

Wind Energy Update



Larry Flowers

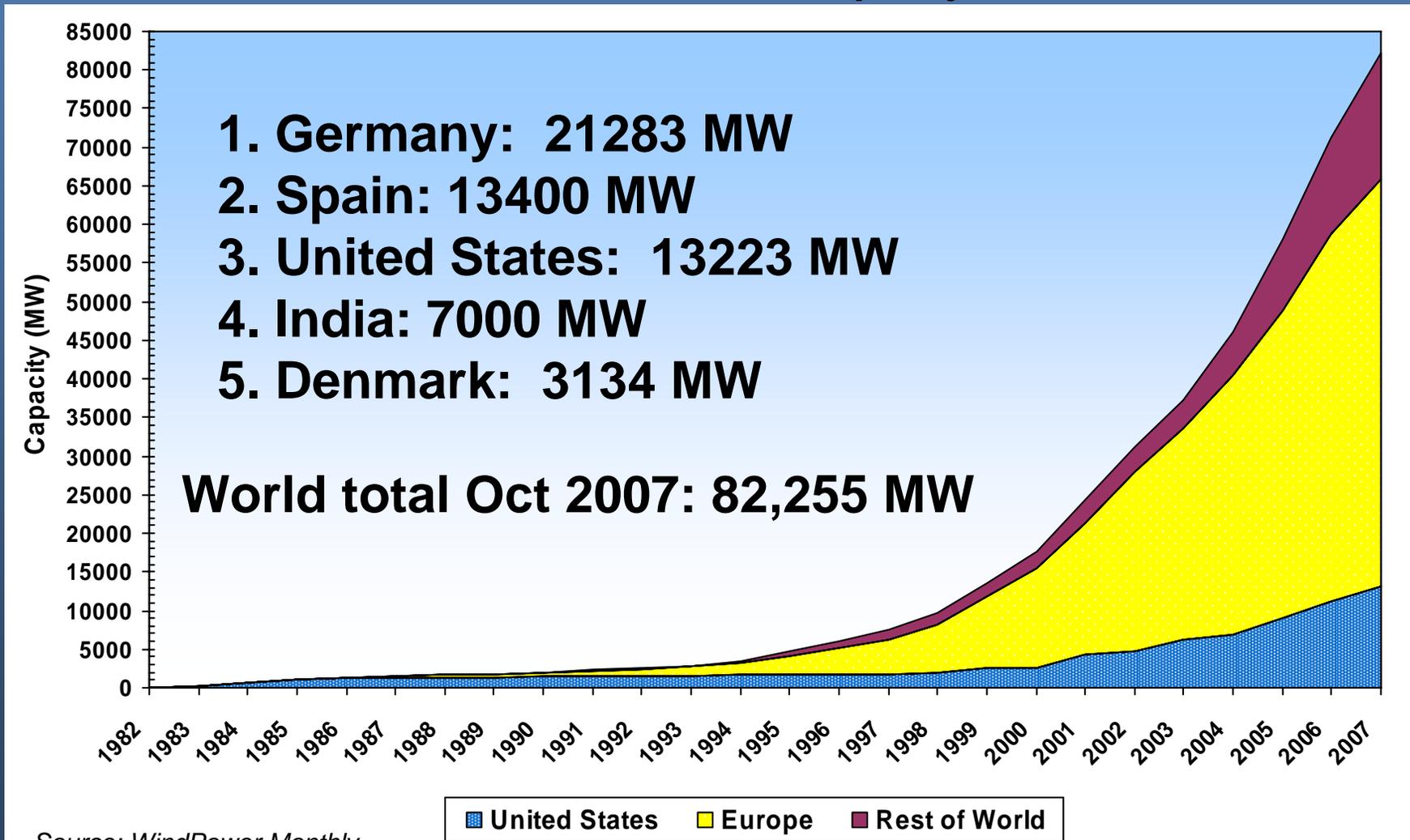
National Renewable Energy Laboratory

December 14, 2007

Indianapolis, IN

People Want Renewable Energy!

Total Installed Wind Capacity



Source: WindPower Monthly

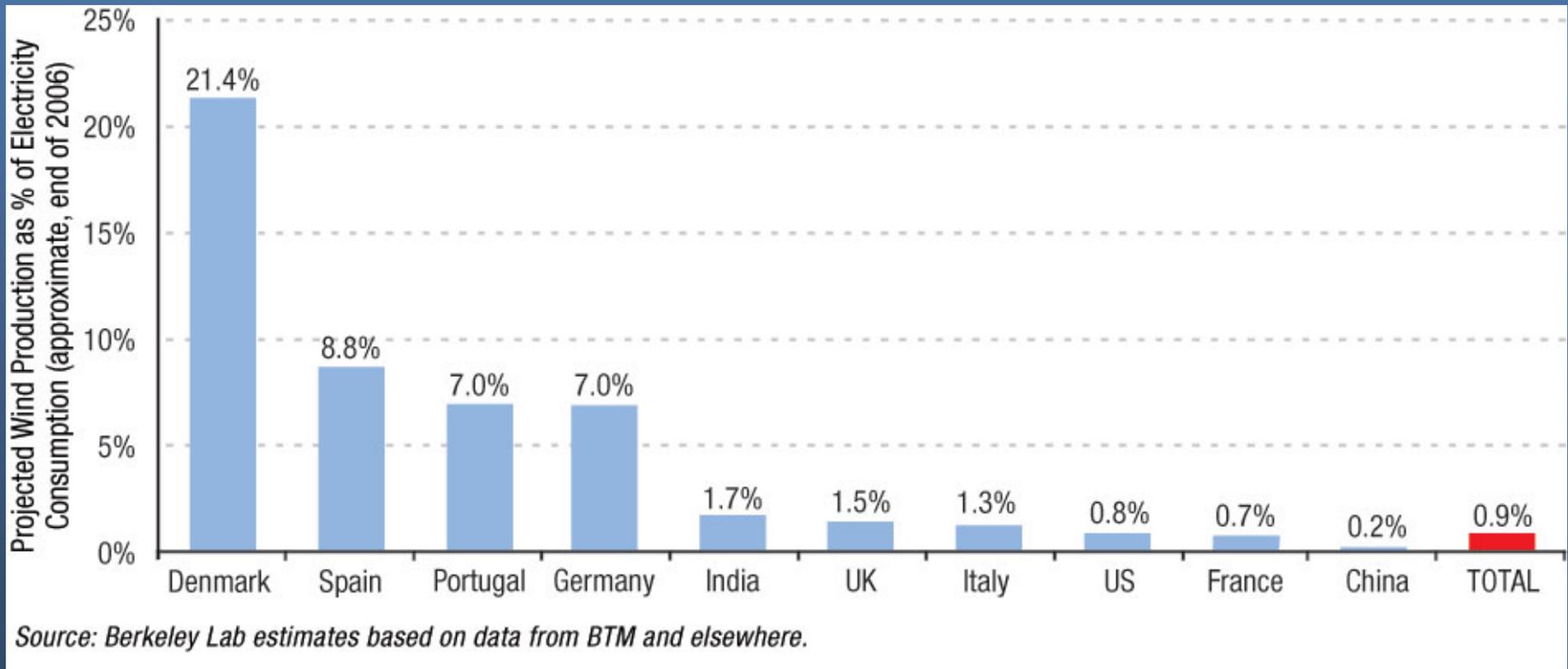
U.S. Leads World in Annual Wind Capacity Additions; Third in Cumulative Capacity

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

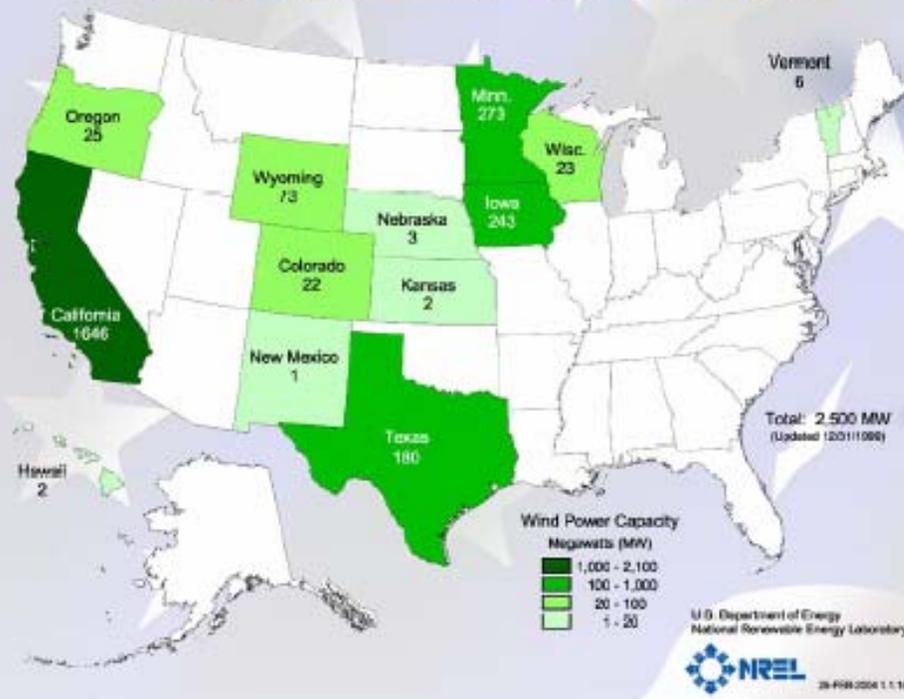
Source: BTM, 2007; AWEA/GEC dataset for U.S. cumulative capacity.

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

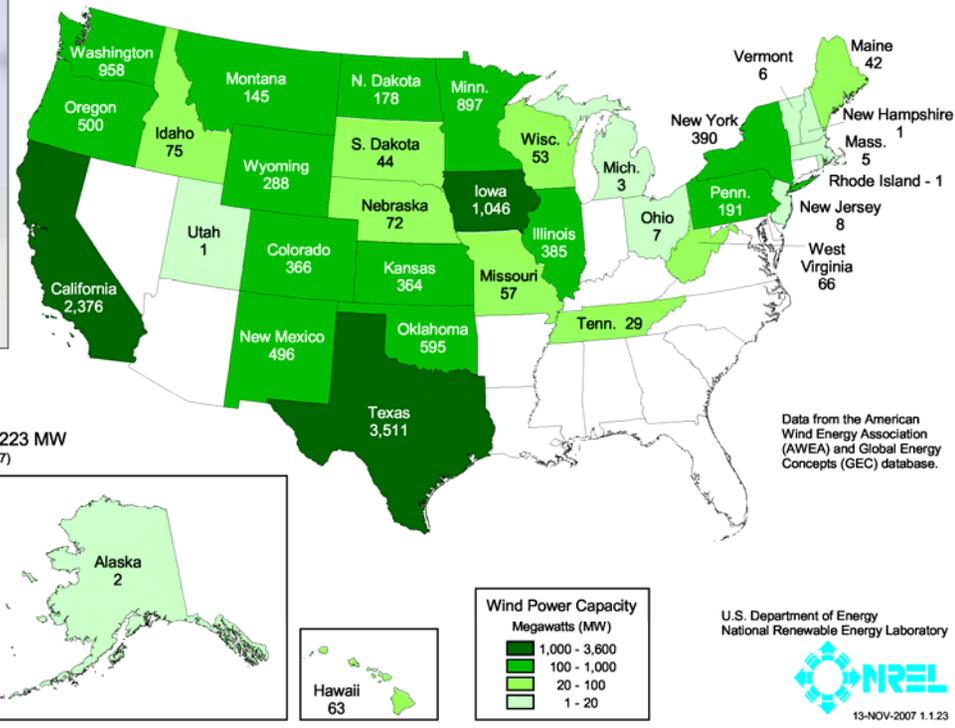


Installed Wind Capacities (‘99 – Oct 07)

1999 Year End Wind Power Capacity (MW)



United States - Current Installed Wind Power Capacity (MW)

