NREL
NATIONAL RENEWABLE ENERGY LABORATORY

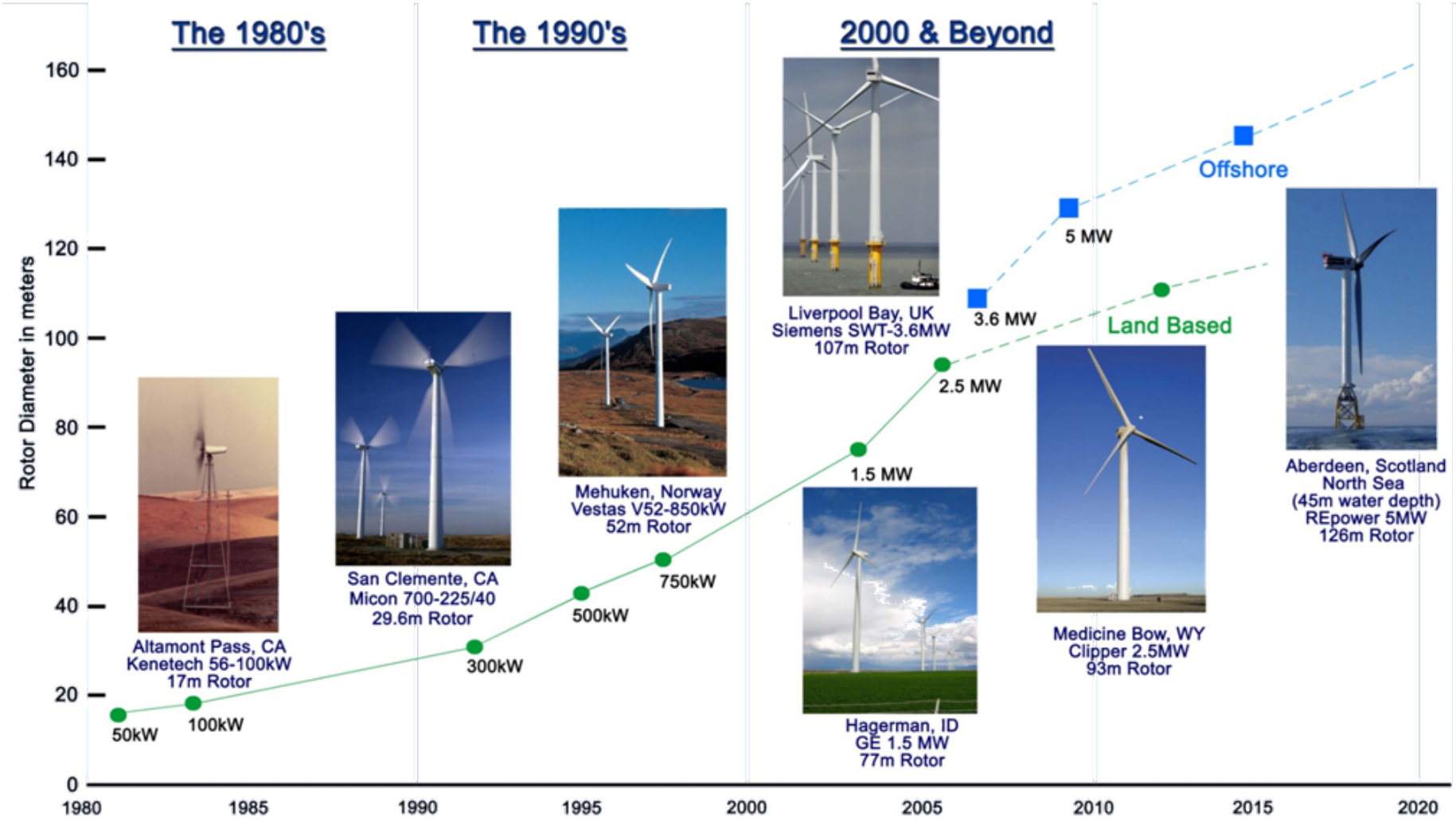
WIND POWERING AMERICA

Wind Energy Update

Wind Powering America
January 2012

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Evolution of Commercial Wind Technology



Sizes and Applications

Small (≤100 kW)

Homes

Farms

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

Midscale (100-1000 kW)

Village Power

Hybrid Systems

Distributed Power

Large, Land-based (1-3 MW)

Utility-scale wind farms

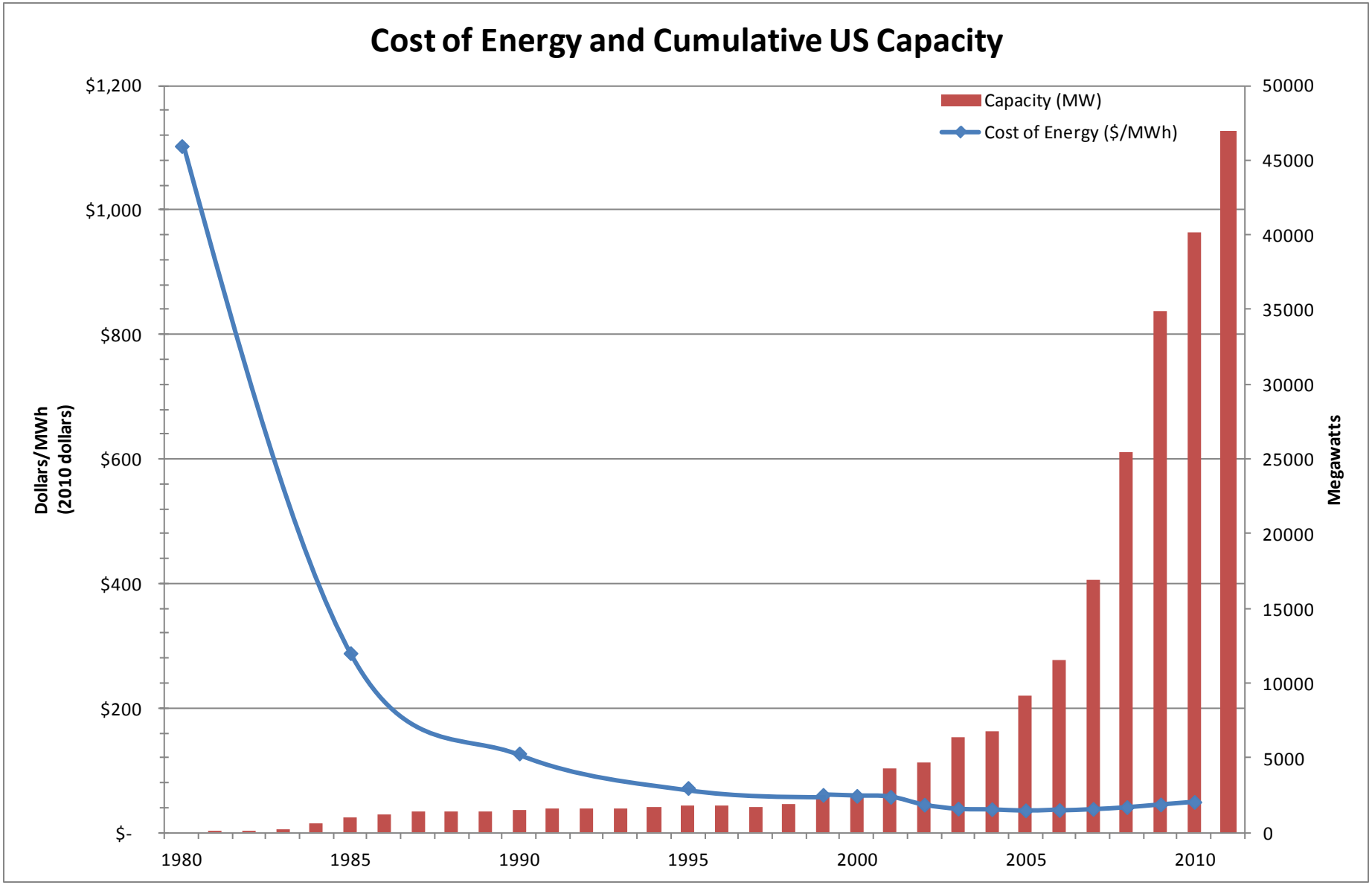
Large Distributed Power

Large, Offshore (3-7 MW)

Utility-scale wind farms, shallow coastal waters

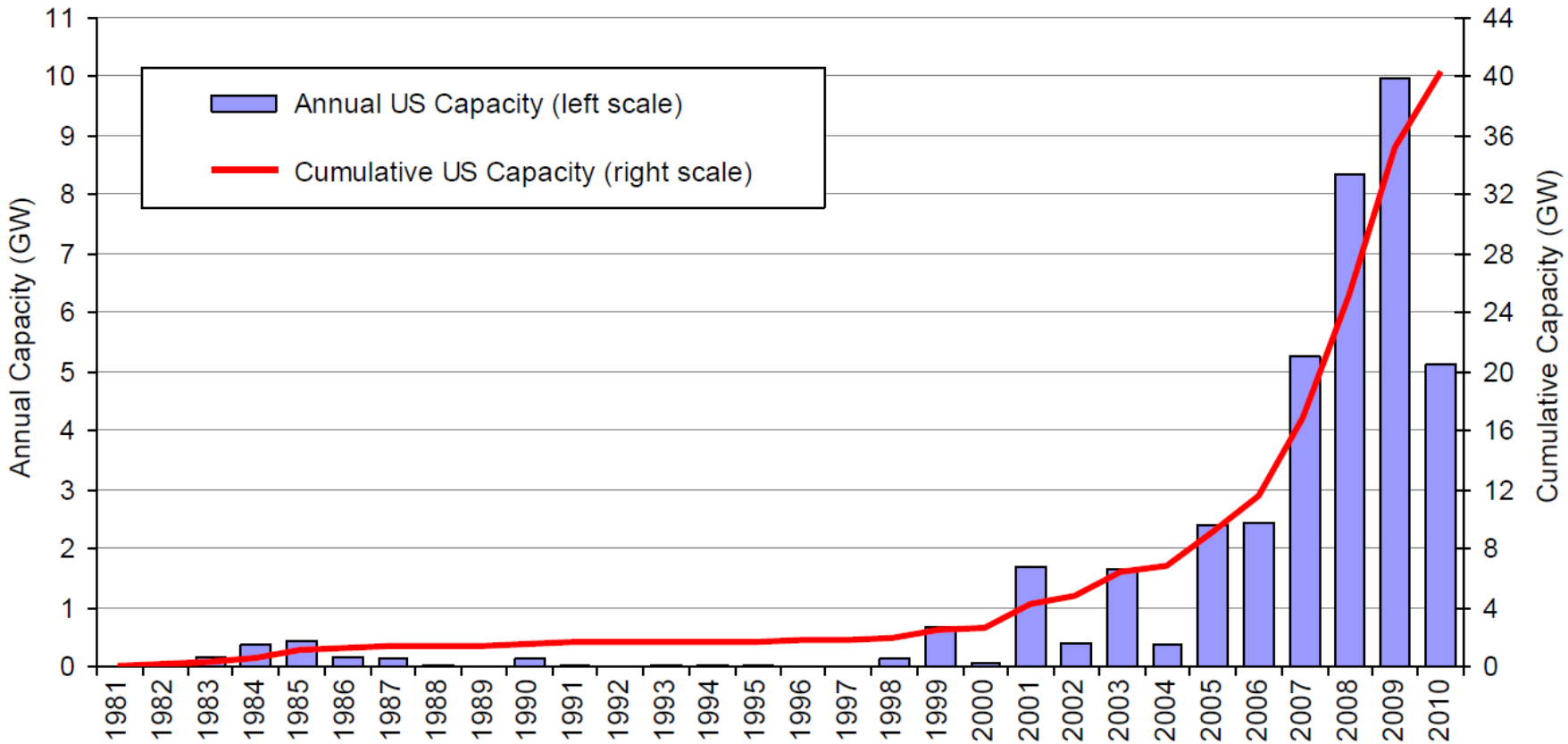
No U.S. installations

Capacity & Cost Trends



As of January 2012 (AWEA)

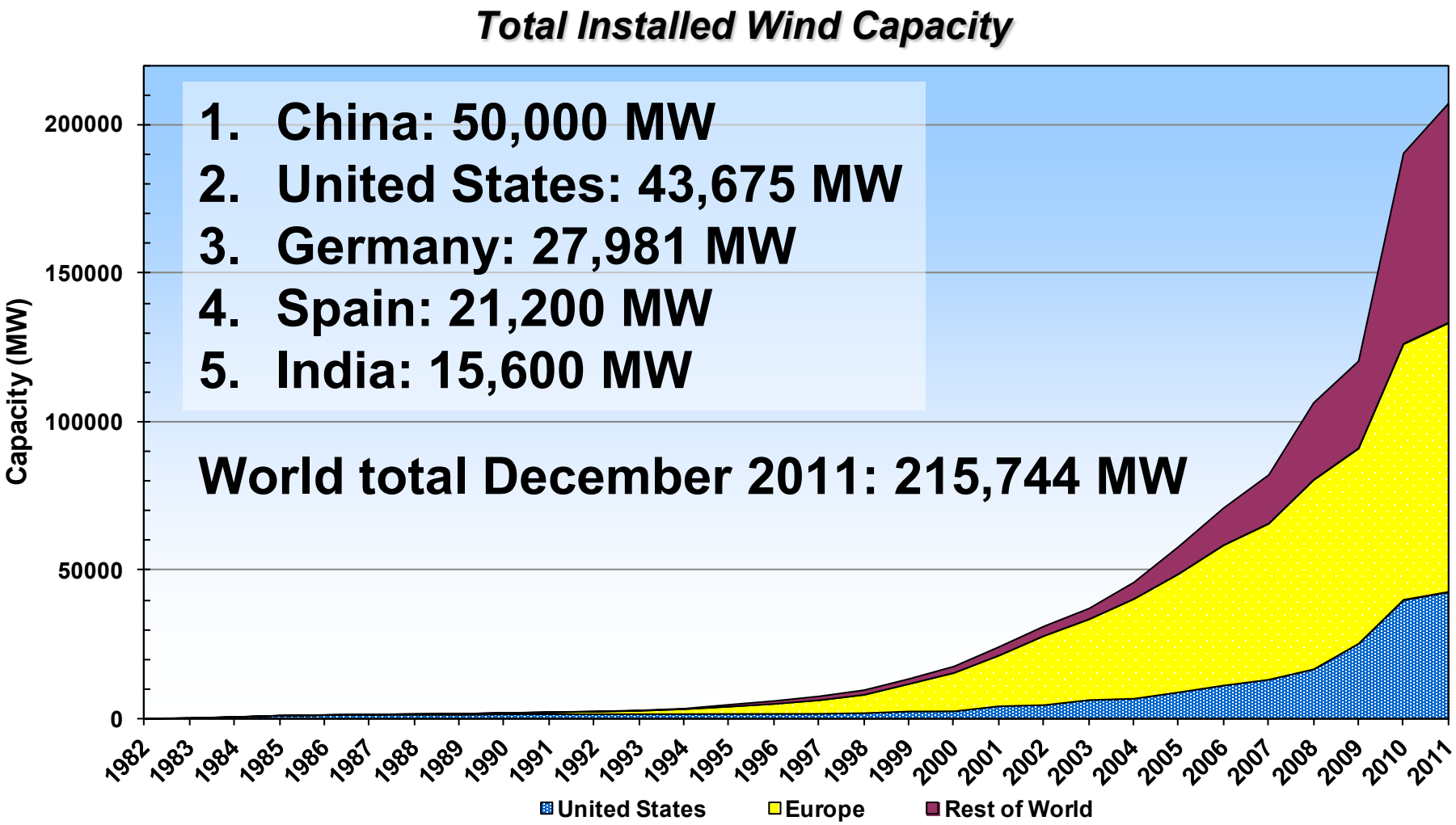
U.S. Wind Power Additions Slowed in 2010



- 5.1 GW of wind power added in 2010 in US, $11 billion in project investment
- Cumulative wind power capacity up by 15%, bringing total to >40 GW
- Factors slowing growth: (1) delayed impact of financial crisis; (2) low natural gas / wholesale electricity prices; (3) slumping overall demand for energy

2010 Wind Market Report, LBNL

People Want Renewable Energy!



Source: WindPower Monthly

Texas Leads Capacity, But Not Penetration

Capacity (MW)				Percentage of In-State Generation			
Annual (2010)		Cumulative (end of 2010)		Actual (2010)*		Estimated (end of 2010)**	
Texas	680	Texas	10,089	Iowa	15.4%	South Dakota	23.2%
Illinois	498	Iowa	3,675	North Dakota	12.0%	Iowa	16.9%
California	455	California	3,253	Minnesota	9.7%	North Dakota	13.5%
South Dakota	396	Minnesota	2,205	South Dakota	8.3%	Minnesota	12.3%
Minnesota	396	Washington	2,104	Kansas	7.1%	Oregon	9.8%
Oklahoma	352	Oregon	2,104	Oregon	7.1%	Wyoming	8.2%
Wyoming	311	Illinois	2,045	Wyoming	6.7%	Colorado	7.8%
Indiana	303	Oklahoma	1,482	Colorado	6.6%	Kansas	7.6%
Oregon	283	North Dakota	1,424	Texas	6.4%	Idaho	7.3%
North Dakota	221	Wyoming	1,412	Oklahoma	5.1%	Oklahoma	6.9%
Idaho	206	Indiana	1,339	New Mexico	5.0%	Texas	6.7%
Washington	196	Colorado	1,299	Washington	4.6%	New Mexico	6.0%
Missouri	149	New York	1,274	Idaho	4.0%	Washington	5.2%
New Mexico	102	Kansas	1,074	California	3.3%	Maine	4.4%
West Virginia	101	Pennsylvania	748	Montana	3.1%	Montana	3.9%
Maine	92	South Dakota	709	Maine	2.9%	California	3.9%
Maryland	70	New Mexico	700	Indiana	2.4%	Indiana	3.0%
Arizona	65	Wisconsin	469	Hawaii	2.3%	Illinois	2.8%
Kansas	61	Missouri	457	Illinois	2.2%	Hawaii	2.3%
Nebraska	60	West Virginia	431	New York	2.0%	New York	2.0%
Rest of U.S.	118	*Rest of U.S.*	1,974	*Rest of U.S.*	0.3%	*Rest of U.S.*	0.3%
TOTAL	**5,113**	**TOTAL**	**40,267**	**TOTAL**	**2.3%**	**TOTAL**	**2.6%**

* Based on 2010 wind and total generation by state from EIA's *Electric Power Monthly*.

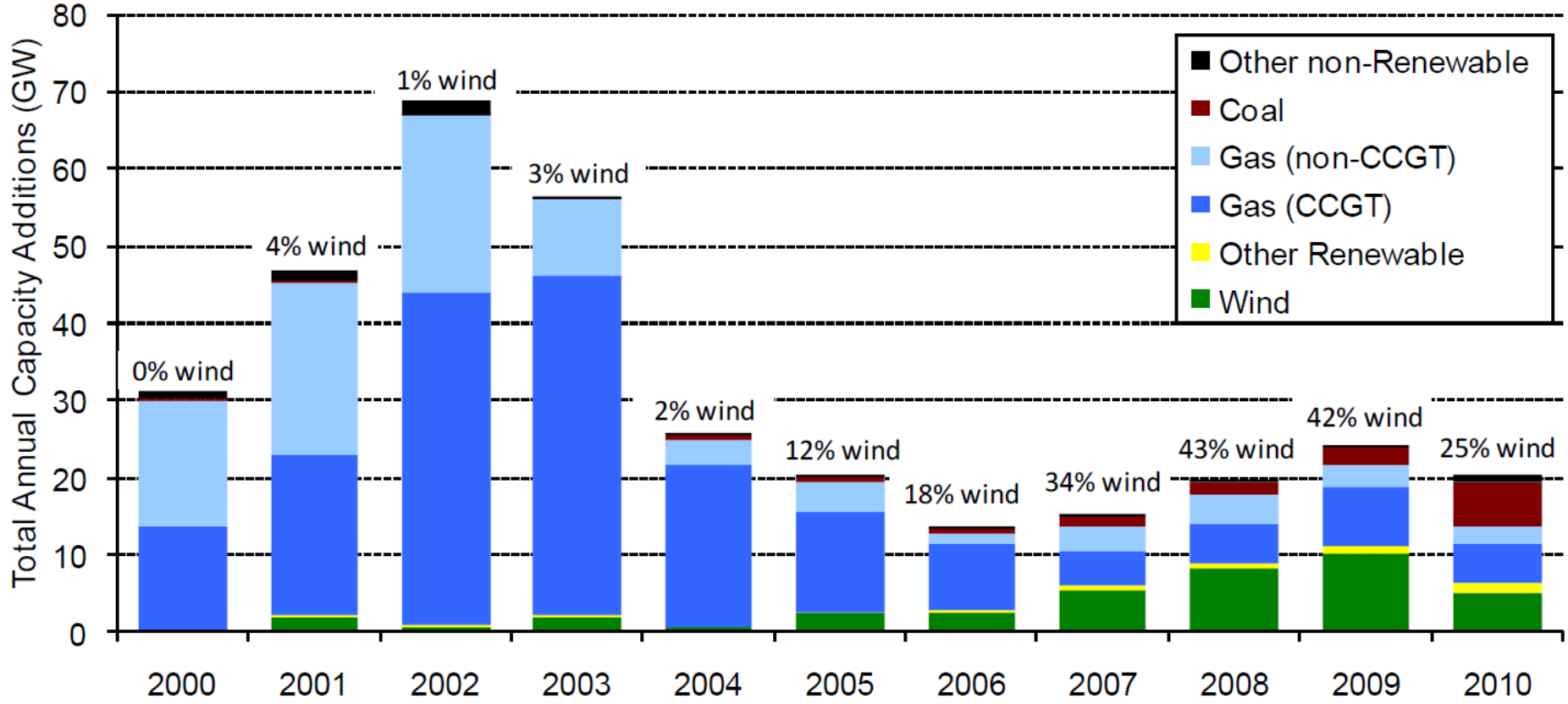
** Based on a projection of wind electricity generation from end-of-2010 wind power capacity, divided by total in-state electricity generation in 2010.

Source: AWEA project database, EIA, Berkeley Lab estimates

At end of 2010:

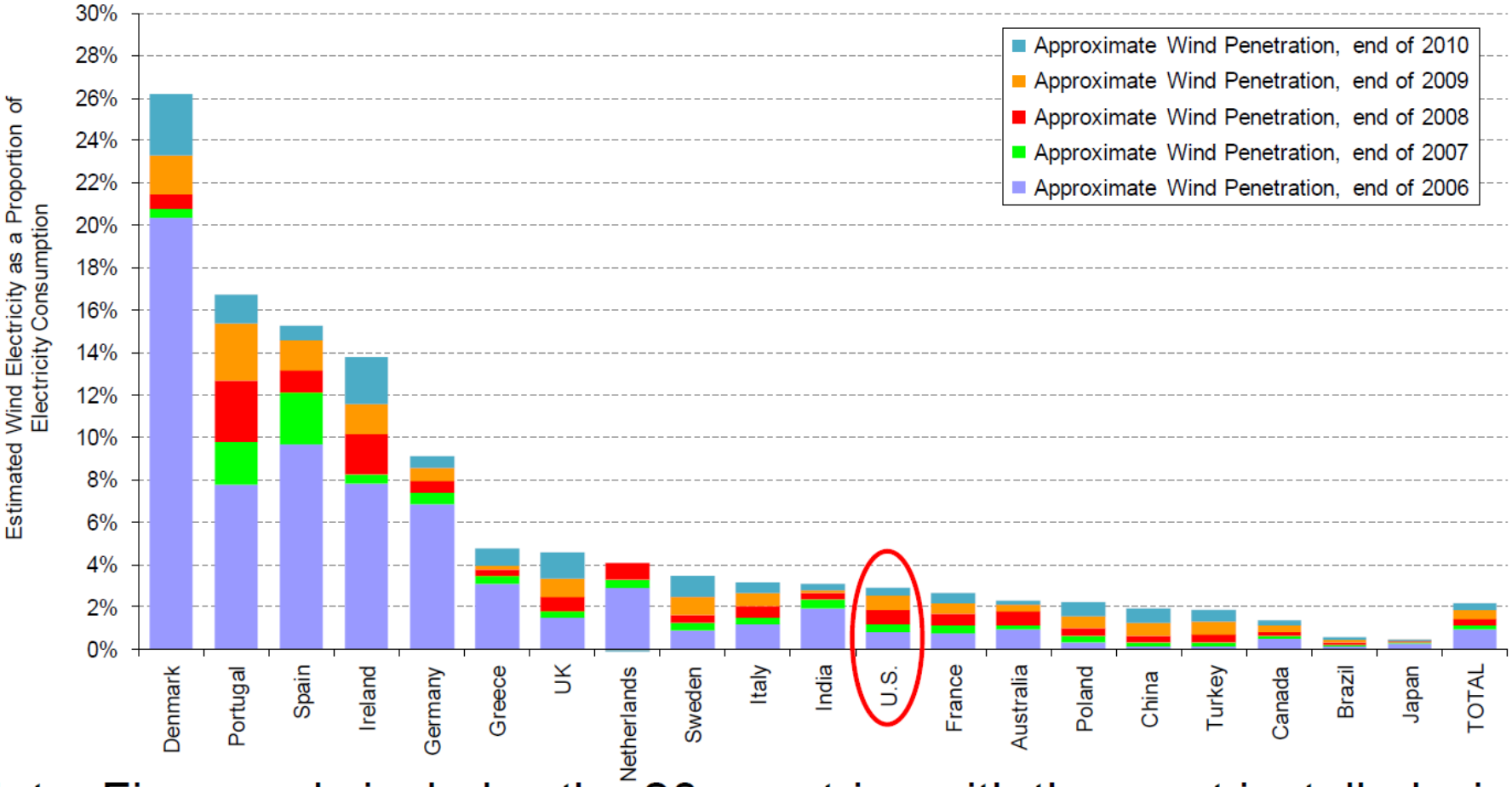
- 17 states had >500 MW of wind capacity (7 had >2000 MW)
- 4 states had the ability to provide >10% of total in-state generation from wind (13 states >5%)

