National Renewable Energy Laboratory
Innovation for Our Energy Future

Overview of Wind Power Generation in the United States

Asian Pacific Partnership Canada Wind Event

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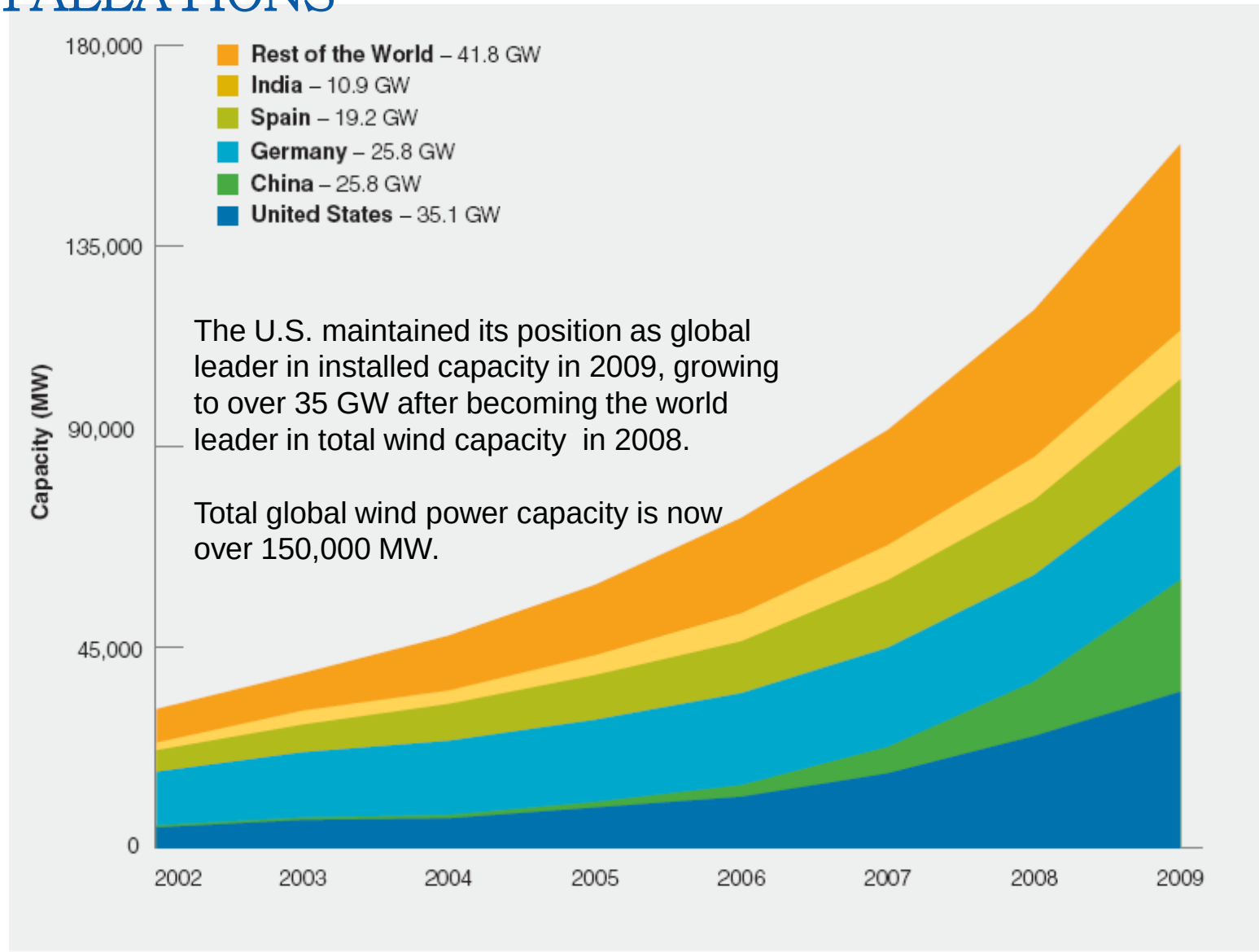
Outline

- U.S. Wind Industry Status
- Wind Installation and Industry Trends
- Price, Cost and Performance Trends
- Future Outlook

U.S. REMAINS GLOBAL LEADER IN WIND INSTALLATIONS



The U.S. maintained its position as global leader in installed capacity in 2009, growing to over 35 GW after becoming the world leader in total wind capacity in 2008.