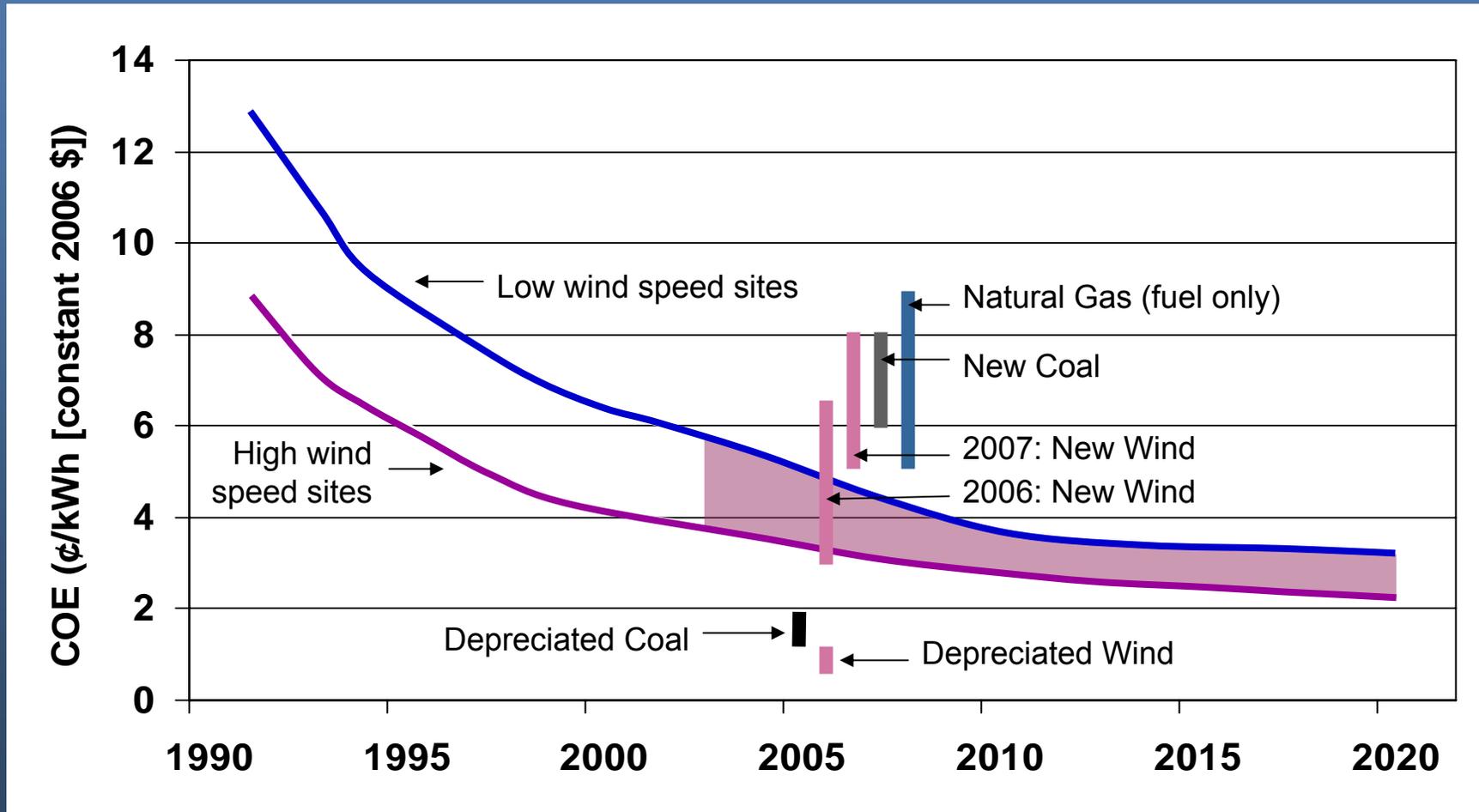


Drivers for Wind Power

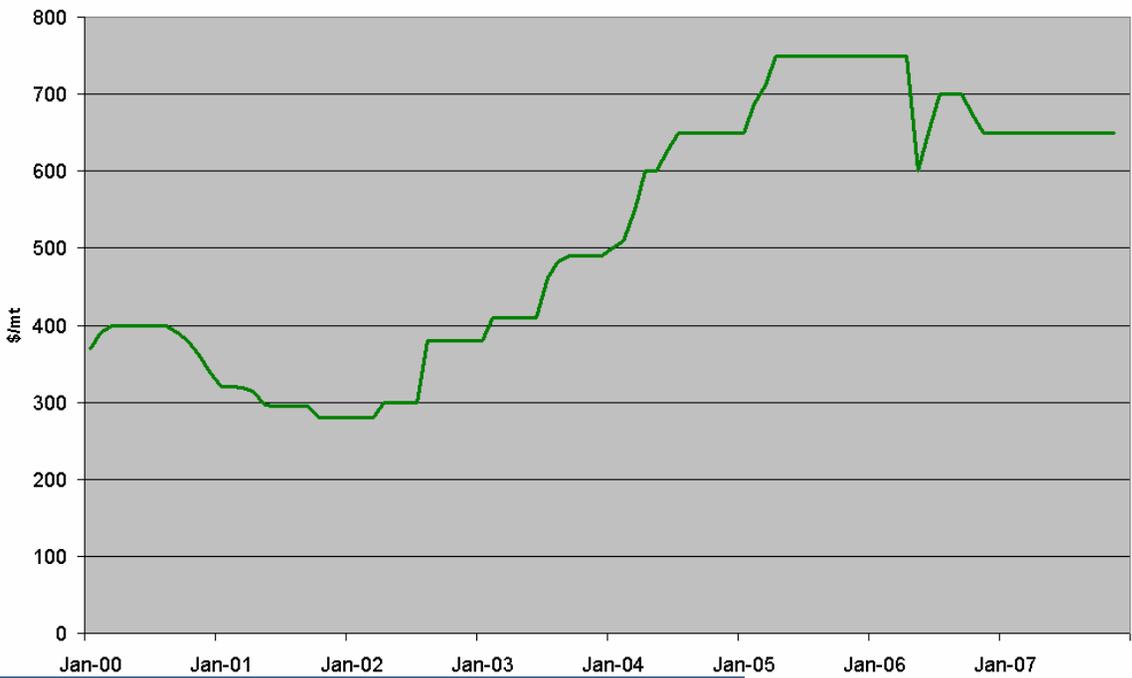
- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Public Support
- Green Power
- Energy Security
- Carbon Risk



Wind Cost of Energy



Historic Steel Prices - Cold Rolled



Steep Slide

The value of the dollar vs. the euro has fallen steadily since its 2000 peak. Dollars are worth a little more than half as many euros as they were five years ago.