Since 2006, Wind has been a major contributor to new U.S. electric capacity



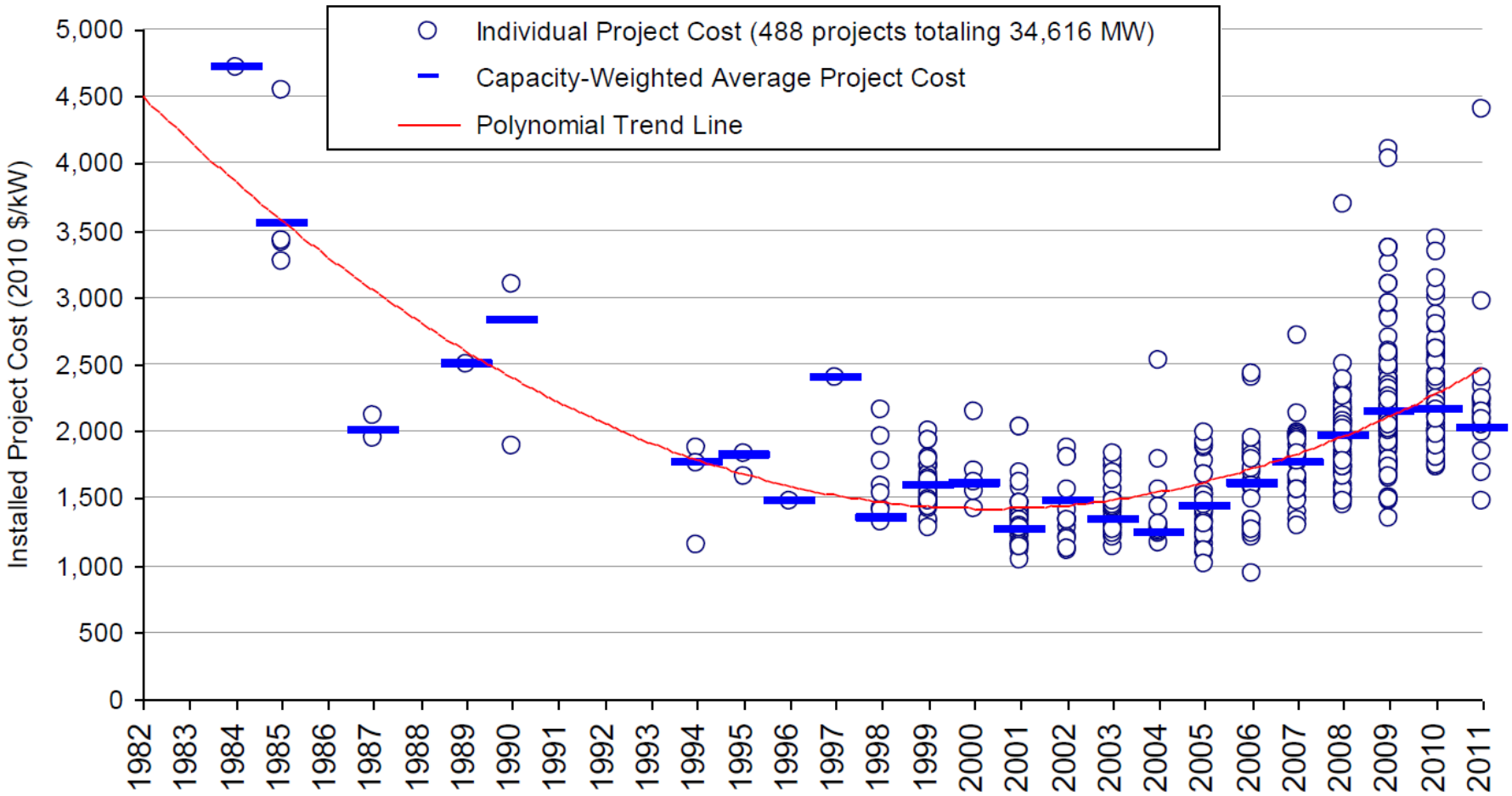
- But 25% in 2010 represents wind's lowest share since 18% in 2006
- Wind slips to 3rd-largest resource added in 2010, after gas and coal

U.S total wind contributions still low compared to other leading countries



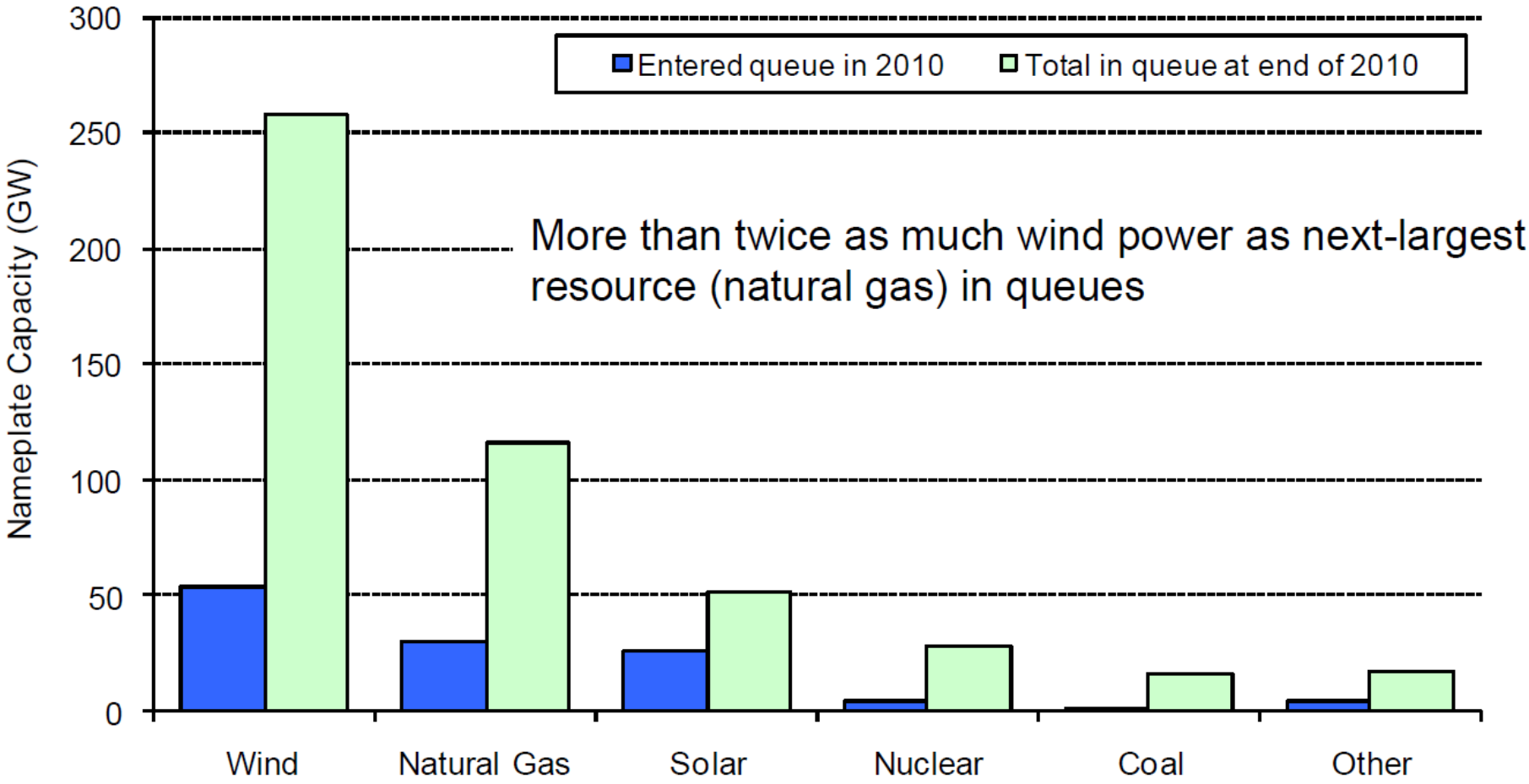
Note: Figure only includes the 20 countries with the most installed wind power capacity at the end of 2010

Average Installed Cost Held Steady in 2010, But is Expected to Decline in 2011/12



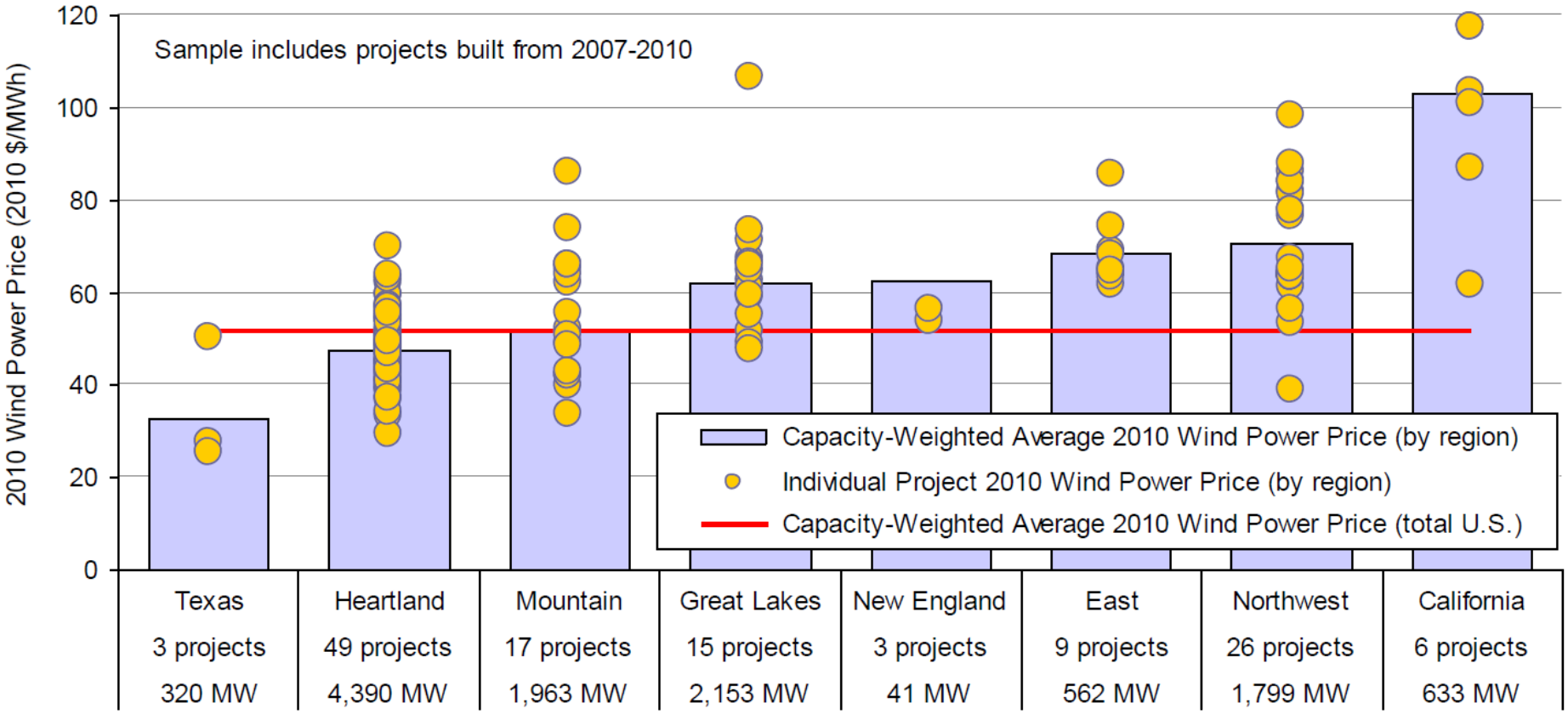
Note: 2011 sample of 17 projects totaling ~1 GW is preliminary

Roughly 260 GW of Wind Power Capacity in Transmission Interconnection Queues



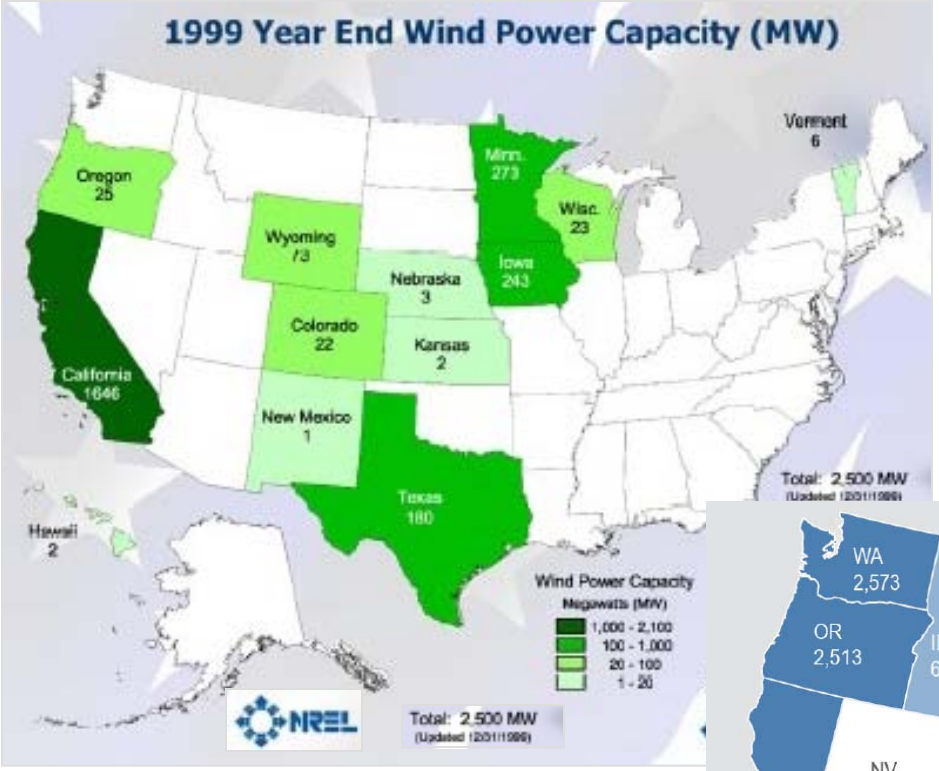
Not all of this capacity will be built….

Regional Differences Explain Some of the Underlying Variability in Wind Sales Prices

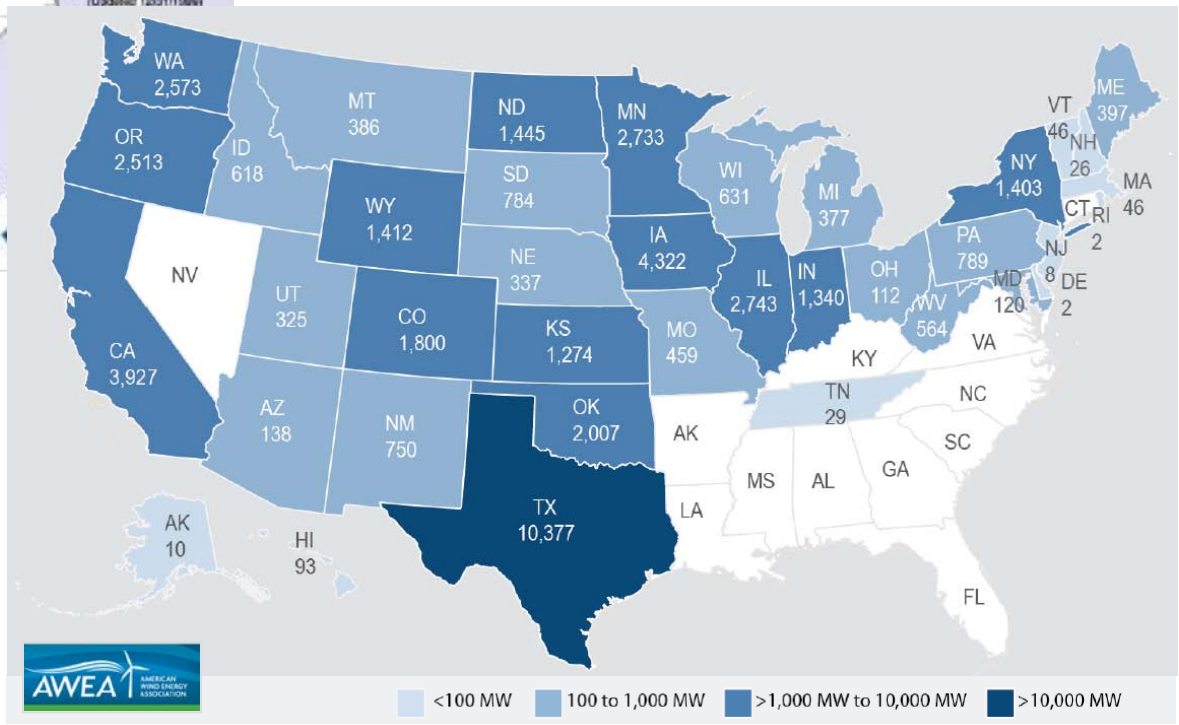


Though sample size is problematic in both regions, Texas and California represent opposite extremes of the regional breakdown

Installed Wind Capacities 1999 – January 2012

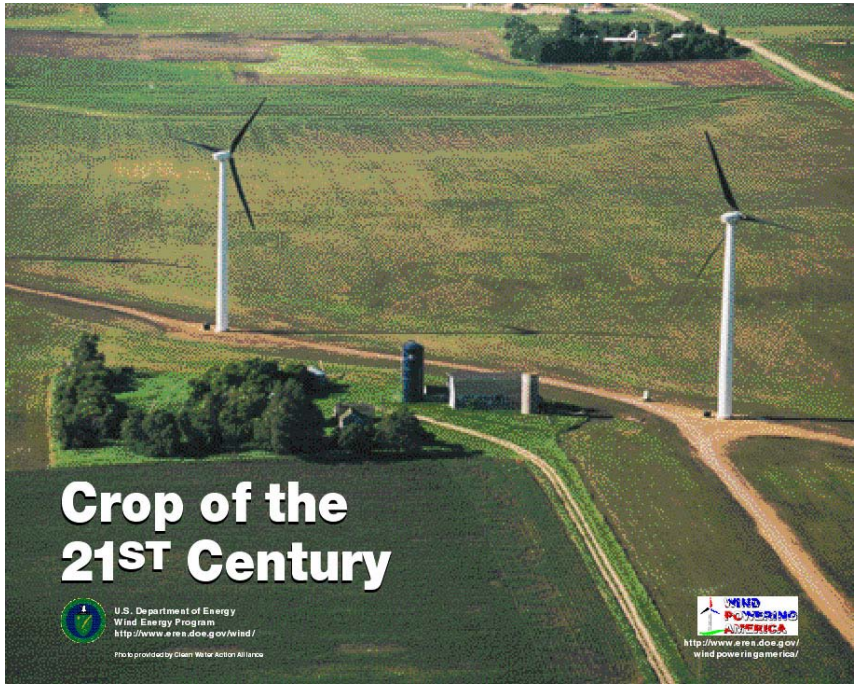


Total Installed Capacity:
46,919 MW
As of January 2012

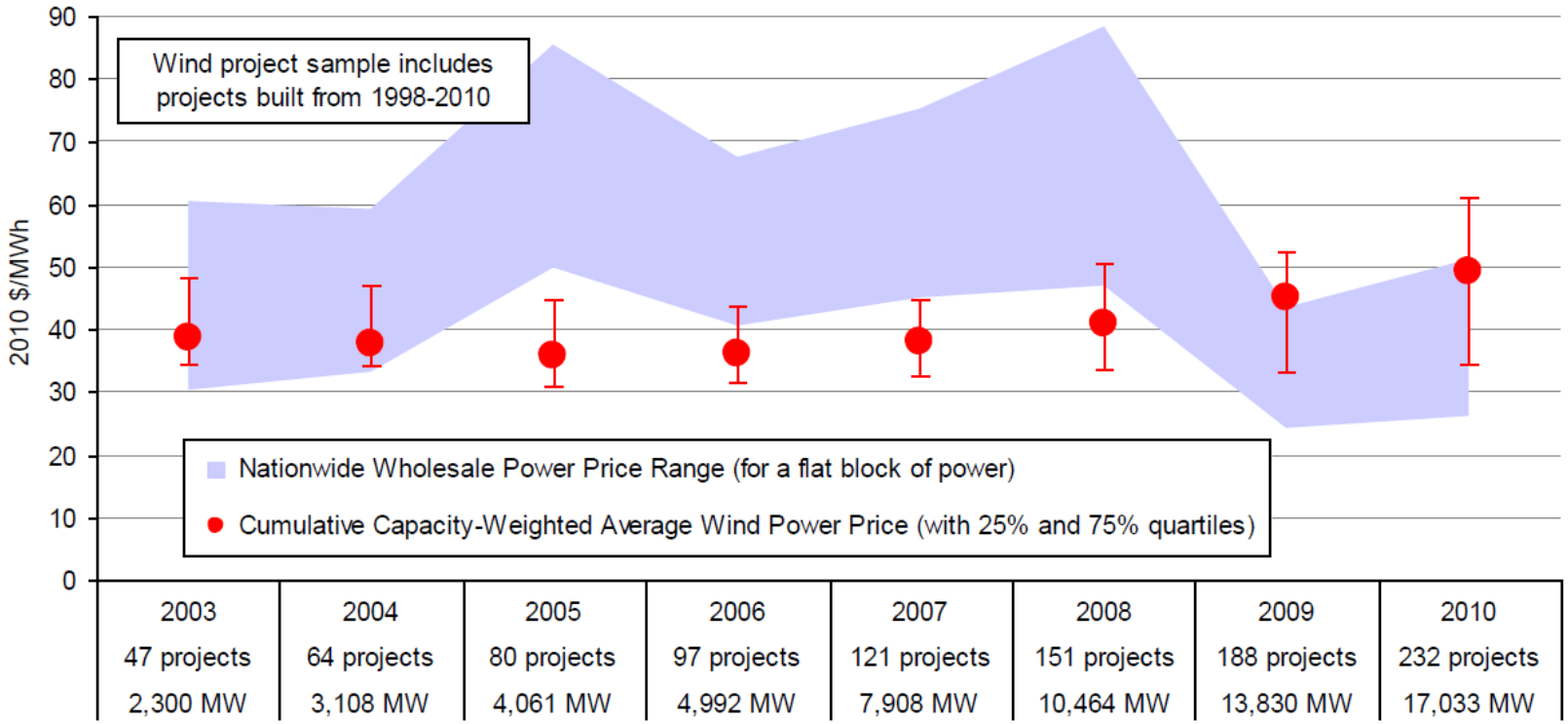


Drivers for Wind Power

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

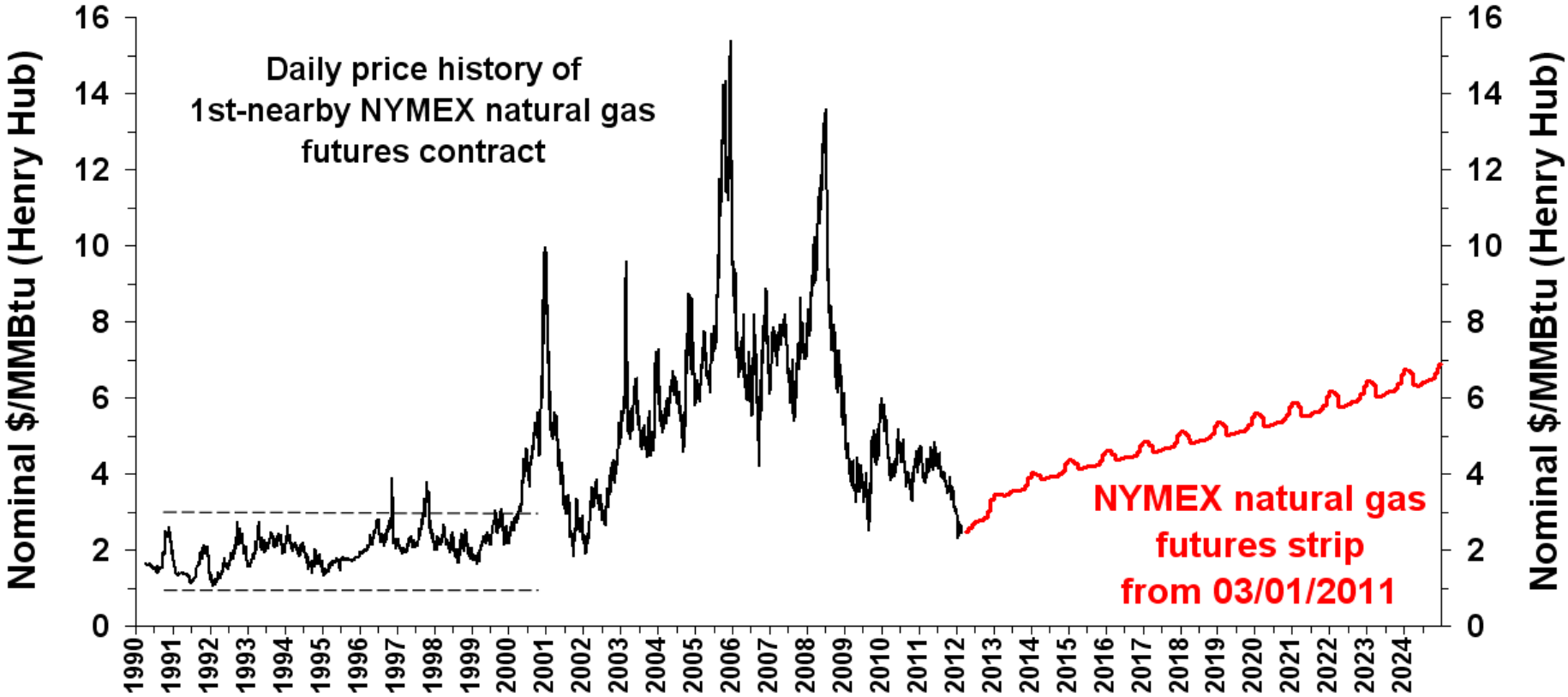


Low Wholesale Electricity Prices Continued to Challenge the Relative Economics of Wind Plants Installed in Recent Years



