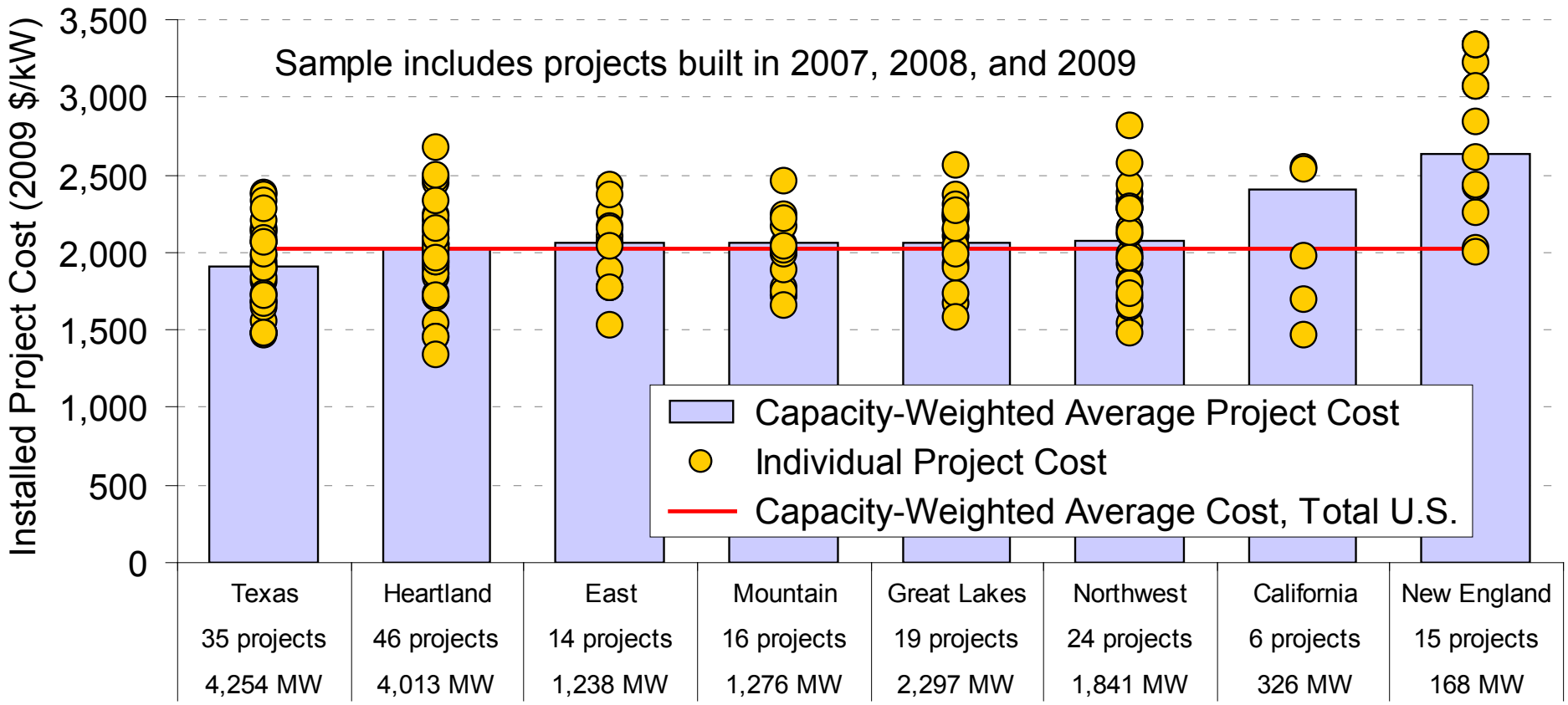
2009 Wind Market Report, LBNL

Interconnection Queues Are Clogged with Wind Projects: Nearly 300 GW



2009 Wind Market Report, LBNL

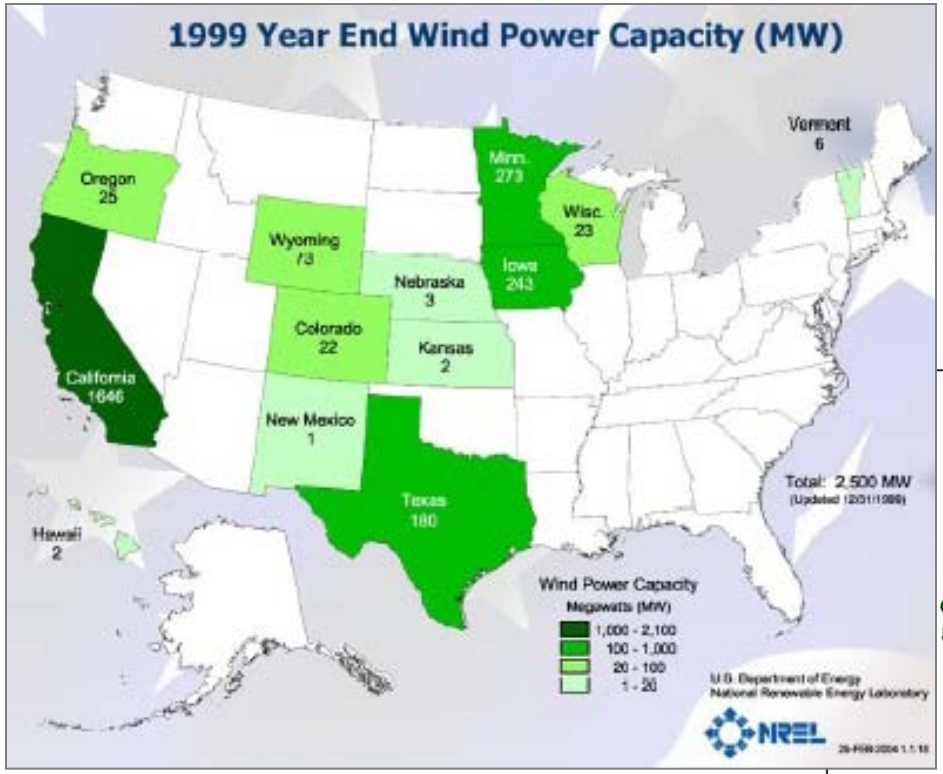
Wind Project Costs Vary Somewhat By Region

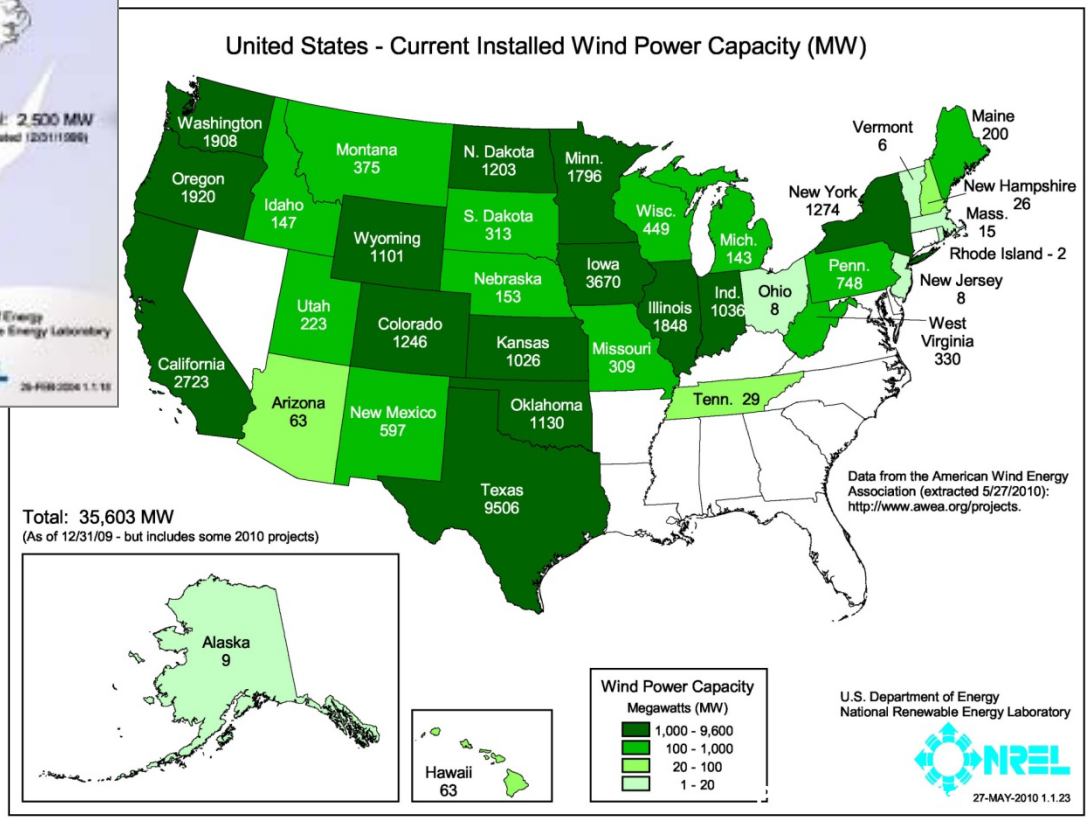


Higher average costs in New England and California; lower average costs in Texas

2009 Wind Market Report, LBNL

Installed Wind Capacities
(‘99 – ‘10)