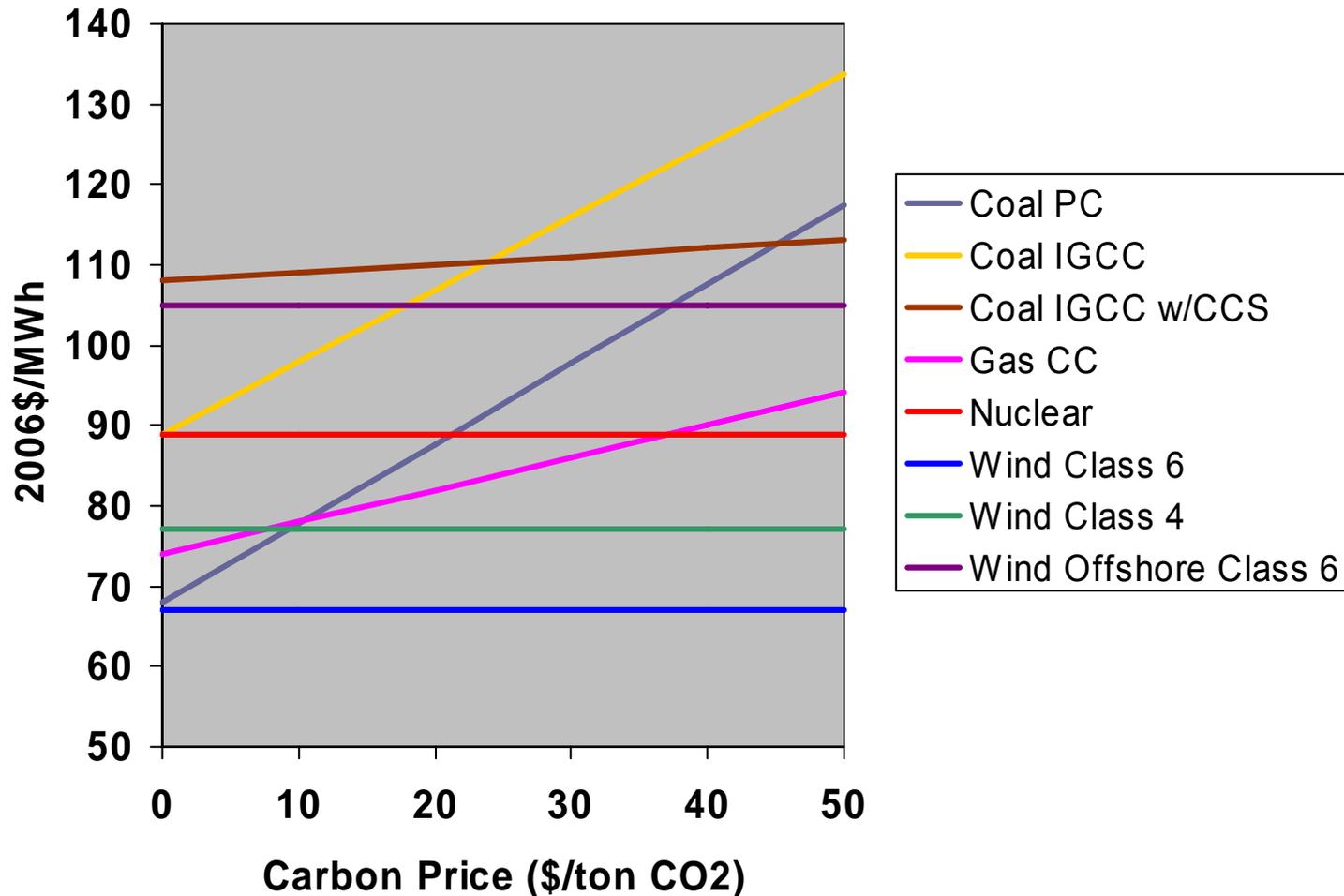


Historic Copper Prices



CO₂ prices significantly increase the cost of coal

Levelized Cost of Electricity (2010) vs. CO₂ Price

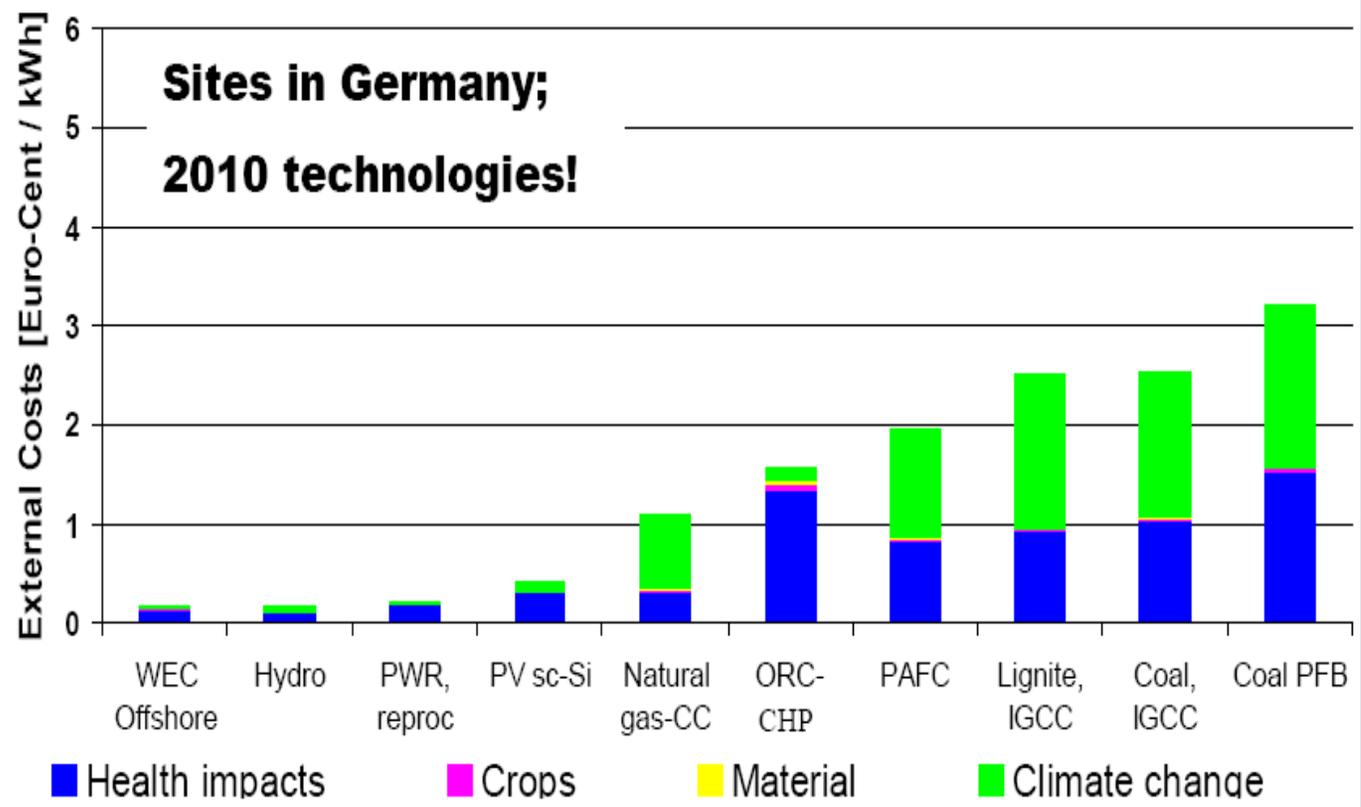


Source: UCS/Black & Veatch

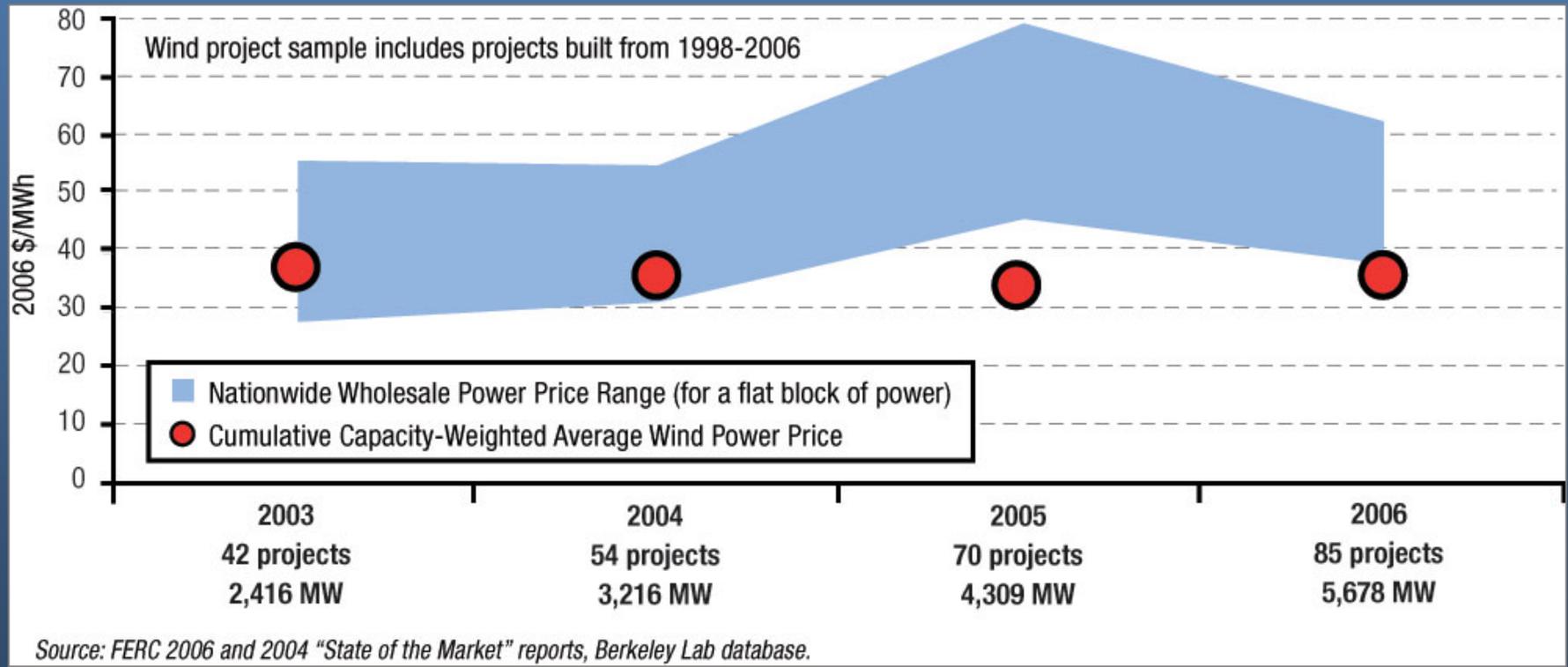
Major Market Distortion: External Costs of Fossil Fuels not Reflected in Pricing

(The PTCs are a bargain)

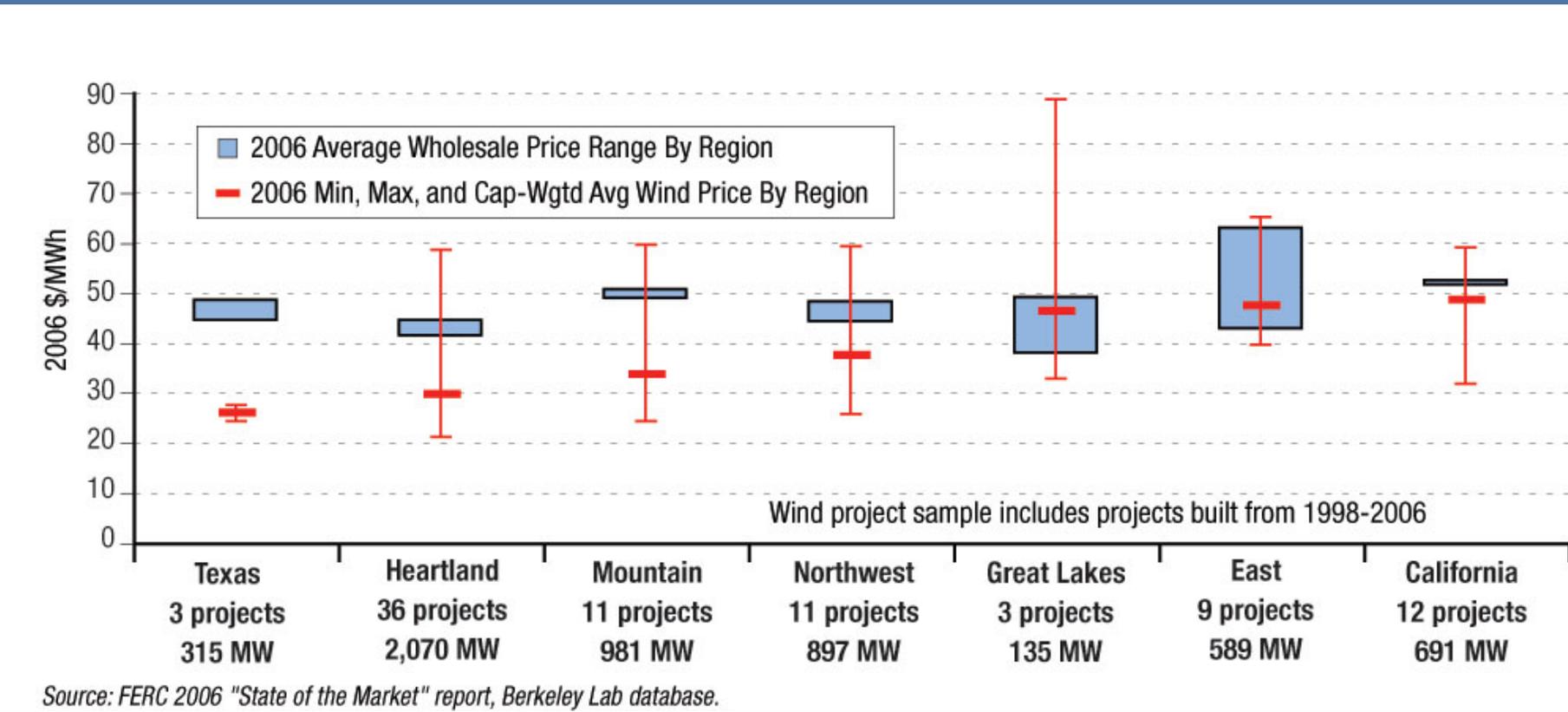
External Costs of Power Stations [Euro-Cent / kWh]
 19 Euro/t CO₂, Nitrates = 0.5 PM₁₀, YOLL_{chronic} = 50.000 Euro



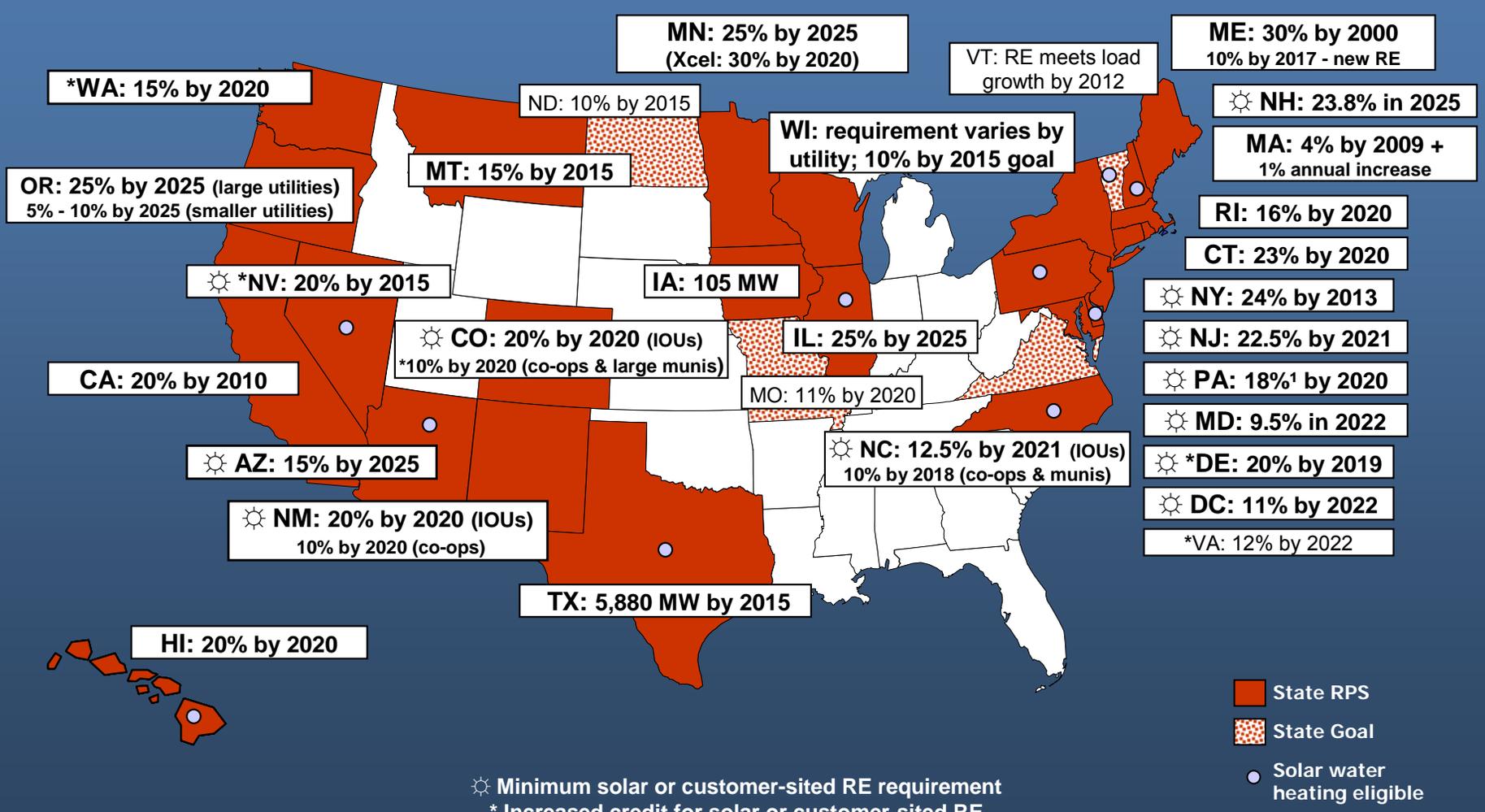
Nationally, Wind Has Been Competitive with Wholesale Power Prices in Recent Years



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



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

Indiana – Economic Impacts

from 1000 MW of new wind development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:

- \$2.7 Million/yr

Local Property Tax Revenue:

- \$16 Million/yr

Construction Phase:

- 1,550 new jobs
- \$189 M to local economies

Operational Phase:

- 250 new long-term jobs
- \$21 M/yr to local economies



Indirect & Induced Impacts

Construction Phase:

- 1,500 new jobs
- \$130 M to local economies

Operational Phase:

- 250 local jobs
- \$25 M/yr to local economies

Totals

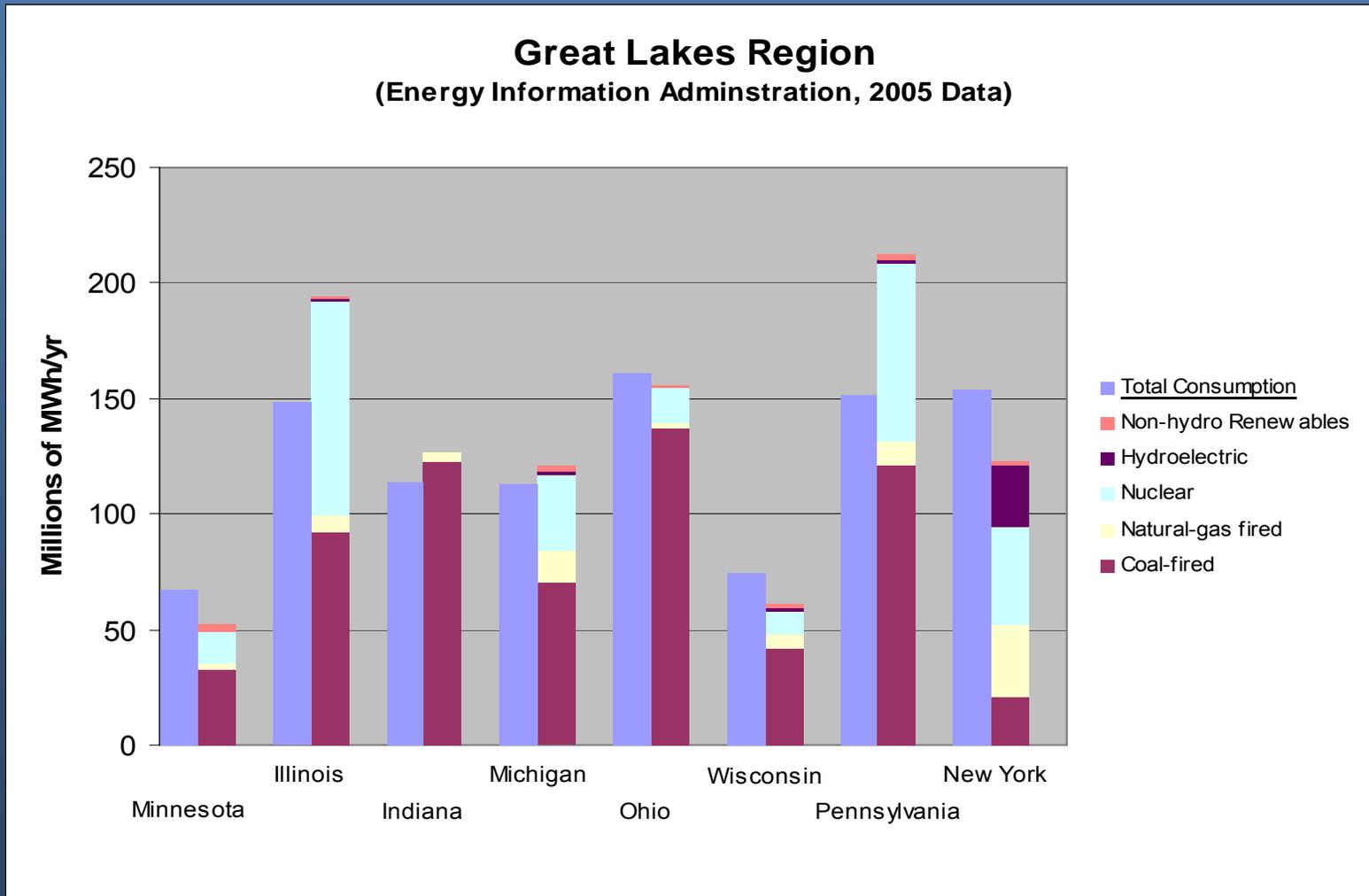
(construction + 20yrs)

Total economic benefit = \$1.3 billion

New local jobs during construction = 3,050

New local long-term jobs = 550

Generation And Consumption by State and Fuel Source

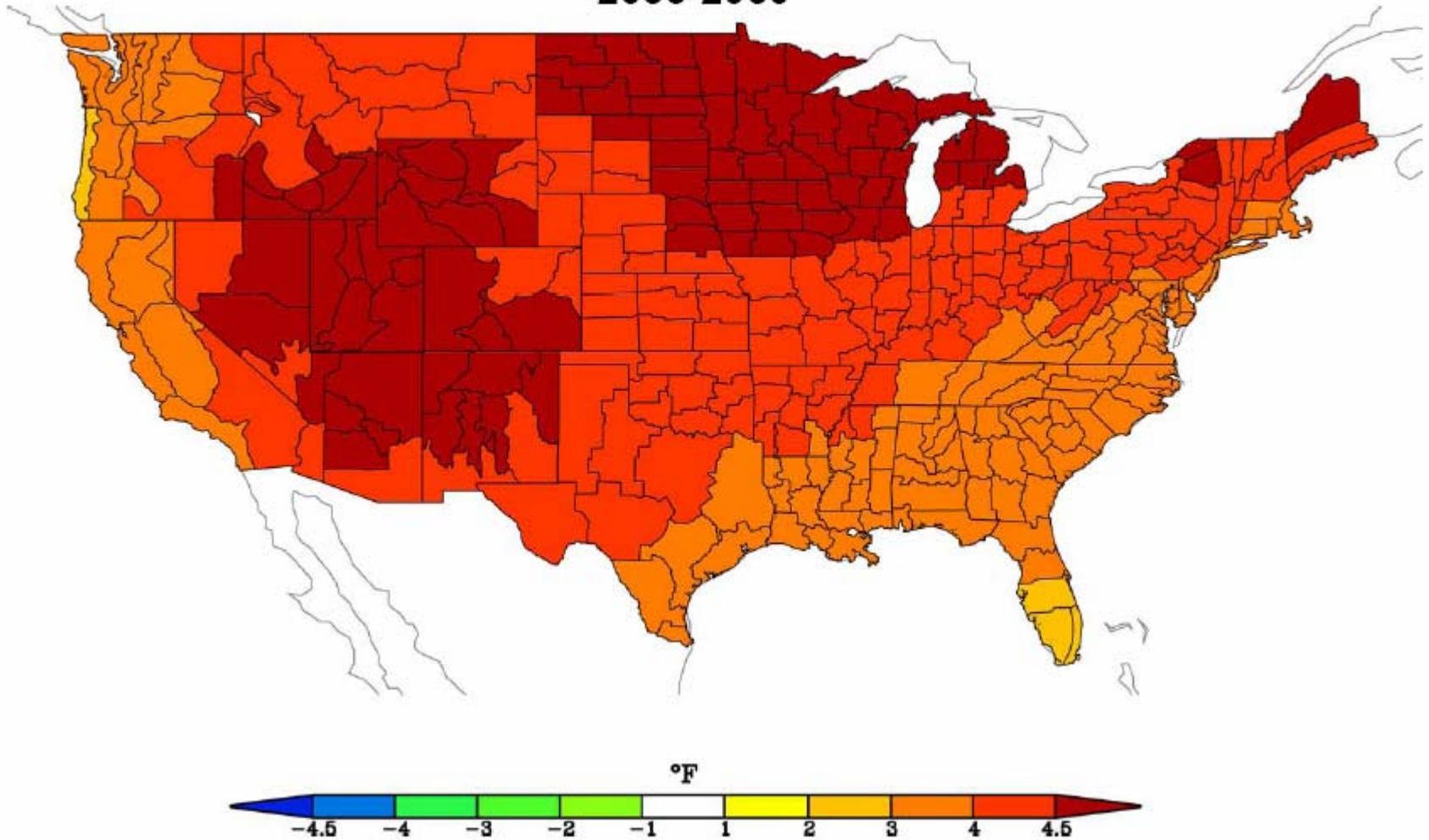


Environmental Benefits

- No SO_x or NO_x
- No particulates
- No mercury
- **No CO₂**
- No water



Change in Annual Temperature 2035-2060



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.



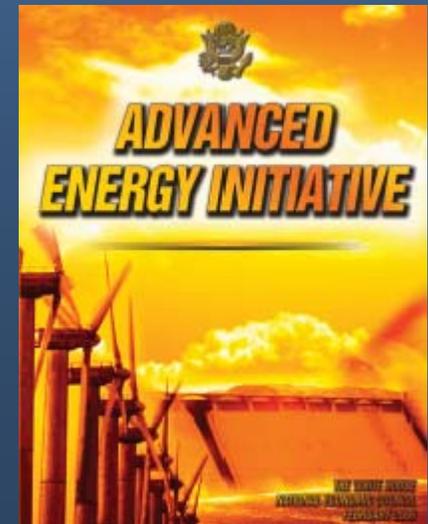
White House photo by Eric Draper

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.”



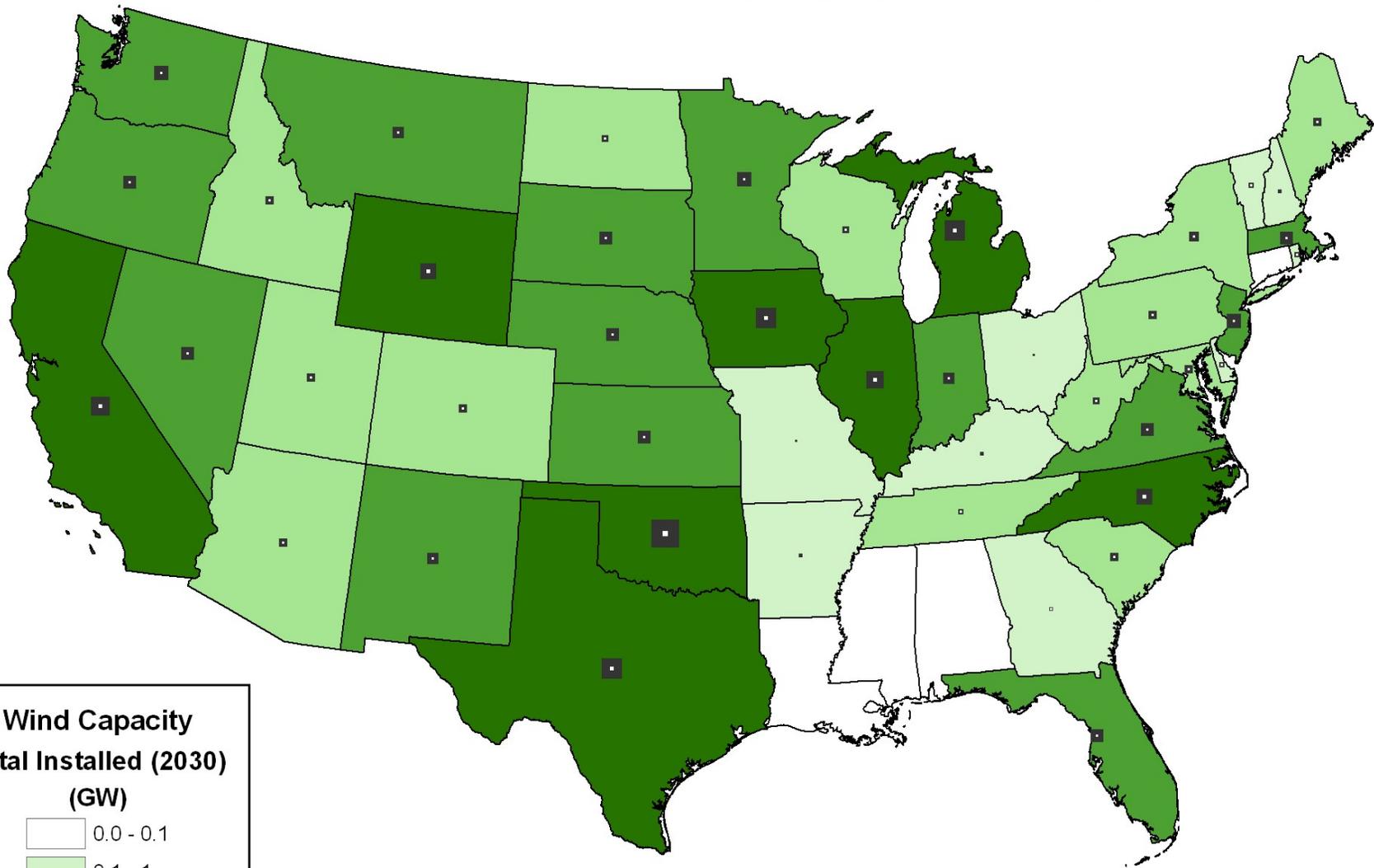
20% Wind-Electricity Vision

*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.*

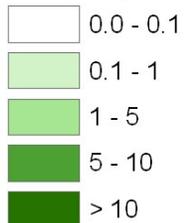
20% Wind-Electricity Vision

- 6 task forces:
 - Technology/Manufacturing
 - Transmission/Utility Operations
 - Siting/Environment
 - Markets/Stakeholders
 - Policy
 - Analysis/Benefits