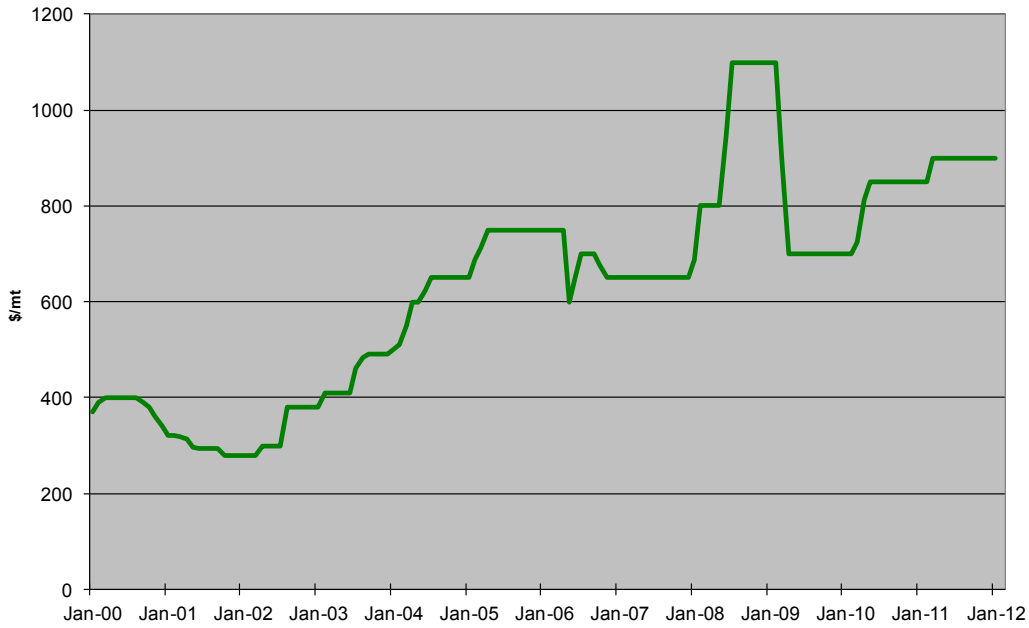
- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- Recent wholesale prices reflect low natural gas prices, driven by weak economy and shale gas
- Price comparison shown here is far from perfect – ***see full report for caveats***

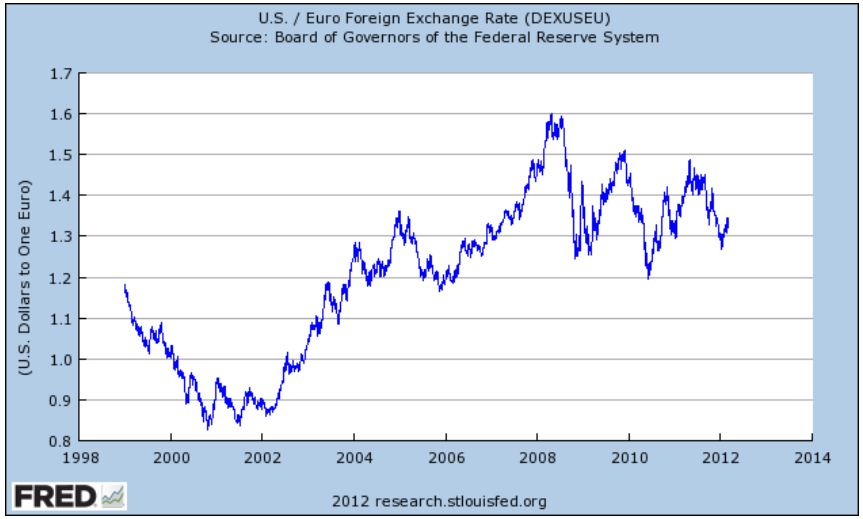
Natural Gas – Historic Prices



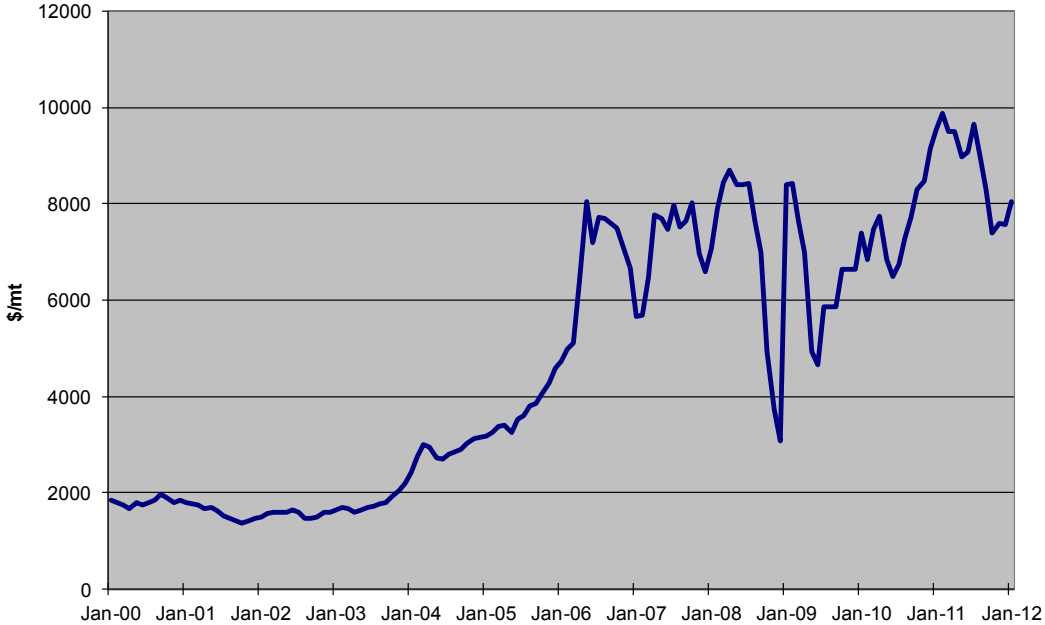
Source: NYMEX, LBNL

Historic Steel Prices - Cold Rolled





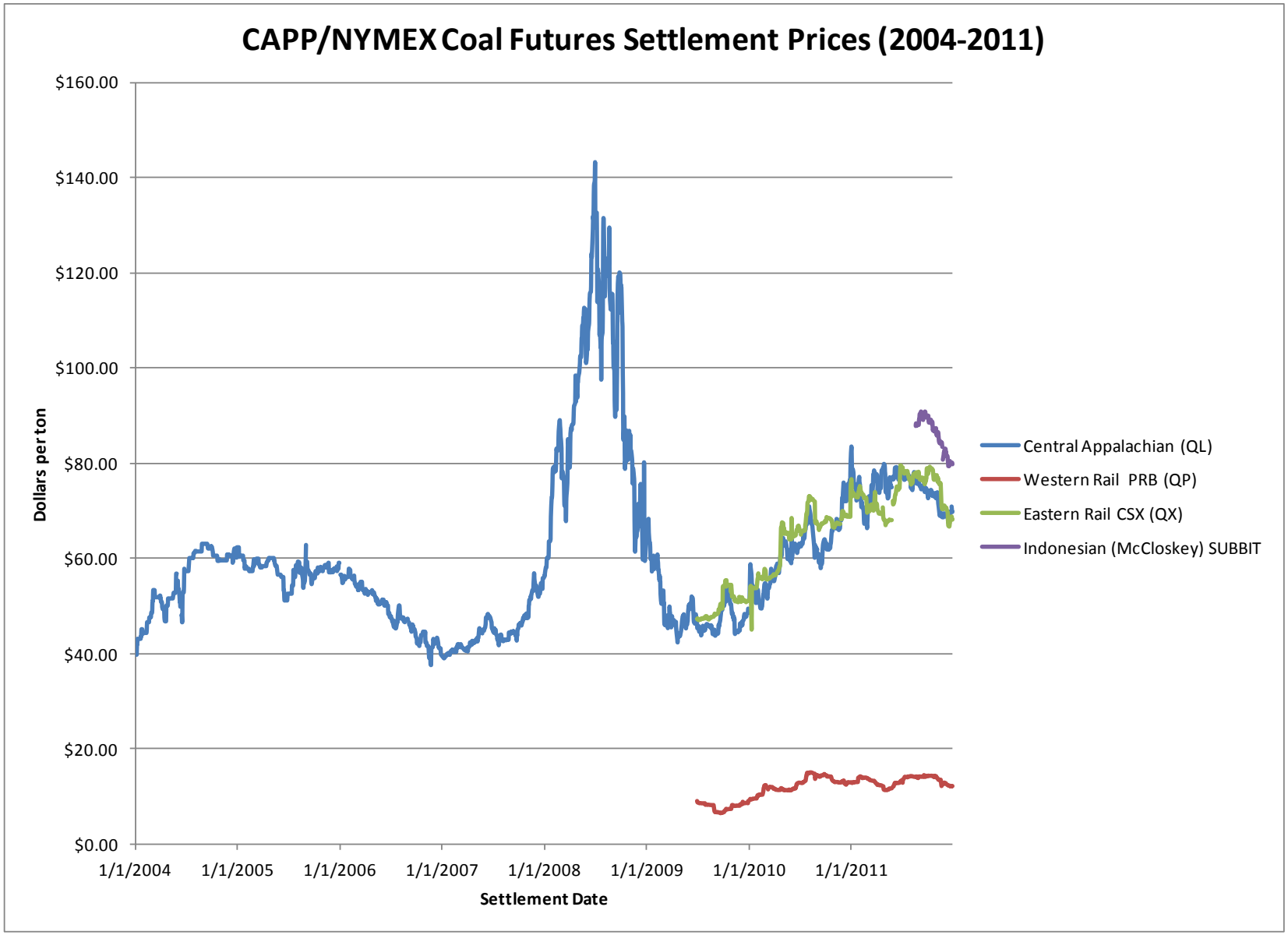
Historic Copper Prices



Wind Cost Drivers

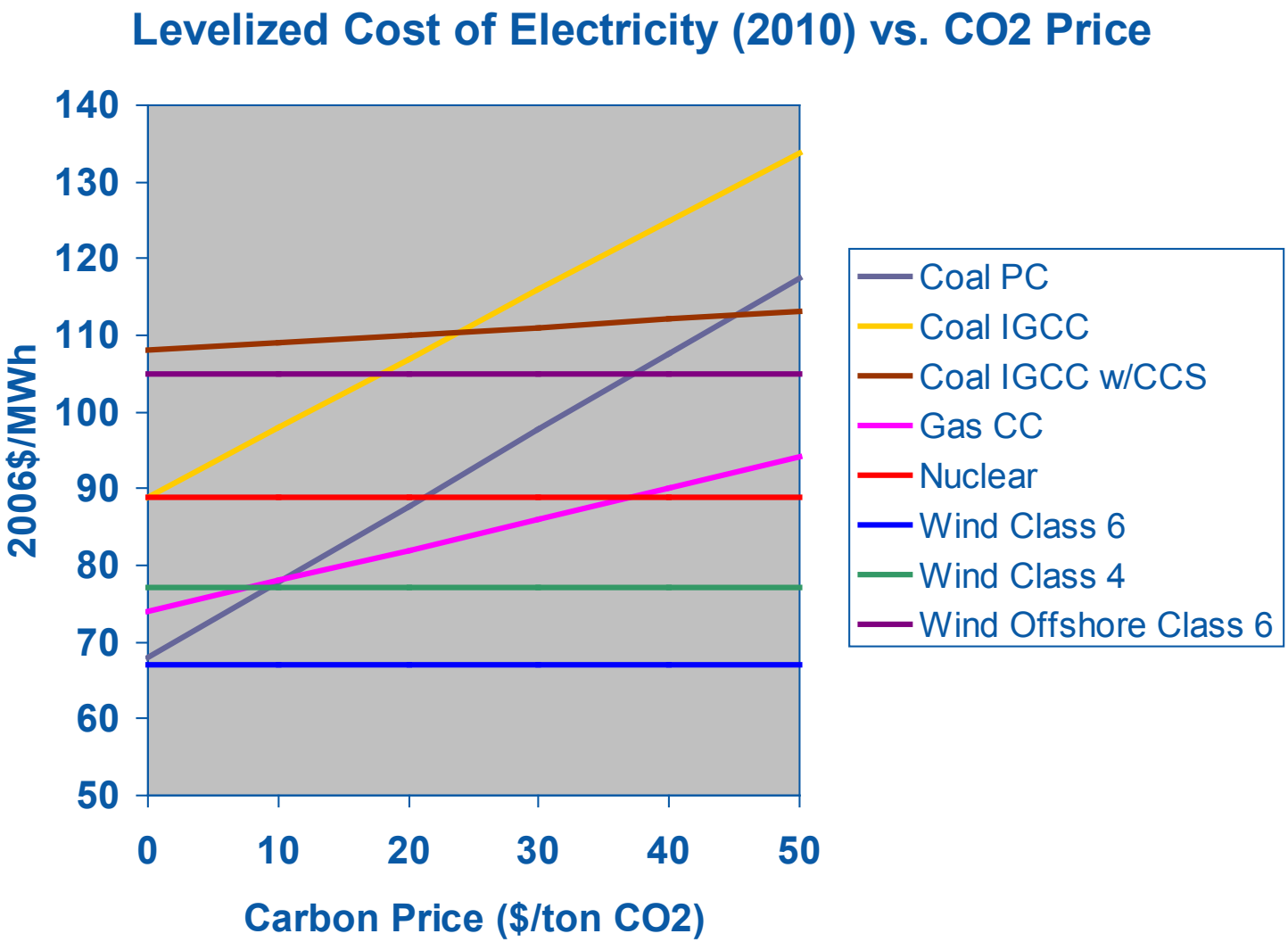
Copper & Steel Price Source: World Bank, Commodity Price Data, Jan 2012

Historical Coal Prices

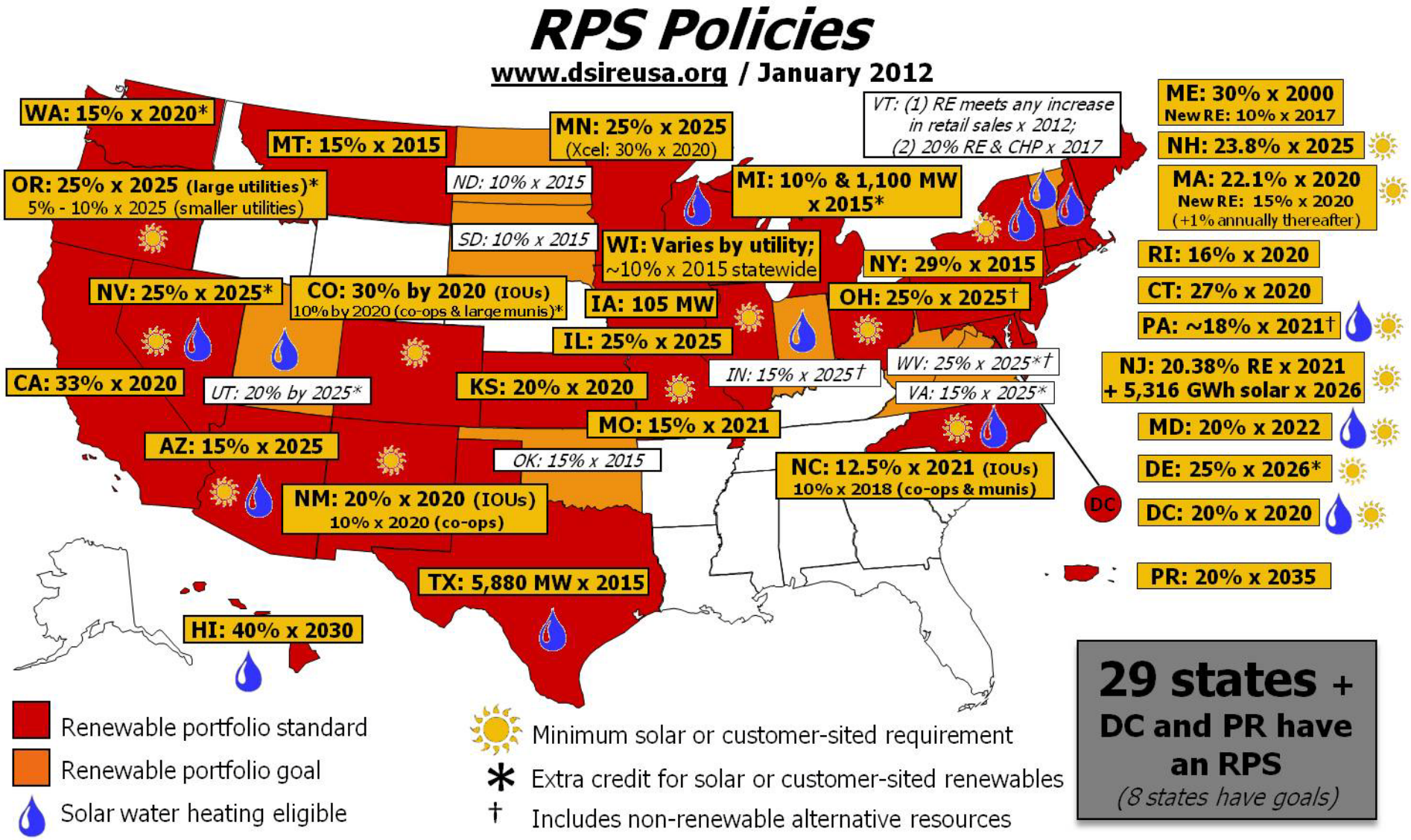


Source: EIA

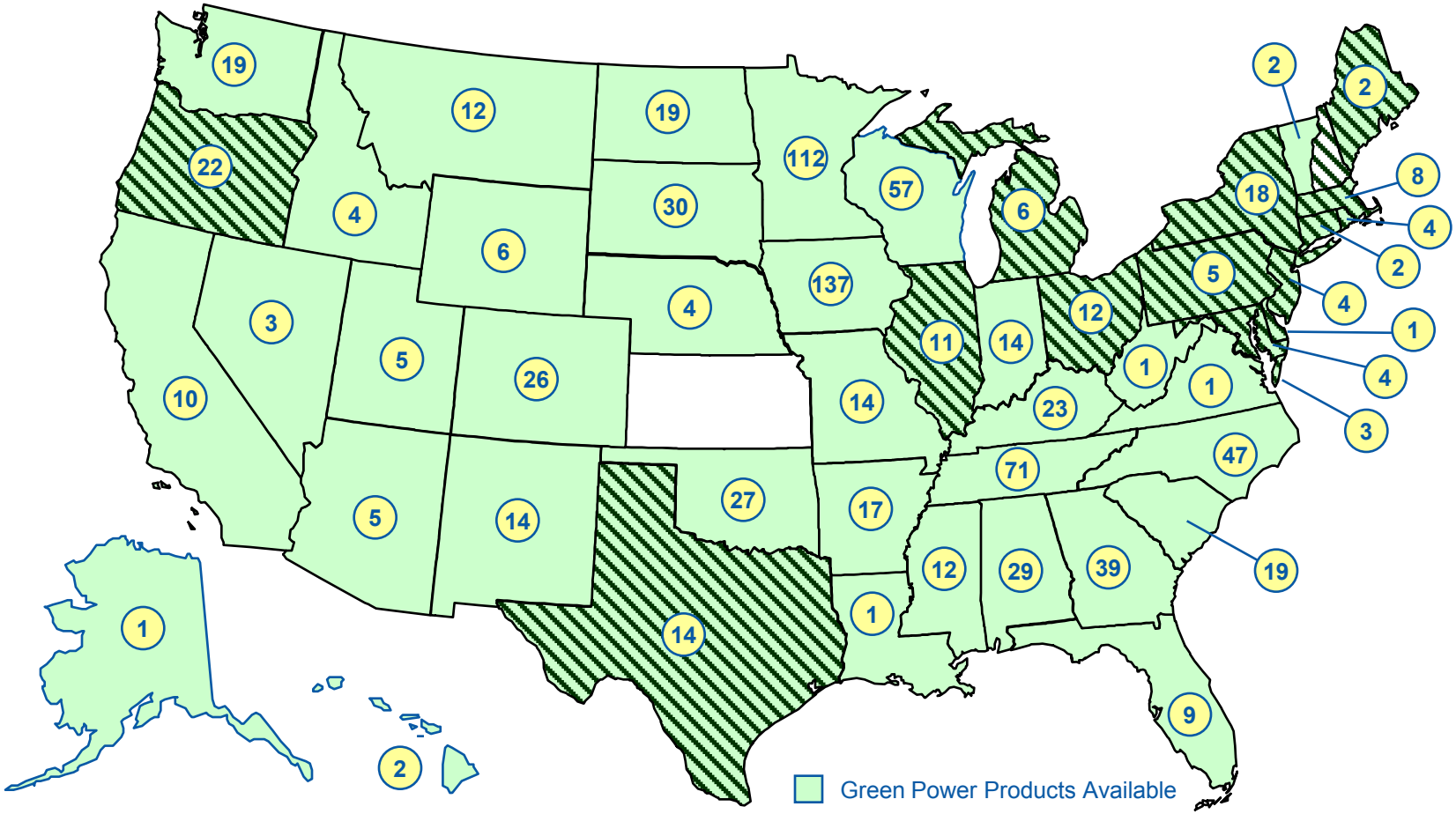
CO_2 prices significantly increase the cost of coal



Renewable Portfolio Standards



States with Green Power Programs

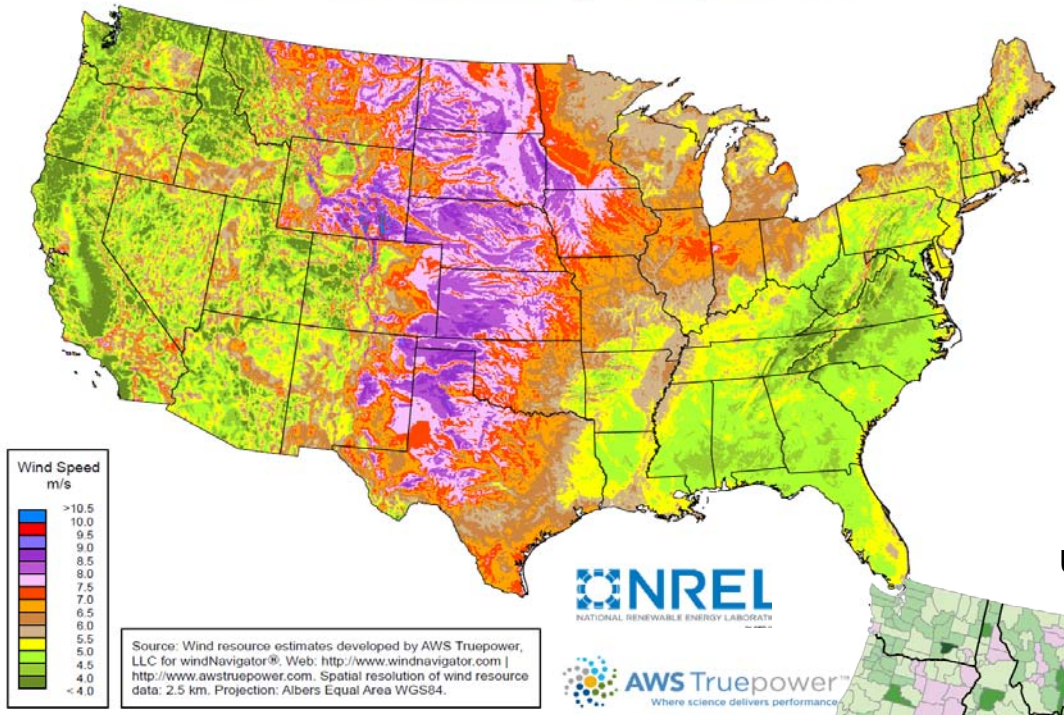


Source: National Renewable Energy Laboratory (September 2008)

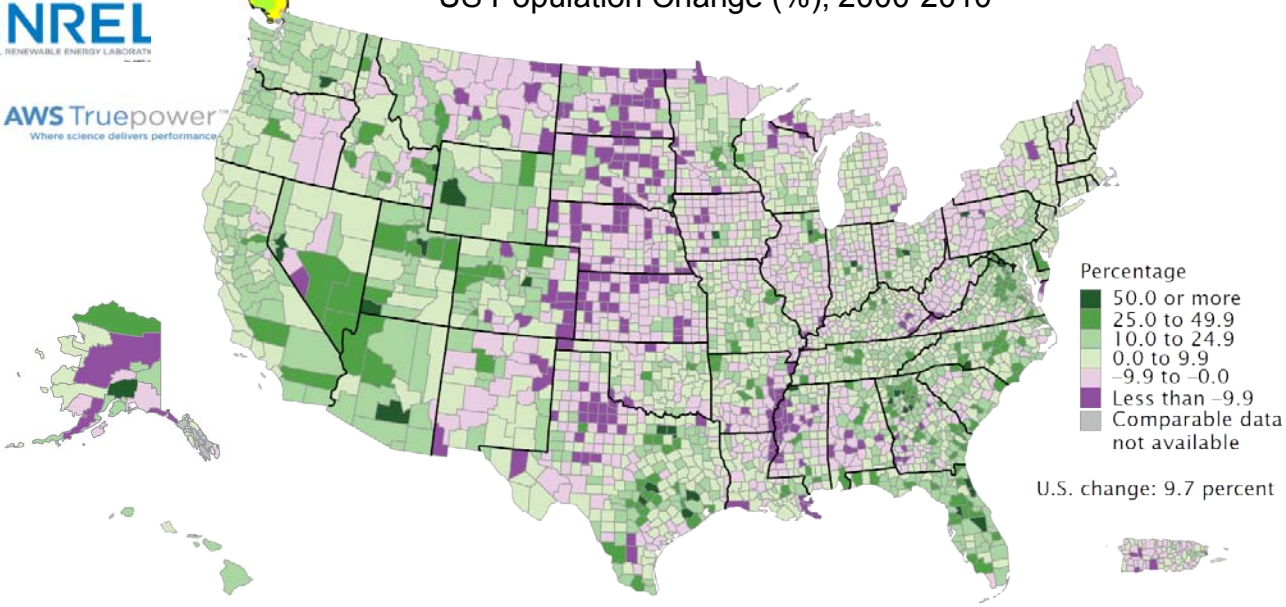
Wind Energy Investors

Windy Rural Areas Need Economic Development

United States - Annual Average Wind Speed at 80 m



US Population Change (%), 2000-2010



Source: U.S. Census Bureau, 2010 Census and Census 2000.