Total global wind power capacity is now over 150,000 MW.

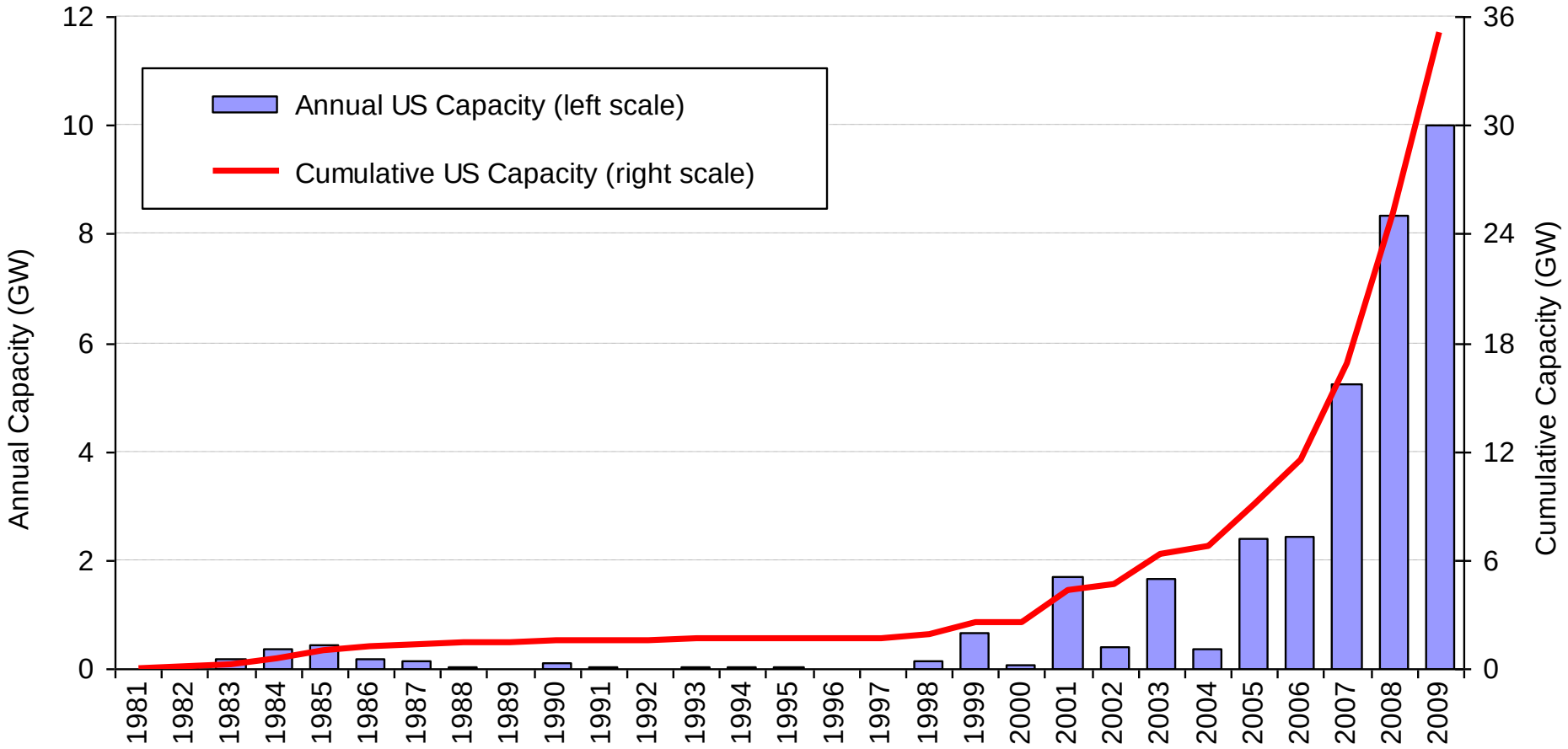
Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