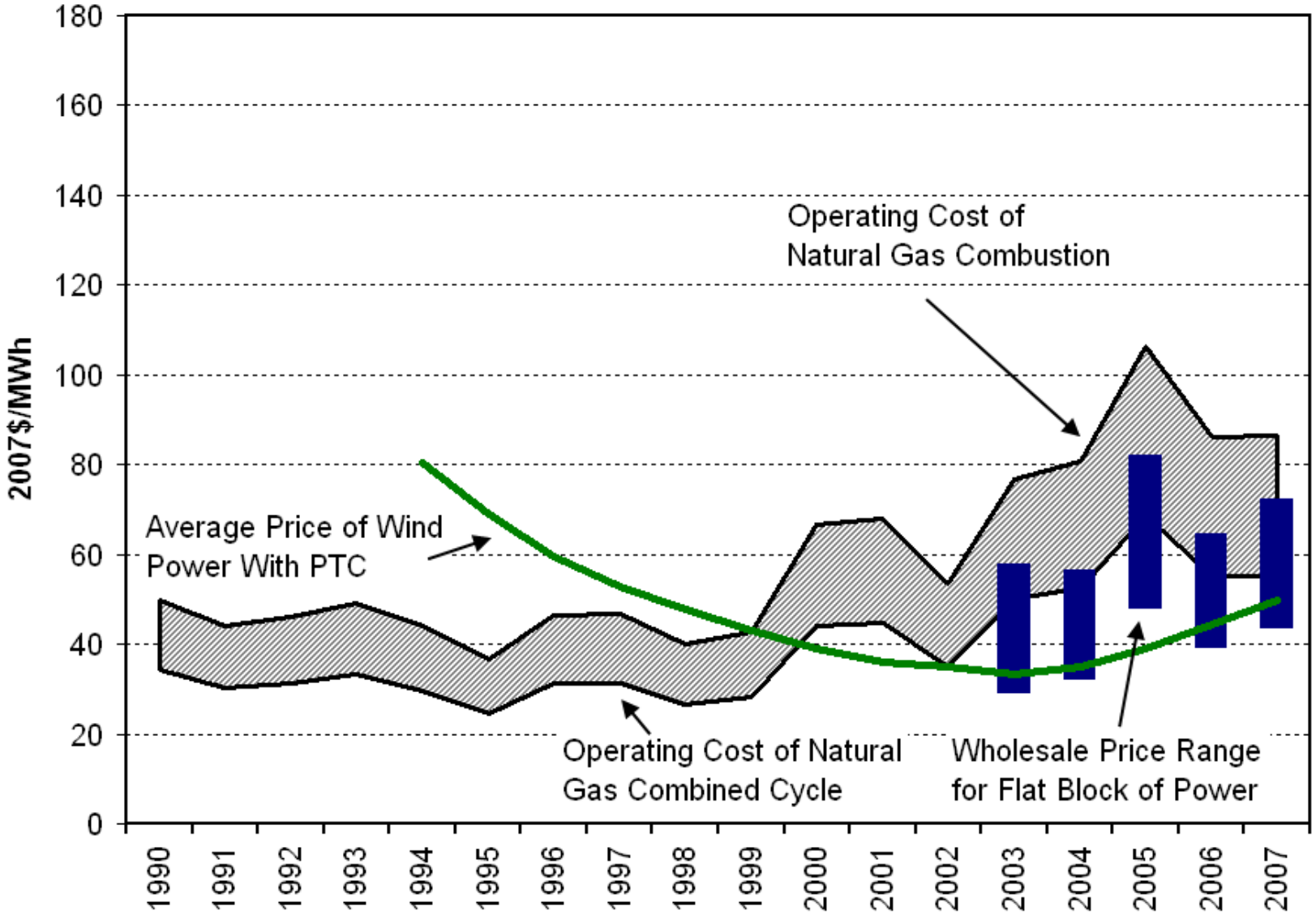




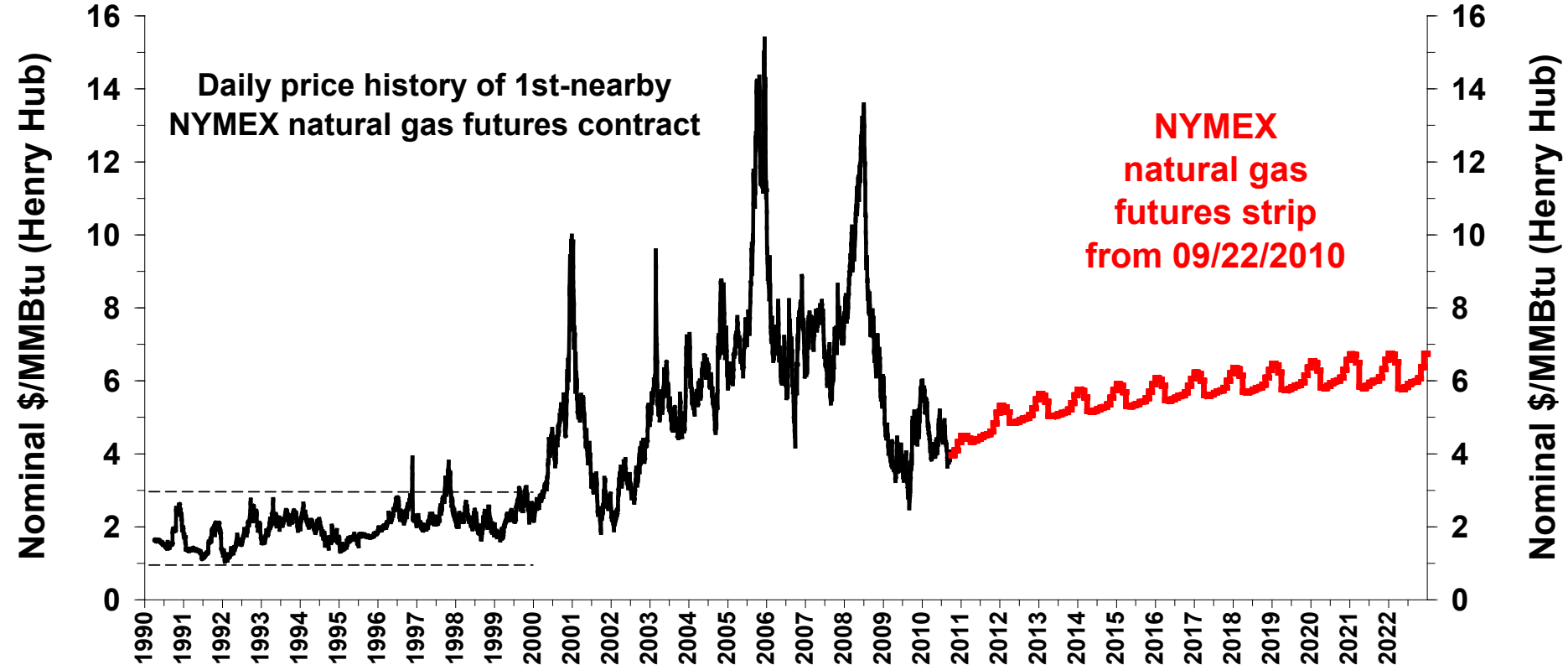
Drivers for Wind Power

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

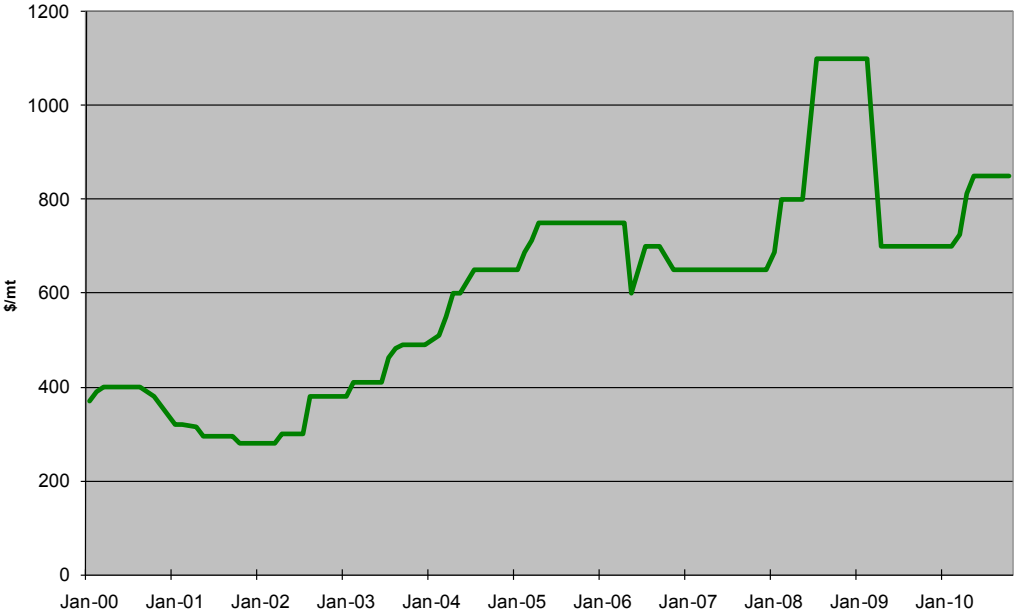
Comparative Generation Costs

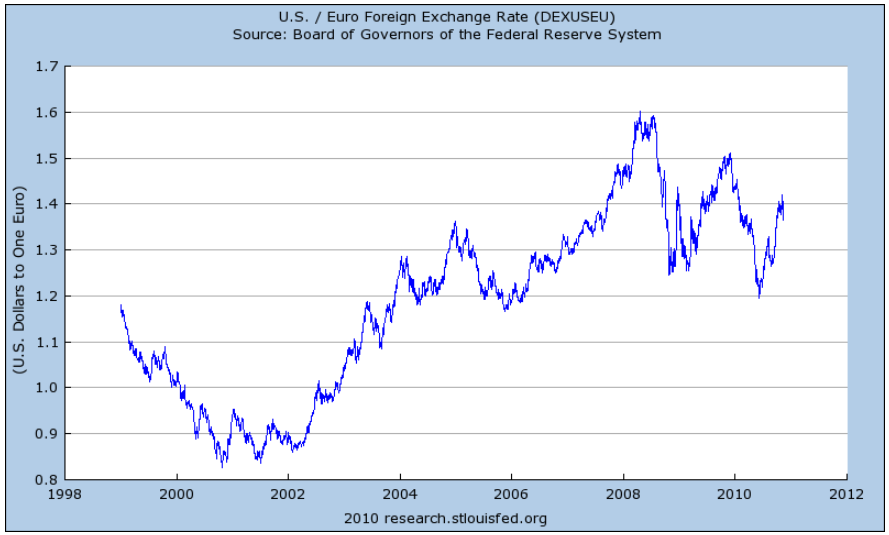


Natural Gas – Historic Prices

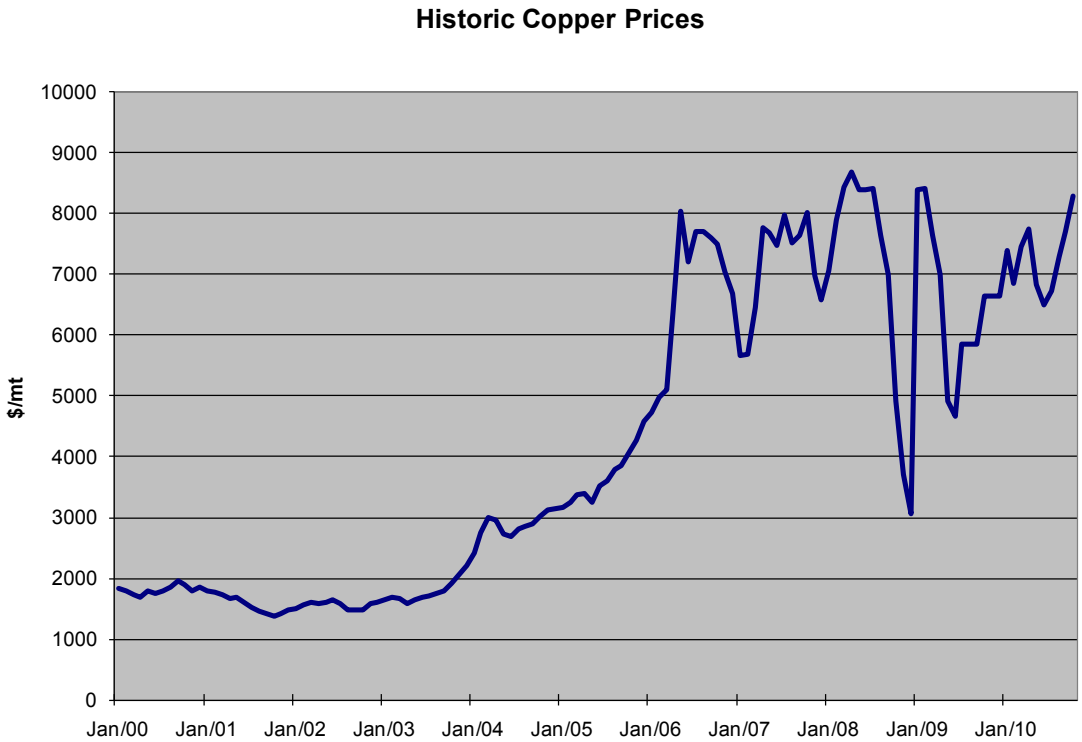


Source: LBNL



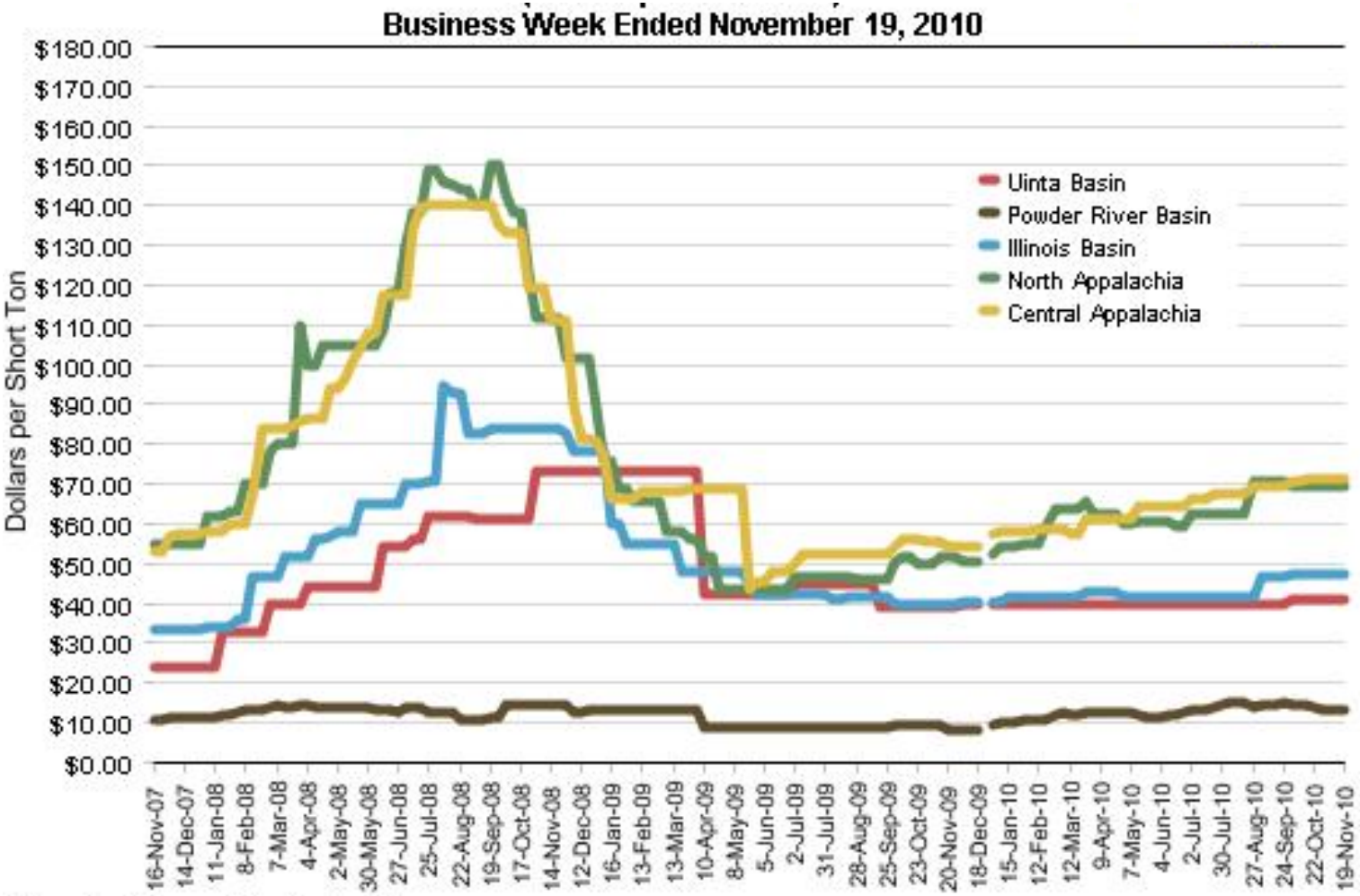


Wind Cost Drivers



Copper & Steel Price Source: World Bank, Commodity Price Data, Sept 2010

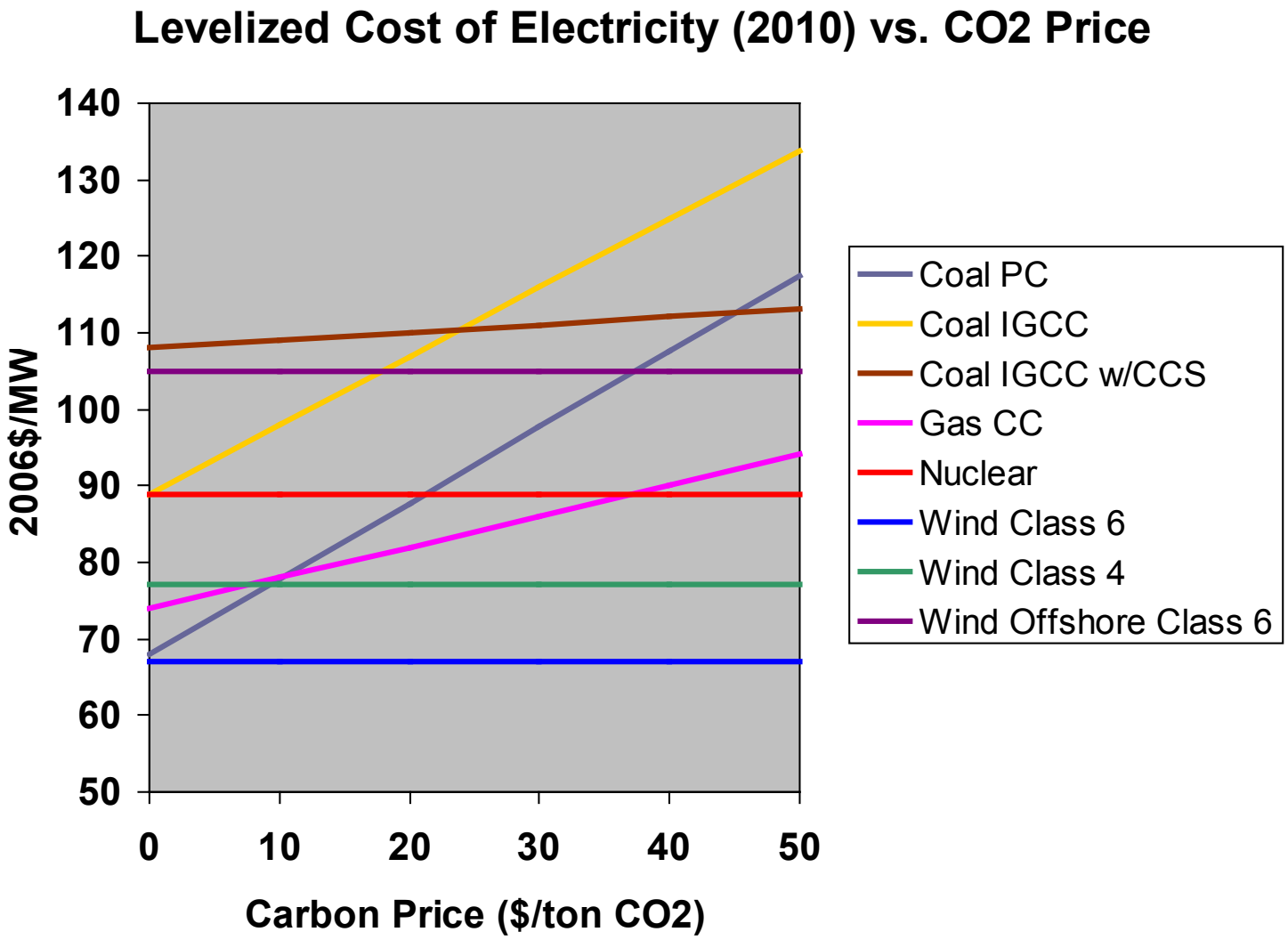
Historical Coal Prices



Key to Coal Commodities by Region'
Central Appalachia: Big Sandy/Kanawha 12,500 Btu, 1.2 lb SO2/mm Btu
Northern Appalachia: Pittsburgh Seam 13,000 Btu, <3.0 lb SO2/mm Btu
Illinois Basin: 11,800 Btu, 5.0 lb SO2/mm Btu
Powder River Basin: 8,800 Btu, 0.8 lb SO2/mm Btu
Uinta Basin in Colo.: 11,700 Btu, 0.8 lb SO2/mm Btu