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

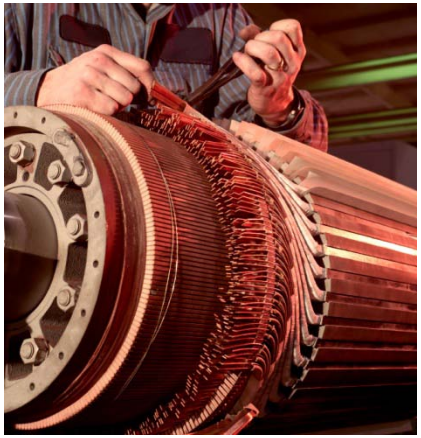
Construction Phase = 1-2 years
Operational Phase = 20+ years

Project Development & Onsite Labor

Sample Jobs:
Truck Drivers
Crane Operators
Earth Moving
Cement Pouring
Management
Support

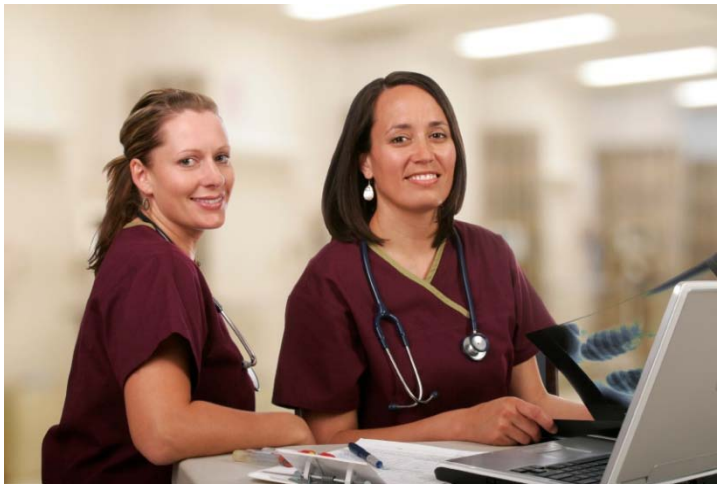
Local Revenues, Turbine, & Supply Chain

Steel mill jobs, parts, services - Equipment manufacturing and sales - Blade and tower manufacturers

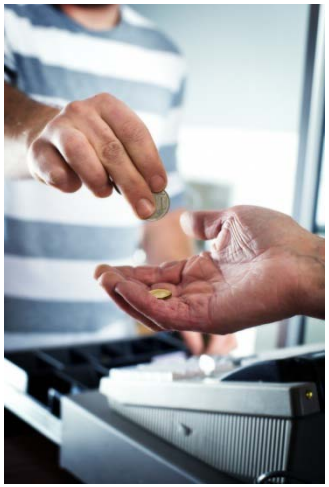


Property taxes - Financing, banking, accounting

Induced Impacts



Money spent on local area goods and services from increased revenue: *sandwich shops, child care, grocery stores, clothing, other retail, public transit, new cars, restaurants, medical services*



Typical U.S. Results from a 100MW Wind Project

Direct Jobs
70-100 Construction jobs*
6-8 Operations & Maintenance Jobs*
Increased Local Revenues
Land lease payments: ~$350,000 - $500,000 per year (3-6% of gross project revenue)
Local property tax revenue: $500,000 - $1million per year
Other Benefits
Stimulate local industry (concrete, roads, environmental, siting, legal)
Stimulate local manufacturing

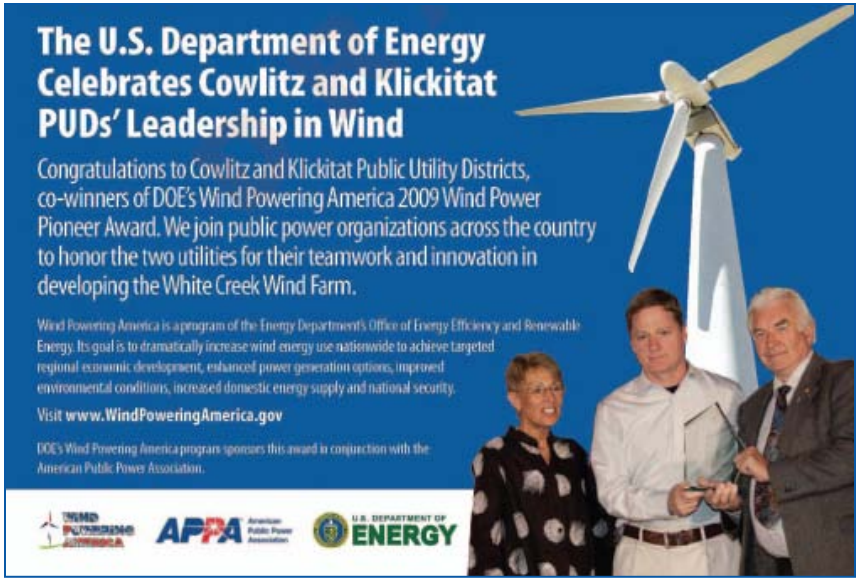
*Jobs are listed as full-time equivalents

Wild Horse Wind Power Project Phase 1 (Ellensburg, WA)

- Owned by Puget Sound Energy
- Commissioned 2006
- 228.6 MW
- (127) 1.8 MW Vestas turbines
- Estimated 2008 property tax payments totaled ~ $1.56 miilion
- Project employed ~ 250 workers during peak construction
- 14-18 O&M positions
- ~ 80 acres of Washington Department of Fish and Wildlife land leased for the project providing between $60,000 and $125,000 annually
- PSE also leases land from state Department of Natural Resources

Image Credit: Annawjacobs, Creative Commons

White Creek Wind Project (Klickitat County, WA)



- Commissioned 2007
- 204.7 MW
- (89) 2.3 MW Siemens turbines
- Last Mile Electric Cooperative- four publicly owned utilities: Tanner Electric Co-op, Lakeview Light & Power, Cowlitz County Public Utility District, Kilickitat County Public Utility District)
- In order to take advantage of production tax credits, the original utility sponsors "sold" the project to White Creek Wind I LLC, a pass-through entity arranged by the broker-dealer arm of Meridian Companies
- Once complete, White Creek's equity sponsors assumed ownership in order to receive the project's tax credits
- Sponsoring utilities hold an option to buy the project back after 10 years

Our Wind Co-Op, Small-Scale Wind Turbine Projects (Washington and Montana)

- Launched in 2002 to help reduce barriers associated with distributed customer-owned wind energy development in the Pacific Northwest
- Installed (10) turbines in Montana and Washington between 2003 – 2006
- Bergey Windpower supported the project by offering a discount on equipment orders by ~ $7,000 per system
- Projects were funded by various organizations including the USDA, DOE, Montana's Department of Environmental Quality and the Bonneville Environmental Foundation
- As a result of the numerous funding sources provided through Our Wind Co-op, the turbine host cost share for the initial 10 sites was reduced by an average of almost 80% to about $8,000, thereby reducing the actual average "payback period" from 55 years to 7 years.

NaturEner's Glacier Wind Power Project (Toole/Glacier County, MT)

- Owned by NaturEner
- Phase 1 – online 2008
- Phase 2 – online 2009
- (210) 1.5 MW Acciona turbines
- Tax Revenue from the project will be ~ $4 million annually for Glacier and Toole Counties
- ~ $1 million in annual land agreements
- Total construction jobs for both phases ~ 350
- ~ 18 permanent positions

Jerome Middle School Wind Turbine (Jerome, ID)

- (1) Skystream 2.4 kW turbine
- Installed November 2008
- Jerome Middle School received a Wind For Schools $4,600 grant through Boise State and the Tidwell Foundation to offset the turbine cost.
- The school solicited the following local companies to donate time & materials in order to reduce the cost of installation:
  - **Starr Corporation:** Foundation kit $373, Concrete $1000, Re-bar $600, Forming material $150, Equipment for digging foundation $320, Labor for foundation $2000.
  - **H & H Utility:** Crane $3000, Pulling wires, Meter, Installation of Turbine
  - **Portneuf Electrical:** 1800 ft (3 wire 600 ft each) 4 gauge, 600 ft bare wire (no insulation) 8 gauge $1500.
  - **Power by Jake** (Jake Cutler): Licensed Electrician $360

In the end, Jerome Middle School paid ~ $3,720 for the turbine tower & various permits.

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

Twin Buttes Wind Farm (Bent County, CO)

- 75 MW (GE 1.5 MW turbines)
- Owned by Iberdrola Energy
- Constructed in 2007
- ~ 100 during peak construction
- Will pay between $3,000 and $6,000 per turbine to landowners annually
- 6 full-time O&M positions
- Will pay ~ $200,000 in property tax annually

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

Elkhorn Ridge Wind Farm (Bloomfield, NE)

- 81 MW (27 Vestas 3 MW turbines)
- 2/3 of the project is owned by Edison Mission Group, 1/3 owned by Tenaska
- Online in 2009
- Wind farm is Nebraska's first Community Based Energy Development (C-BED) project
- C-BED requires projects to have 1/3 ownership by Nebraska residents
- ~ 100 people employed during construction
- 6 fulltime O&M positions
- Project will bring in ~ $5.7 million in property taxes over the next 5 yrs
- ~ $2.4 million of property tax money over the next five years will go to Bloomfield Community School District
- ~$325,000 in annual land lease payments

Spearville Wind Energy Facility (Spearville, KS)

Image Credit: Jennifer Sovanski, Creative Commons

- 100.5 MW (67 GE 1.5 MW turbines)
- Owned by Kansas City Power & Light
- Online in 2006
- ~ 200 people employed during construction
- 11-12 fulltime O&M positions
- In lieu of taxes, KCP&L gives nearly $15 million over next 30 years split between seven different taxing entities
- ~ $2,000 per year for landowners
- Between $200 million and $300 million spent in the community (steel, cement, hired locals and basic purchases)

Bluegrass Ridge Wind Farm (Gentry County, MO)

Image Credit: Peter Young, Creative Commons

- 56.7 MW (Suzlon 2.1 MW turbines)
- Owned by Wind Capital Group/John Deere
- Constructed in 2007
- Between 100 and 150 workers during peak construction
- Will pay between $81,000 and $135,000 to landowners annually
- Suzlon hired 9 individuals for O&M positions (4 local)
- Slated to pay more than $500,000 in property tax in 2008

Rail Splitter Wind Farm (Logan and Tazewell, IL)

- Owned by Horizon Wind Energy
- Commissioned 2009
- 100.5 MW
- (67) 1.5 MW GE turbines
- More than 200 employed during peak construction
- Expected to employ 10-15 O&M
- Annual Lease payments will be in excess of $500,000 and annual Neighbor payments will be in excess of $50,000.
- In the first year, Logan County is expected to receive ~ $234,000 in tax revenue
- Tazewell County local governments and school district are expected to receive $513,000 in tax revenue
- Of the 67 turbines, 29 will be located in Logan County, 38 will be in Tazewell
- Logan County also received ~ $230,000 in building permit fees.

Photo courtesy of Julie Collins Bates

Streator Cayuga Ridge South Wind Power Project (Livingston County, Illinois)

- Owned by Iberdrola Renewables
- Commissioned 2010
- 300 MW
- (150) 2 MW Gamesa Turbines
- More than 450 employed during peak construction
- Expected to employ 15-20 O&M
- 398,766 total project man-hours worked
- Annual Lease payments will be ~$1,200,000
- $2,700,000-3,500,000 annually in tax revenue for Livingston County

Photo courtesy of Greater Livingston County Economic Development Council

Harvest Wind Farm (Chandler and Oliver Townships, MI)

- 52.8 MW (32 Vestas1.65 MW)
- Owned by John Deere Wind Energy
- Online 2008
- 80 jobs will be created during construction phase
- Six to ten permanent employees
- Land lease payments: ~$3,000/turbine/yr
- Project was supported with state tax incentive worth $6.5 million over 12 yrs
- Project will receive ~ $5 million in sales tax exemptions through Michigan's manufacturing/industrial processing exemption.

Byers Auto Group Wind Turbines (Columbus & Delaware County, OH)

- Proven Energy 15 kW – Delaware County, OH. Dedicated on November 19, 2010.
- Northern Power Systems 100 kW – Columbus, OH. Dedicated on October 22, 2010.
- Idea originated while constructing new Toyota showroom at the Delaware County location
- Partially funded through an Ohio Department of Development Grant for $200,000 and the Section 1603 of the Federal Tax Code that provided one-third of the total project cost in the form of a line item tax credit.
- Total cost of nearly $600,000 for both installations.
- Columbus turbine Zoning and Permitting process - city used existing language pertaining to cellular towers.
- Delaware County Zoning and Permitting process – group presented project to Delaware Planning Commission before receiving permission to install.
- Renier Construction and Architectural Alliance secured all building permits that were needed to begin construction

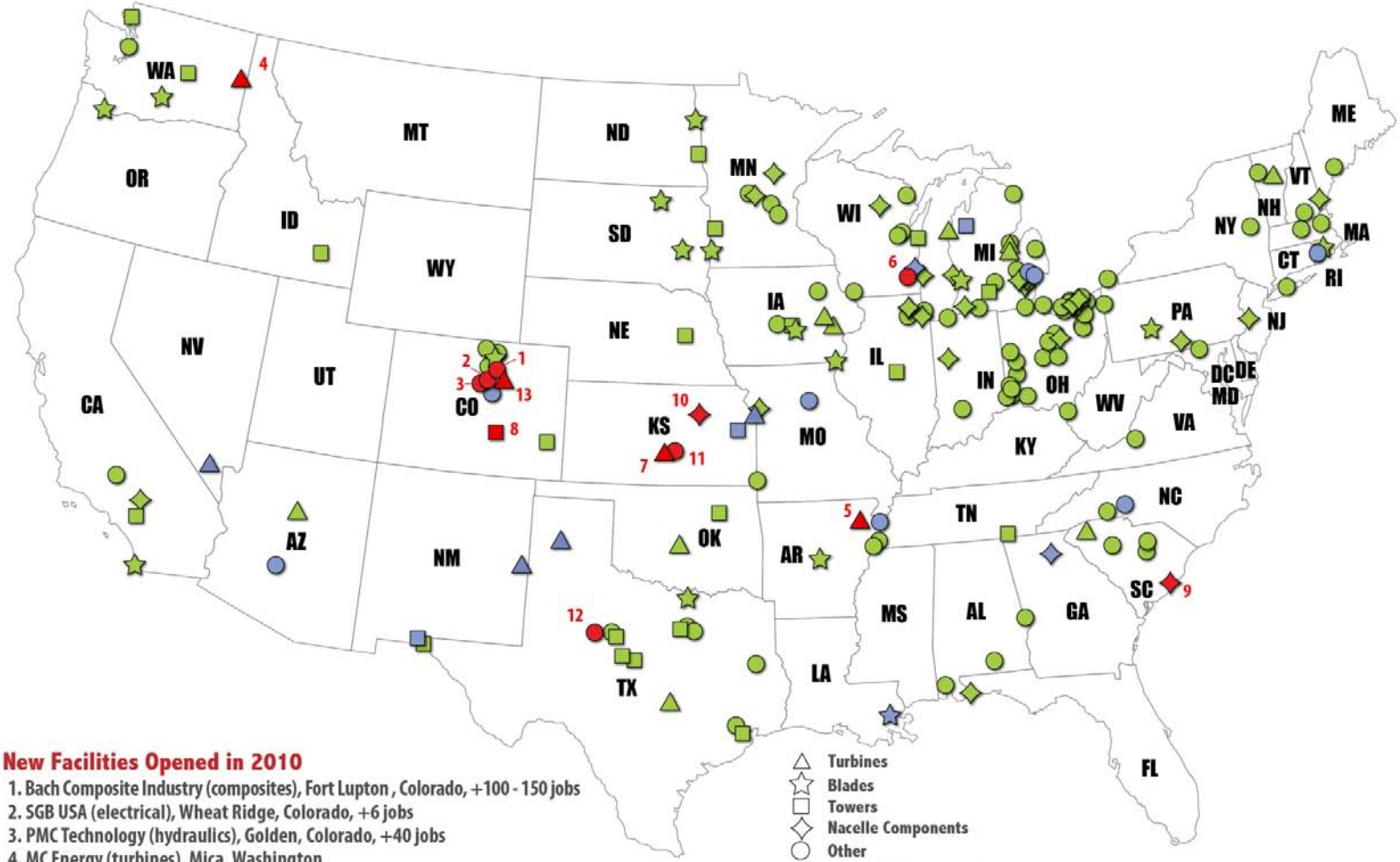
Senior Housing Complex (Winter Harbor, ME)

- Bergey Excel 10-kW turbine
- Installed August 2007
- Reduces energy costs for residents of a subsidized elderly housing complex
- Entirely funded by a federal Residential Energy Assistance Challenge (REACH) grant
- Wind turbine and tower cost $40,190
- Installation cost $24,346
- 3-year maintenance package included
- Town debated: Is the wind turbine a tower (not subject to zoning) or a structure (regulated by zoning)?
- Verdict: turbine is NOT a structure

Hull Wind II (Hull, MA)

- Owned by Hull Municipal Light and Power (HMLP)
- Commissioned in 2006
- (1) Vestas 1.8 MW Turbines
- Total cost of project ~$3 million
- Annual O&M expenses are ~$25,000, Insurance premiums = $16,000/year
- HMLP signed a separate contract with Harvard University for 50,000 MWh of RECs from Hull Wind II for a total of $1.8 million
- The federal government provides a performance-based renewable generation incentive payment of ~ $0.018/kWh to municipal utilities called the Renewable Energy Production Incentive (REPI)

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



New Facilities Opened in 2010

1. Bach Composite Industry (composites), Fort Lupton , Colorado, +100 - 150 jobs
2. SGB USA (electrical), Wheat Ridge, Colorado, +6 jobs
3. PMC Technology (hydraulics), Golden, Colorado, +40 jobs
4. MC Energy (turbines), Mica, Washington
5. Nordex (turbines), Jonesboro, Arkansas, +425 jobs
6. Avanti Wind Systems (fall protection), New Berlin, Wisconsin
7. Siemens (turbines), Hutchinson, Kansas, +400 jobs
8. Vestas (towers), Pueblo, Colorado, +500 jobs
9. IMO Group (nacelles and components), Charleston, South Carolina, +190 jobs
10. Jupiter Group (nacelle covers and spinners), Junction City , Kansas, +120 jobs
11. Draka (electrical), Hutchinson, Kansas, +20 jobs
12. EMA Electromecanica (electronics), Sweetwater, Texas, +13 jobs
13. Vestas (turbines), Brighton, Colorado, +700 jobs

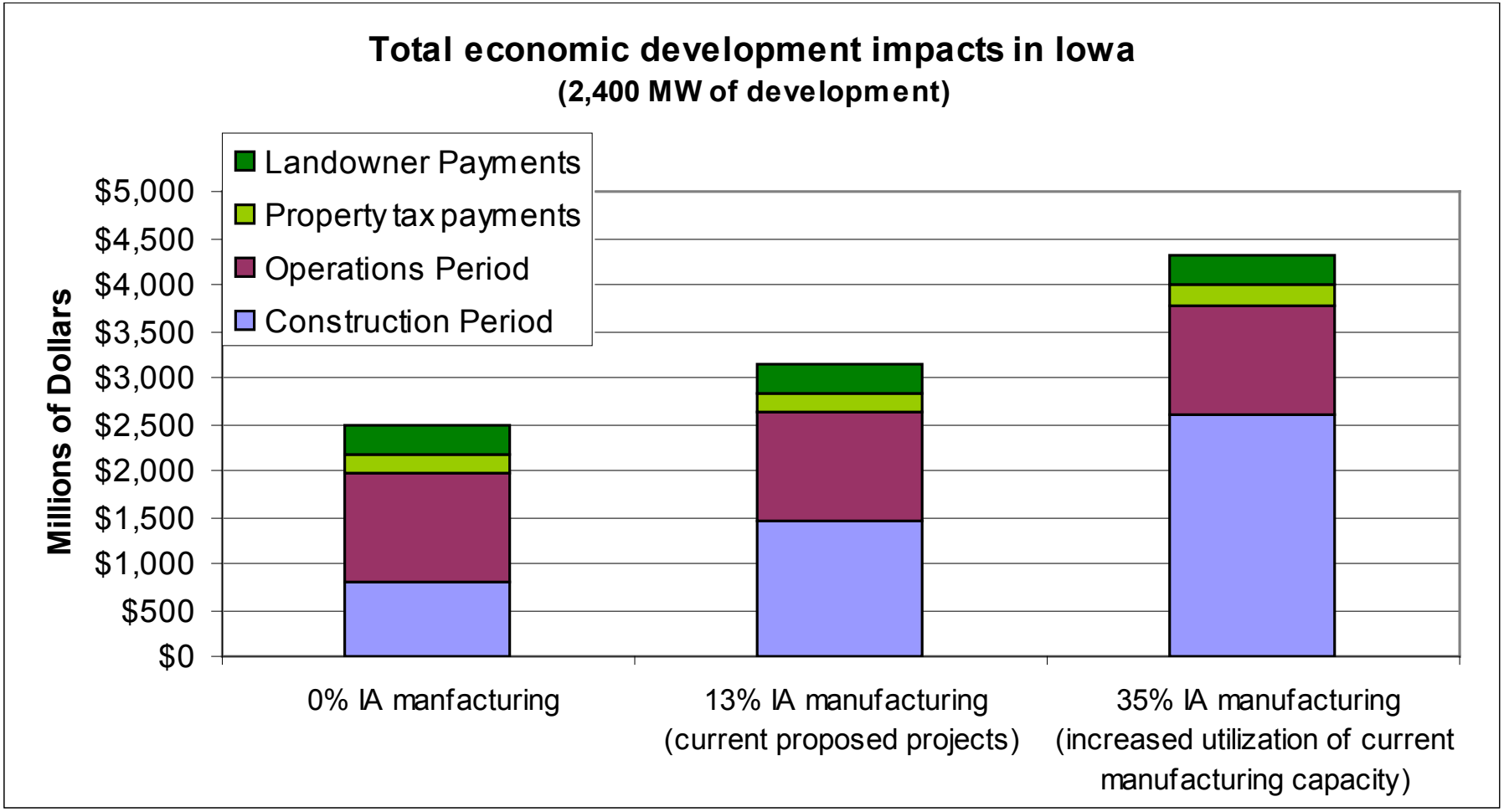
Turbines
Blades
Towers
Nacelle Components
Other
New facilities opened in 2010
New facilities announced in 2010
Existing facilities online prior to 2010

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 and/or nacelle assembly and in some cases the manufacturing of towers, nacelle components, blades or other components.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

This map was created by NREL for the U.S. Department of Energy.
April 25, 2011
Billy J. Roberts