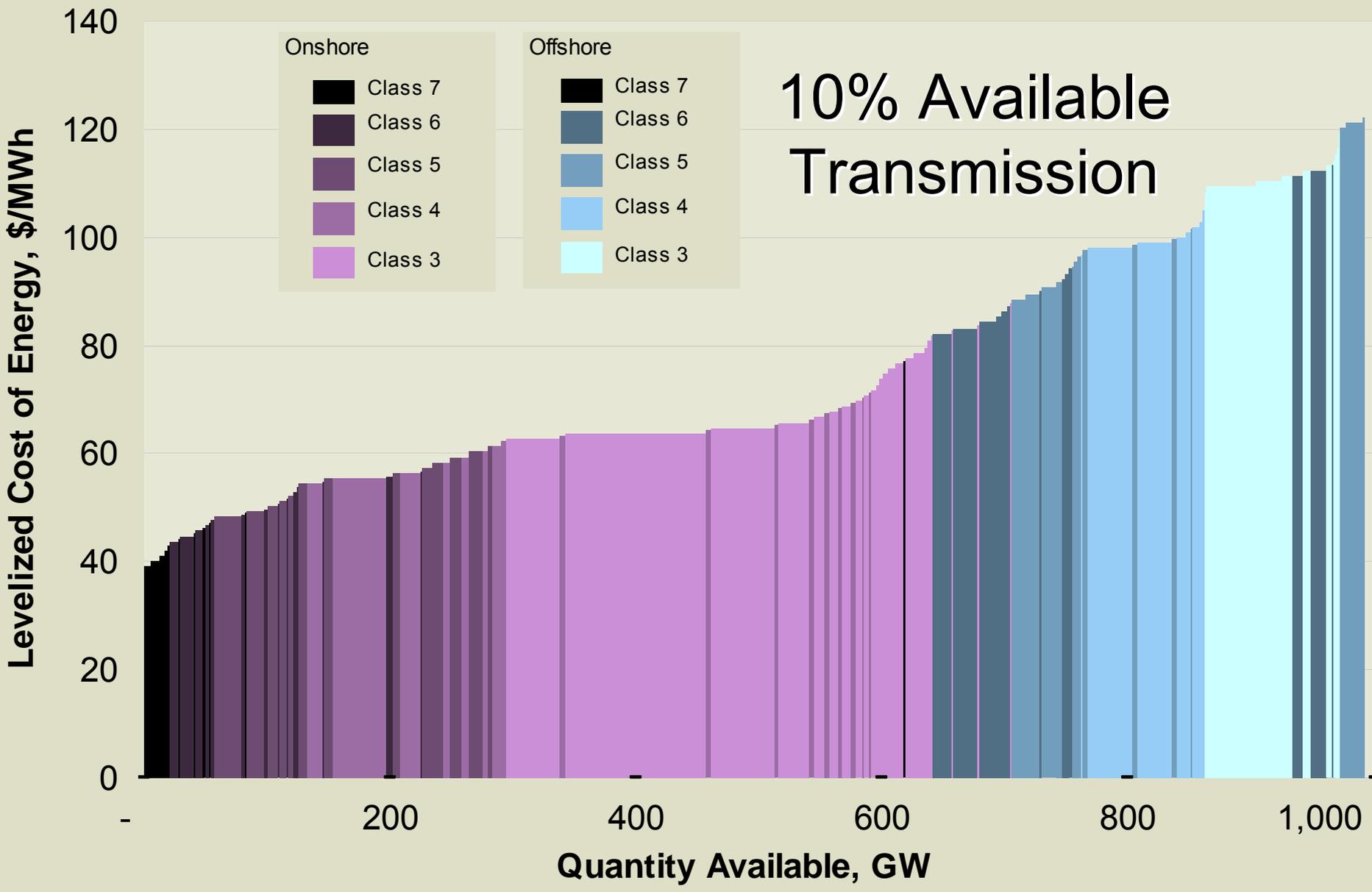
Installed Wind Nameplate Capacity by State (2030)



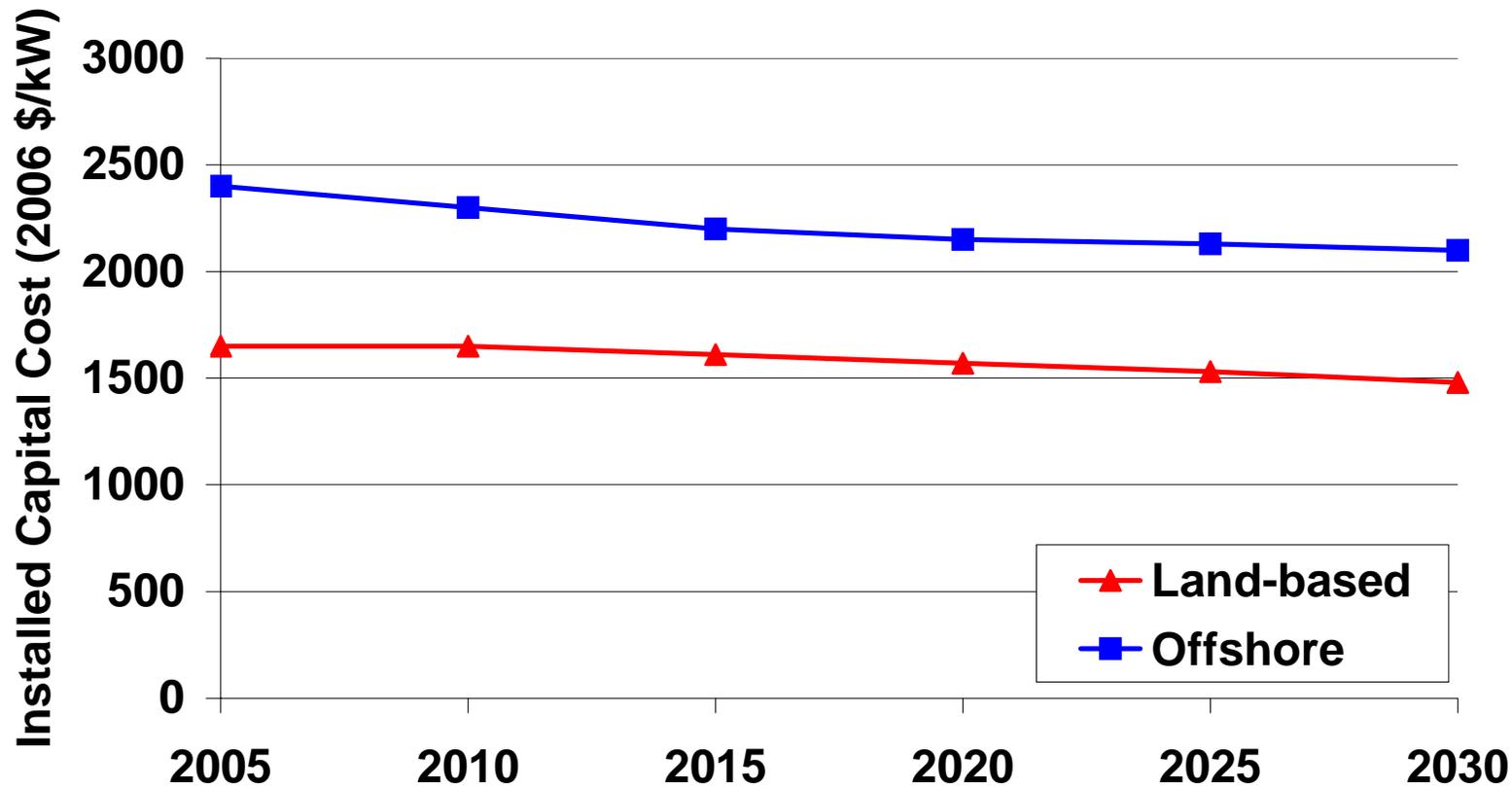
Wind Capacity Total Installed (2030) (GW)



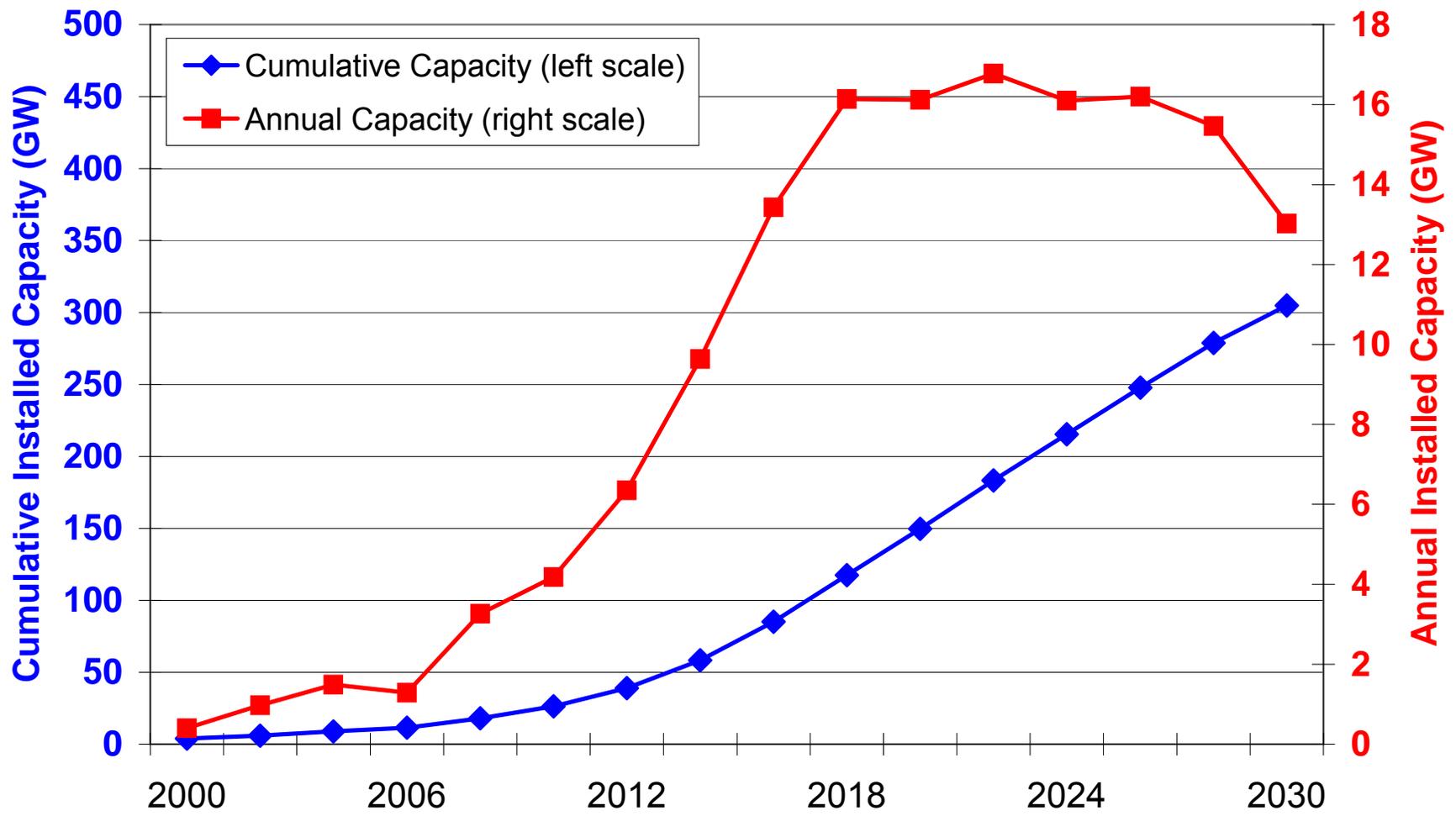
The black square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The white square represents the actual land area that would be dedicated to the wind turbines (2% of the black square).



Wind Capital Cost



What does 20% Wind look like?