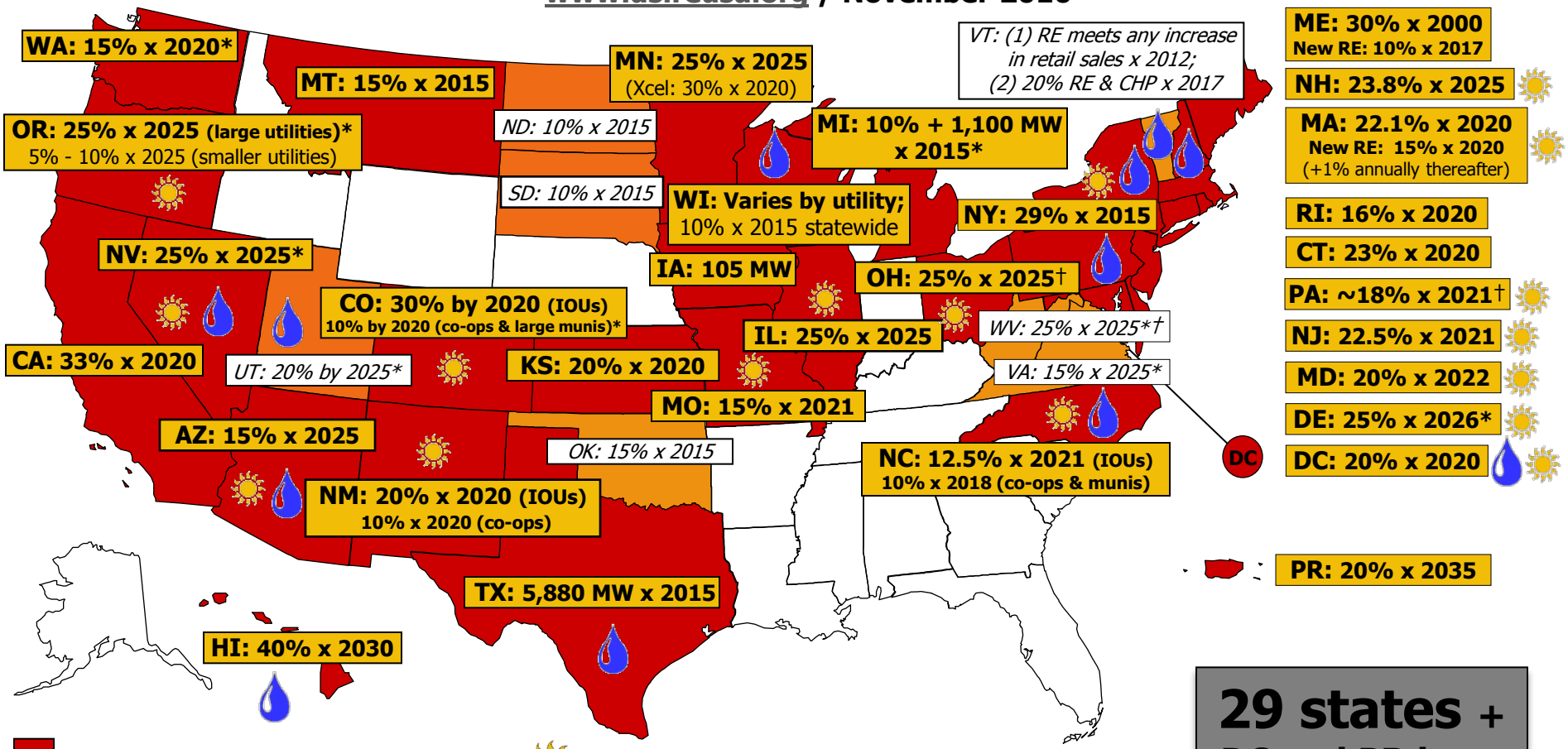
Source: EIA

CO_2 prices significantly increase the cost of coal



Renewable Portfolio Standards

www.dsireusa.org / November 2010



Renewable portfolio standard

Renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

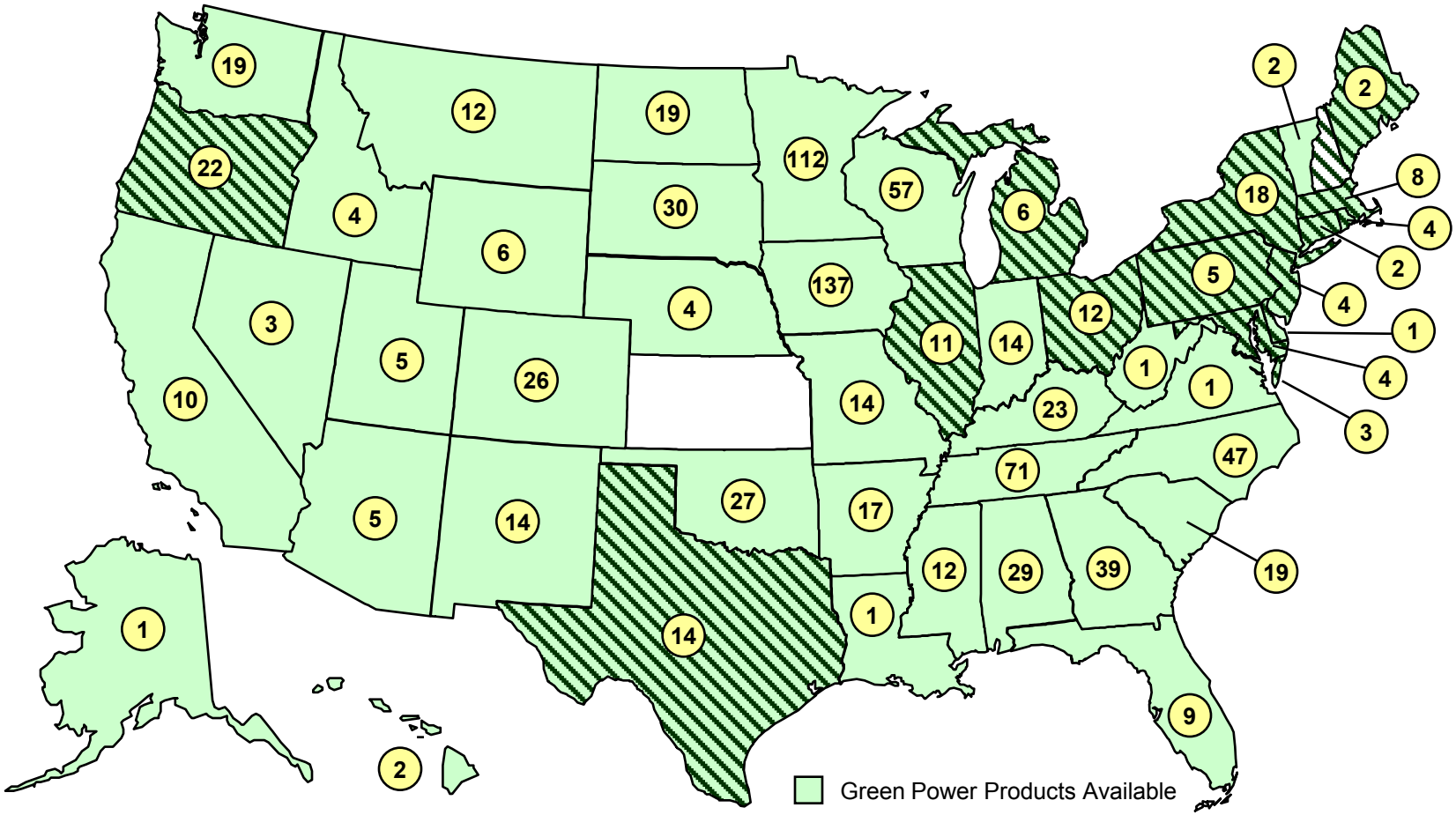
* Extra credit for solar or customer-sited renewables

† Includes non-renewable alternative resources

29 states + DC and PR have an RPS

(7 states have goals)

States with Green Power Programs



Source: National Renewable Energy Laboratory (September 2008)

Wind Energy Investors

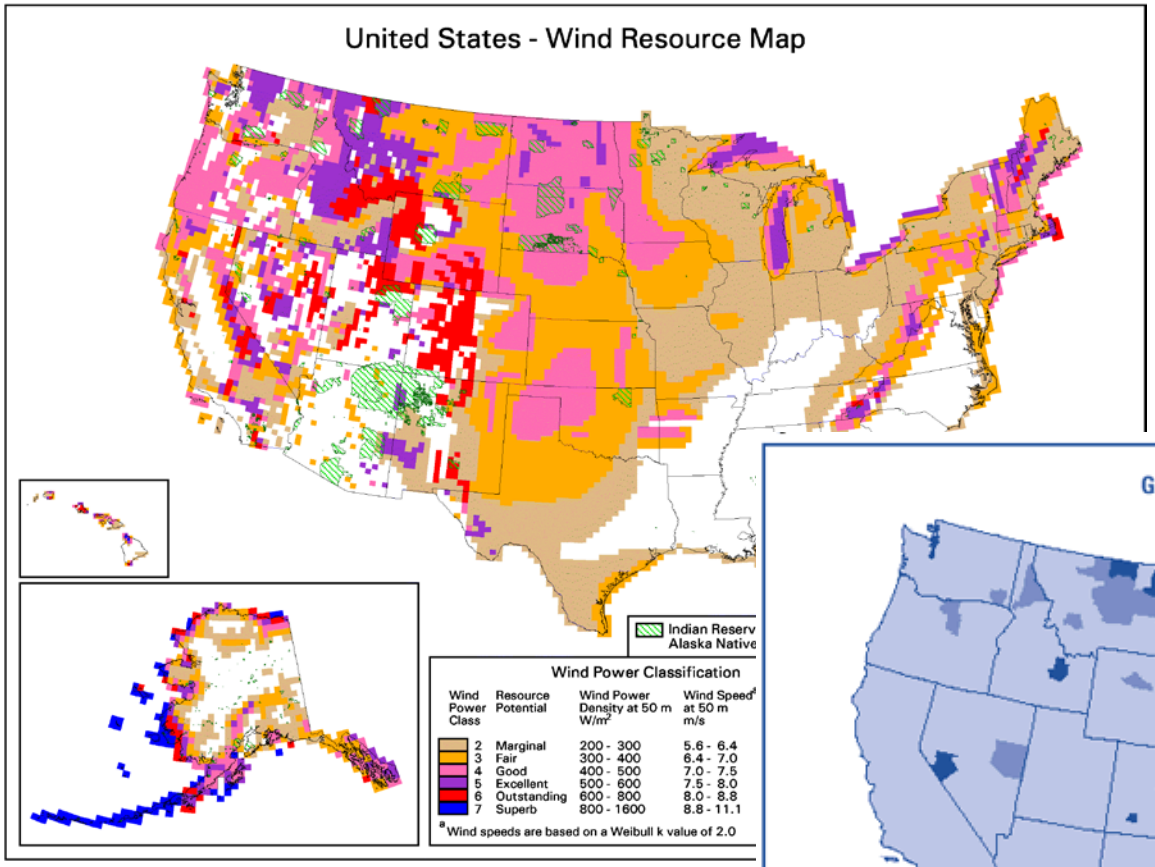
SIEMENS

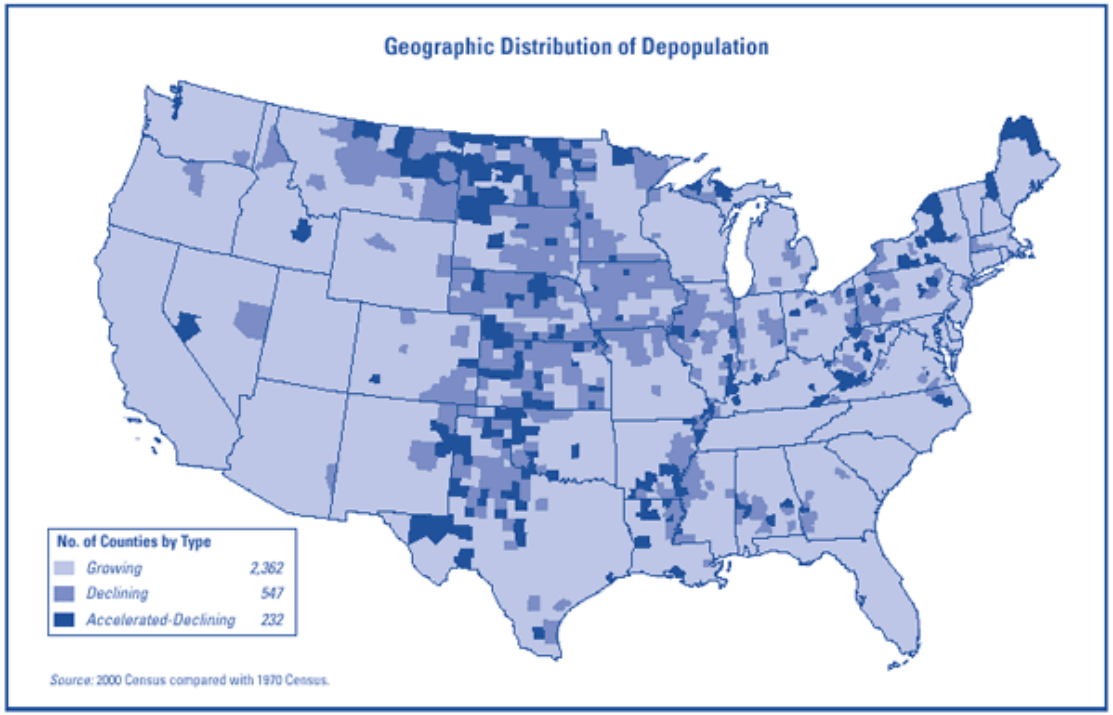
BP Solar

JOHN DEERE

Vestas

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

Direct jobs and parts during construction

Truck drivers,
crane operators

Wind Turbine Components

Earth moving, cement pouring

Management and support

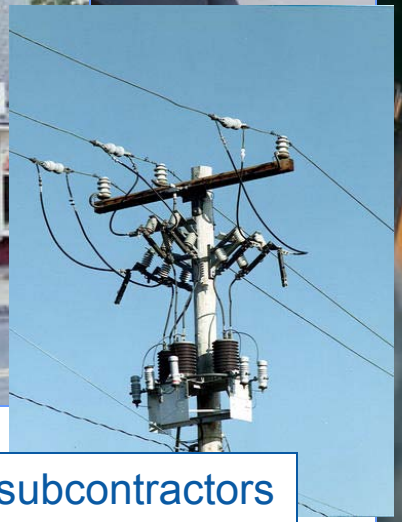
Construction

Direct wind project jobs during **operations**

Operations and maintenance, management

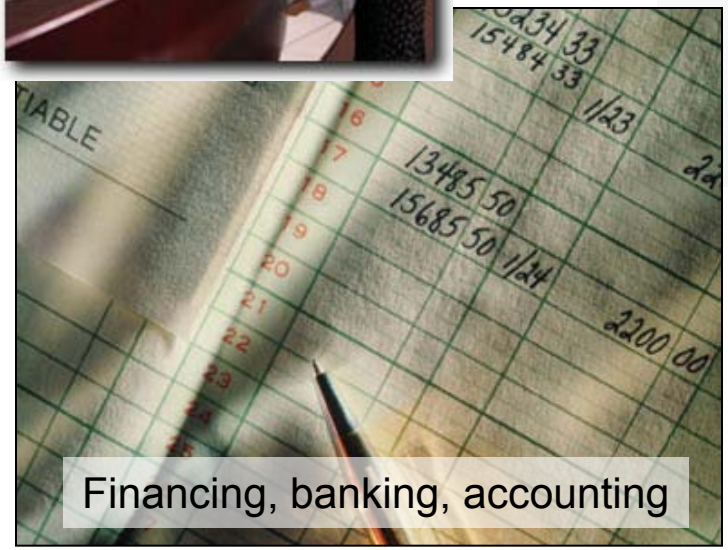
Landowner royalties

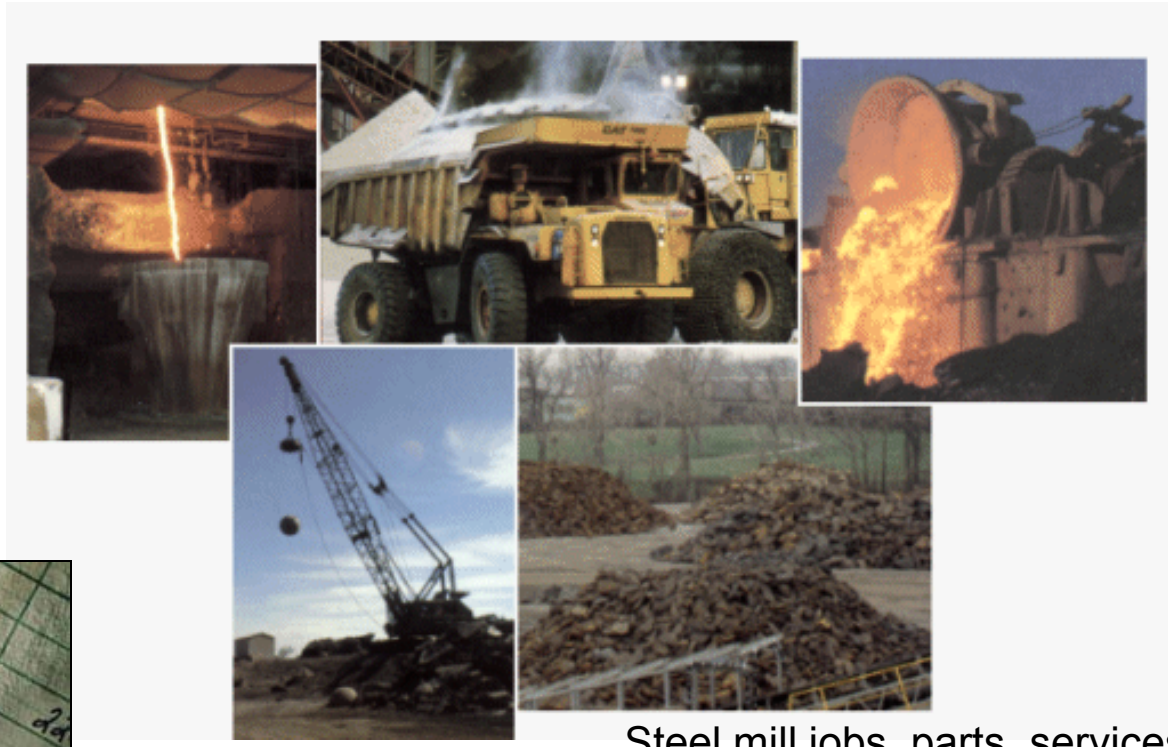
Parts and materials purchased



Utility services and subcontractors

Indirect jobs, services, materials





Steel mill jobs, parts, services

Photos: E.C.Levy, Inc, Detroit, MI

Wind subcomponent manufacturing and sales

Induced jobs, services, materials

Child care, grocery store, clothing, other retail, public transit, new cars, restaurants, medical services

Jobs and Economic Impacts from the JEDI Model

Wind Energy's Economic Impacts

JEDI Model Version W1.09.03e

Wind energy's economic "ripple effect"

Project Development & Onsite Labor Impacts

Construction Workers
Management
Administrative Support

Legal, siting, and permitting
Cement truck drivers
Road crews
Maintenance workers

Turbine & Supply Chain Impacts

Blades, towers, gear boxes

Boom truck & management, gas and gas station workers

Supporting businesses, such as bankers financing the construction, contractor, manufacturers and equipment suppliers. Utilities.

Hardware store purchases and workers, spare parts and their suppliers

Induced Impacts

Jobs and earnings that result from the spending supported by the project, including benefits to grocery store clerks, retail salespeople, and child care providers

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

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

South Dakota Wind Energy Center

- 40.5 MW (1.5-MW turbines)
- Landowner payments: $3,500-$4,000/year
- 100 – 125 workers during peak construction
- 3 fulltime O&M positions
- **Property taxes: $220,000/year**
- Sales and use tax: $1.2 million payable in 2003
- Located near Highmore, SD (population 808)
- Owned by FPL Energy
- Constructed in 2003

Peetz Table Wind Energy Center, CO

- 400.5 MW (1.5-MW turbines)
- Landowner payments: $2 million/year, $65 million over 30-year period
- 300 – 350 workers during peak construction (80% local)
- **16 – 18 O&M positions**
- Total annual tax payments: $2.3 million/year (10% of total county budget); $70 million over 30 years
- Located near Peetz, CO
- Owned by FPL Energy
- Constructed in 2007