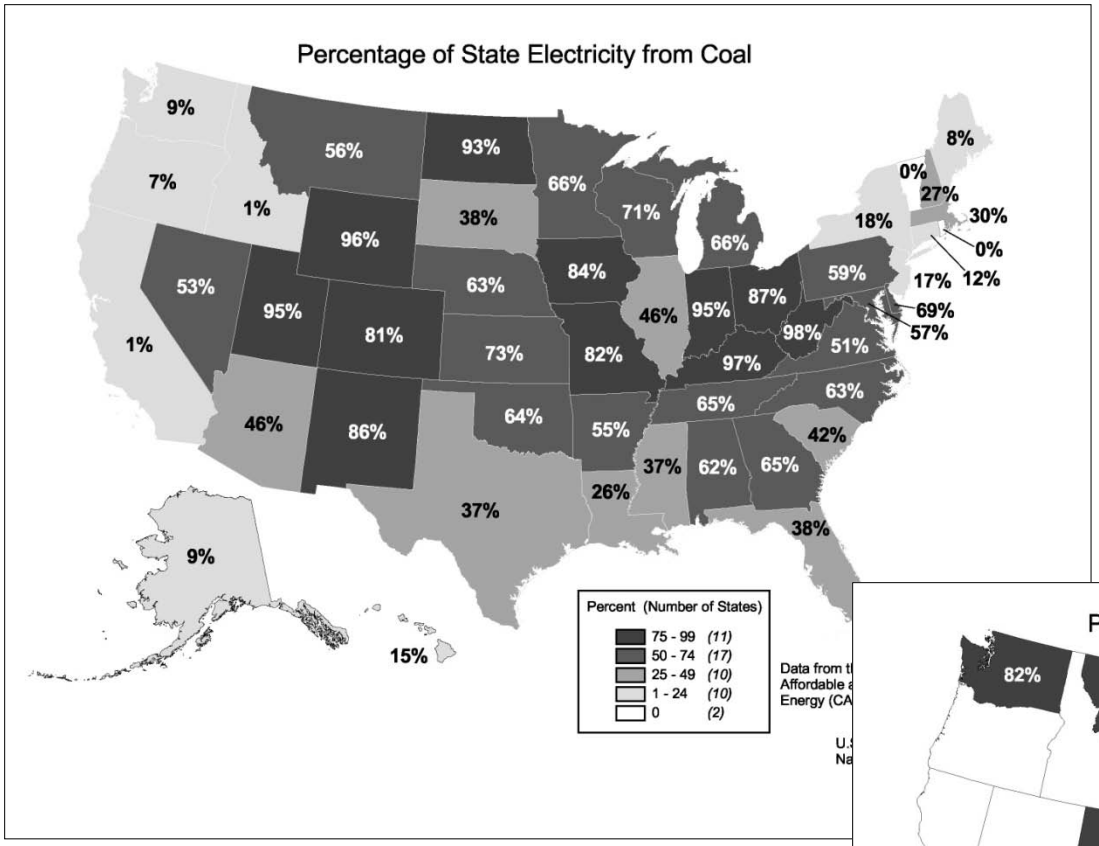
Manufacturing and Economic Development

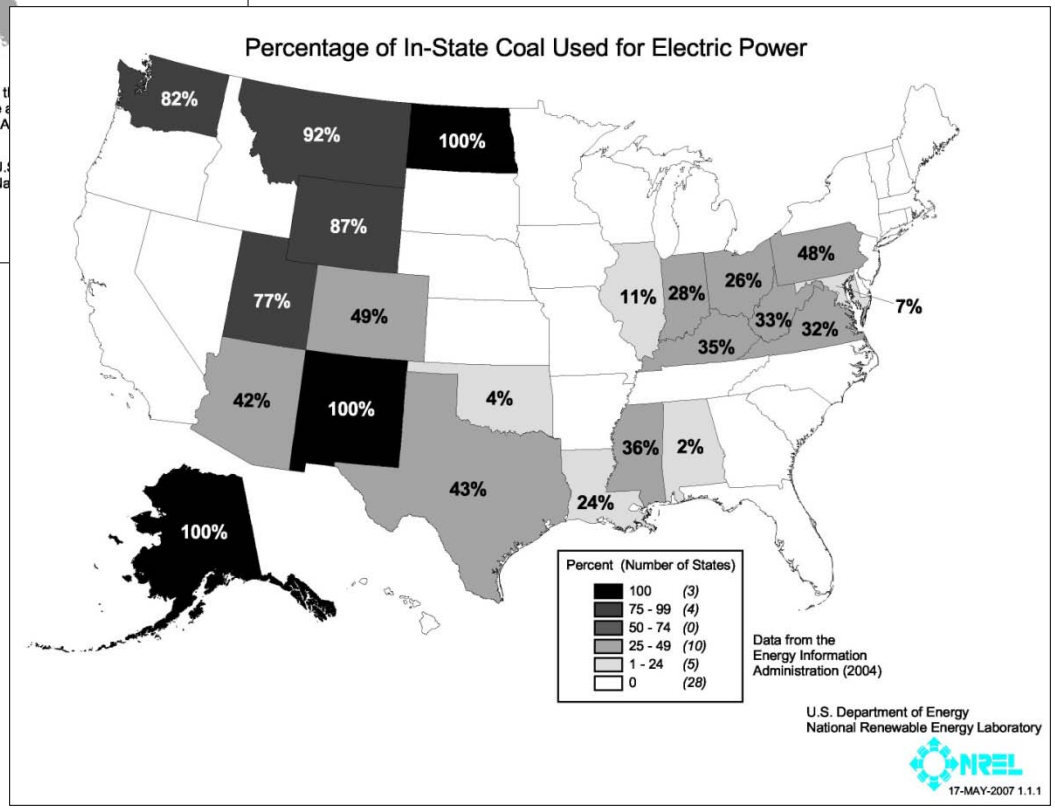


Local Ownership Models

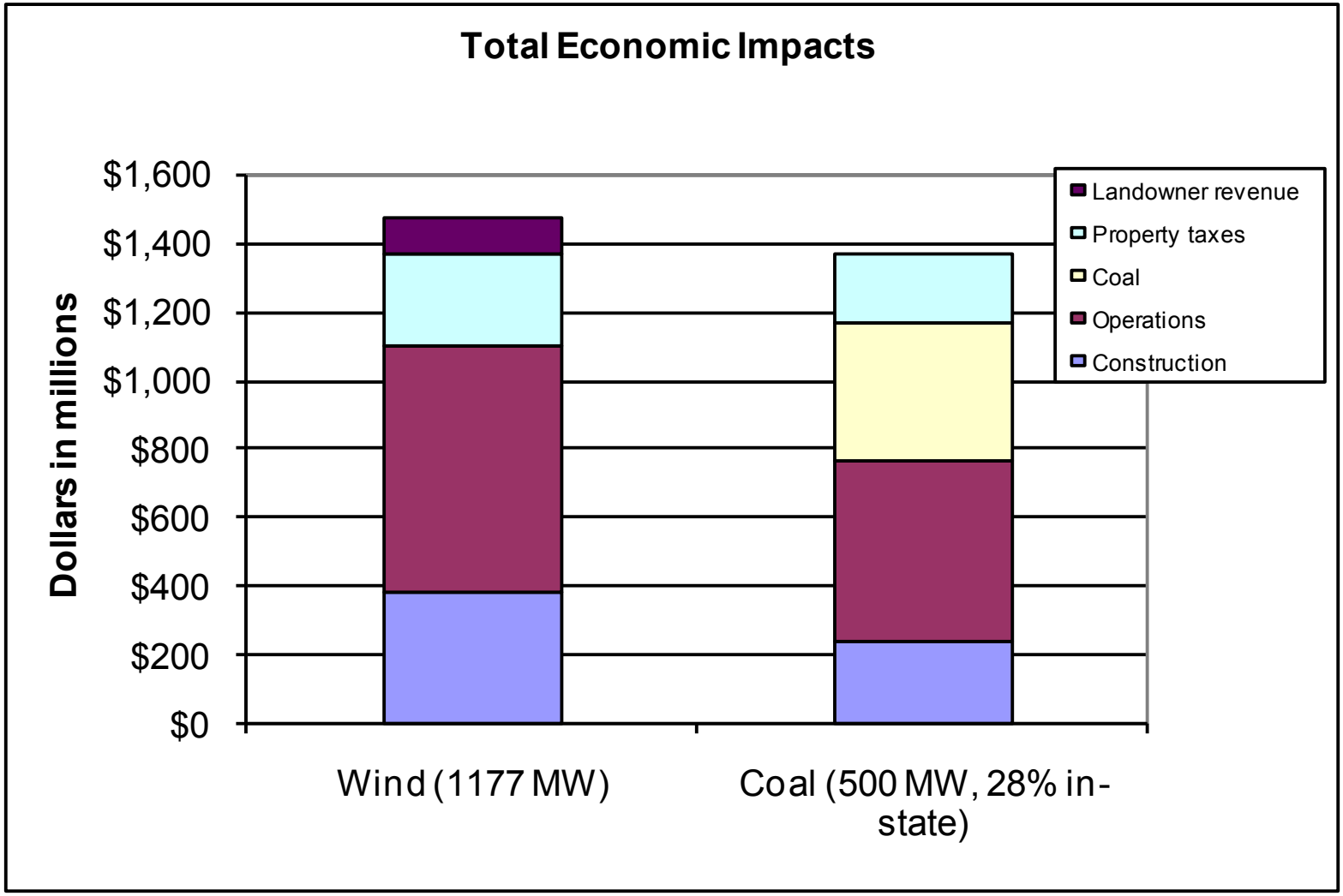
- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale

© L. Kennedy


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

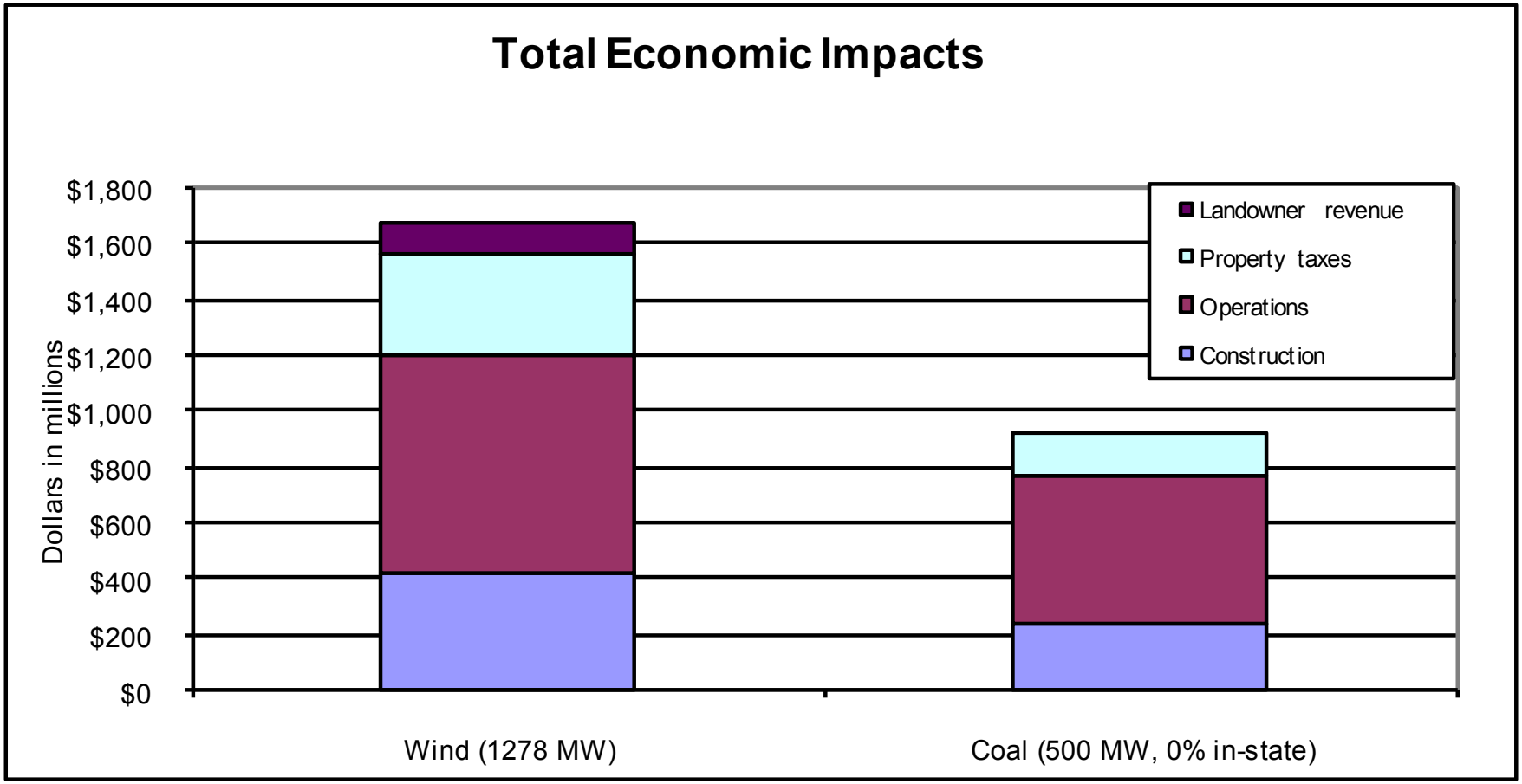

Percentage of In-State Coal Used for Electric Power
82%
92%
100%
87%
48%
26%
11%
28%
7%
77%
49%
33%
32%
35%
42%
100%
4%
36%
2%
43%
24%
100%
Percent (Number of States)
100 (3)
75 - 99 (4)
50 - 74 (0)
25 - 49 (10)
1 - 24 (5)
0 (28)
Data from the
Energy Information
Administration (2004)
U.S. Department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

Comparing wind and coal in Indiana



Constant 2007 dollars

Comparing wind and coal in Michigan



Constant 2007 dollars

Jobs and Economic Impact from the JEDI Model:

1,000 MW of 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 economy

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

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

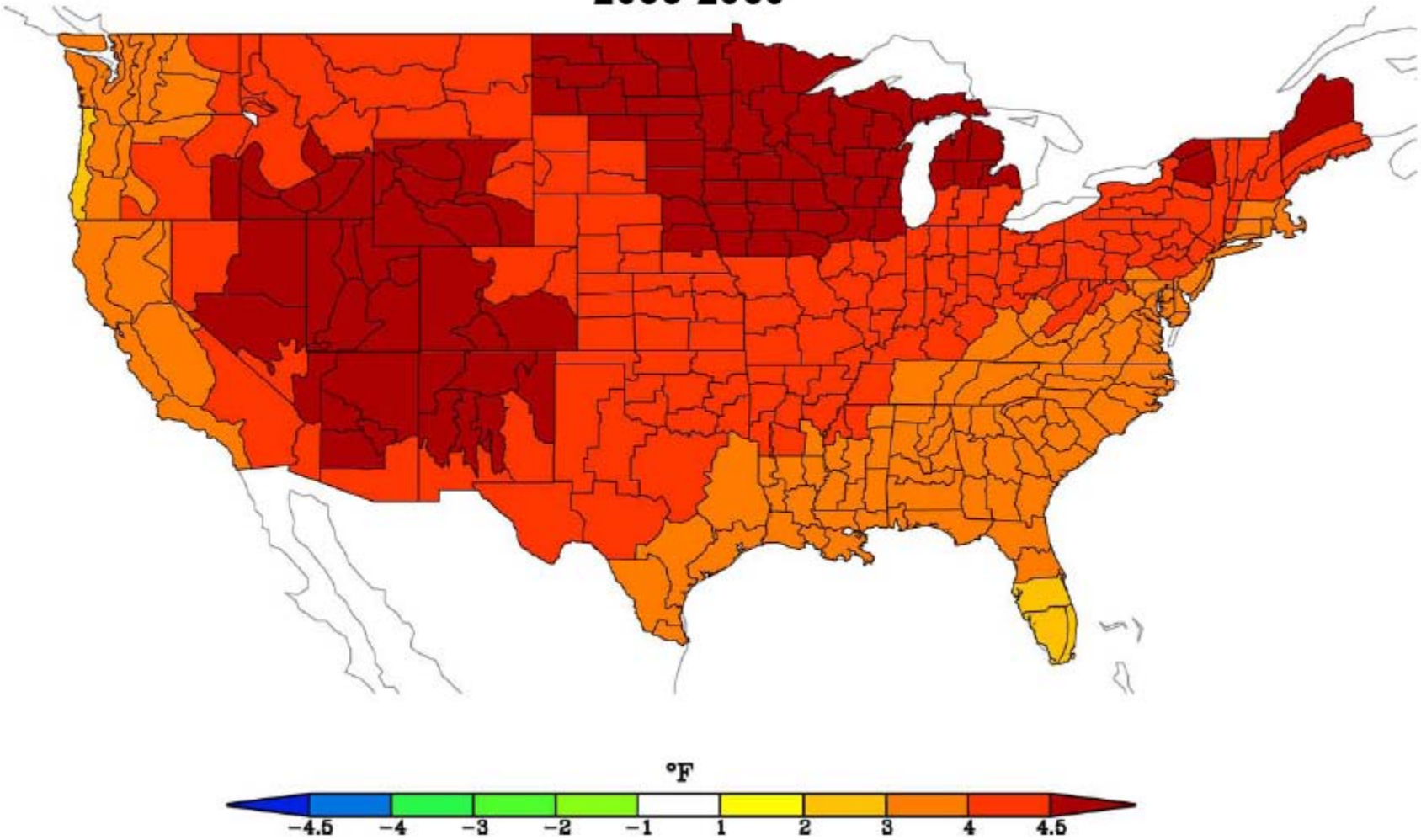
Construction Phase = 1-2 years
Operational Phase = 20+ years

Environmental Benefits

Environmental impacts of wind are limited to immediate locality.

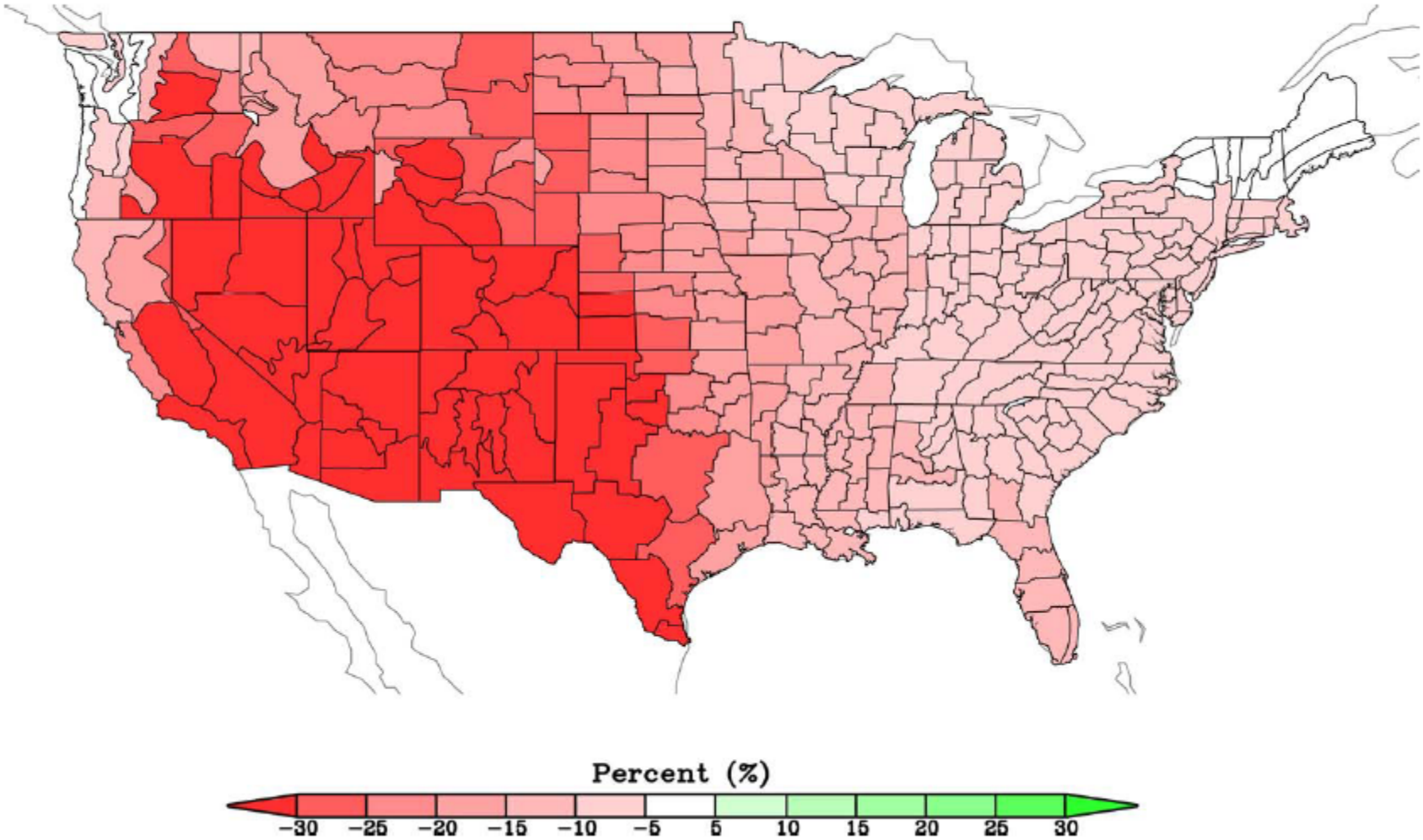
- No SOx or NOx
- No particulates
- No mercury
- No CO2
- No water
- No waste

Change in Annual Temperature
2035-2060



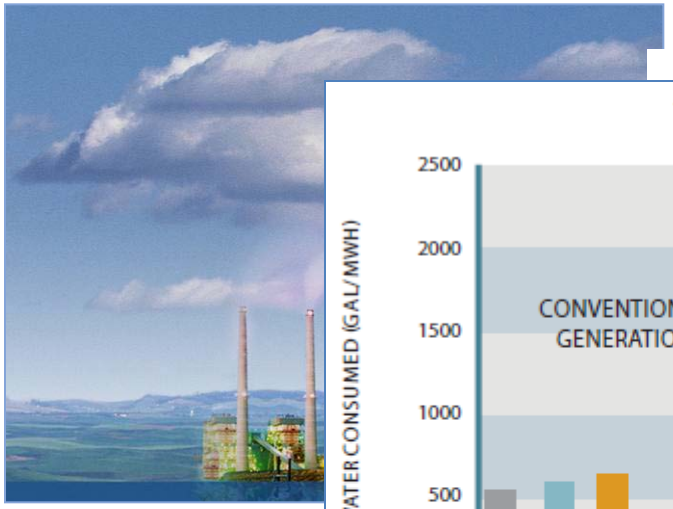
Source: NOAA

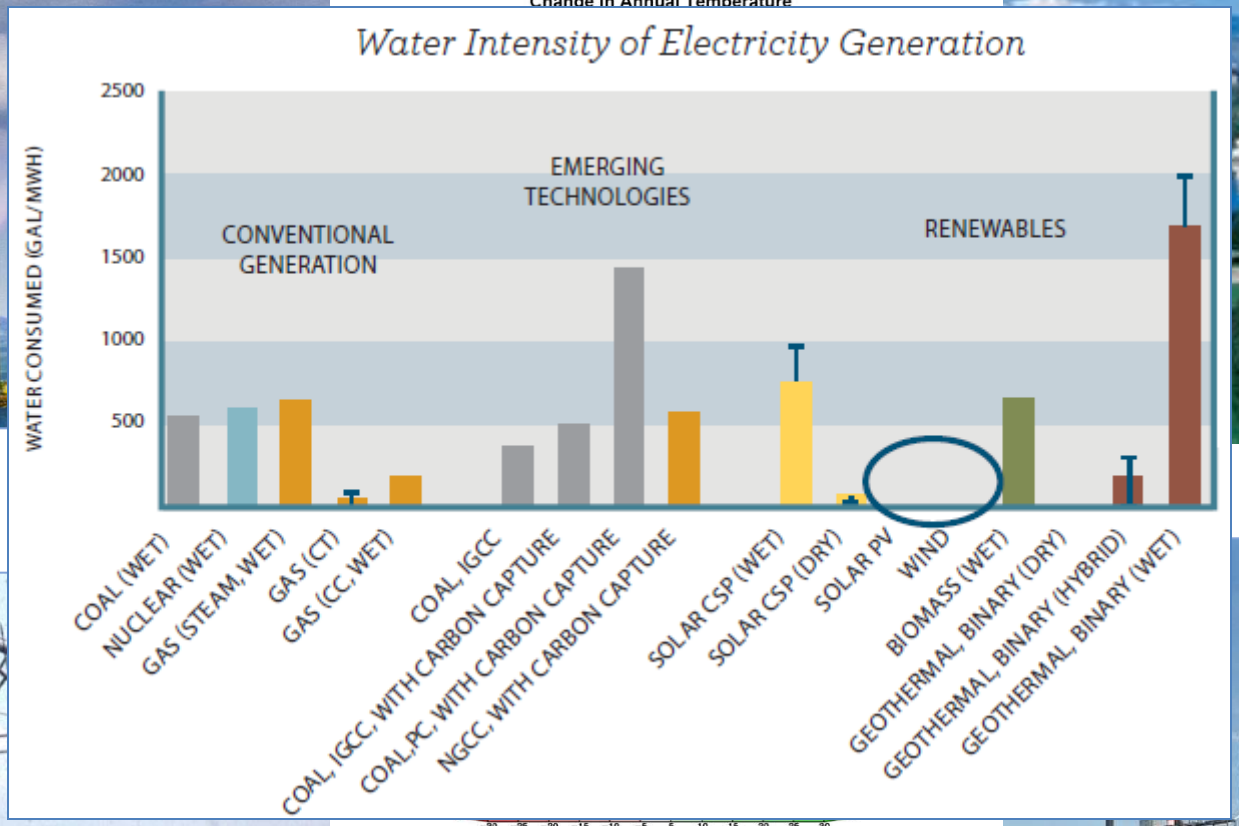
Change in Annual (PCPN-Potential Evapotranspiration) 2035-2060

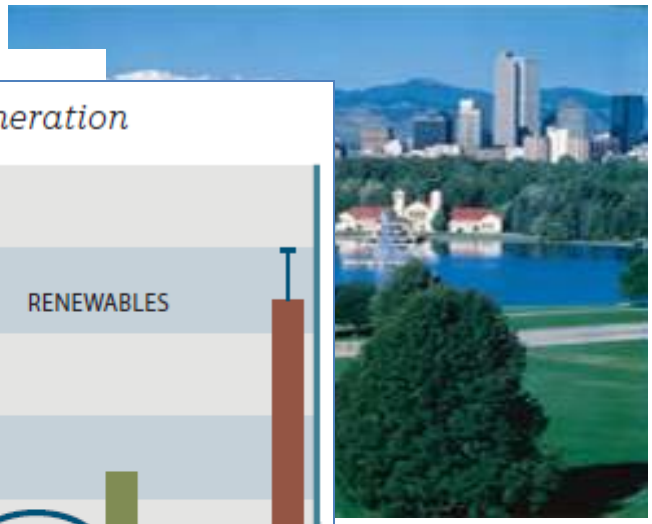


Source: NOAA

Energy-Water Nexus







Sources: EPRI, NOAA, Western Resource Advocates

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

Key Issues for Wind Power

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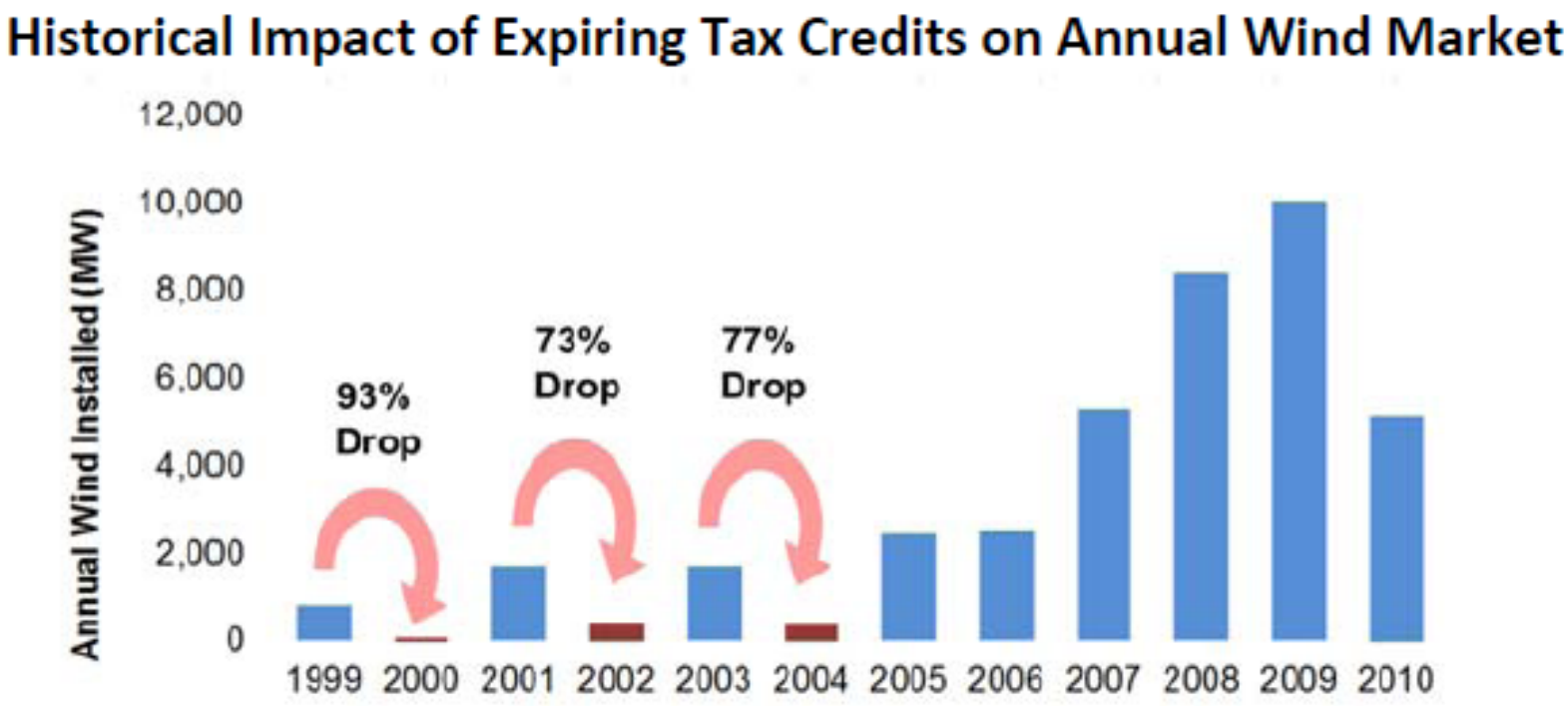
- Accounting for non-monetary value: green power, no fuel price risk, reduced emissions
- Siting and Permitting: environmental impact, avian, federal land
- Social Acceptance: noise, visual, home values, public perception