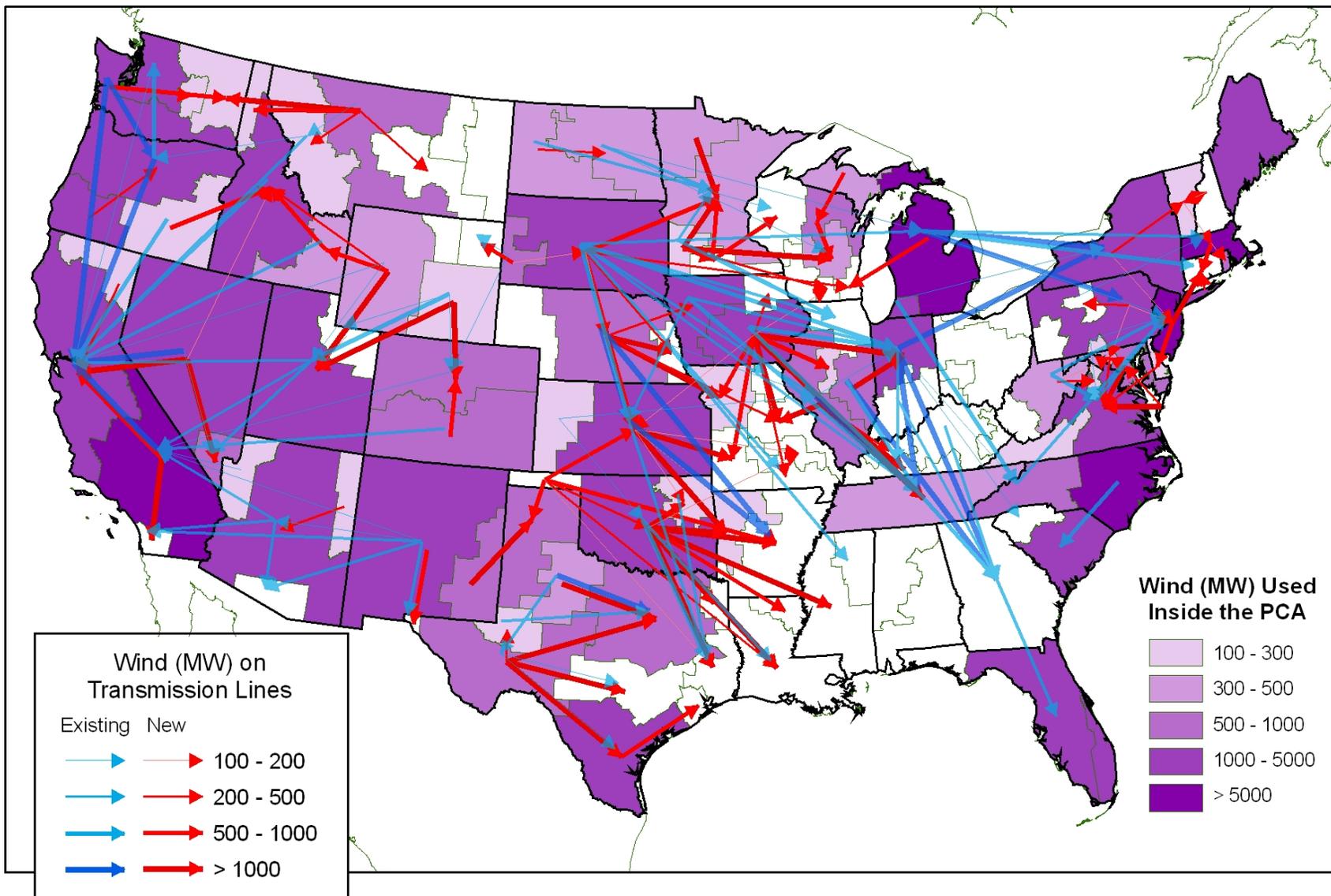


Source: AWEA 20% Vision

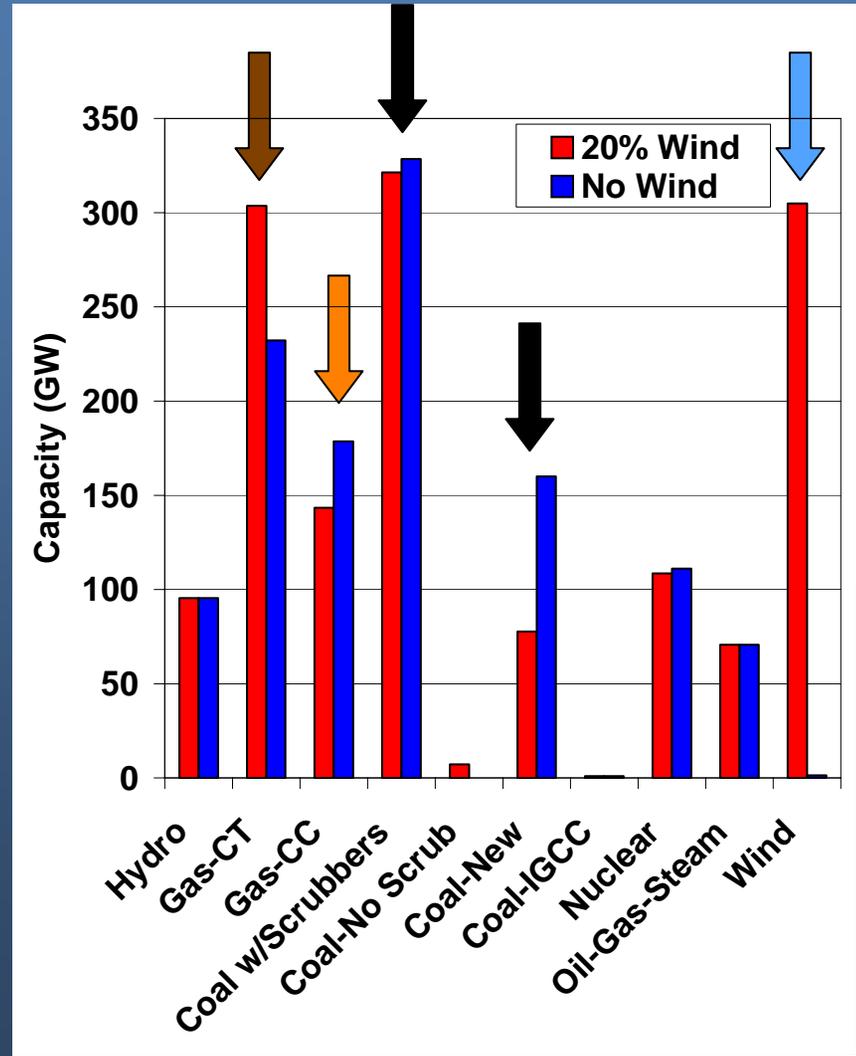
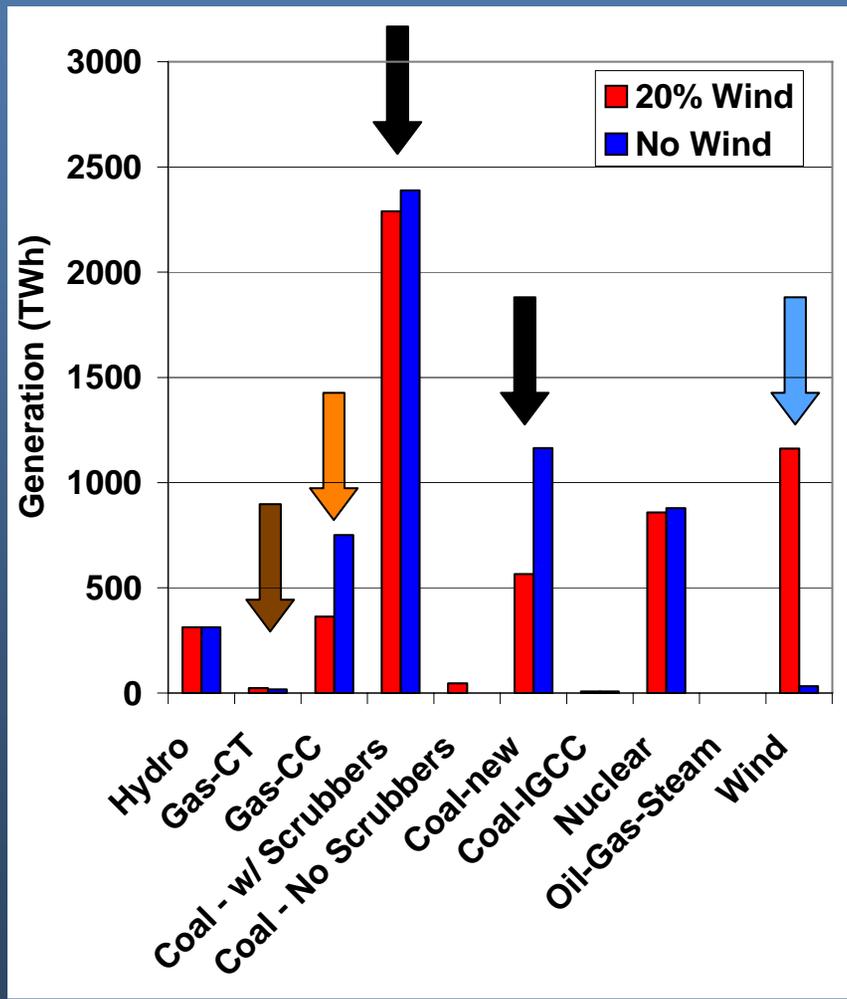
2030 - Between PCA Transfers and In-PCA Use for Wind (All Classes)

Total Between PCA Transfer \geq 100 MW (all power classes, onshore and offshore)

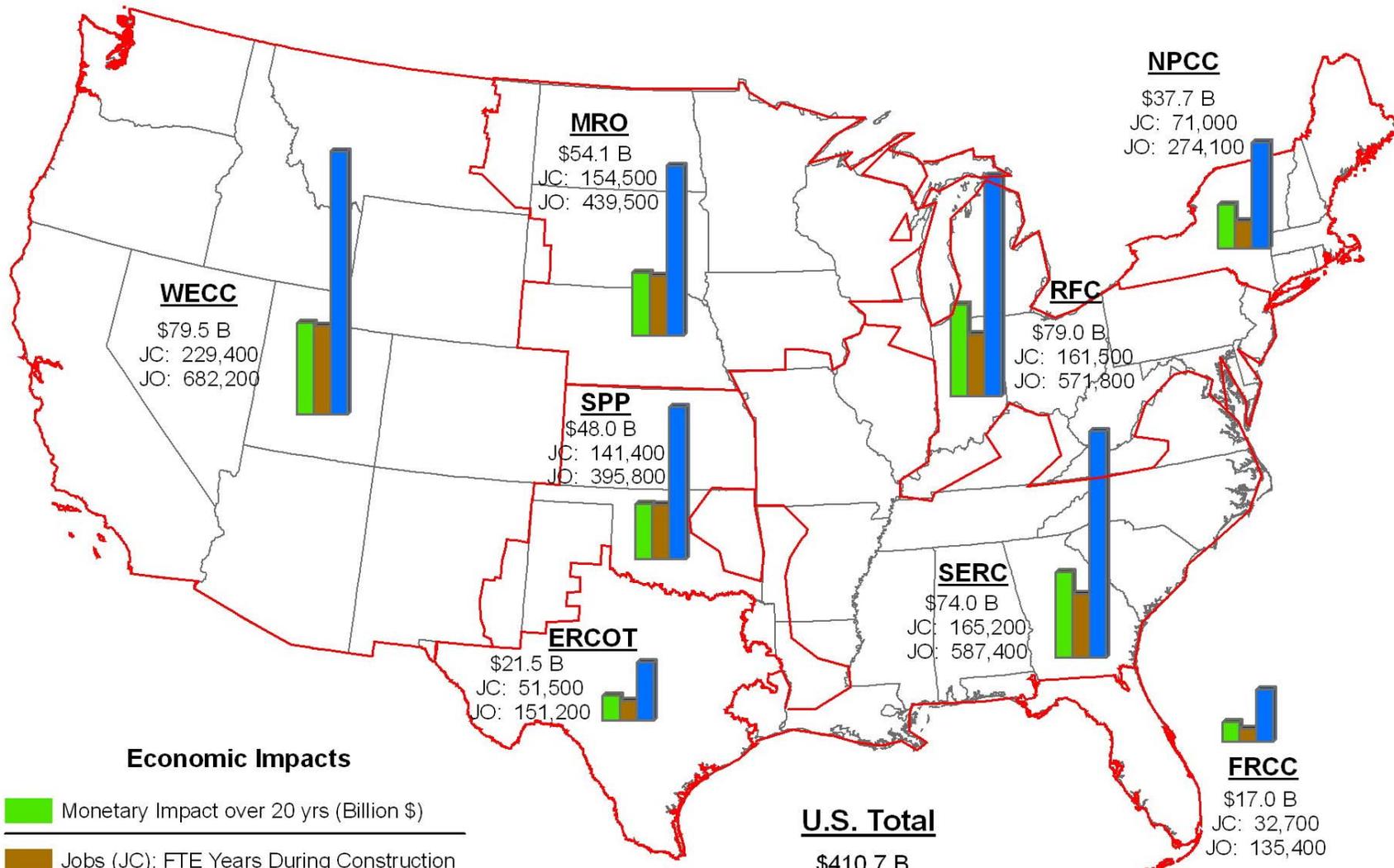
Arrows originate and terminate at the centroid of the PCA for visualization purposes; they do not represent physical locations of transmission lines.



Generation Mix with and without 20% Wind



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. Department of Energy
National Renewable Energy Laboratory



Cumulative impacts from 2007-2030

From the 20% Scenario- 300 GW new Onshore and Offshore development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:

- \$782 M

Local Property Tax Revenue:

- \$1,877 M

Construction Phase:

- 1.75 M FTE jobs
- \$ 293 B to the US economy

Operations:

- 1.16 M FTE jobs
- \$122 B to the US economy



Indirect & Induced Impacts

Construction Phase:

- 4.46 M FTE jobs
- \$651 B to the US economy

Operations:

- 2.15 M FTE jobs
- \$293 B to the US economy

Totals

(construction + 20yrs)

- **Total economic benefit** = \$1,359 billion
- **New jobs during construction** = 6.2 M FTE jobs
- **New operations jobs** = 3.3 M FTE jobs

All monetary values are in 2006 dollars.
Construction Phase = 1-2 years

Economic Impacts (Onshore and Offshore)

From the 20% Vision (62 GW new development)

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:

- \$156 Million/year

Local Property Tax Revenue:

- \$640 Million/year

Construction Phase:

- 91.3 thousand new jobs
- \$12.0 Billion to local economies

Operational Phase:

- 14.9 thousand new long-term jobs
- \$1.4 Billion/yr to local economies



Indirect Impacts

Construction Phase:

- 36.1 thousand new jobs
- \$3.6 Billion to local economies

Operational Phase:

- 3.7 thousand local jobs
- \$420 Million/yr to local economies

Induced Impacts

Construction Phase:

- 55.2 thousand new jobs
- \$5.7 Billion to local economies

Operational Phase:

- 10.5 thousand local jobs
- \$1.1 Billion/yr to local economies

Totals (construction + 20 yrs)

Total economic benefit = \$79 Billion

New local jobs during construction = 182,600

New local long-term jobs = 29,100

Construction Phase = 1-2 years

Operational Phase = 20+ years₃₀

Indiana – Economic Impacts

From the 20% Scenario
6,773 MW new development

Wind energy's economic "ripple effect"

Direct Impacts

Payments to Landowners:

- \$20 Million/yr

Local Property Tax Revenue:

- \$105 Million/yr

Construction Phase:

- 10,500 new jobs
- \$1.3 B to local economies

Operational Phase:

- 1,700 new long-term jobs
- \$145 M/yr to local economies



Indirect & Induced Impacts

Construction Phase:

- 1,000 new jobs
- \$880 M to local economies

Operational Phase:

- 1,800 local jobs
- \$170 M/yr to local economies

Totals

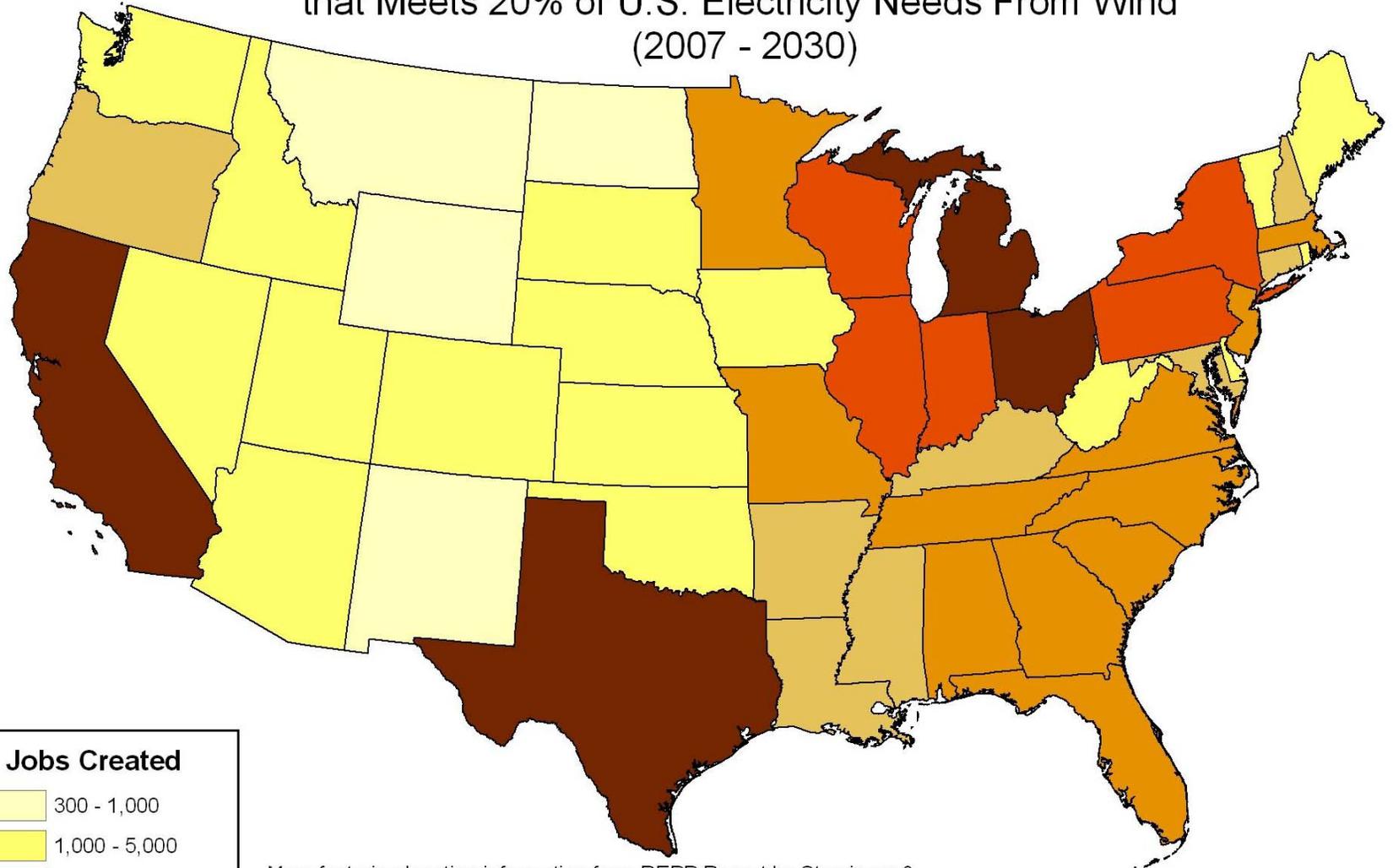
(construction + 20yrs)

Total economic benefit = \$8.5 B

New local jobs during construction = 20,500

New local long-term jobs = 3,600

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

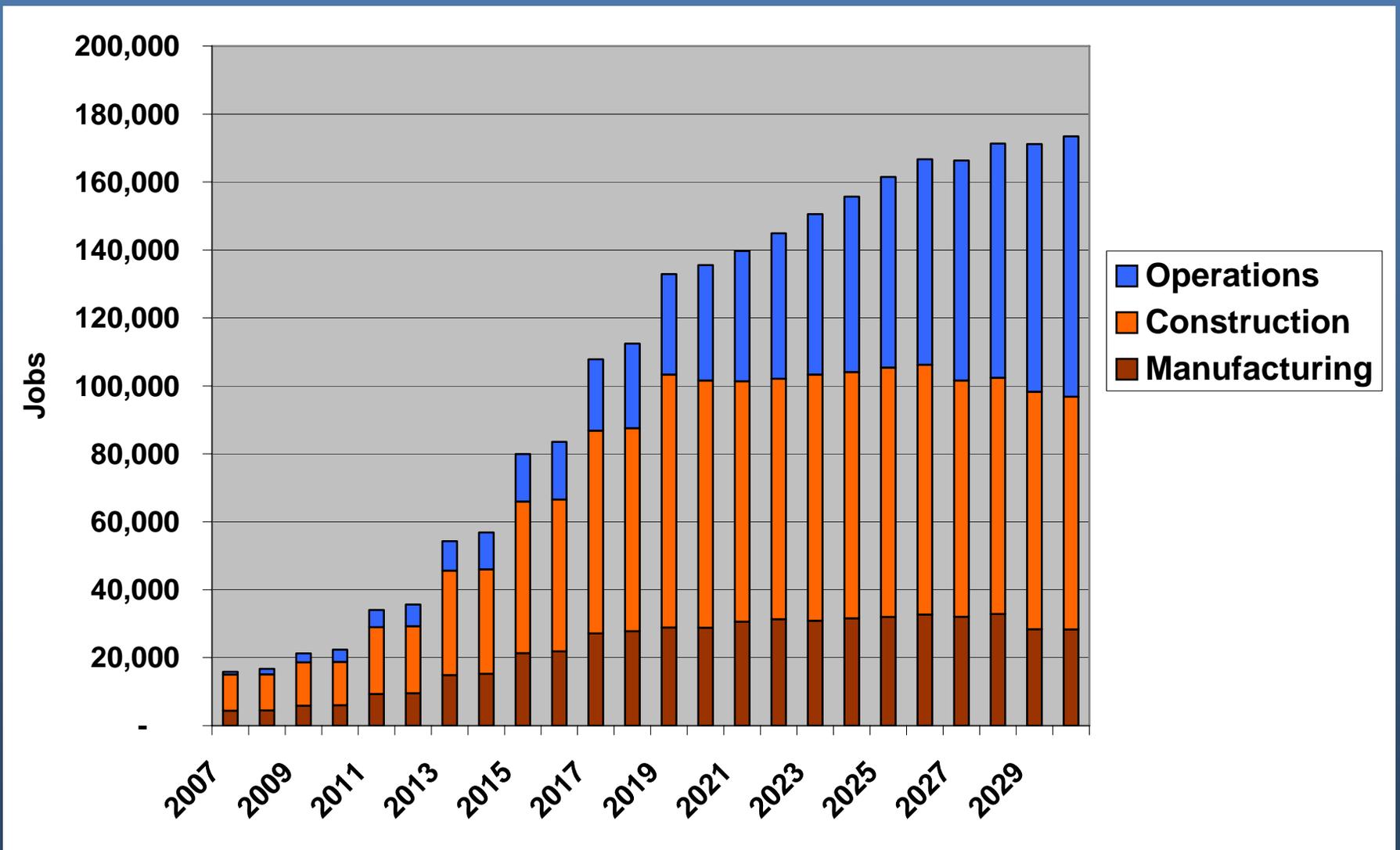


Manufacturing location information from REPP Report by Sterzinger & Svrcek (2004)

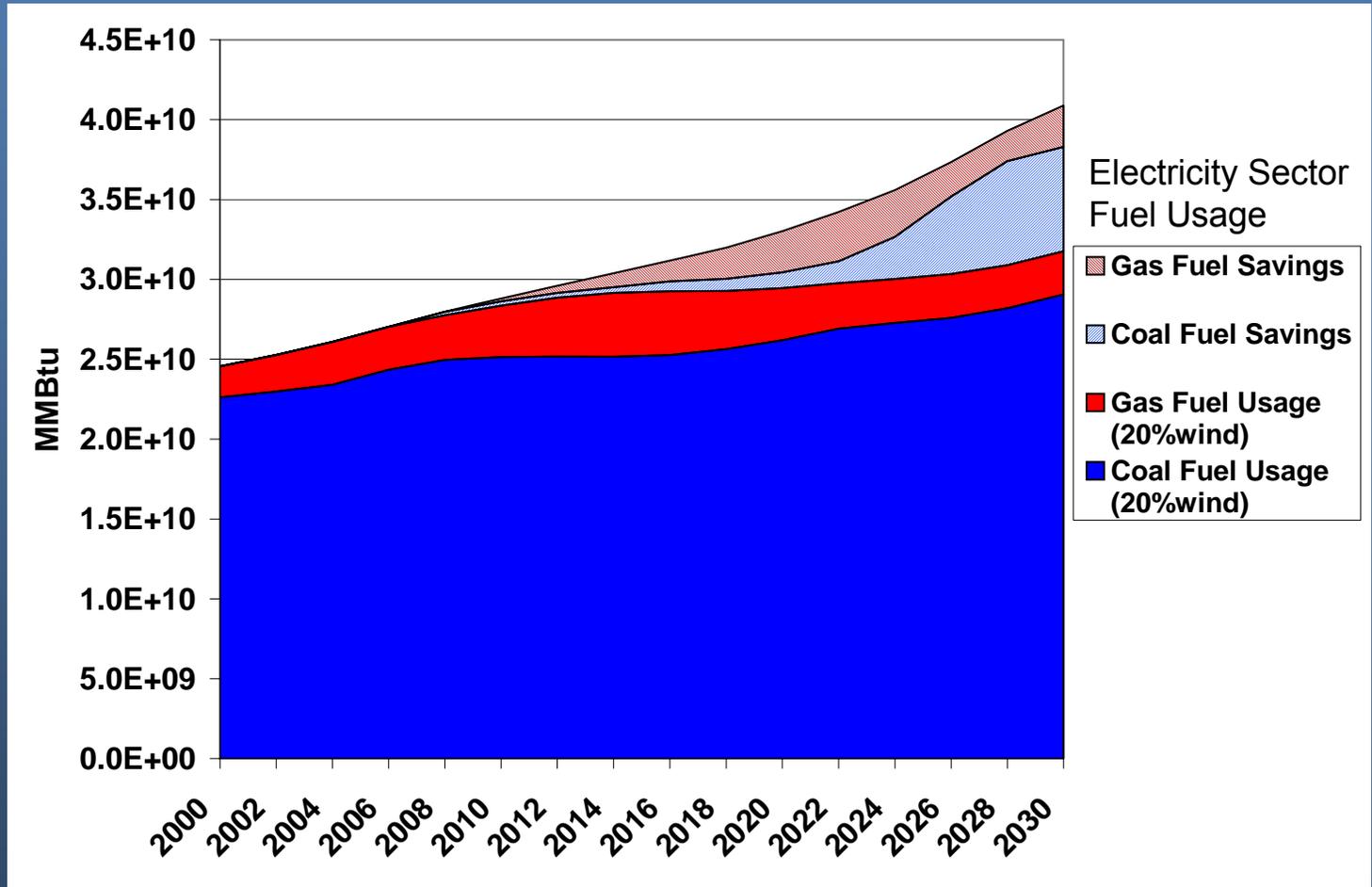
Major component assumptions: 50% of blades are manufactured in U.S. in 2004 increasing to 80% in 2030, 26% of towers are from the U.S. in 2004 increasing to 50% in 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.