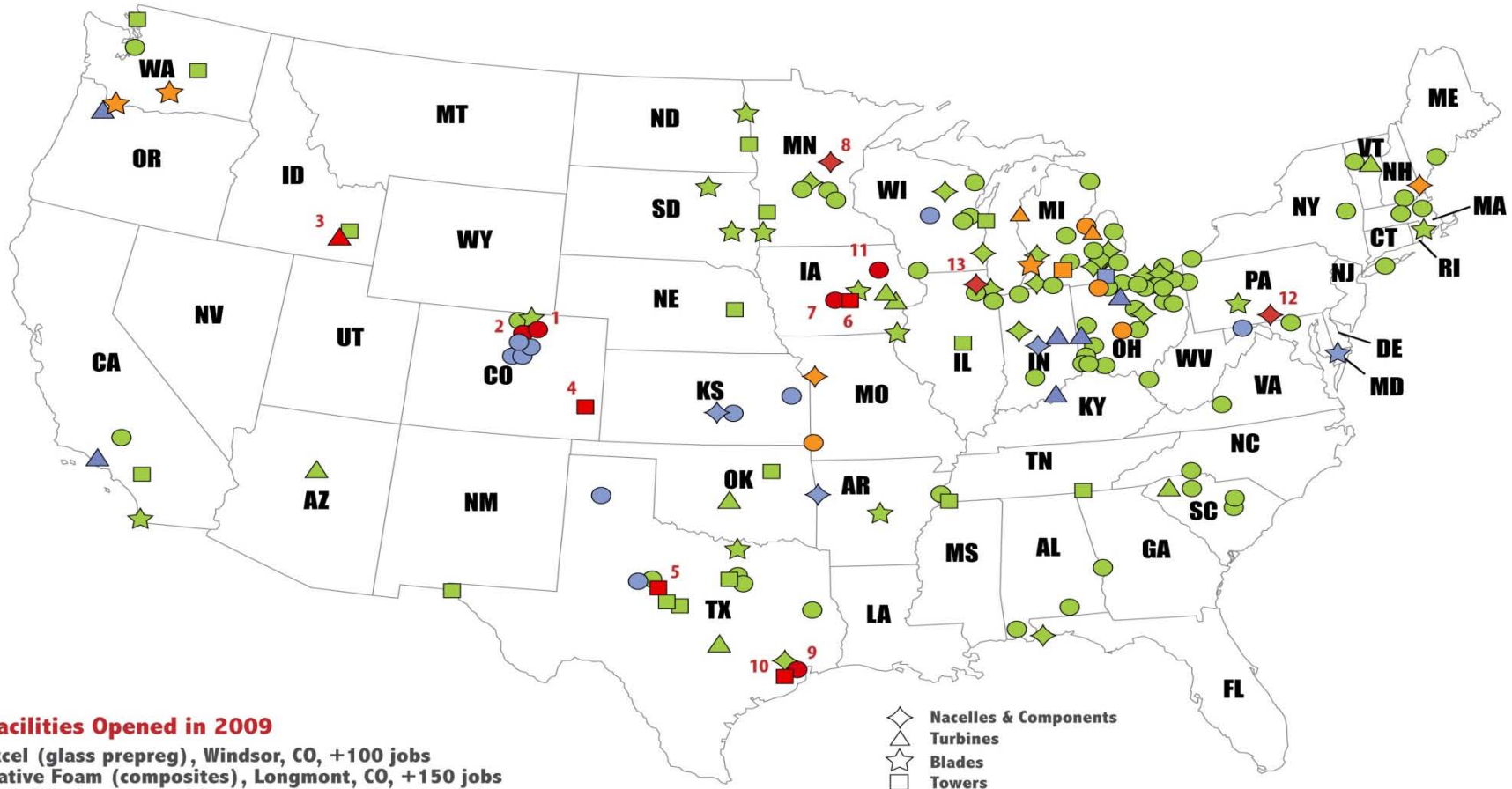
Weatherford Wind Energy Center, OK

- 147 MW (1.5-MW turbines)
- **Landowner payments: $300,000 in annual lease payments**
- 150 workers during peak construction
- 6 fulltime O&M positions
- Property taxes: $17 million over 20 years
- Sawartzky Construction received $300,000 in revenue from the project
- Owned by FPL Energy
- Constructed in 2005

Wyoming Wind Energy Center

- 144 MW (1800-kW turbines)
- Landowner payments: $18 million over the life of the project
- 175 workers during peak construction (25% local)
- 8 fulltime O&M positions
- Property taxes: $1 million (2006/7)
- **50 Wyoming companies subcontracted during the construction period**
- Located in Uinta County, WY (population 20,213)
- Owned by FPL Energy
- Constructed in 2003

Soaring Demand Spurs Expansion of U.S. Wind Turbine Manufacturing



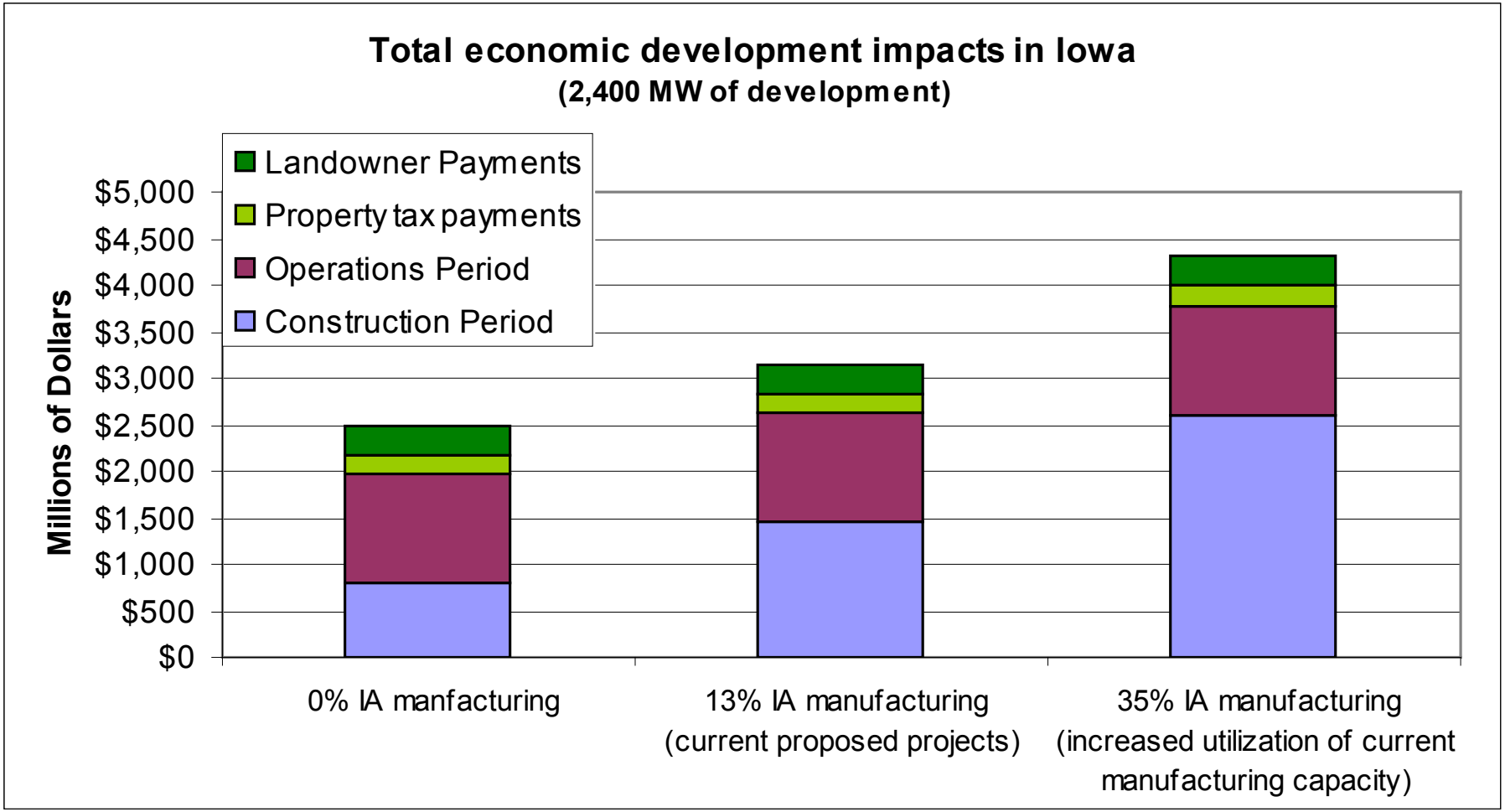
New Facilities Opened in 2009

1. Hexcel (glass prepreg), Windsor, CO, +100 jobs
2. Creative Foam (composites), Longmont, CO, +150 jobs
3. Nordic Windpower (turbines), Pocatello, ID, +160 jobs
4. Dragon Wind (towers), Lamar, CO, +60-80 jobs
5. Tower Tech (towers), Abilene, TX, +150 jobs
6. Trinity Structural Towers (towers), Newton, IA, +140 jobs
7. Goian North America (elevation systems), Ankeny, IA, +12 jobs
8. Mille Lacs Band of Ojibwe (generators), Mille Lacs Reservation, MN, +7 jobs
9. RLTC Wind Towers (towers), MacGregor, TX, +75-250 jobs
10. RBC Bearings (bearings), Houston, TX, +35 jobs
11. Sector 5 Technologies (components), Oelwein, IA, +99 jobs
12. Vacon Inc (AC drives), Chambersburg, PA, +94 jobs
13. Winergy (gear drives), Elgin, IL, +300 jobs

Figure includes wind turbine and component manufacturing facilities, as well as other supply chain facilities, but excludes corporate headquarters and service-oriented facilities. The facilities shown here are not intended to be exhaustive. Those facilities designated as "Turbines" may include turbine assembly and/or turbine component manufacturing, in some cases also including towers, nacelles and blades.

This map was created by
The National Renewable Energy Laboratory
for the U.S. Department of Energy.
April 22, 2010

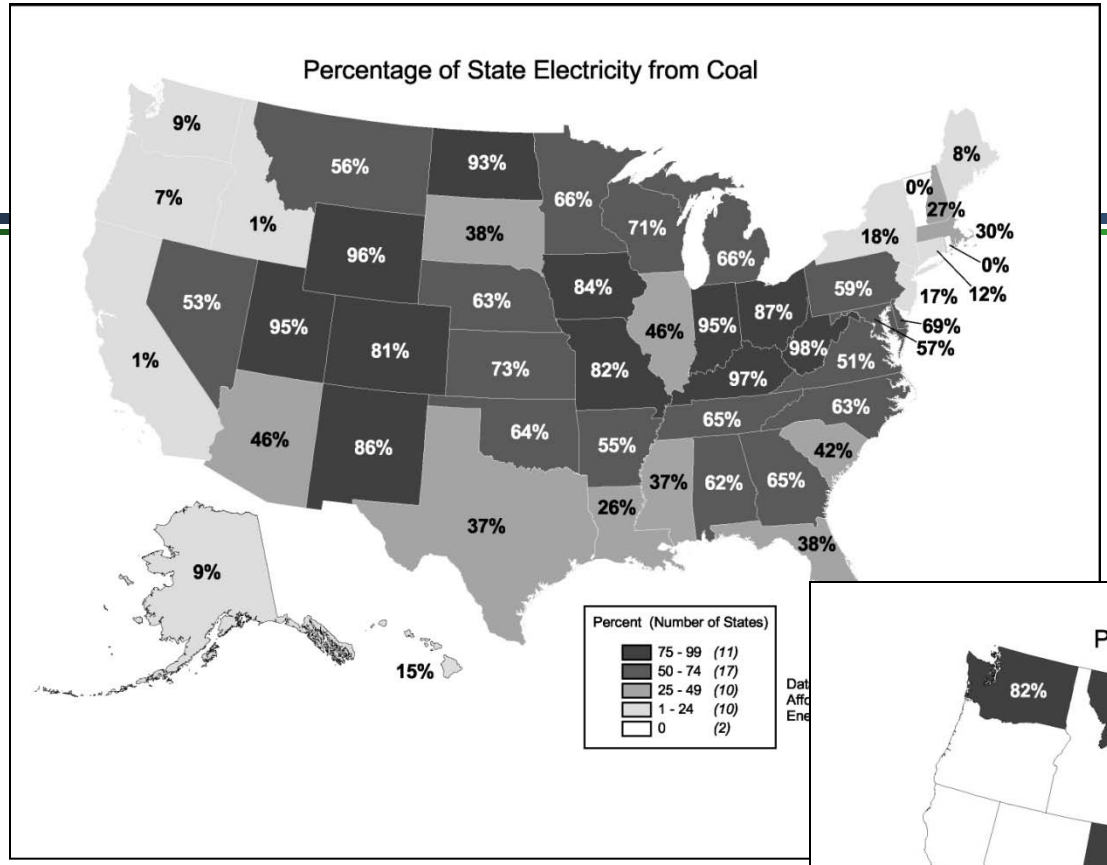
Manufacturing and Economic Development

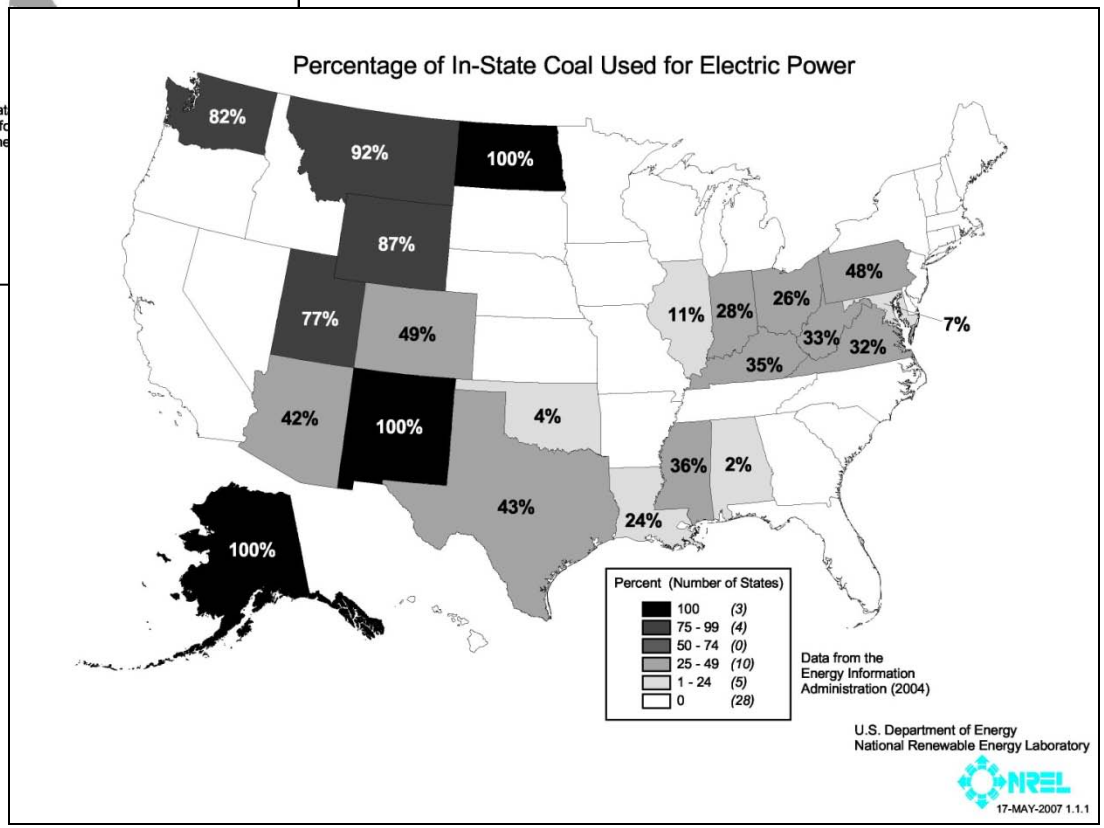


Local Ownership Models

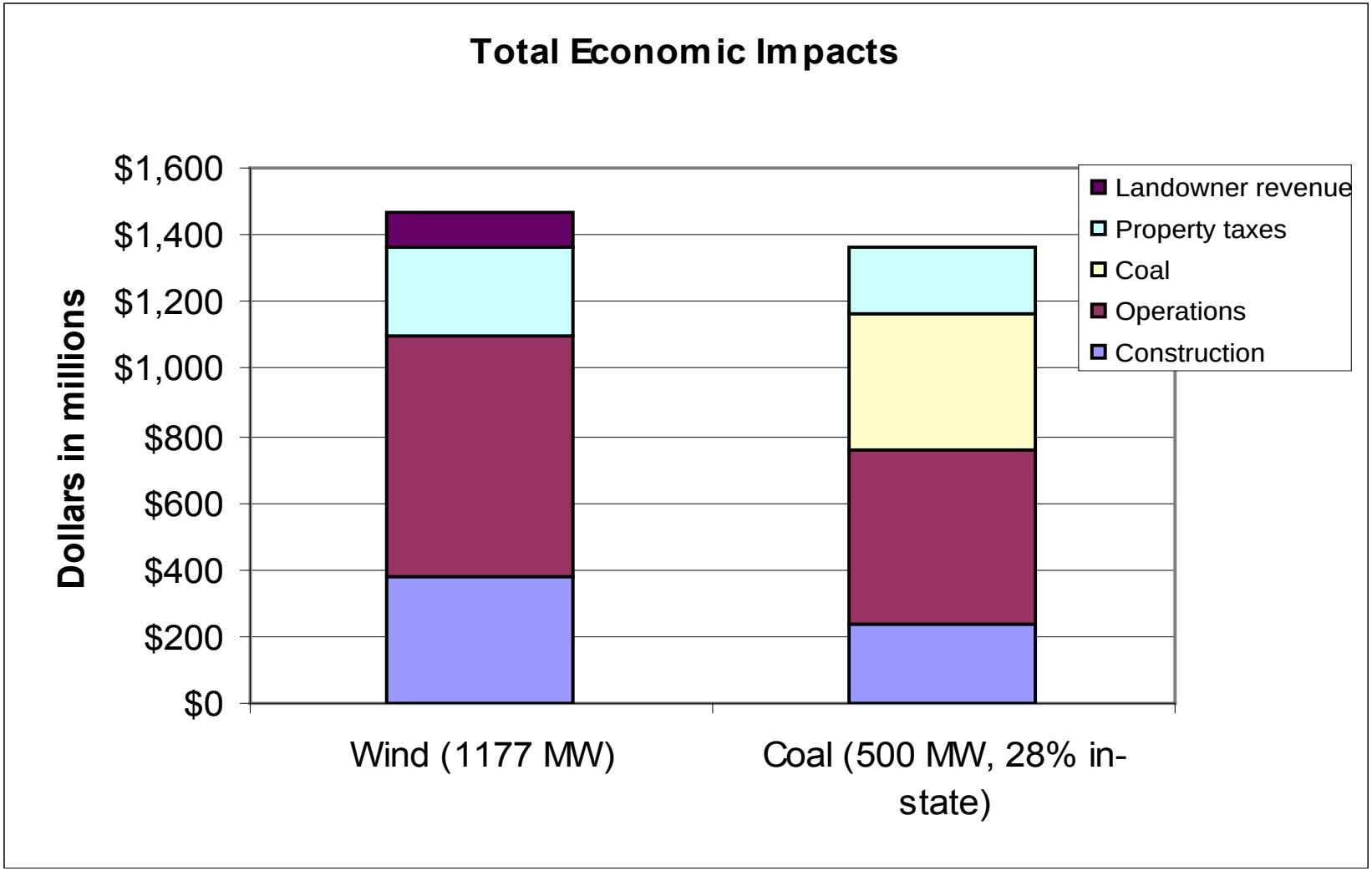
- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale

© L. Kennedy


Percentage of State Electricity from Coal
9%
56%
93%
66%
71%
8%
0%
27%
30%
7%
1%
38%
18%
96%
66%
0%
84%
59%
53%
63%
17%
12%
95%
81%
46%
95%
87%
69%
1%
73%
82%
98%
51%
57%
97%
63%
46%
86%
64%
55%
65%
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%
11%
28%
26%
7%
77%
49%
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

Comparing wind and coal in Indiana



Constant 2007 dollars

Jobs and Economic Impacts from the JEDI Model

1,000 MW of New Wind Power in Colorado

JEDI Model Version W1.09.03e

Wind energy's economic "ripple effect"

Project Development & Onsite Labor Impacts

Landowner Revenue:
- $3 million/year

Local Property Taxes:
- $5.7 million/year

Construction Phase:
- 502 new jobs
- $39 million to local economies

Operational Phase:
- 51 new jobs
- $3.4 M/year to local economies

Turbine & Supply Chain Impacts

Construction Phase:
- 3,059 new jobs
- $414.8 million to local economies

Operational Phase:
- 73 new jobs
- $16.3 million/year to local economies

Induced Impacts

Construction Phase:
- 1,197 new jobs
- $143.1 million to local economies

Operational Phase:
- 63 new jobs
- $7.6 million/year to local economies

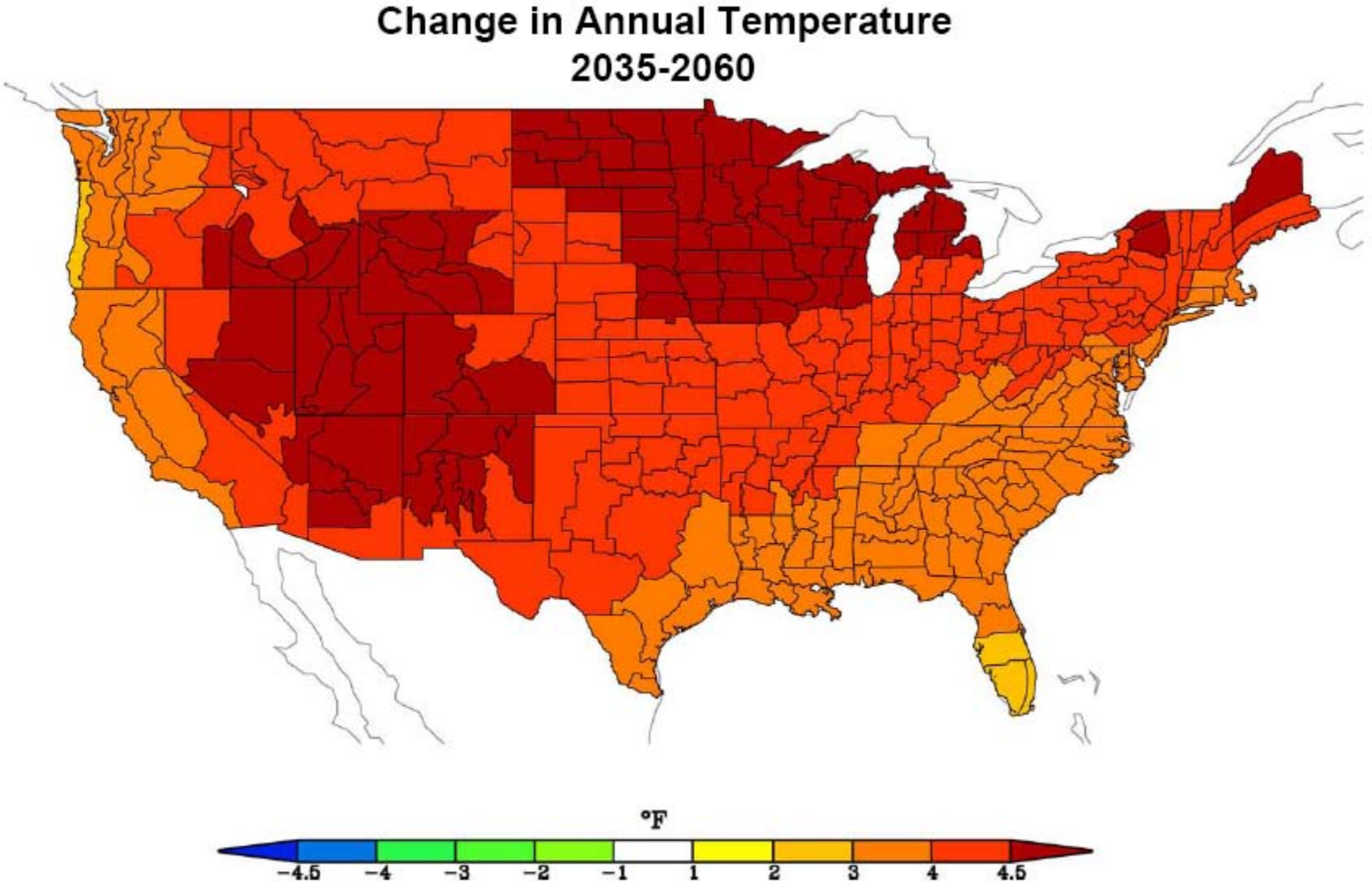
Totals (construction + 20 years)

Total economic benefit:	$1.32 billion
New local jobs during construction:	4,758
New local long-term jobs:	187

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

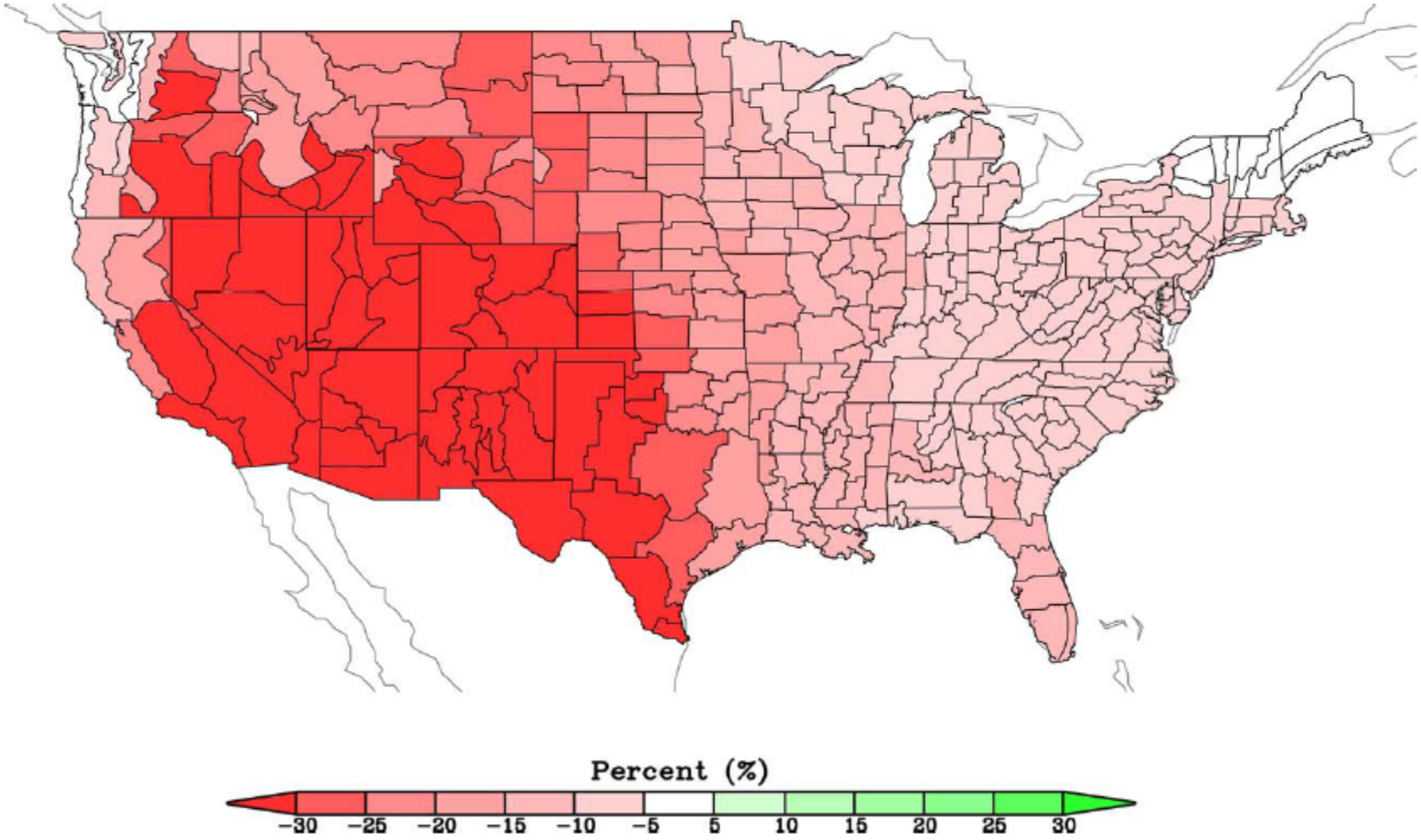
Environmental Benefits

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



Source: NOAA

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

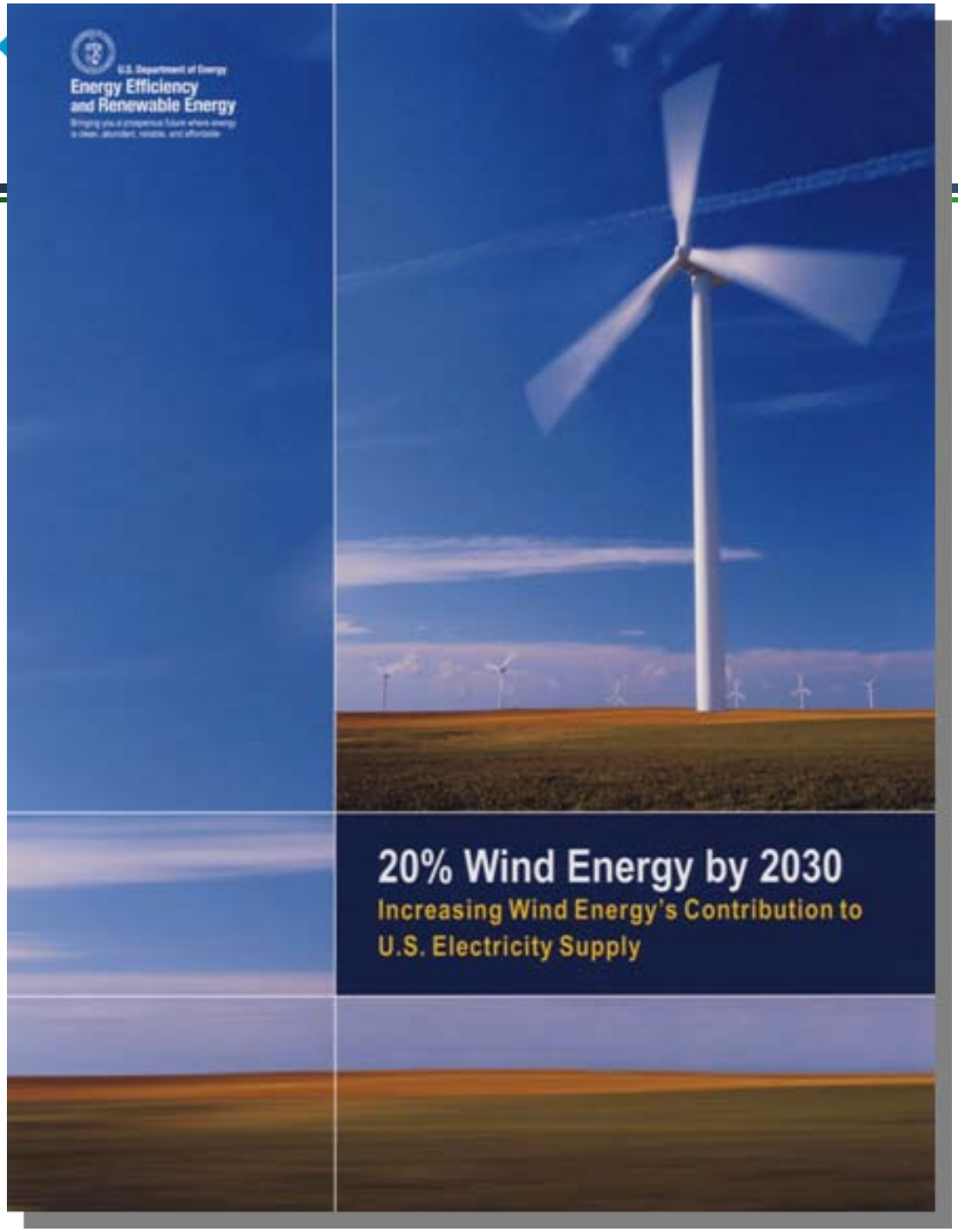


Source: NOAA

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



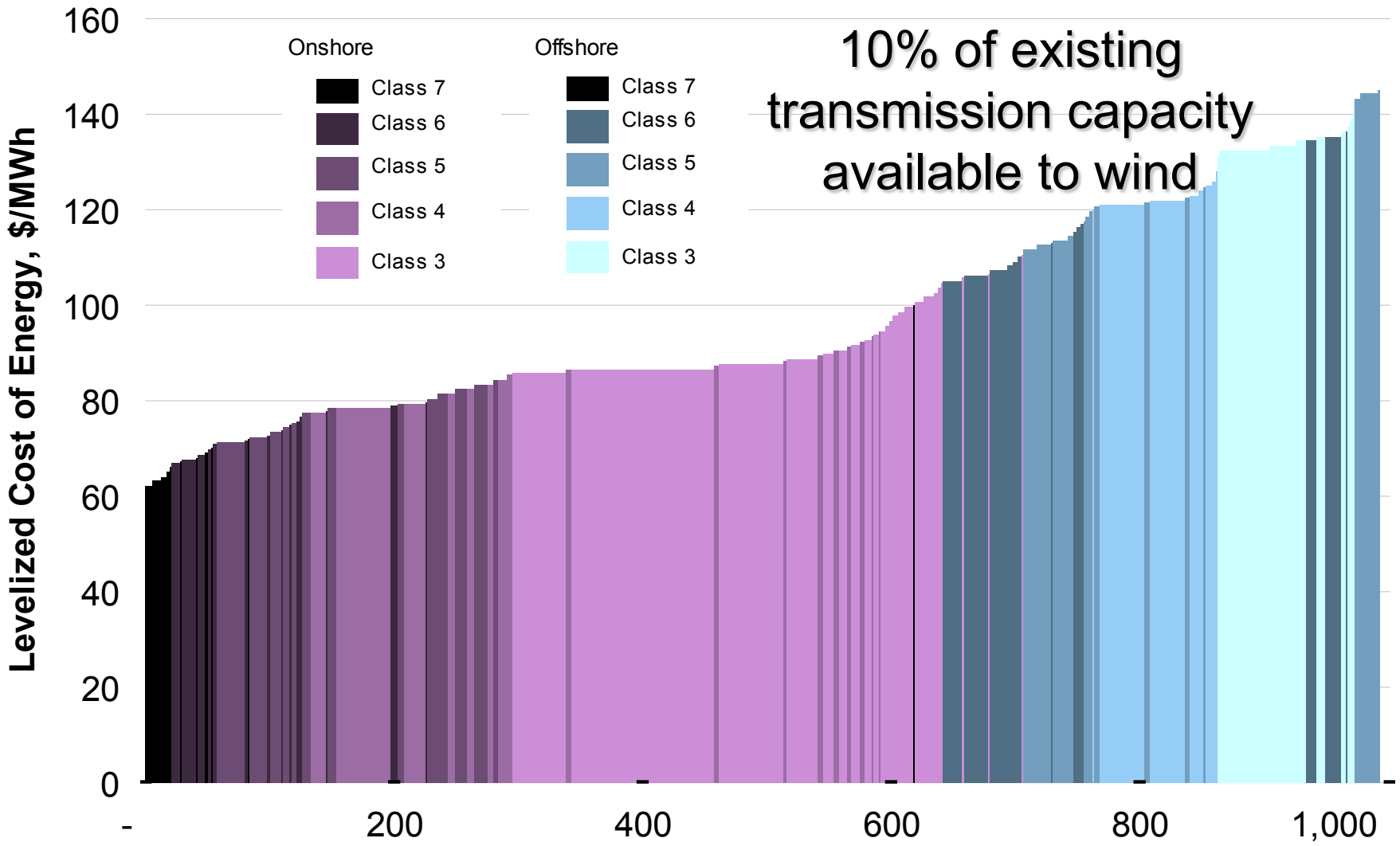
"The future ain't what it used to be."