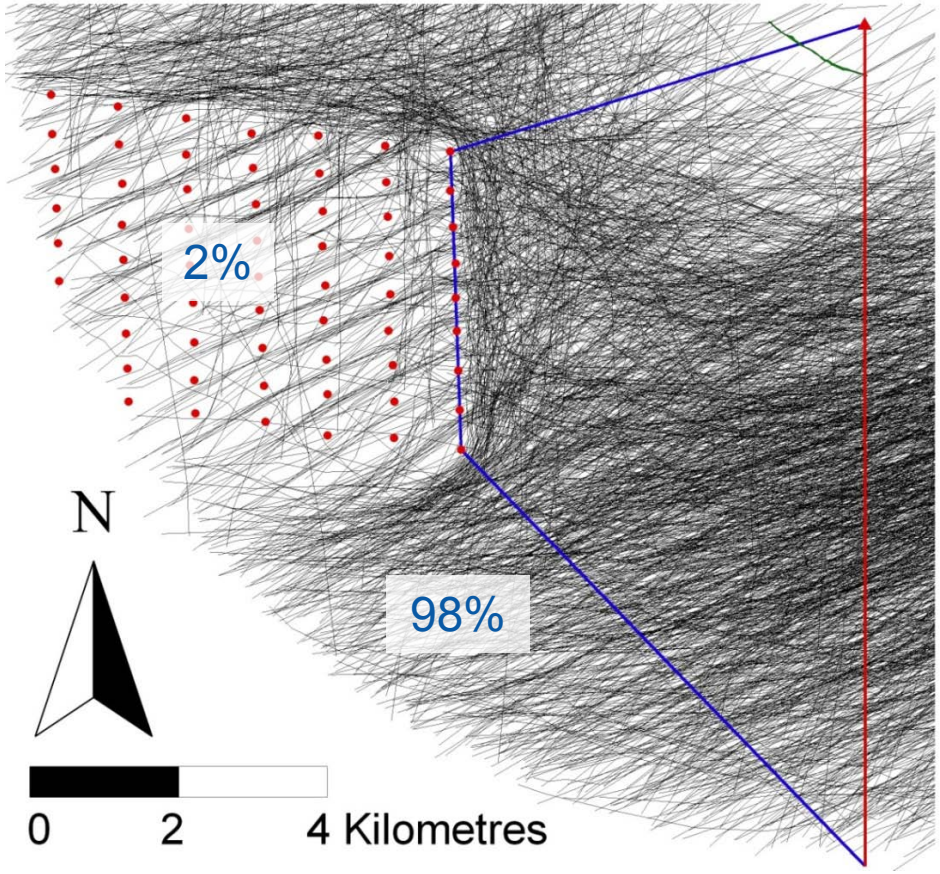
Policy and Capital Instability

- Inconsistency results in instability and lack of investment in manufacturing capability
- Policy implementation affects industry growth and stability.

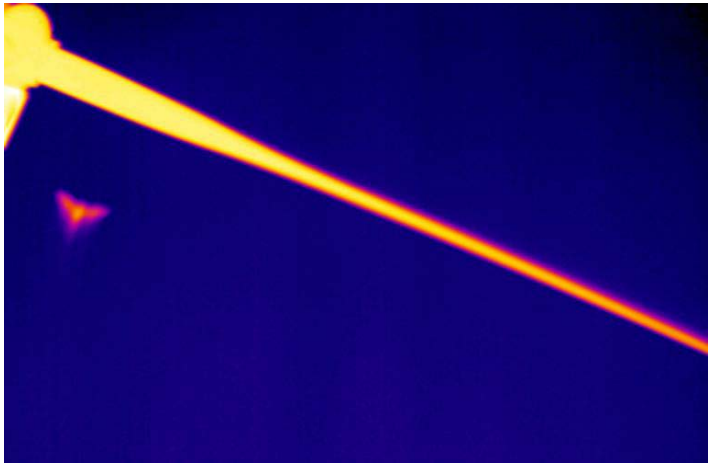


Avian (Bird) Research

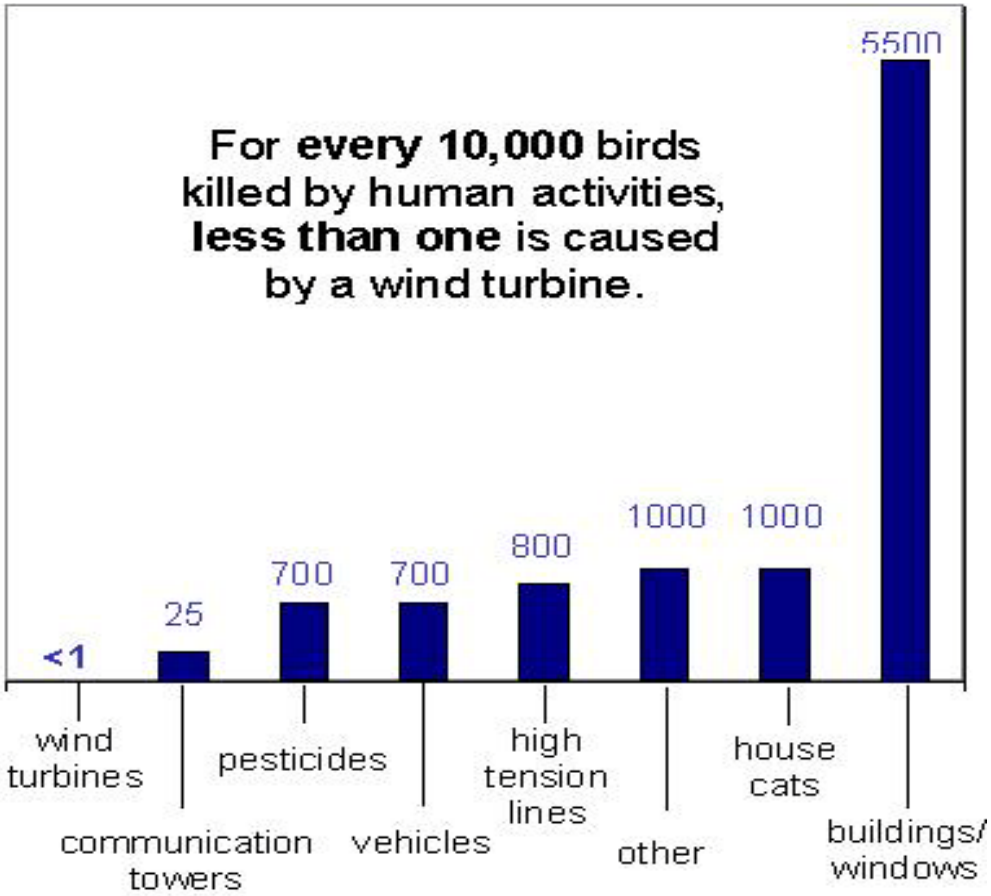
- Over 200 projects, two problem sites.
- Biggest problem was in Altamont Pass.
- Manage by careful site selection.



Nysted Windfarm - Denmark



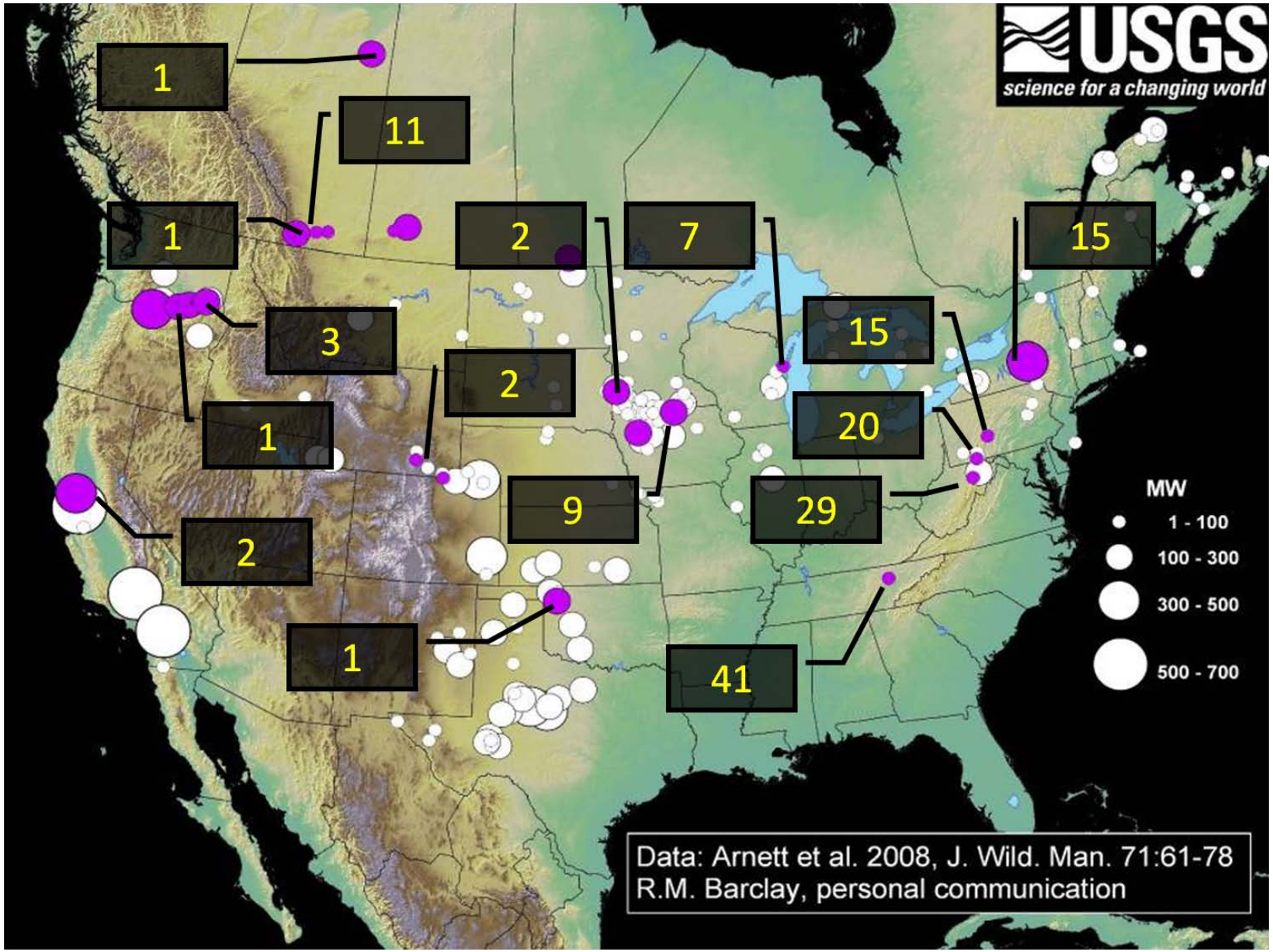
Summary of Anthropogenic Causes of Bird Mortality,
- Erickson et. al., 2002



http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/1029-1042.pdf

Installation of enough wind to power eliminate all anthropogenic CO2 emission worldwide would result in between 1.4 to 14 million deaths – less than 1% that were killed by the Avian flu pandemic in 2005

Bat Fatality Estimates (per MW)



Mitigation and Management Options

Implementation mitigating

- Pre-construction assessment
    - Determine and avoid high risk areas
- Impact mitigation

Operation mitigation

- Curtailment during high risk periods that may be predictable

Technological

- Development of techniques that deter or alert animals.

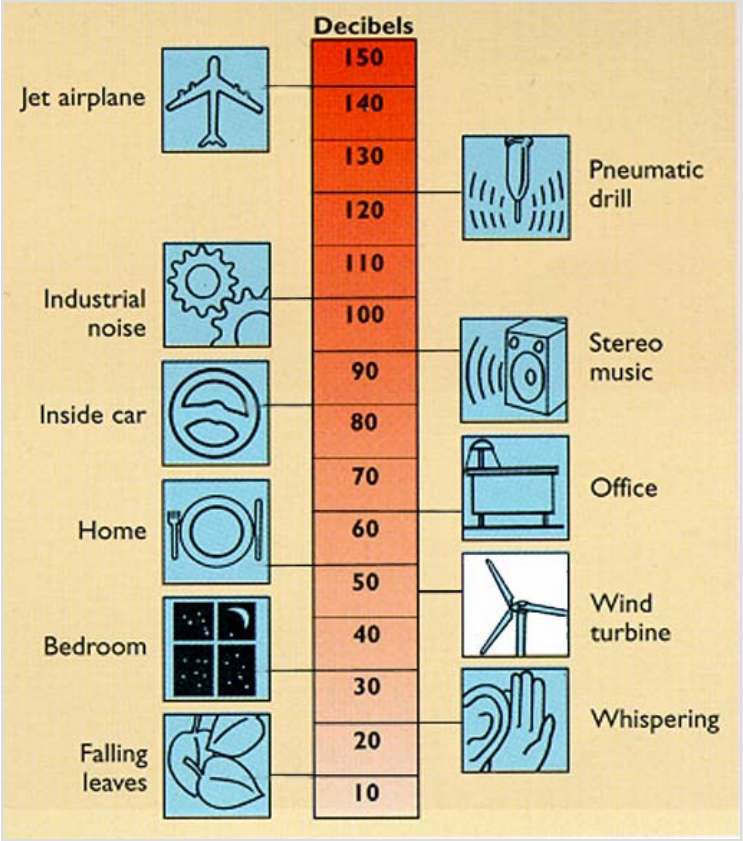
How loud are wind turbines?

Wind turbines make noise and that noise has an impact.
What is the sound level of a utility-scale wind turbine?

- Depends on the turbine, but a maximum of 45 db at 350 meters
- Sound analysis is very common

But that's not the whole story:

- Relative level of noise as it relates to background level
- Individual noise sensitivity
- Average vs. instantaneous levels
- Noise can impact health – though:
  - Those who "use" the land
  - Those that "own" the land
  - People who like the concept vs. people who have a negative view



The key is to visit a wind turbine

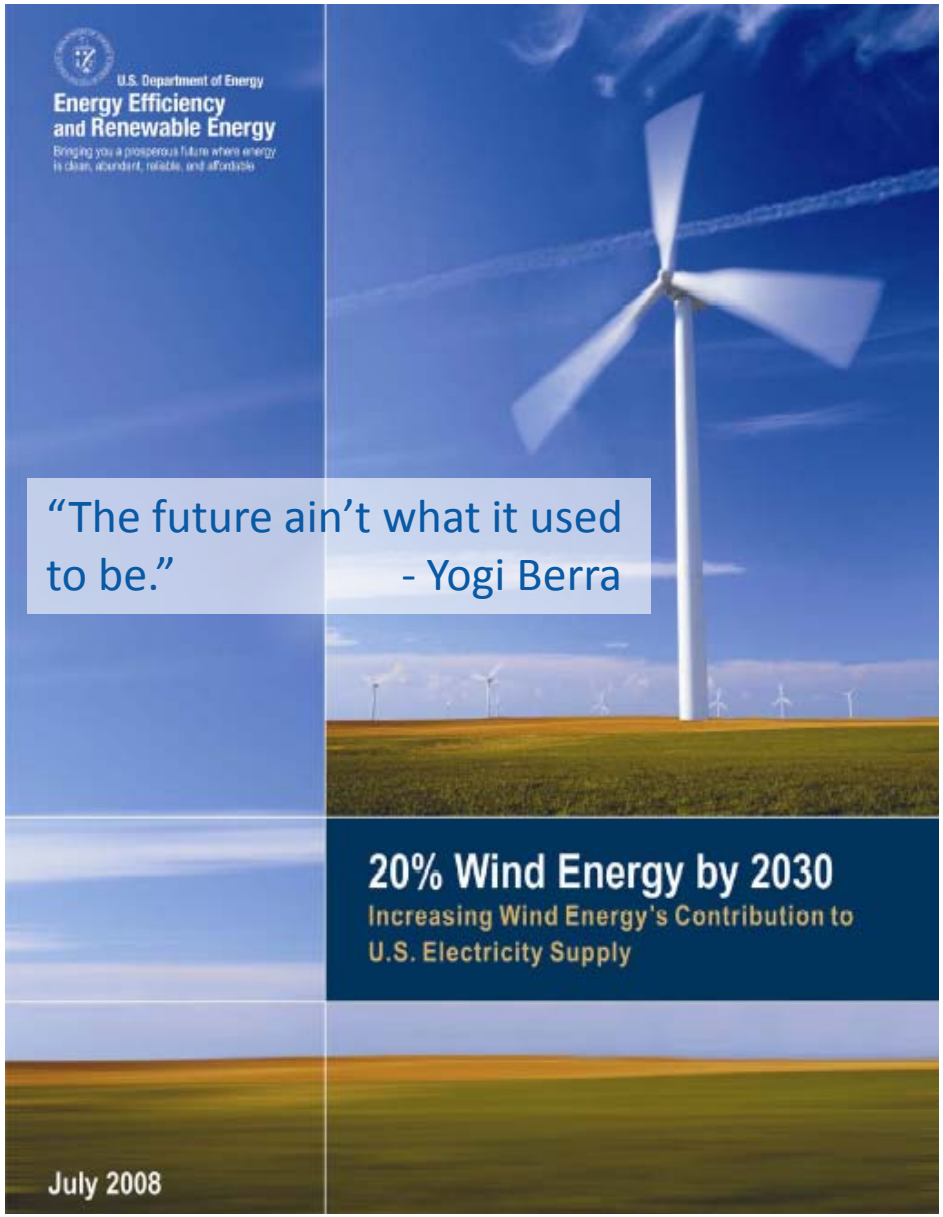
Visual Impact & Land Ownership

Kasigluk, Alaska

San Cristobal, Galapagos

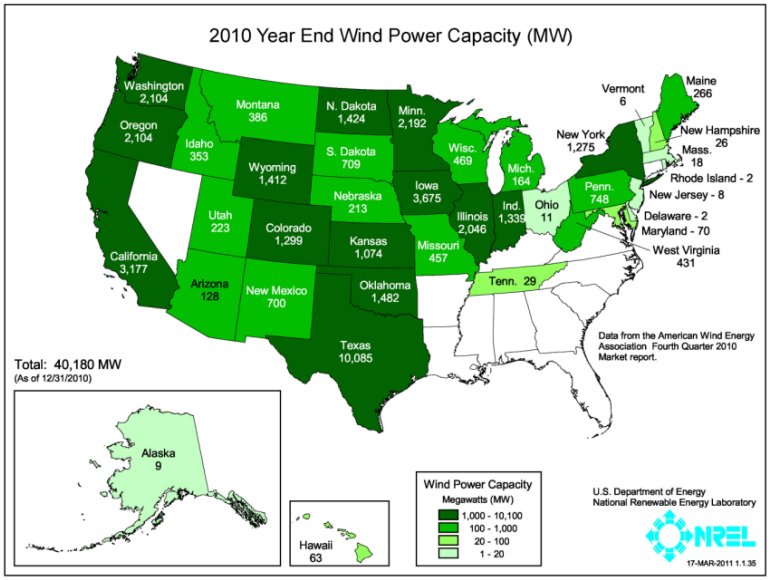
- Clear, but not very well documented impact.
- Based on data from new and existing wind plants - no clear long term cost impact to housing near wind farms, even for large homes
- People who have demonstrated economic benefit are much more likely to support the project
- Define the discussion, don't let project proponents do that.
- A large amount of visualization tools available to allow people to see what the site will look like – take advantage of them

20% Wind Energy by 2030

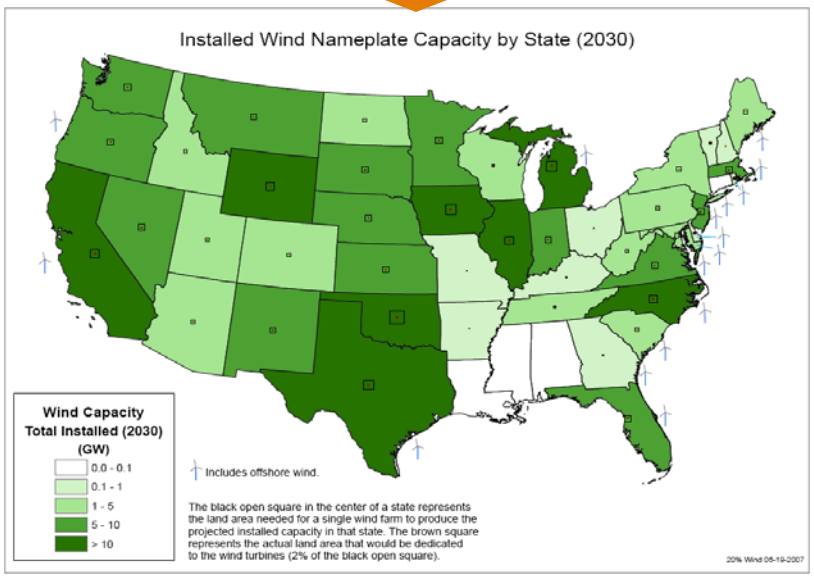


"The future ain't what it used to be." - Yogi Berra

2 %



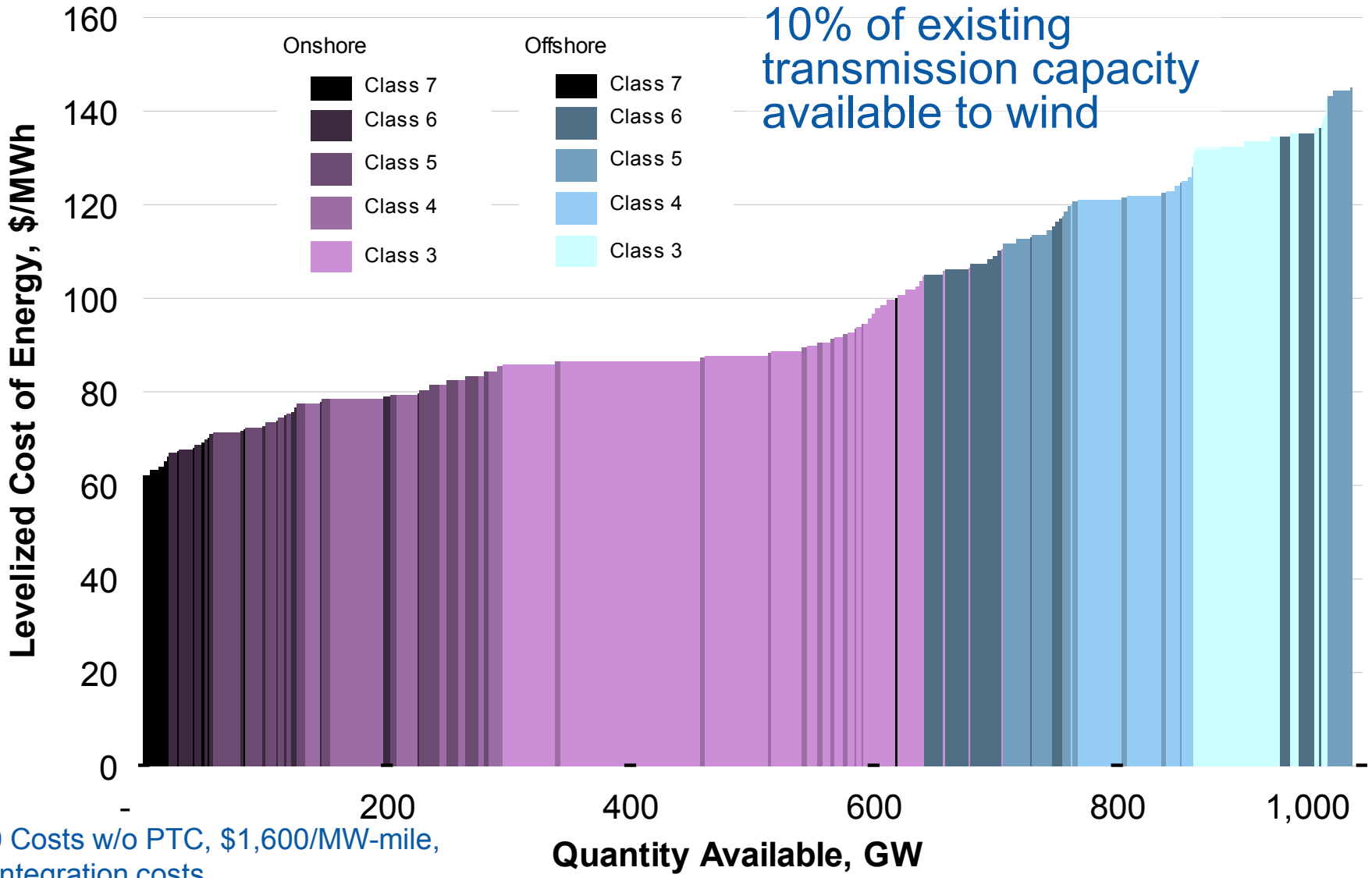
20 %



The 20% Technical Report

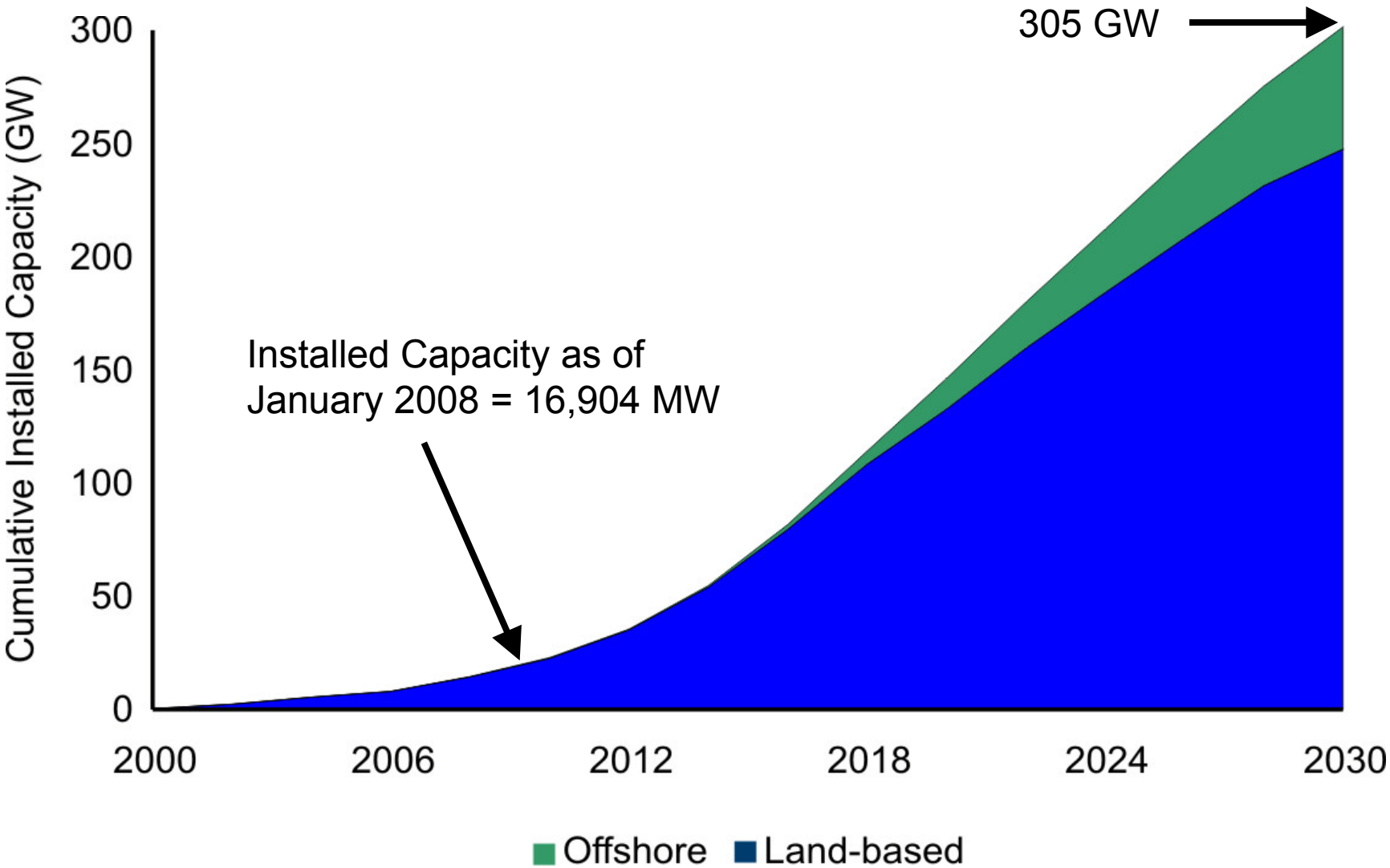
- Explores one scenario for reaching 20% wind electricity by 2030 and contrasts it to a scenario in which no new U.S. wind power capacity is installed
- Is not a prediction, but an analysis based on one scenario
- Does not assume specific policy support for wind
- Is the work of more than 100 individuals 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