Wind_Vision_Jobs_06-19-2007 - DRAFT

20% Wind Vision Employment

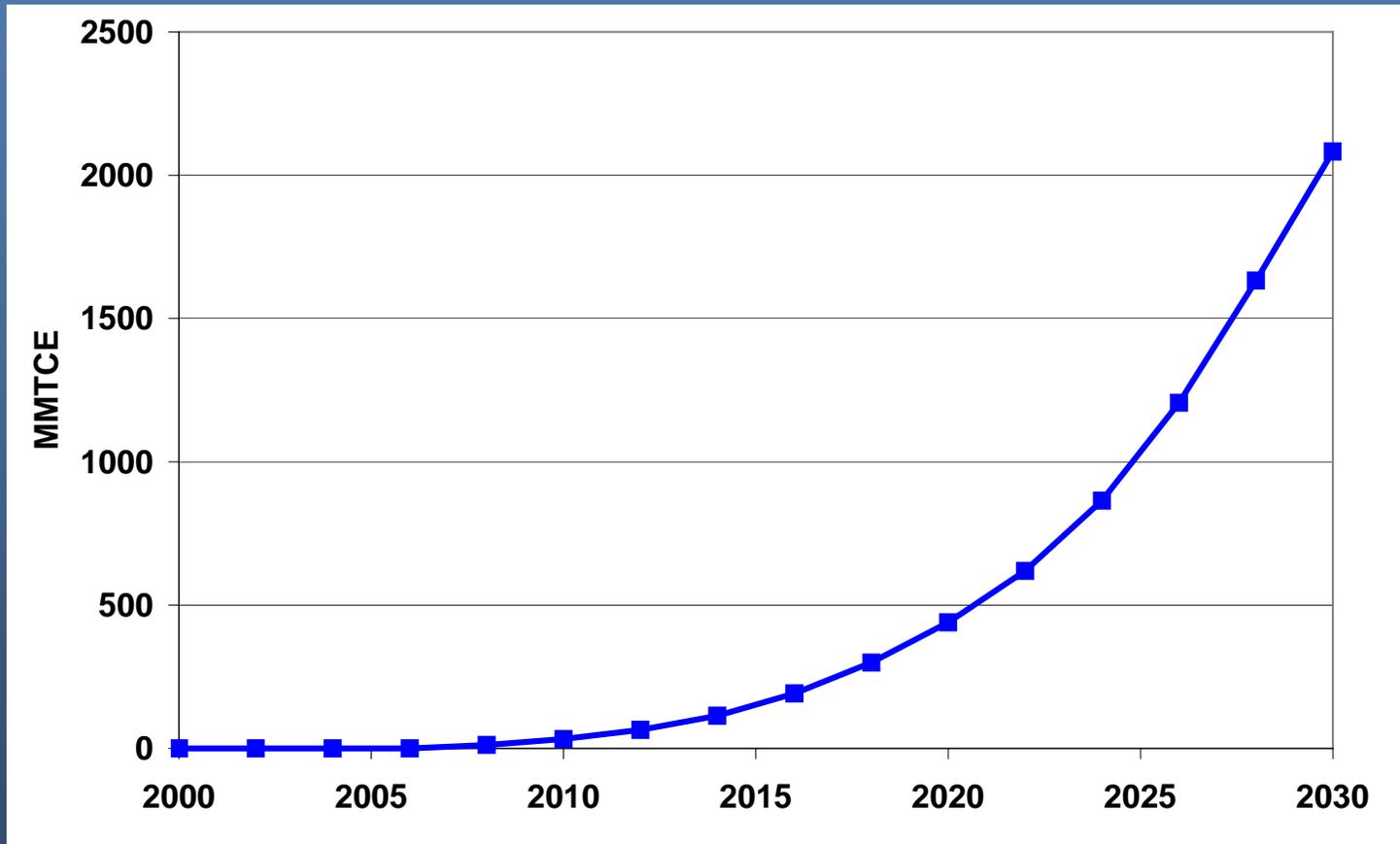


Fuel Savings From Wind



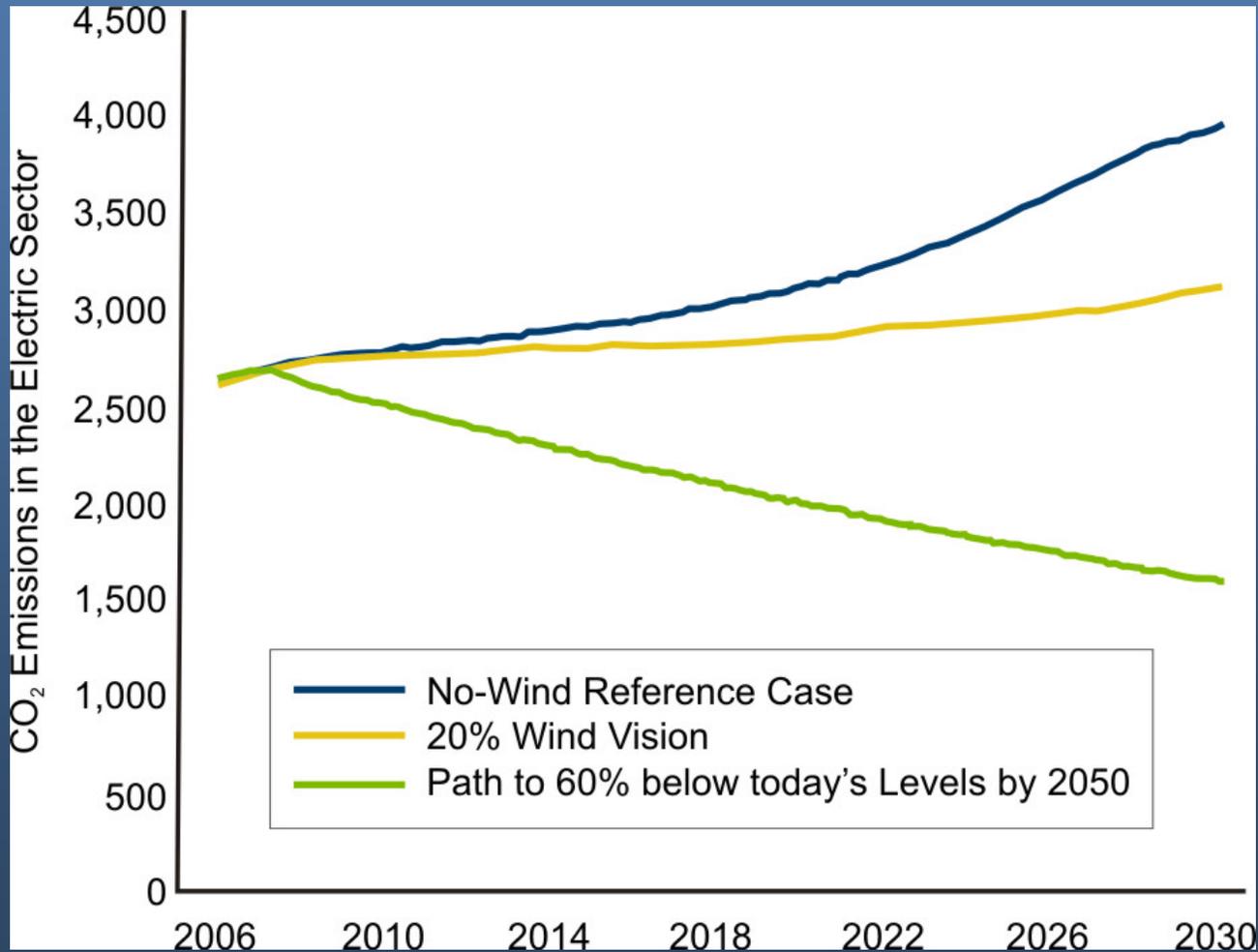
Reduction in National Gas Consumption in 2030 (%)	Natural Gas Price Reduction in 2030 (2006\$/MMBtu)	Present Value Benefits (billion 2006\$)	Levelized Benefit of Wind (\$/MWh)
11%	0.6 -1.1- 1.5	86 - 150 - 214	16.6 - 29 - 41.6

Cumulative Carbon Savings

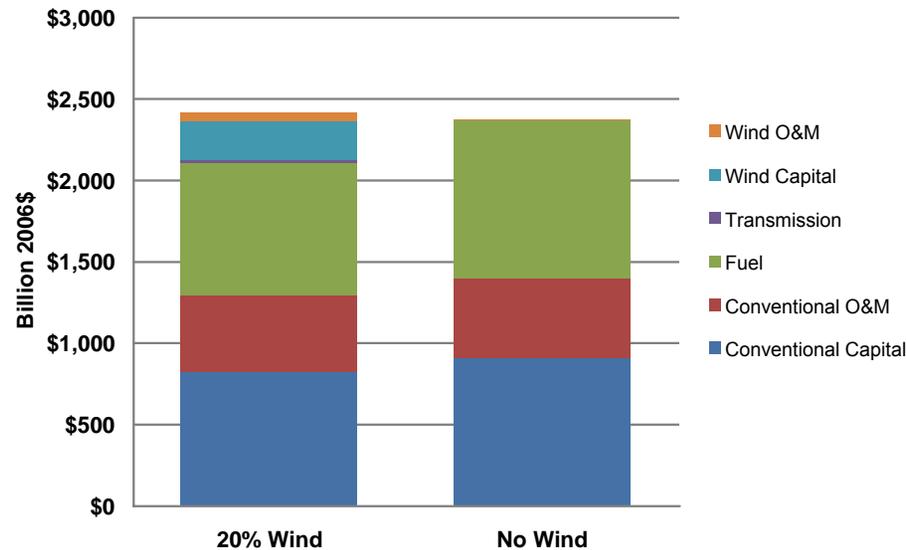


Cumulative Carbon Savings (2007-2050, MMTCE)	Present Value Benefits (billion 2006\$)	Levelized Benefit of Wind (\$/MWh-wind)
4,182 MMTCE	\$ 50 - \$145	\$ 9.7/MWh - \$ 28.2/MWh

Electric Sector CO₂ Emissions



Incremental Cost of 20% Wind Vision



Vision Scenario	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)**
20% Wind	\$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** & **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	140,000 direct \$450 billion total
Reductions in natural gas use and price pressure	11% \$150 billion
Net Benefits: \$205B + Water savings	

Market Challenges

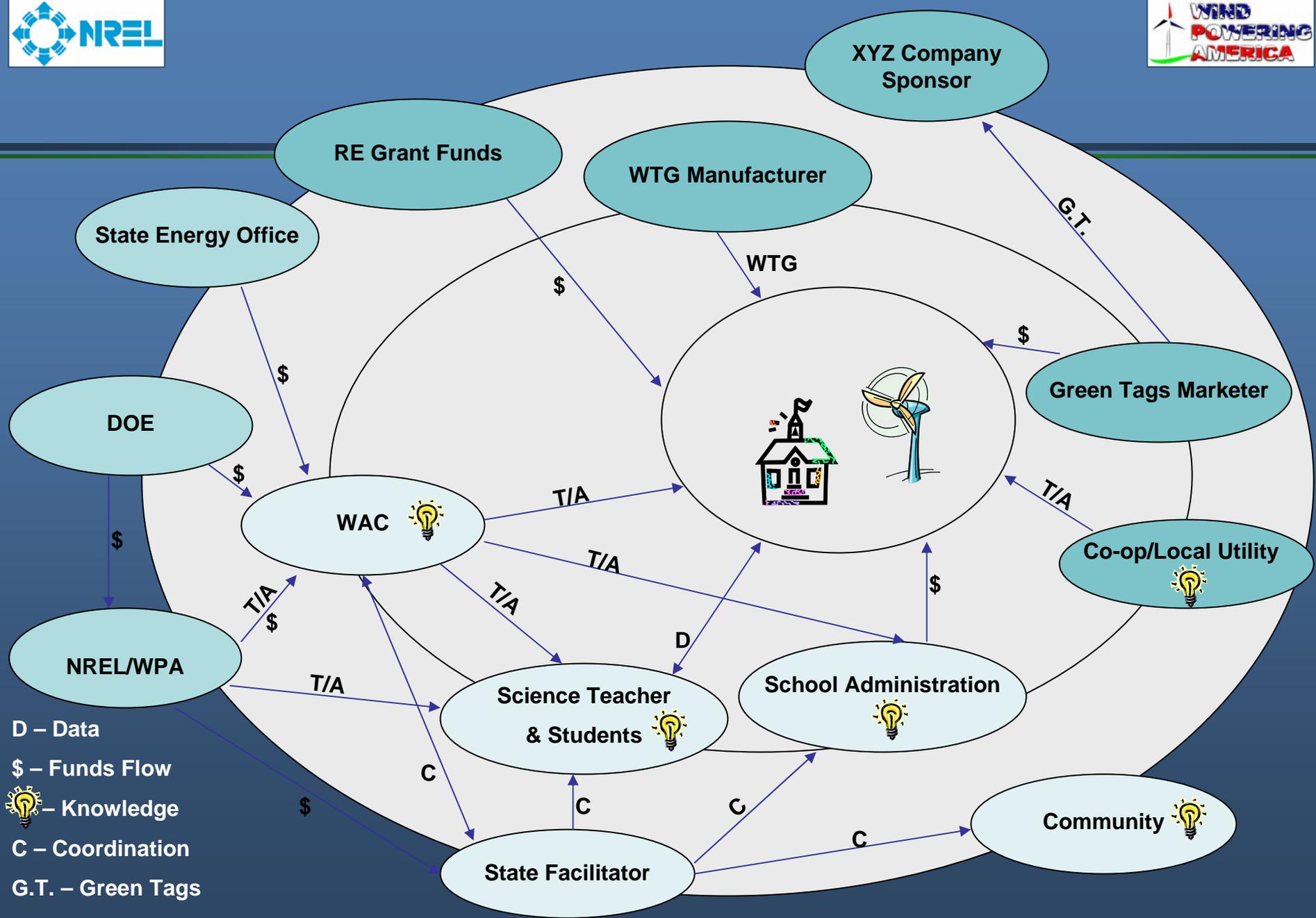
- National and state policy uncertainty
- Mixed stakeholder perspectives and knowledge
- Electricity supply planning based on capacity
- Variable wind output viewed as unreliable
- Incomplete comparative generation assessments
- Mismatch of wind and transmission development timeframes
- Federal lending all source requirements for G&T's
- Lack of interstate approach to transmission development
- Need for utility financial incentives to own wind facilities
- High cost and low turbine availability for community projects
- Uncertainty in emerging emissions REC markets

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: February 2008

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

- A. Lincoln



D – Data
 \$ – Funds Flow
 – Knowledge
 C – Coordination
 G.T. – Green Tags
 WTG – Wind Turbine
 T/A – Technical Assistance

Carpe Ventem