- Yogi Berra

The 20% Technical Report

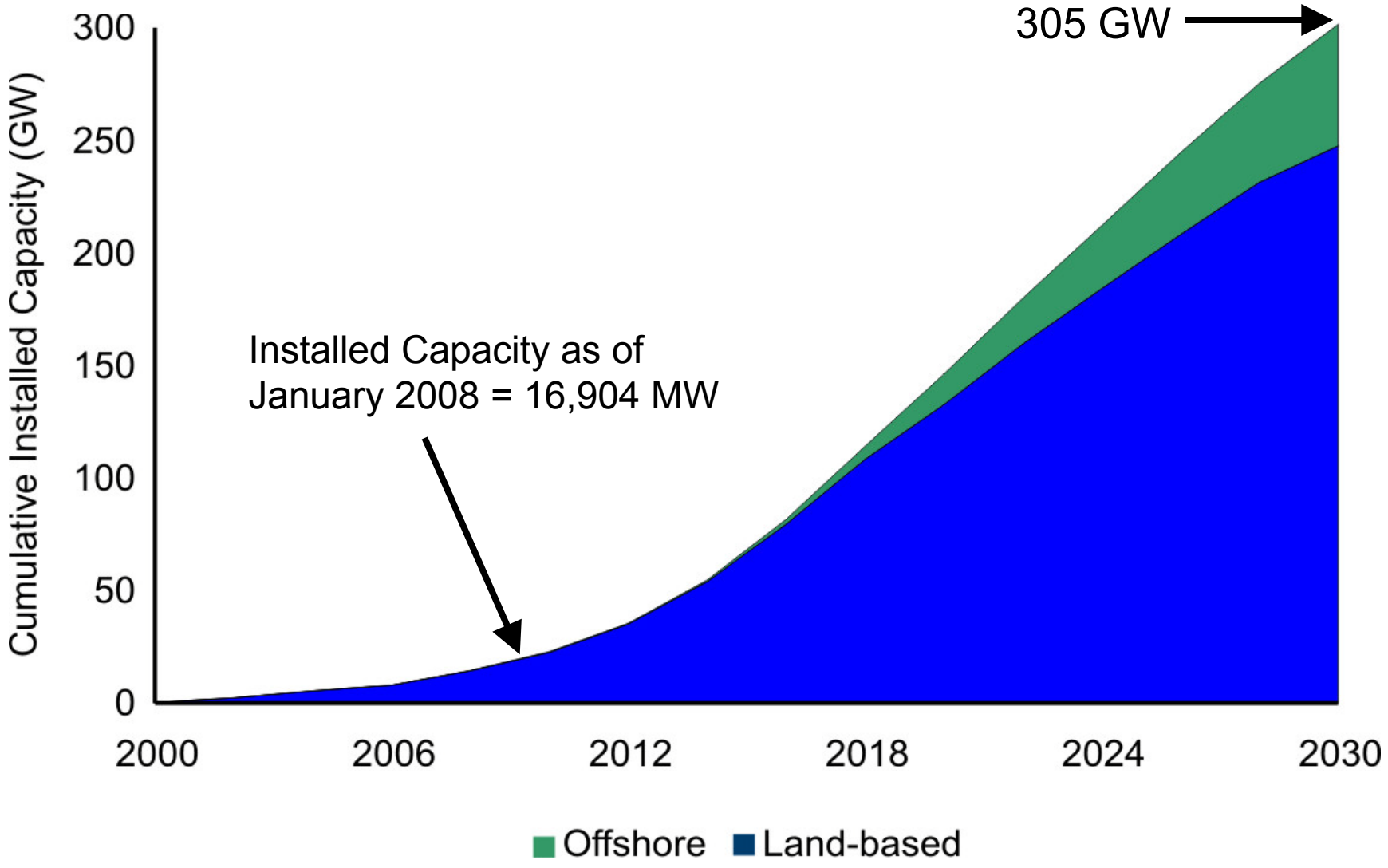
- Explores one scenario for reaching 20% wind electricity by 2030 and contrasts it to a scenario in which no new U.S. wind power capacity is installed
- Is not a prediction, but an analysis based on one scenario
- Does not assume specific policy support for wind
- Is the work of more than 100 individuals involved from 2006 - 2008 (government, industry, utilities, NGOs)
- Critically examines wind's roles in energy security, economic prosperity and environmental sustainability

Supply Curve for Wind Energy: Energy and Transmission Costs

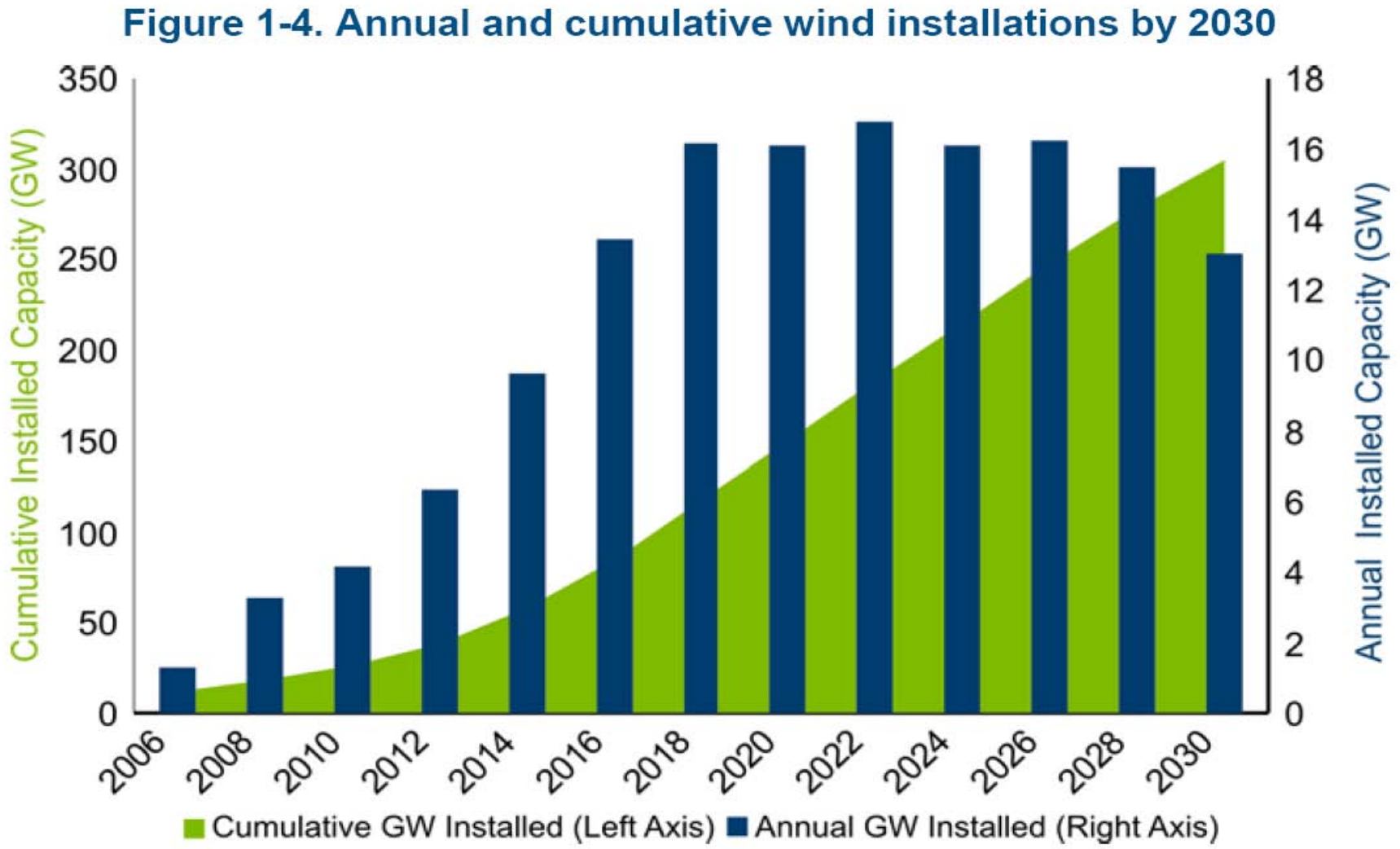


2010 Costs w/o PTC, $1,600/MW-mile, w/o Integration costs

20% Wind Scenario

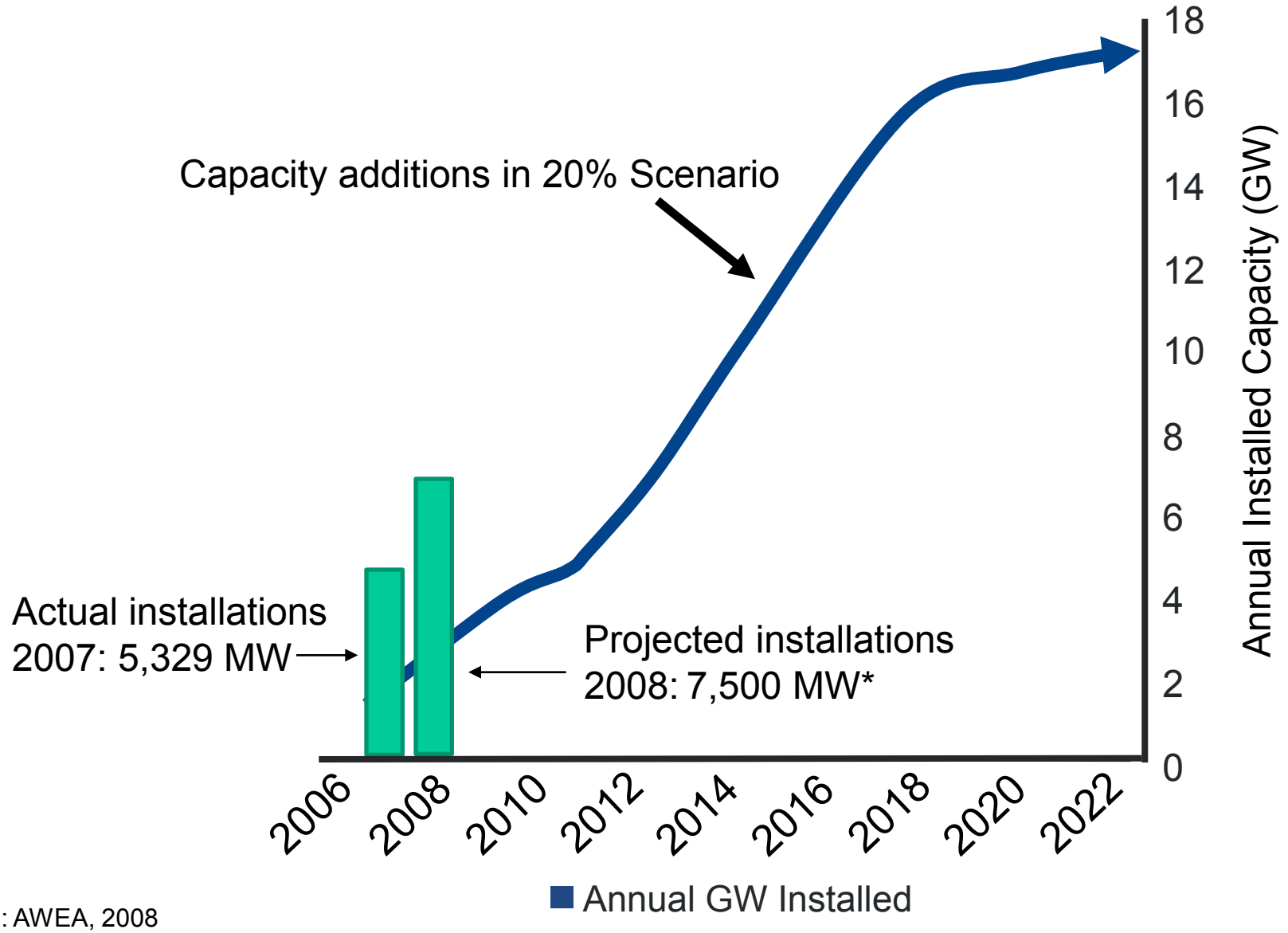


What does 20% Wind look like?