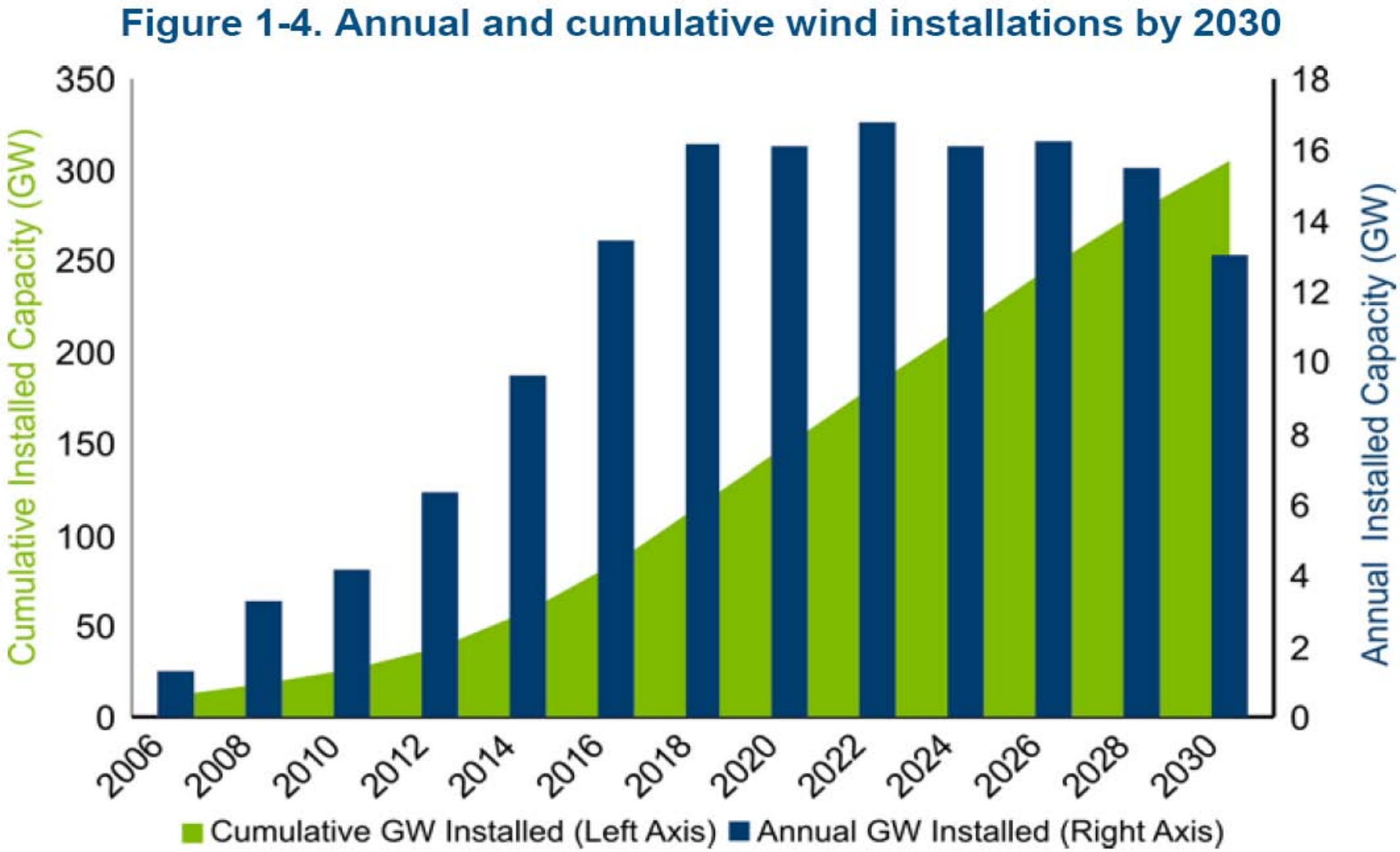


2010 Costs w/o PTC, $1,600/MW-mile, w/o Integration costs

20% Wind Scenario

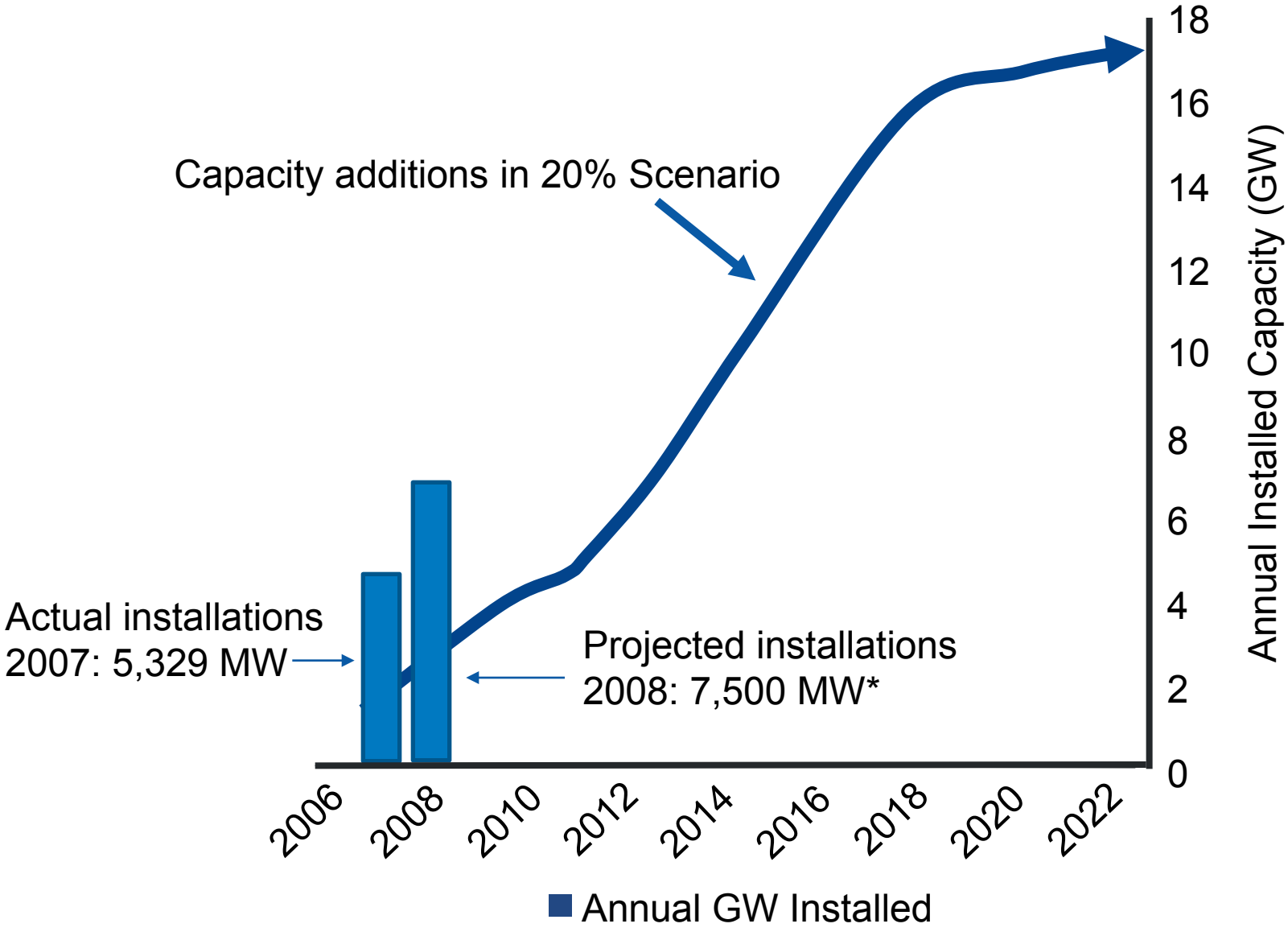


What does 20% Wind look like?



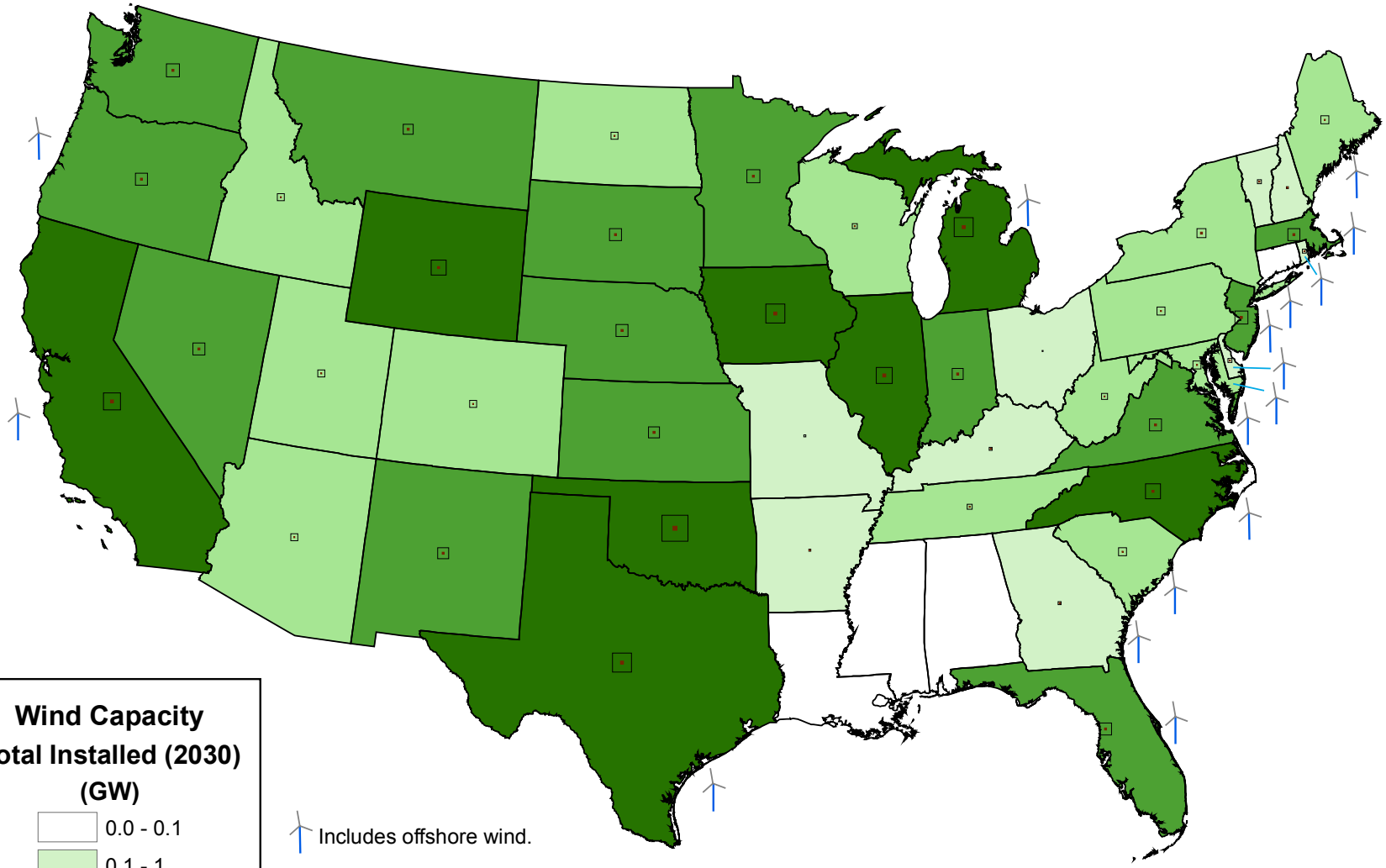
Source: DOE 20% Report

Annual Installed Capacity vs. Current Installed Capacity



Source: AWEA, 2008

46 States Would Have Substantial Wind Development by 2030



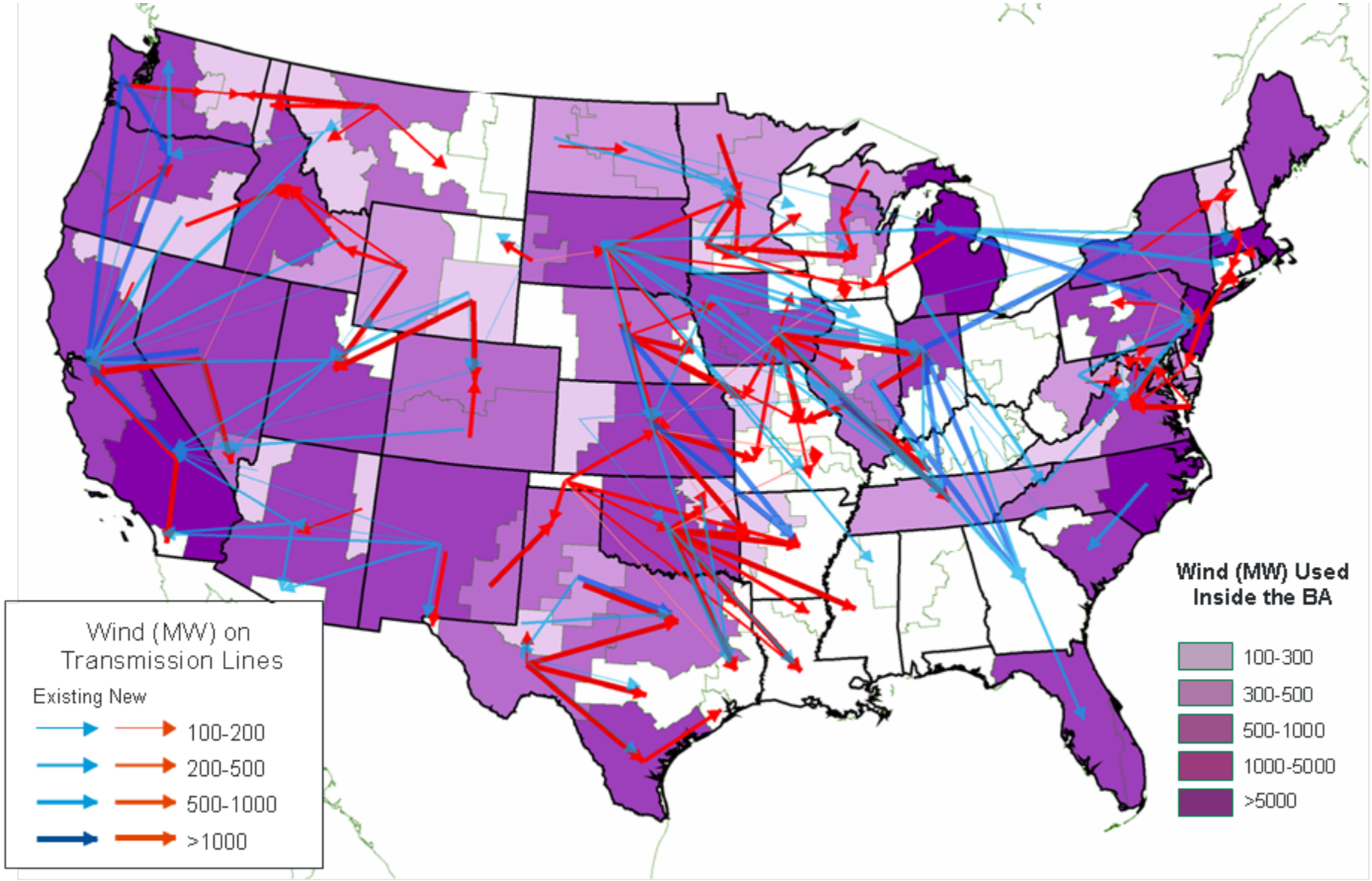
Wind Capacity Total Installed (2030) (GW)

- 0.0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- > 10

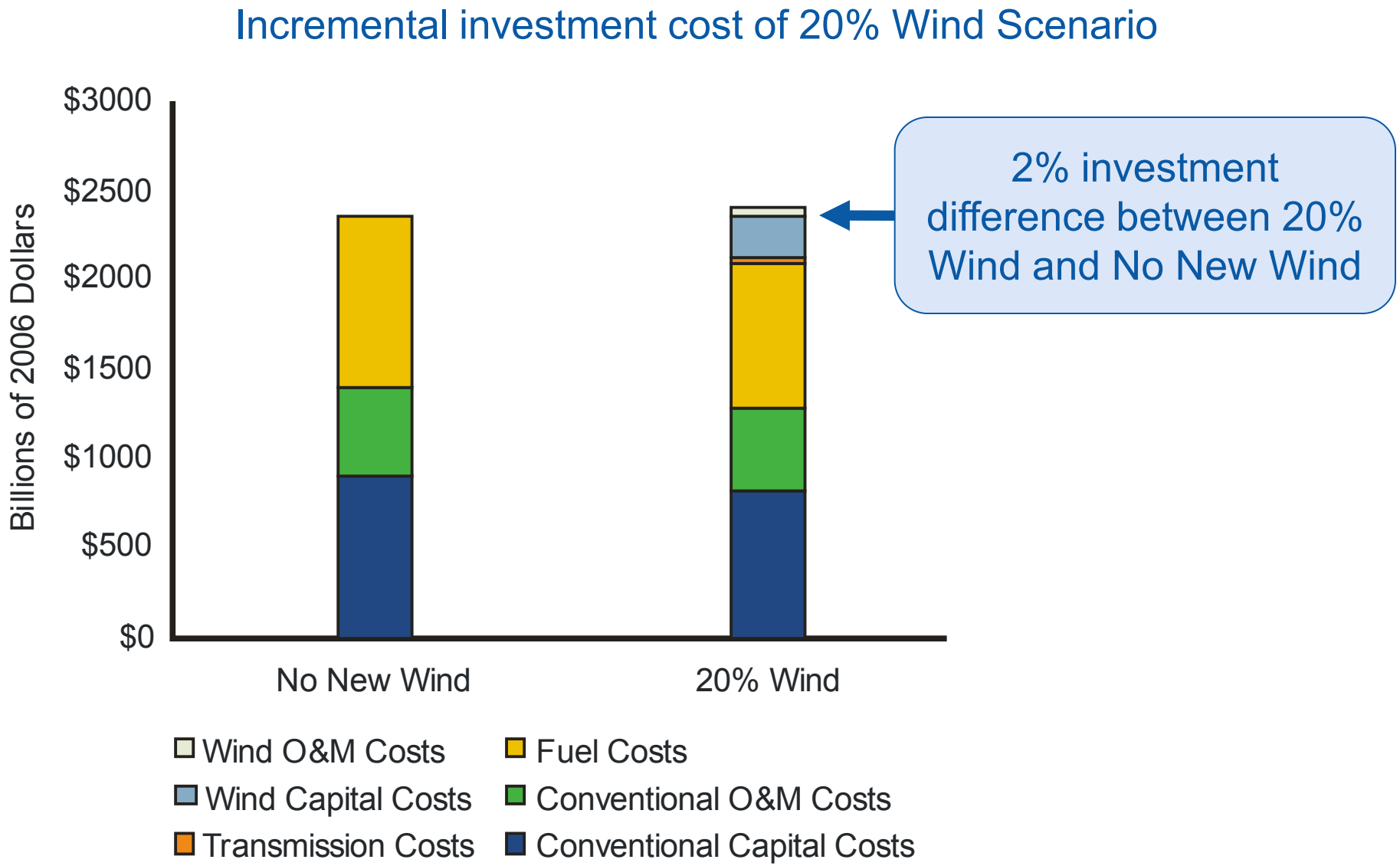
Includes offshore wind.