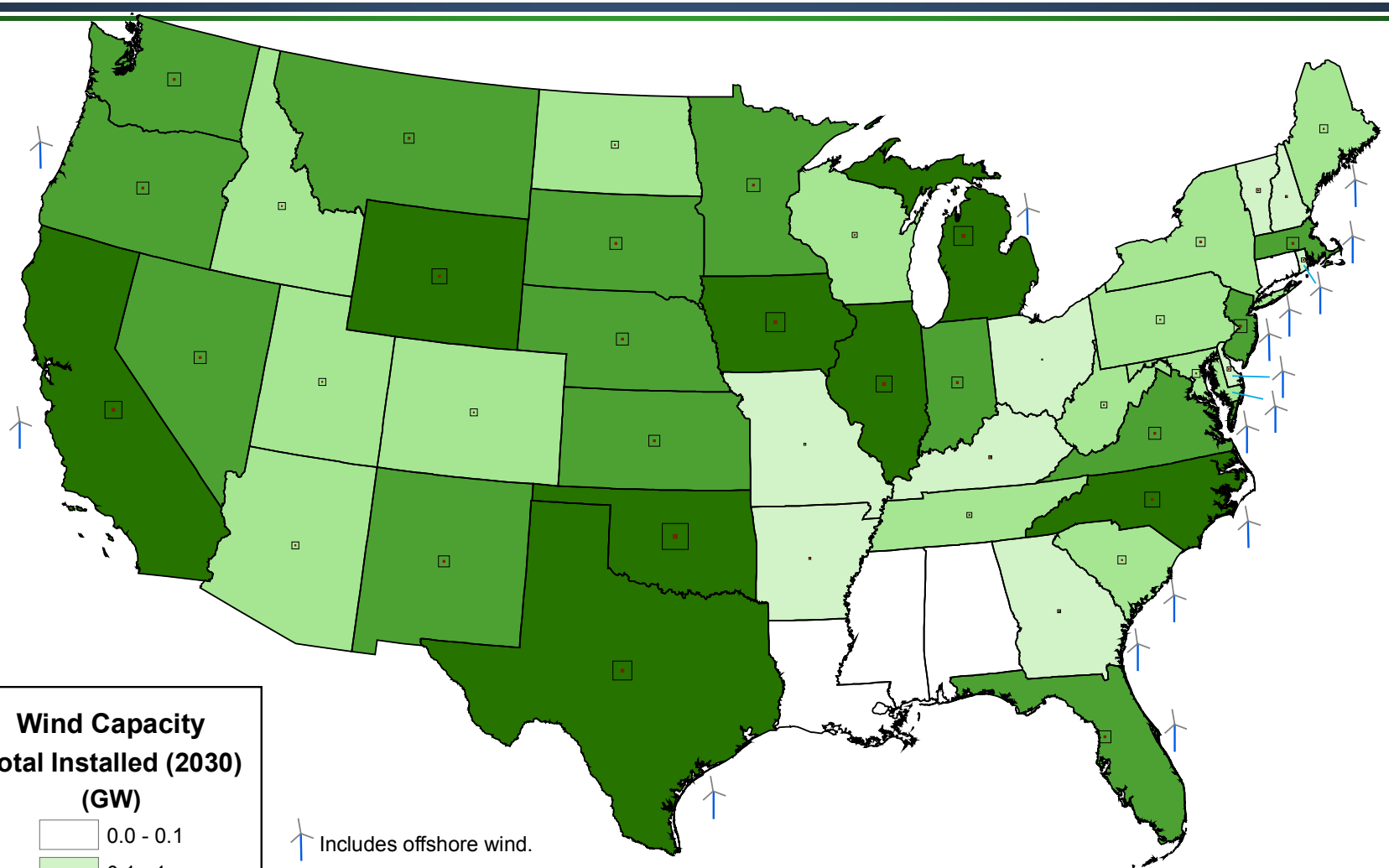
Source: DOE 20% Report

Annual Installed Capacity vs. Current Installed Capacity



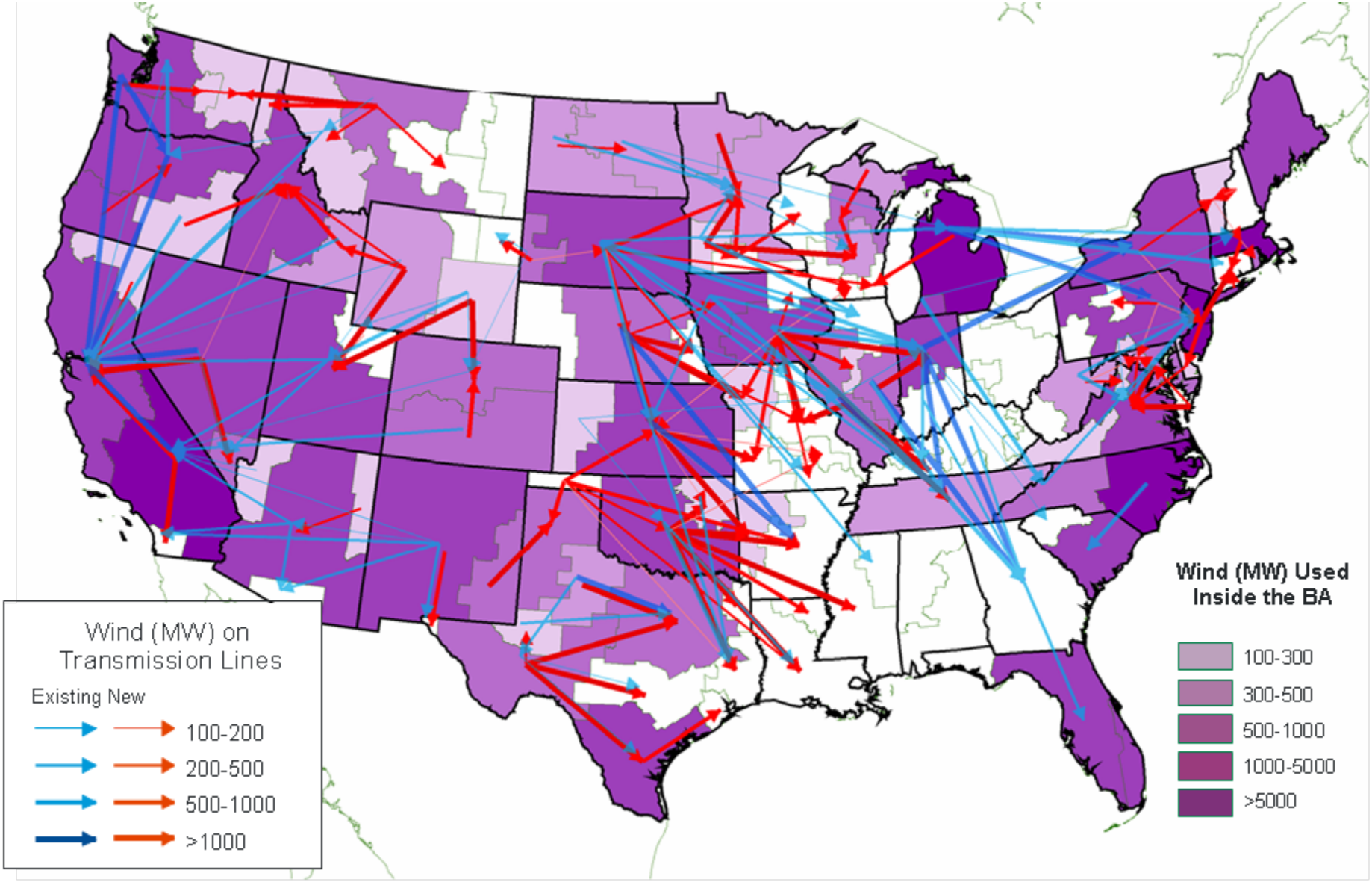
Source*: AWEA, 2008

46 States Would Have Substantial Wind Development by 2030

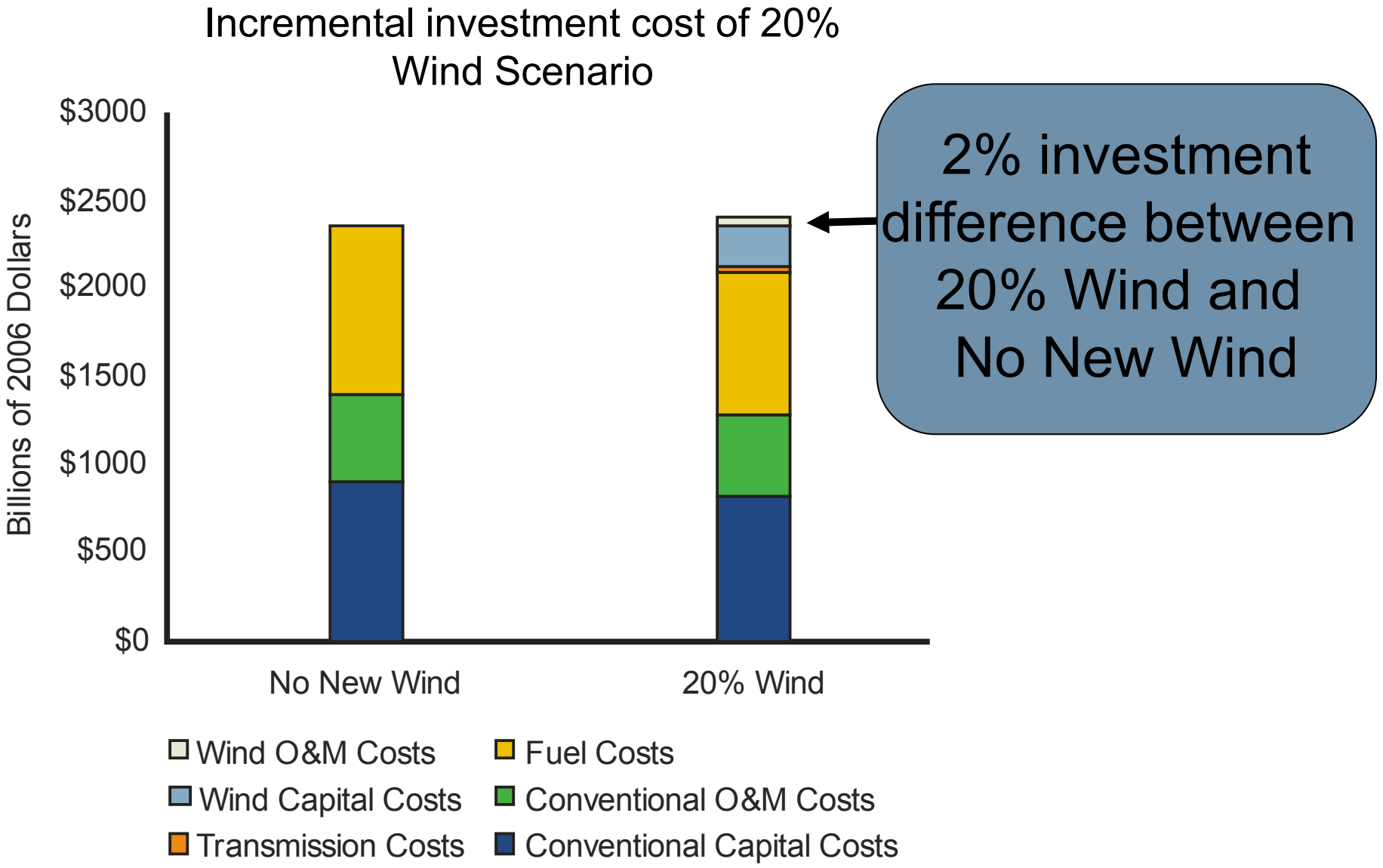


The black open square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The brown square represents the actual land area that would be dedicated to the wind turbines (2% of the black open square).

Need for New Transmission: Existing and New in 2030

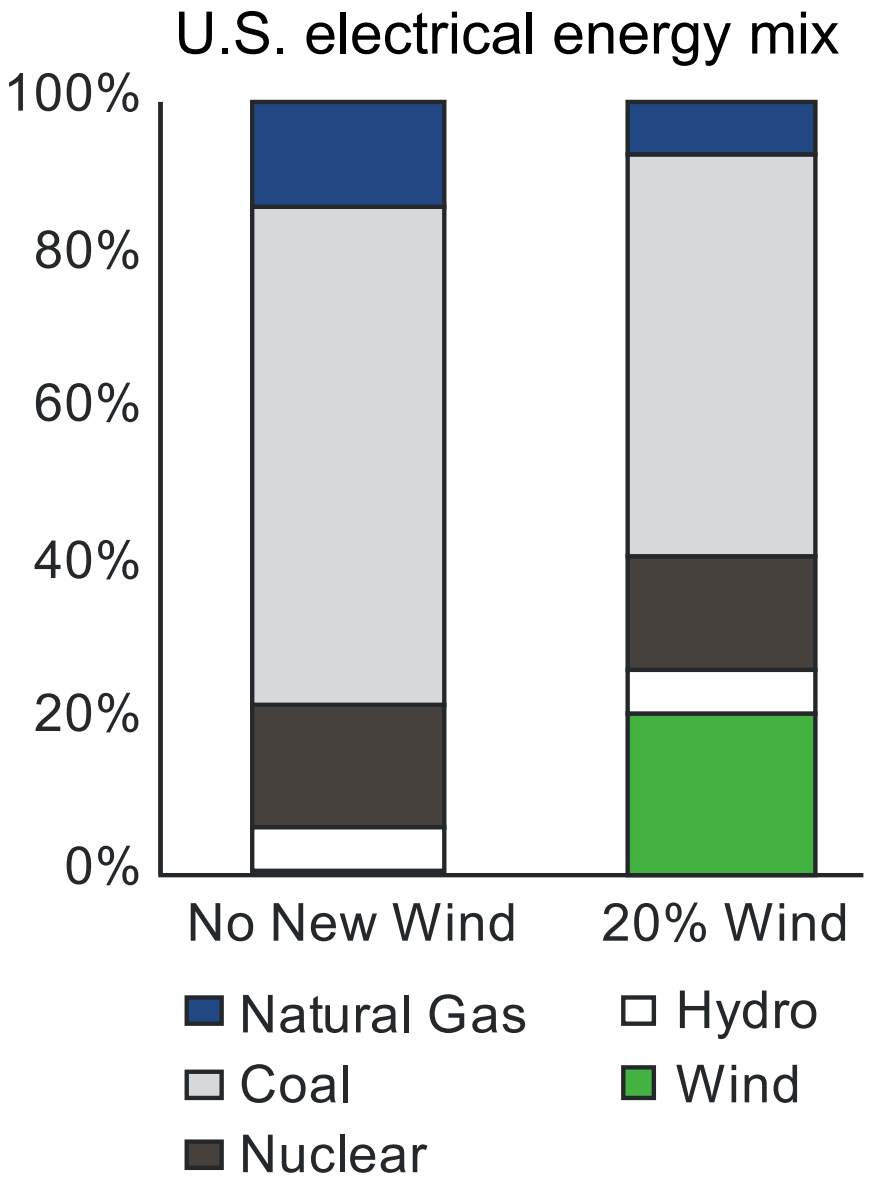


Economic Costs of 20% Wind Scenario



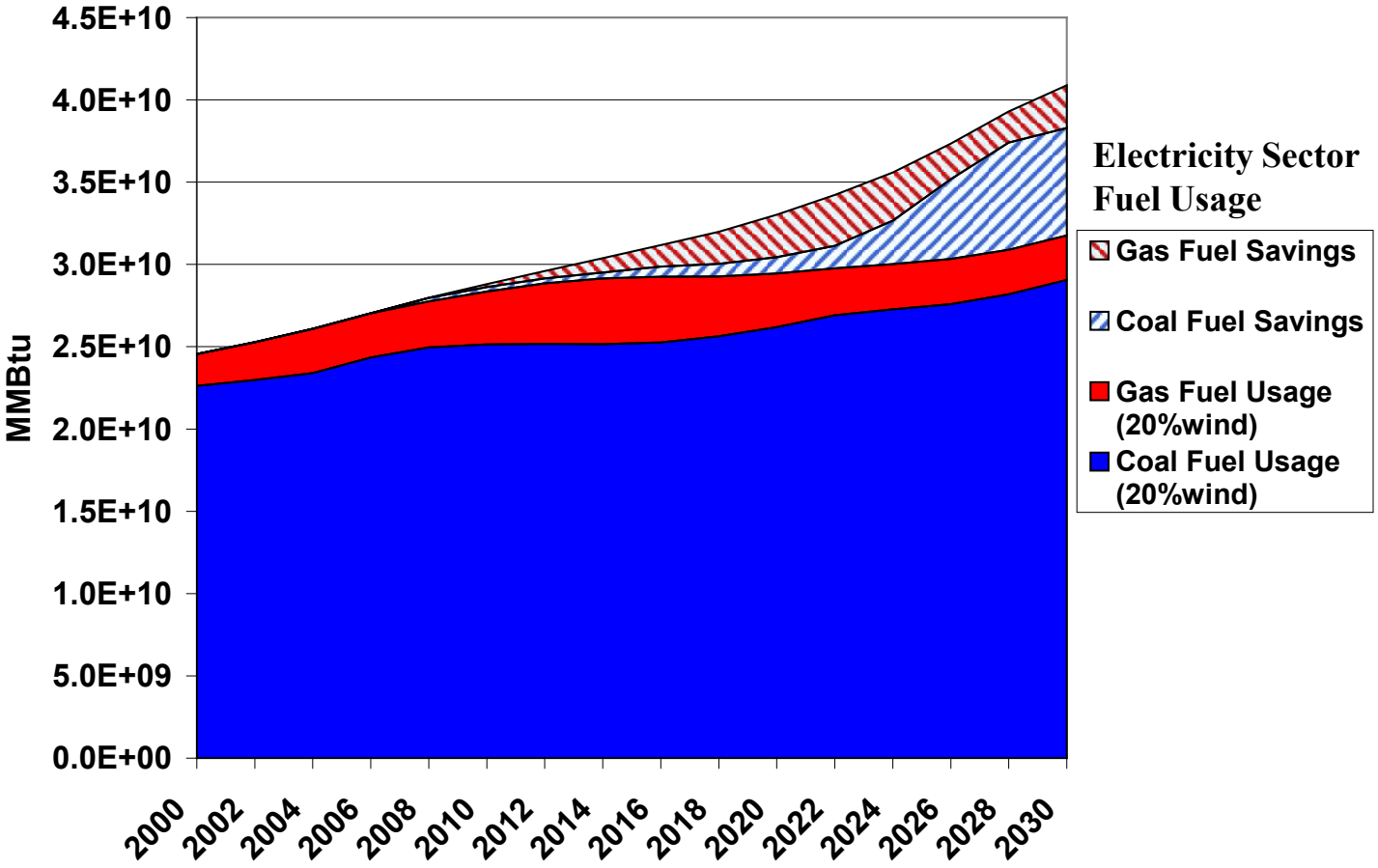
20% Wind Scenario Impact on Generation Mix in 2030

- Reduces electric utility natural gas consumption by 50%
- Reduces total natural gas consumption by 11%
- Natural gas consumer benefits: $86-214 billion*
- Reduces electric utility coal consumption by 18%
- Avoids construction of 80 GW of new coal power plants



Source *: Hand et al., 2008

Fuel Savings from Wind

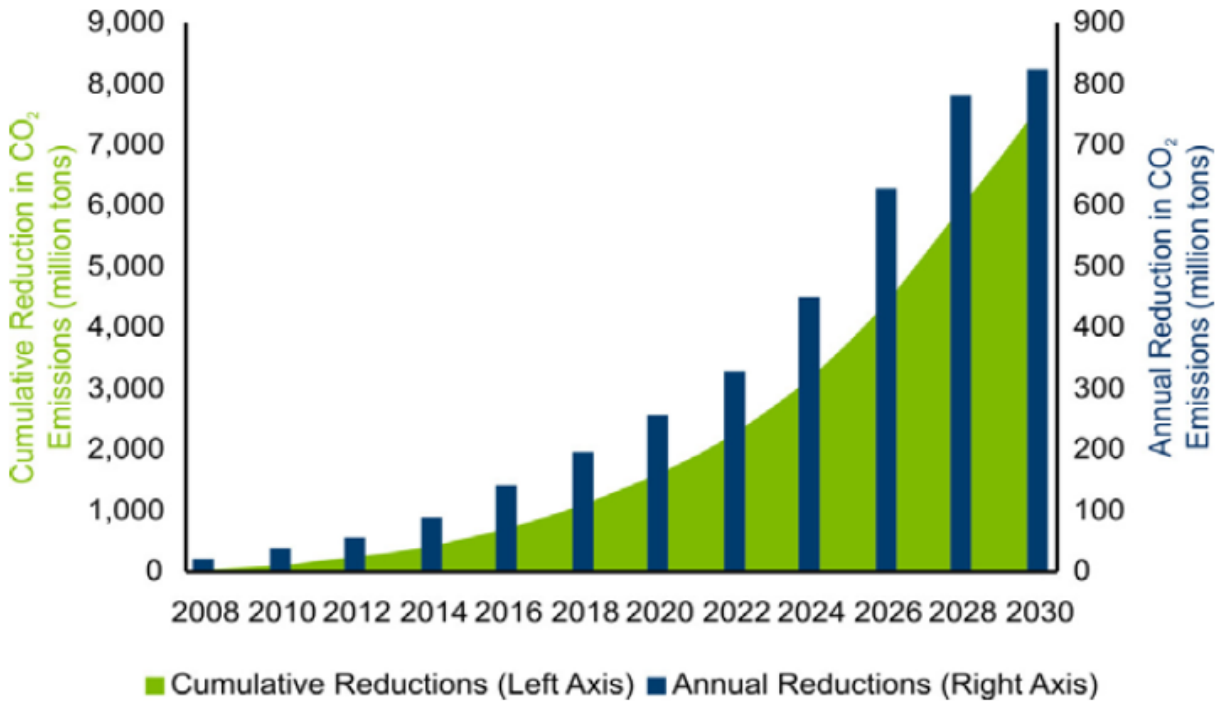


Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006$/MMBtu)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh)
11%	0.6 -**1.1**- 1.5	86 - **150** - 214	16.6 - **29** - 41.6

Cumulative Carbon Savings

Figure 1-12. Annual CO_2 emissions avoided (vertical bars) would reach 825 million tons by 2030.

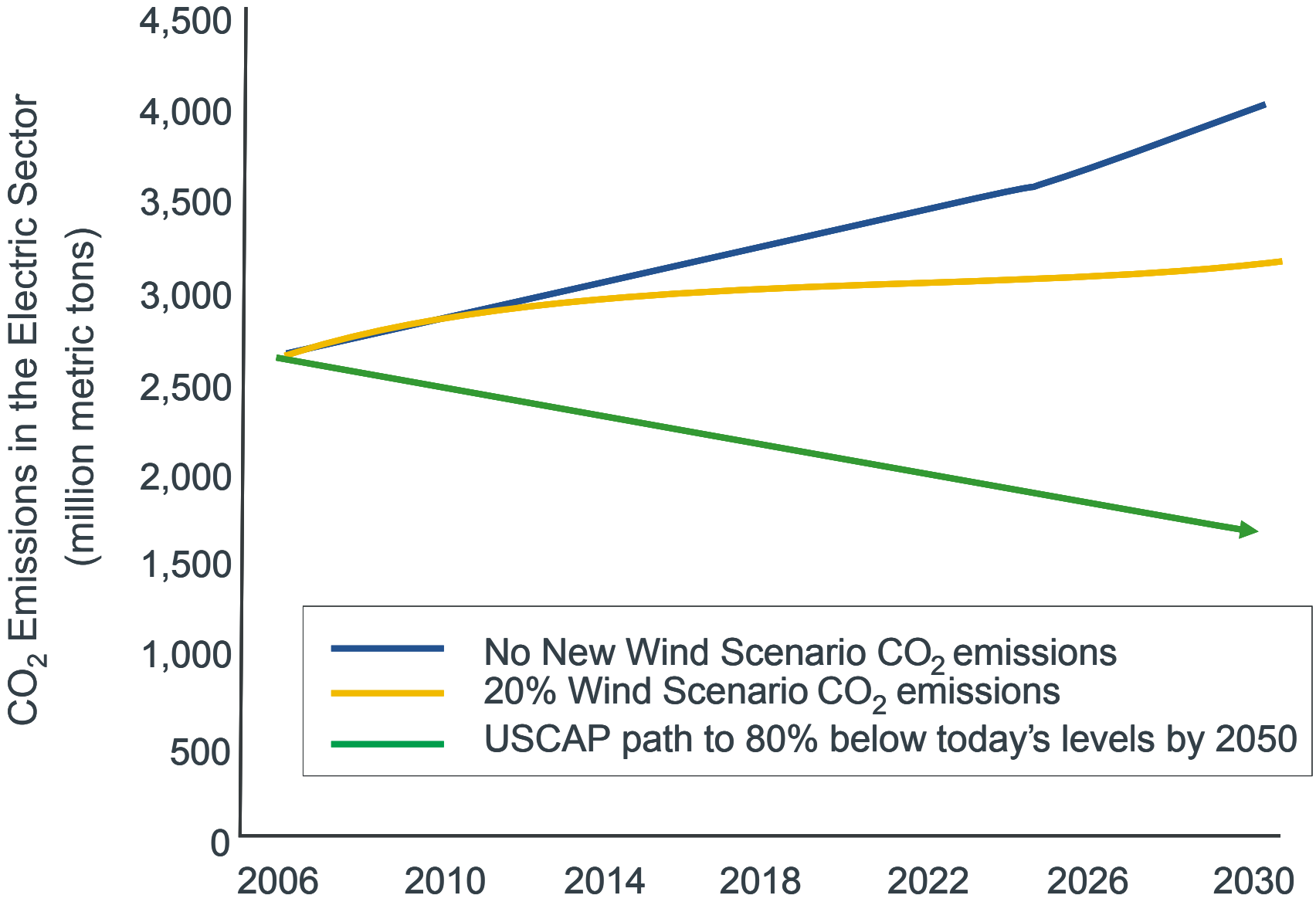
The cumulative avoided emissions by 2030 would total 7,600 million tons.