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

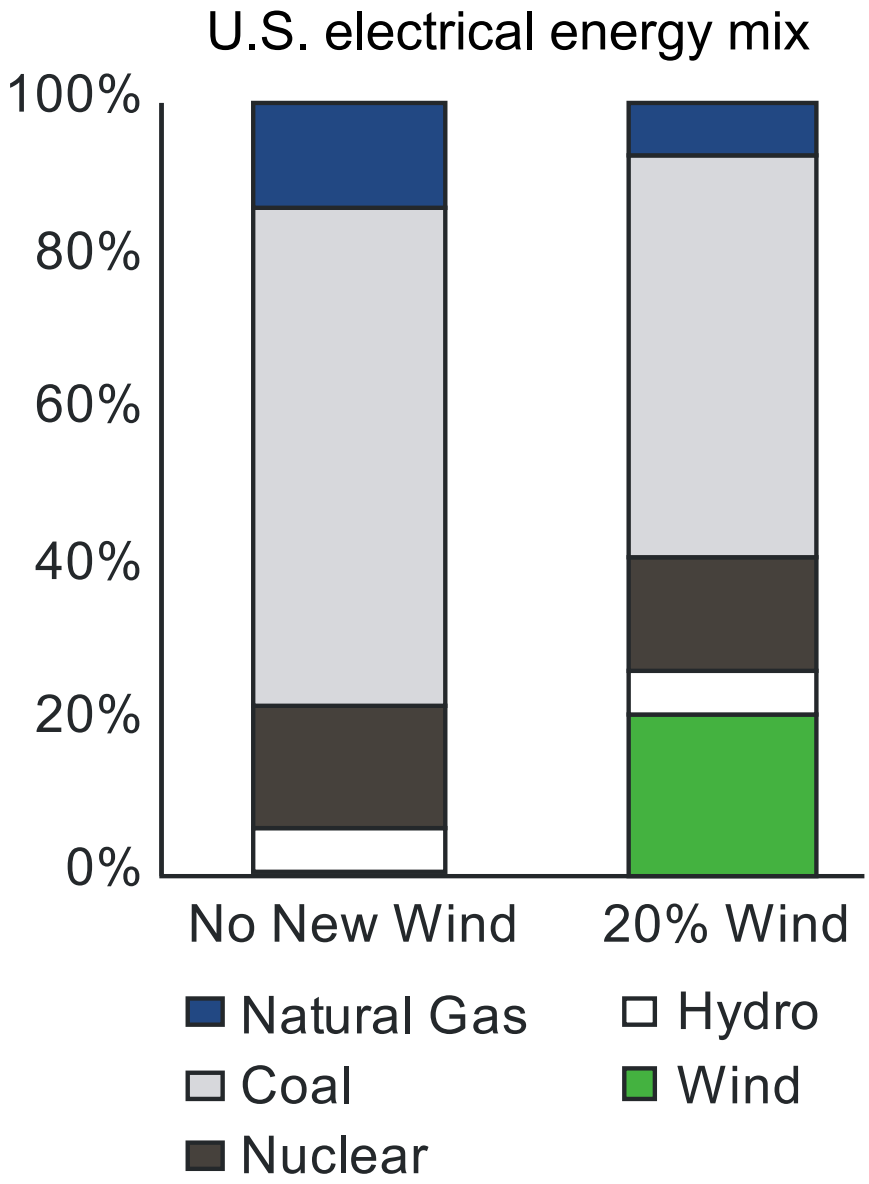


Economic Costs of 20% Wind Scenario



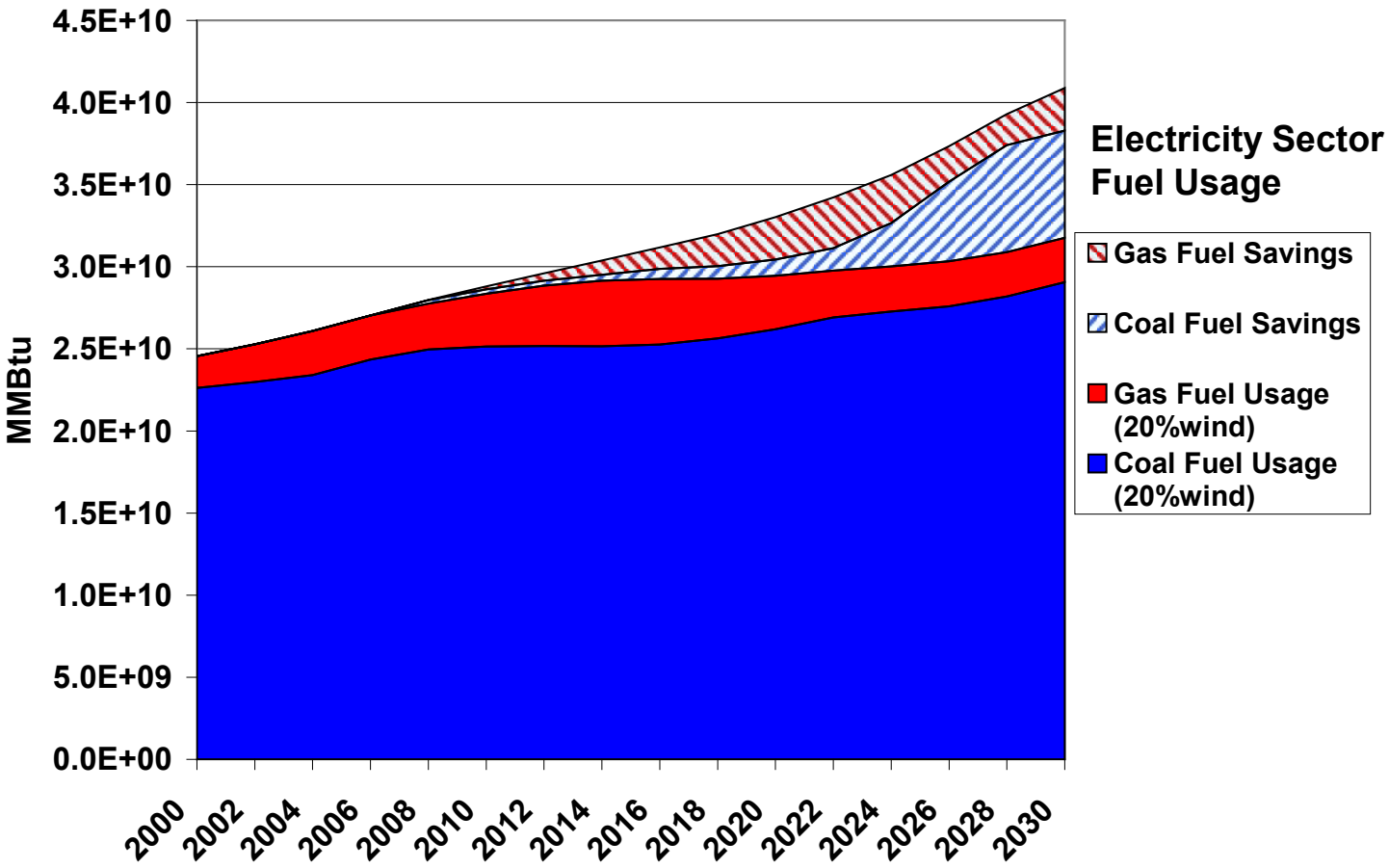
20% Wind Scenario Impact on Generation Mix in 2030

- 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

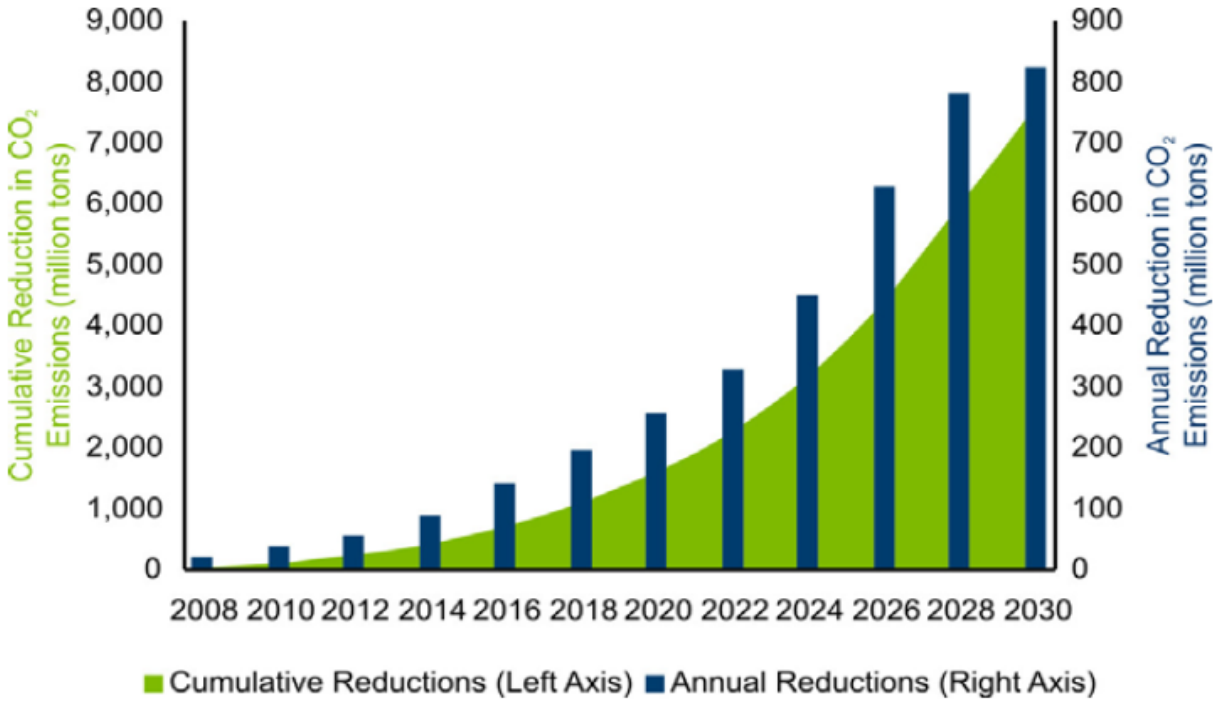


Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006$/MMBtu)	Present Value Benefits (billion 2006$)	Levelized Benefit of Wind ($/MWh)
11%	0.6 -**1.1**- 1.5	86 - **150** - 214	16.6 - **29** - 41.6

Cumulative Carbon Savings

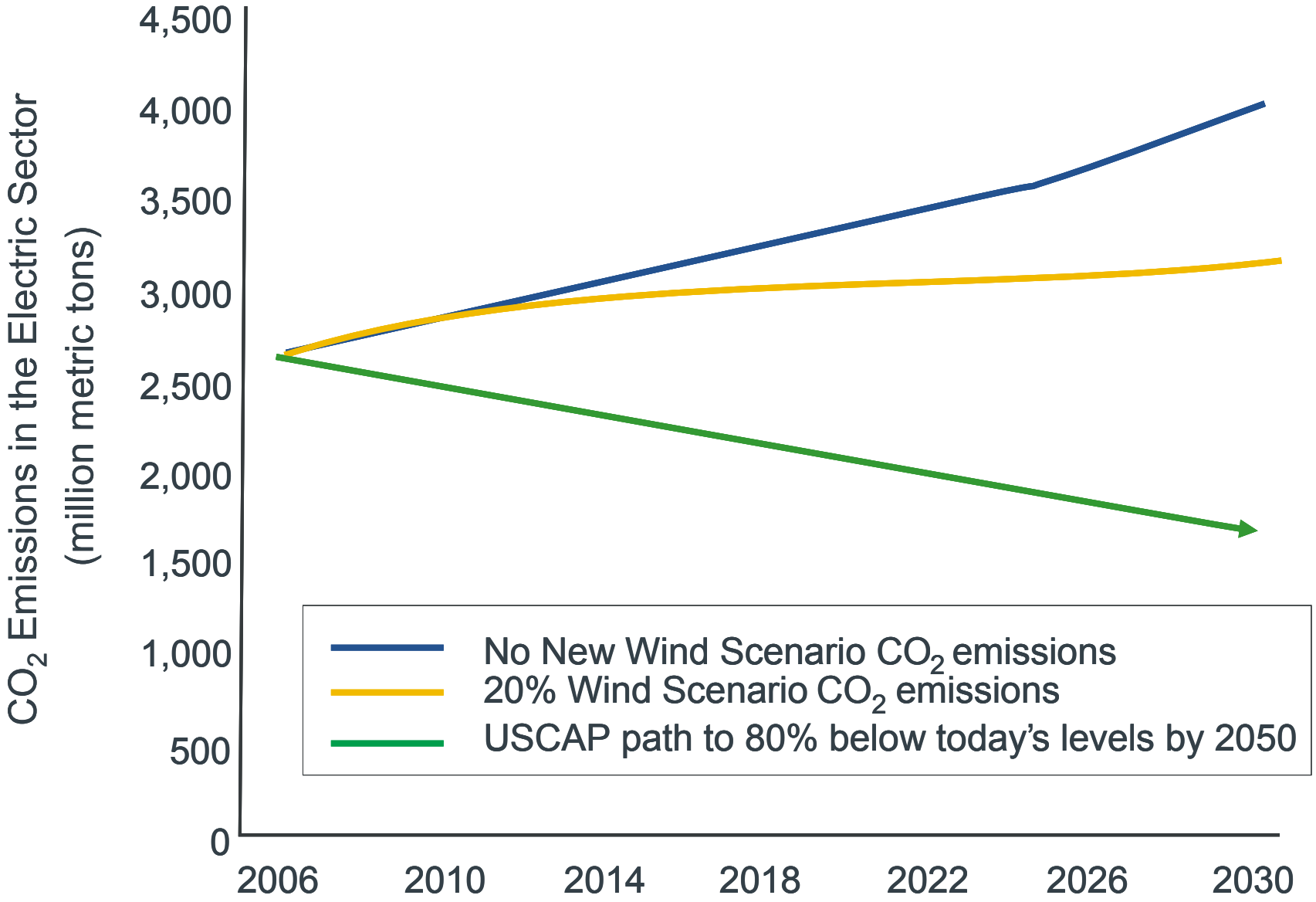
Figure 1-12. Annual CO_2 emissions avoided (vertical bars) would reach 825 million tons by 2030.

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

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

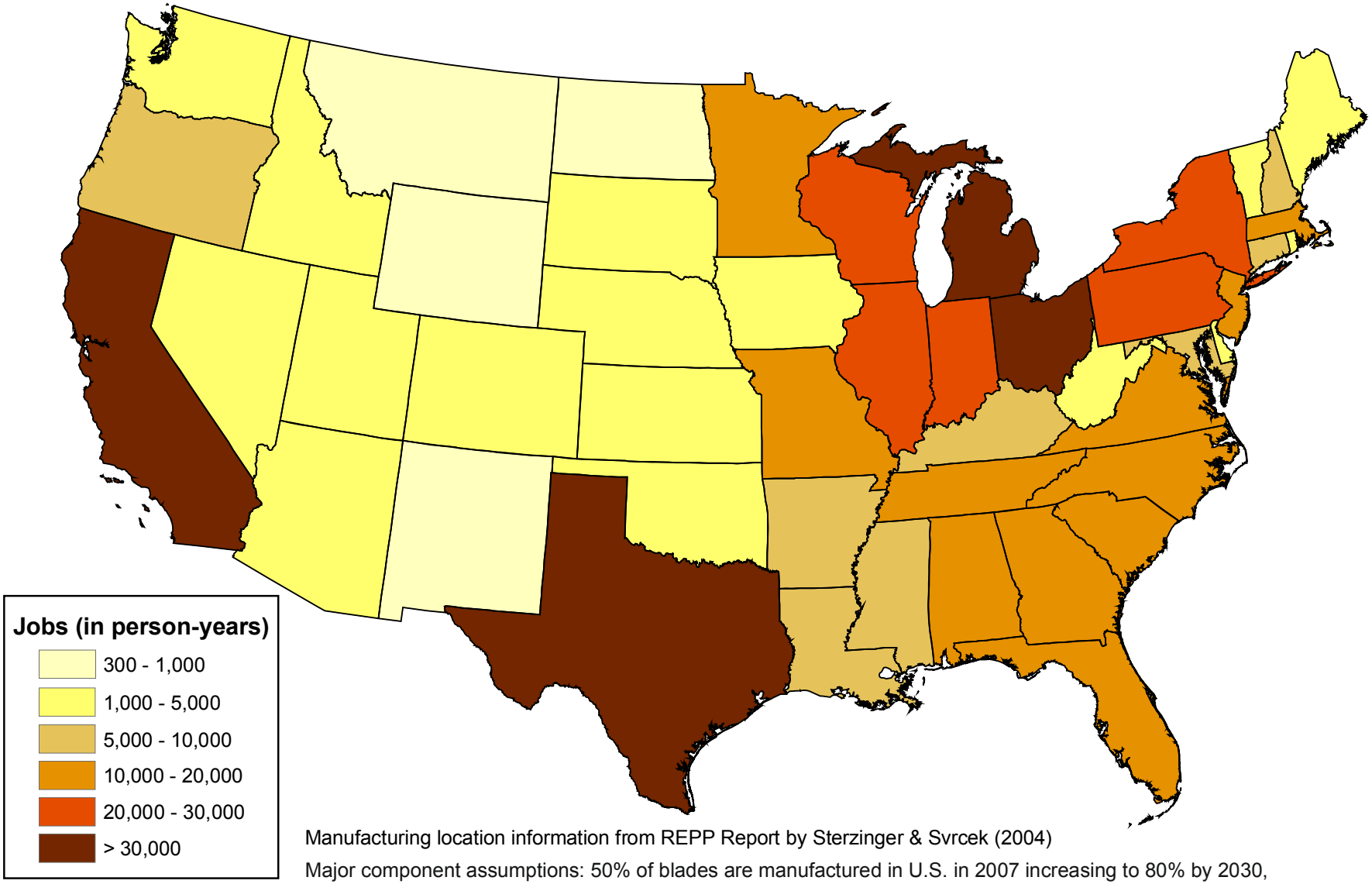
Construction Phase = 1-2 years
Operational Phase = 20+ years

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

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

Manufacturing Jobs Supported by State

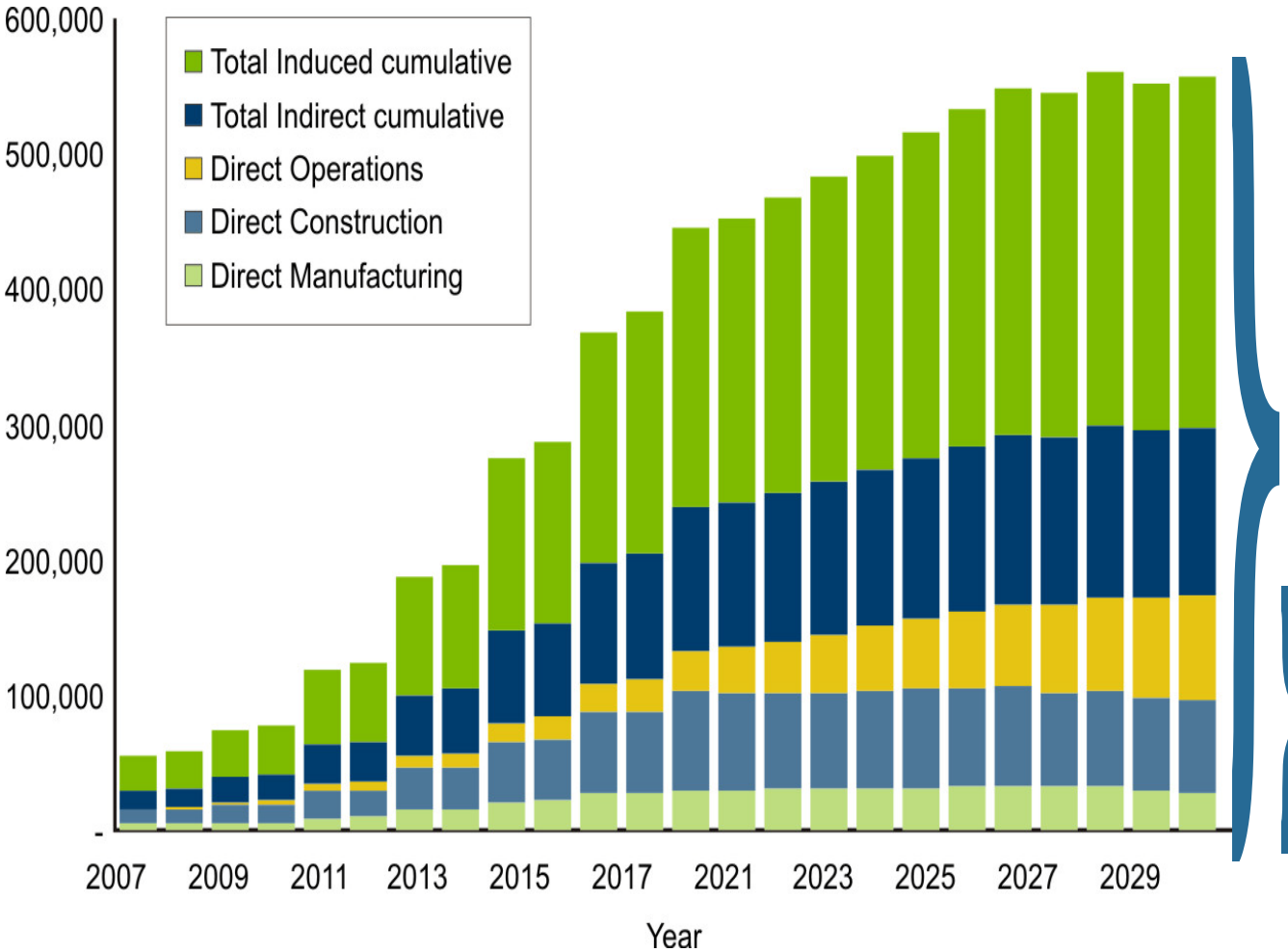


Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

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

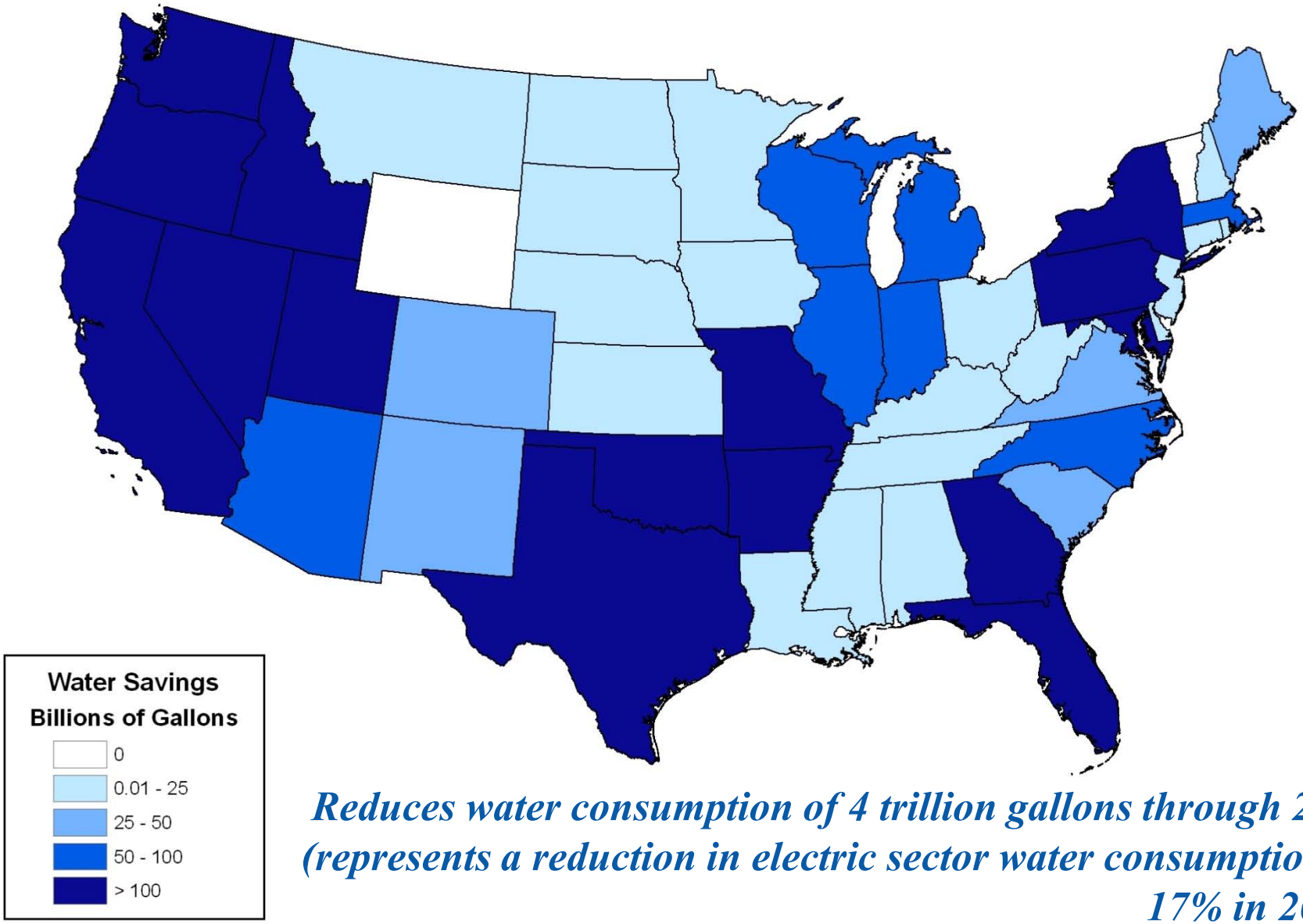
Over 500,000 jobs would be supported between 2007 and 2030



Over 500,000 jobs supported by the industry in 2030

Approx. 180,000 directly employed by wind

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

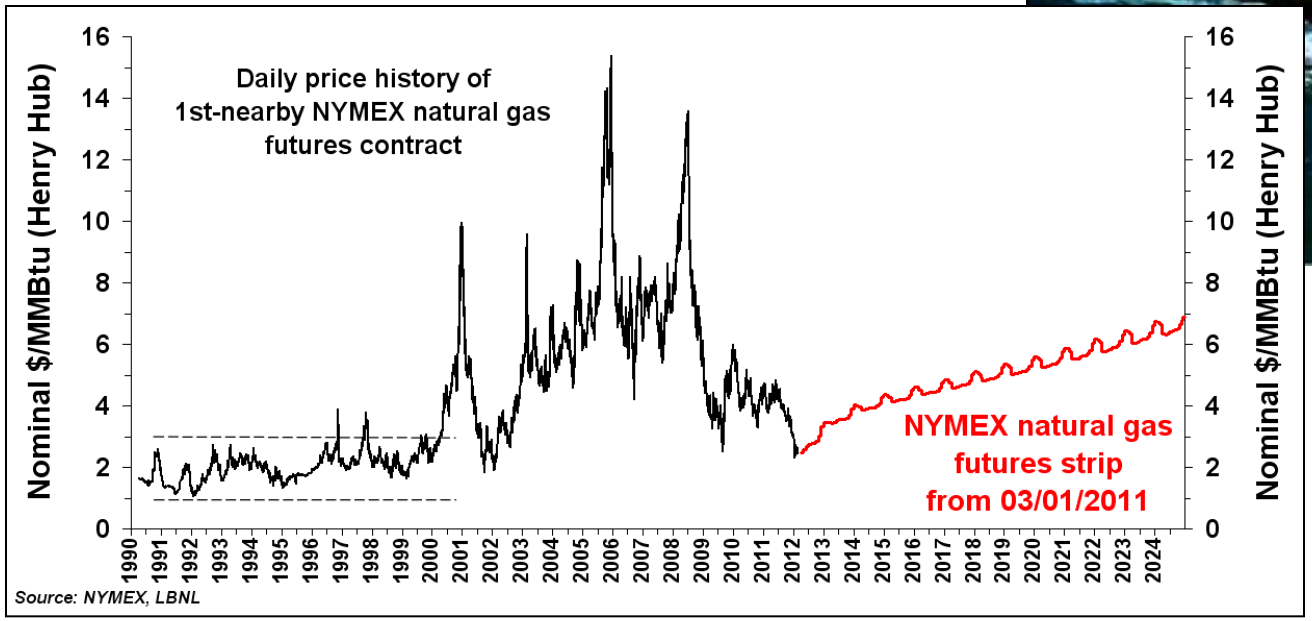
Wind power avoids the negative impacts of fossil fuel-based electricity generation:

- 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

PIX 00560

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

- Wind is no longer a niche technology in the US and around the world
- Wind technology is competitive in the market
- There are many drivers to the expanded development of wind
- There are issues to wind development – so wind is not applicable everywhere
- Change is hard – and there are many who like the way things are working now
- But the nation needs energy and all energy has an impact
- 20% wind energy penetration is possible but will not happen under business as usual scenario
- Policy choices will have a large impact on assessing the timing and rate of achieving a 20% goal
- 20% Wind by 2030 report: May 2008 (www.20percentwind.org)

20% wind is possible…

…with stakeholders like you!

Carpe Ventem

For more information, visit the Wind Powering America website, www.windpoweringamerica.gov or email us at: wpa@nrel.gov

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