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

Source: DOE 20% Vision Report

CO2 Emissions from the Electricity Sector



National (U.S.) Economic Impacts

Cumulative Impacts from 2007-2030

From the 20% Scenario – 300 GW new Onshore and Offshore Development

JEDI Model Version W1.09.03e

Wind energy's economic "ripple effect"

Project Development & Onsite Labor Impacts

Landowner Revenue:
- $783 million

Local Property Taxes:
- $1,877 million

Construction Phase:
- 834,072 FTE jobs
- $65 billion to the US economy

Operational Phase:
- 366,441 FTE jobs
- $17 B to the US economy

Local Revenue, Turbine, & Supply Chain Impacts

Construction Phase:
- 2.63 M FTE jobs
- $526 billion to the US economy

Operational Phase:
- 1.3 M FTE jobs
- $207 billion to the US economy

Induced Impacts

Construction Phase:
- 2.75 M FTE jobs
- $353 billion to the US economy

Operational Phase:
- 1.64 M FTE jobs
- $192 billion to the US economy

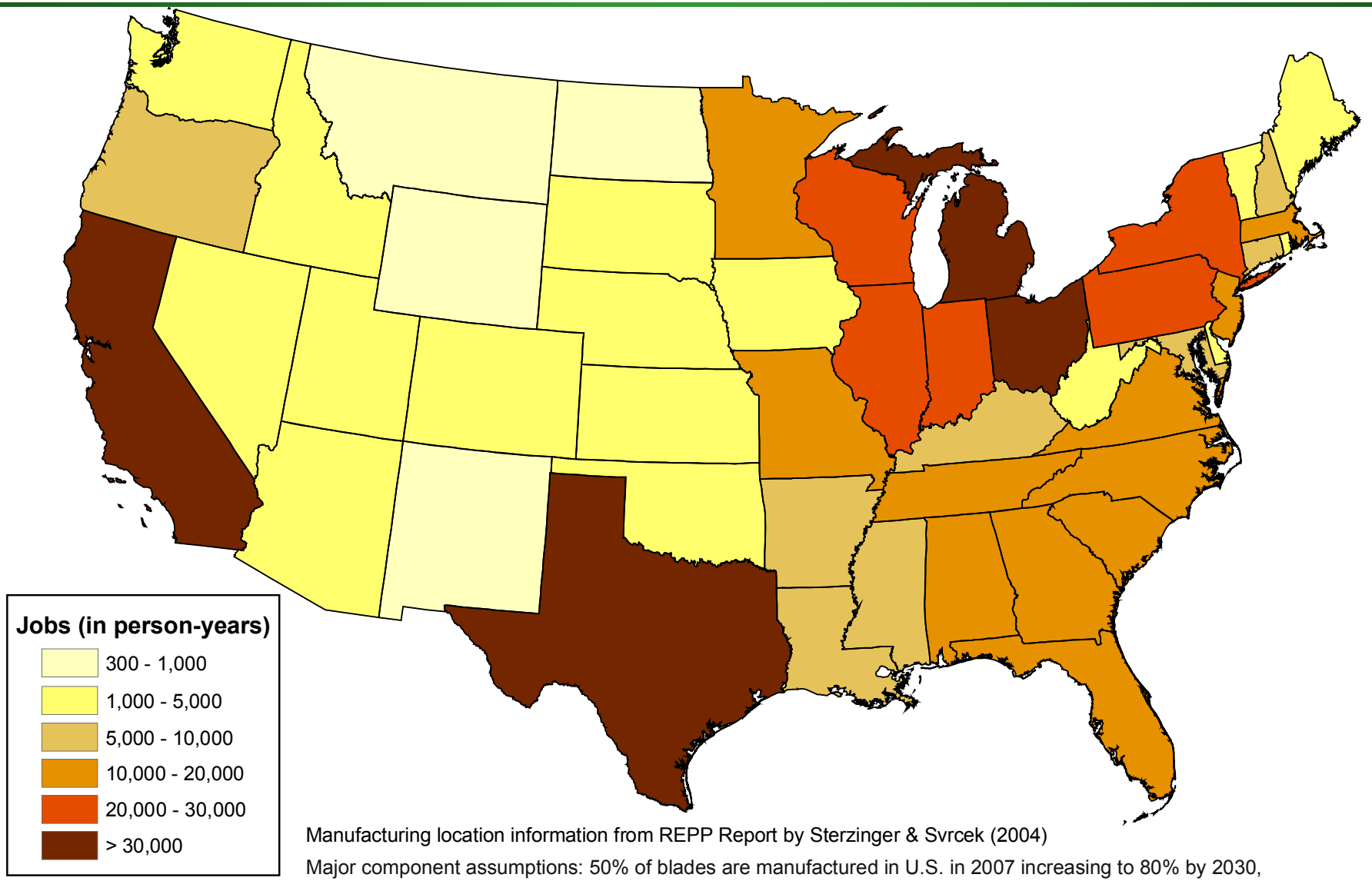
***Totals** (construction + 20 years)*

Total economic benefit: $1.36 trillion
New local jobs during construction: 6.2 M FTE
New local long-term jobs: 3.3 M FTE

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

All assumptions based on DOE Report: *20% Wind Energy by 2030*

Manufacturing Jobs Supported by State

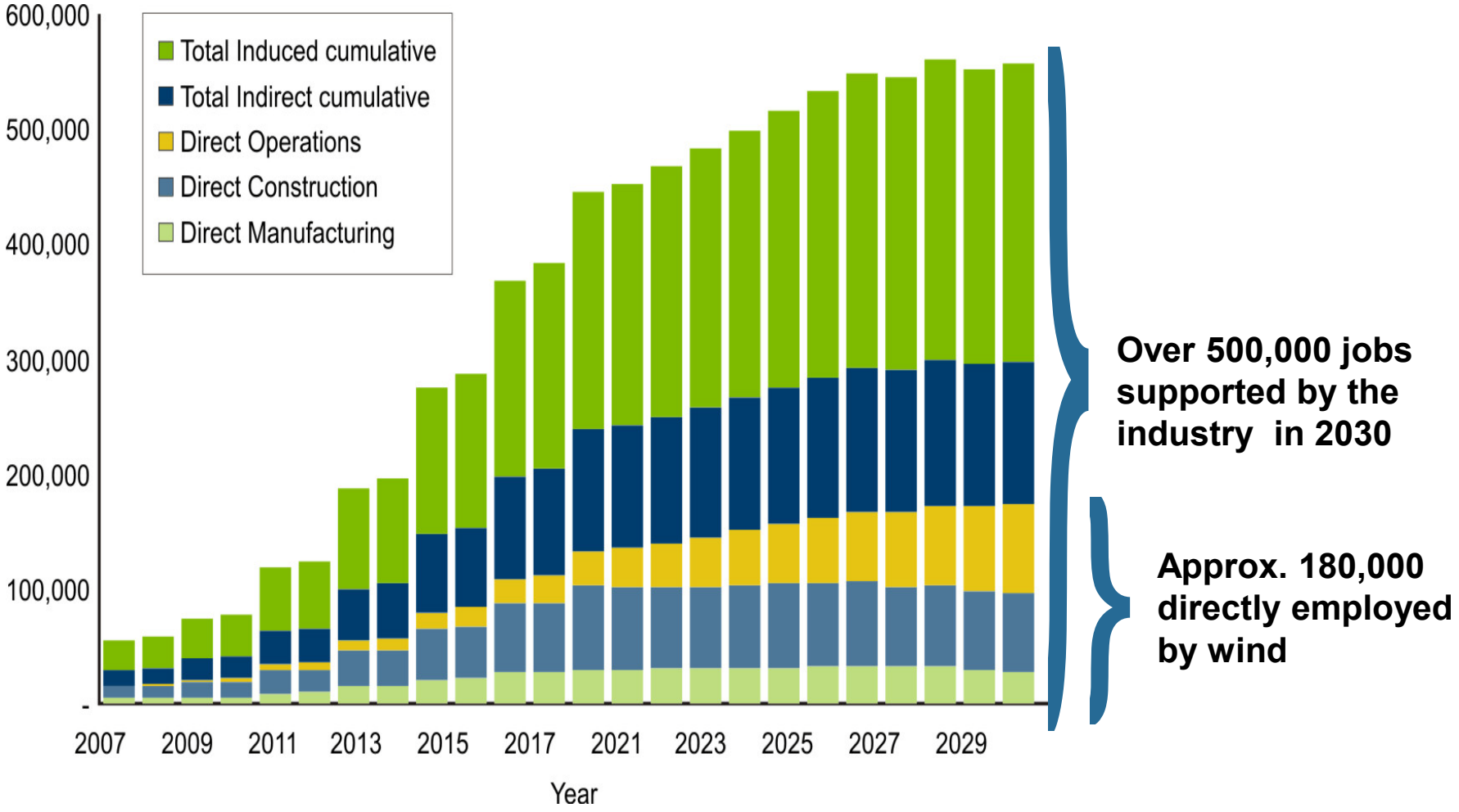


Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

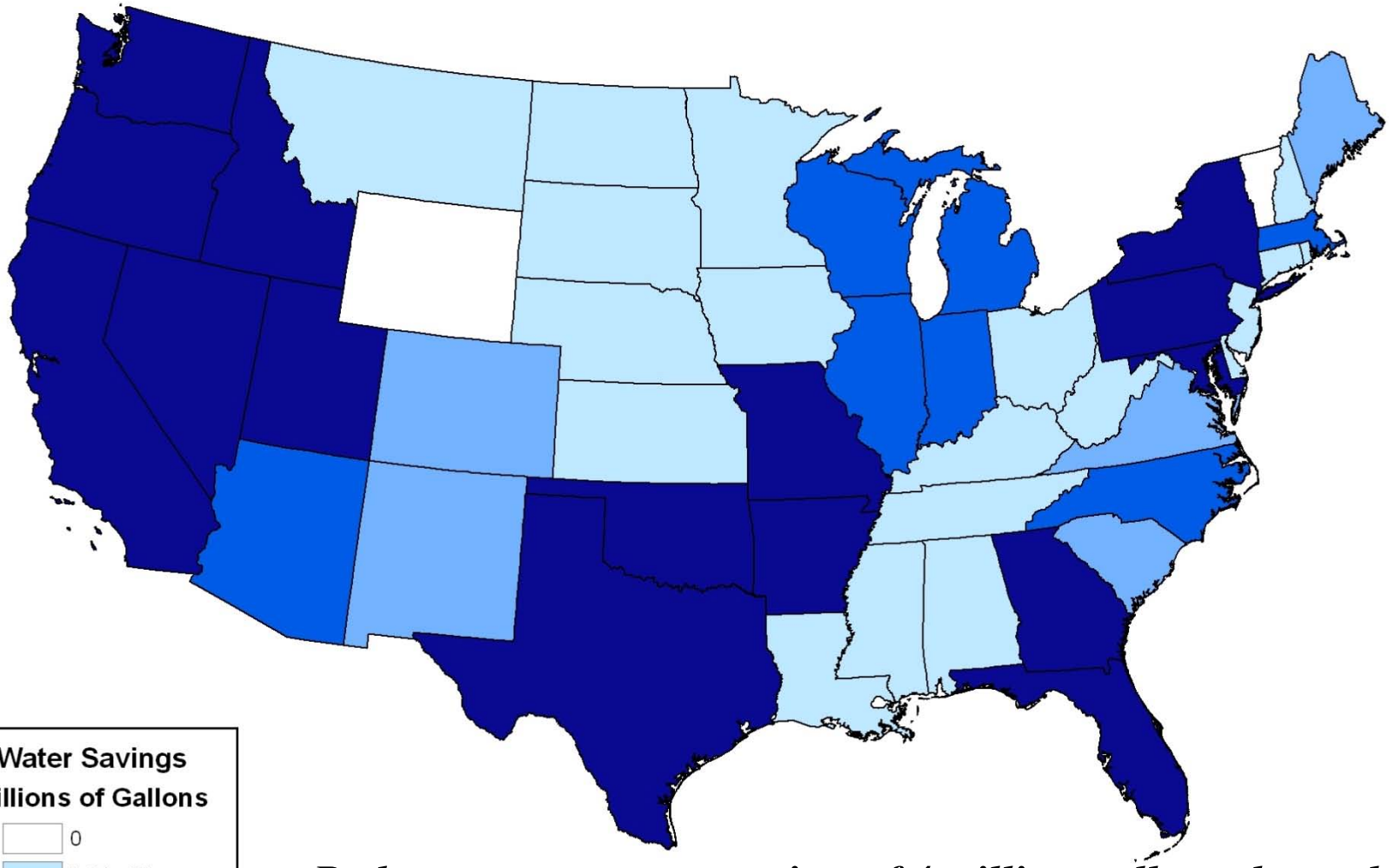
Major component assumptions: 50% of blades are manufactured in U.S. in 2007 increasing to 80% by 2030, 26% of towers are from the U.S. in 2007 increasing to 50% by 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.

Jobs Supported by the 20% Scenario

Over 500,000 jobs would be supported between 2007 and 2030



Cumulative Water Savings from 20% Scenario



Reduces water consumption of 4 trillion gallons through 2030 (represents a reduction in electric sector water consumption by 17% in 2030)

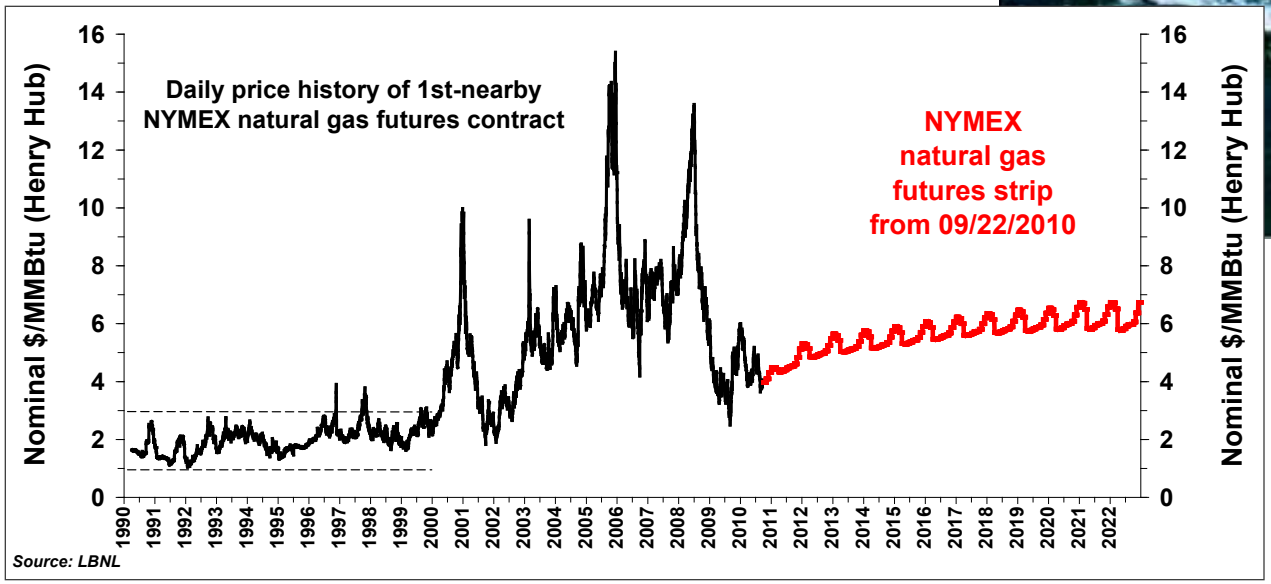
Wind Power Avoids Other Negative Impacts

- Wind power avoids the negative impacts of fossil fuel-based electricity generation:
  - Air emissions of mercury or other heavy metals
  - Emissions from extracting and transporting fuels
  - Lake and streambed acidification
  - Production of toxic solid wastes, ash, or slurry

Photo courtesy: NREL

Other Benefits of 20% Wind Energy

- Improves energy security by diversifying electricity portfolio with an indigenous energy source
- Reduces fossil fuel demand and fuel prices, helping to stabilize electricity rates



Results: Costs & Benefits

Incremental direct cost to society	**$43 billion**
Reductions in emissions of greenhouse gasses 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	150,000 direct $450 billion total
Reductions in natural gas use and price pressure	11% **$150 billion**
Net Benefits: $205B + Water savings	

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 report: May 2008 (www.20percentwind.org)

Wind Stakeholders

Carpe Ventem










www.windpoweringamerica.gov