U.S. Led World in Cumulative Capacity, But Fell to 2nd in Annual Capacity Growth

Annual Capacity (2009, MW)		Cumulative Capacity (end of 2009, MW)	
China	13,750	**U.S.**	**35,155**
U.S.	**9,994**	China	25,853
Spain	2,331	Germany	25,813
Germany	1,917	Spain	18,784
India	1,172	India	10,827
Italy	1,114	Italy	4,845
France	1,104	France	4,775
U.K.	1,077	U.K.	4,340
Canada	950	Portugal	3,474
Portugal	645	Denmark	3,408
Rest of World	4,121	*Rest of World*	22,806
TOTAL	**38,175**	**TOTAL**	**160,080**

Source: BTM Consult; AWEA project database for U.S. capacity

U.S. Wind Power Capacity Up >40% in 2009

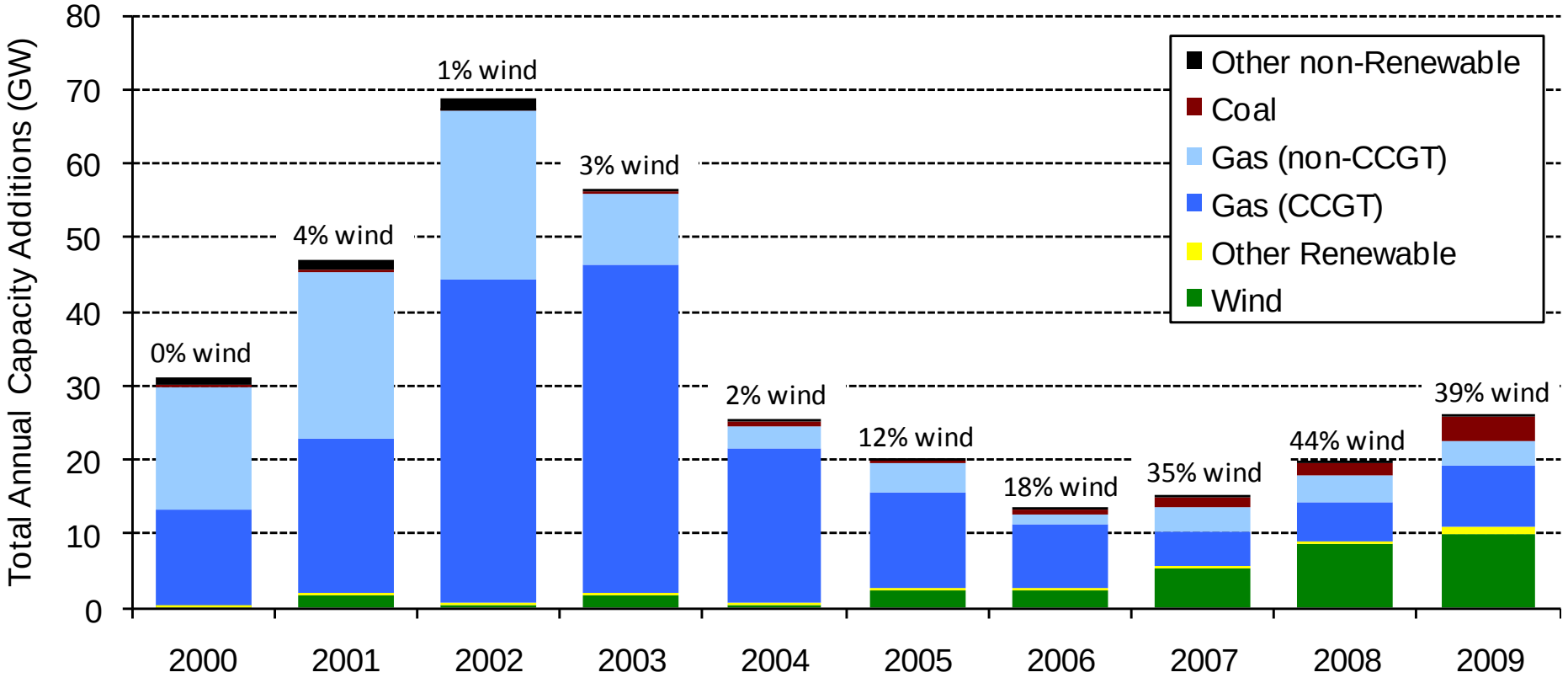


Record year for new U.S. wind power capacity:

- 10 GW of wind power added in 2009, bringing total to ~35 GW
- Nearly $21 billion in 2009 project investment

Source: DOE 2009 Wind Technologies Market Report

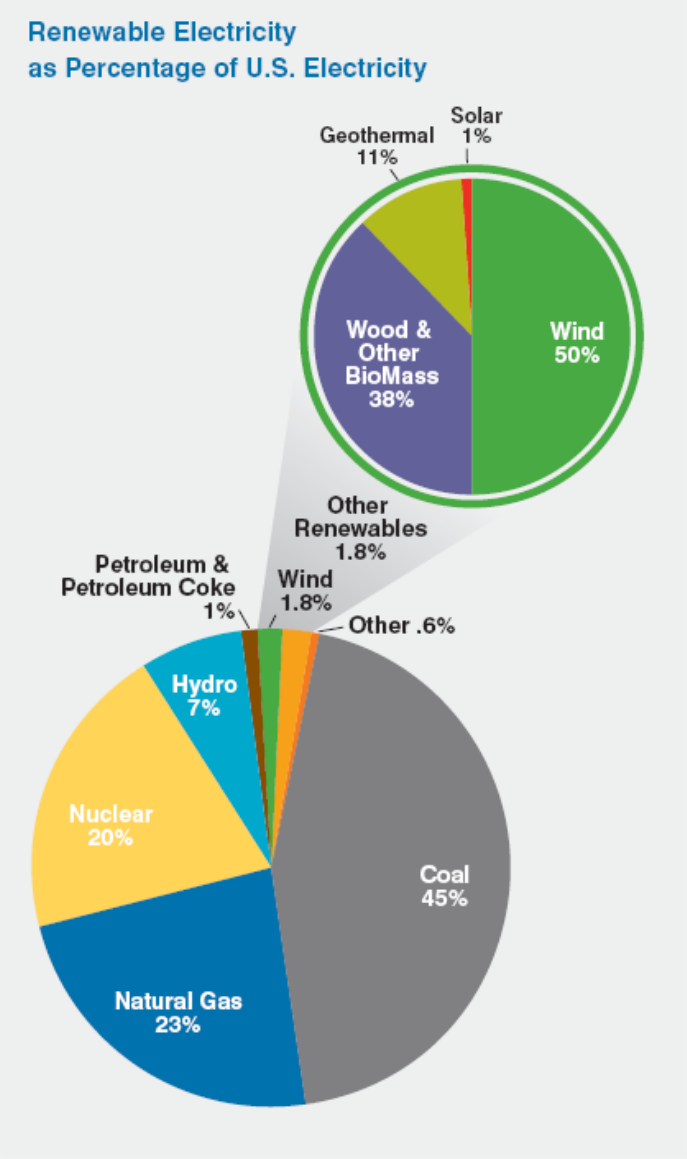
Wind Power Contributed 39% of All New Generating Capacity in the U.S. in 2009



Wind was the 2nd-largest resource added for the 5th-straight year

Source: DOE 2009 Wind Technologies Market Report

U.S. GENERATION MIX



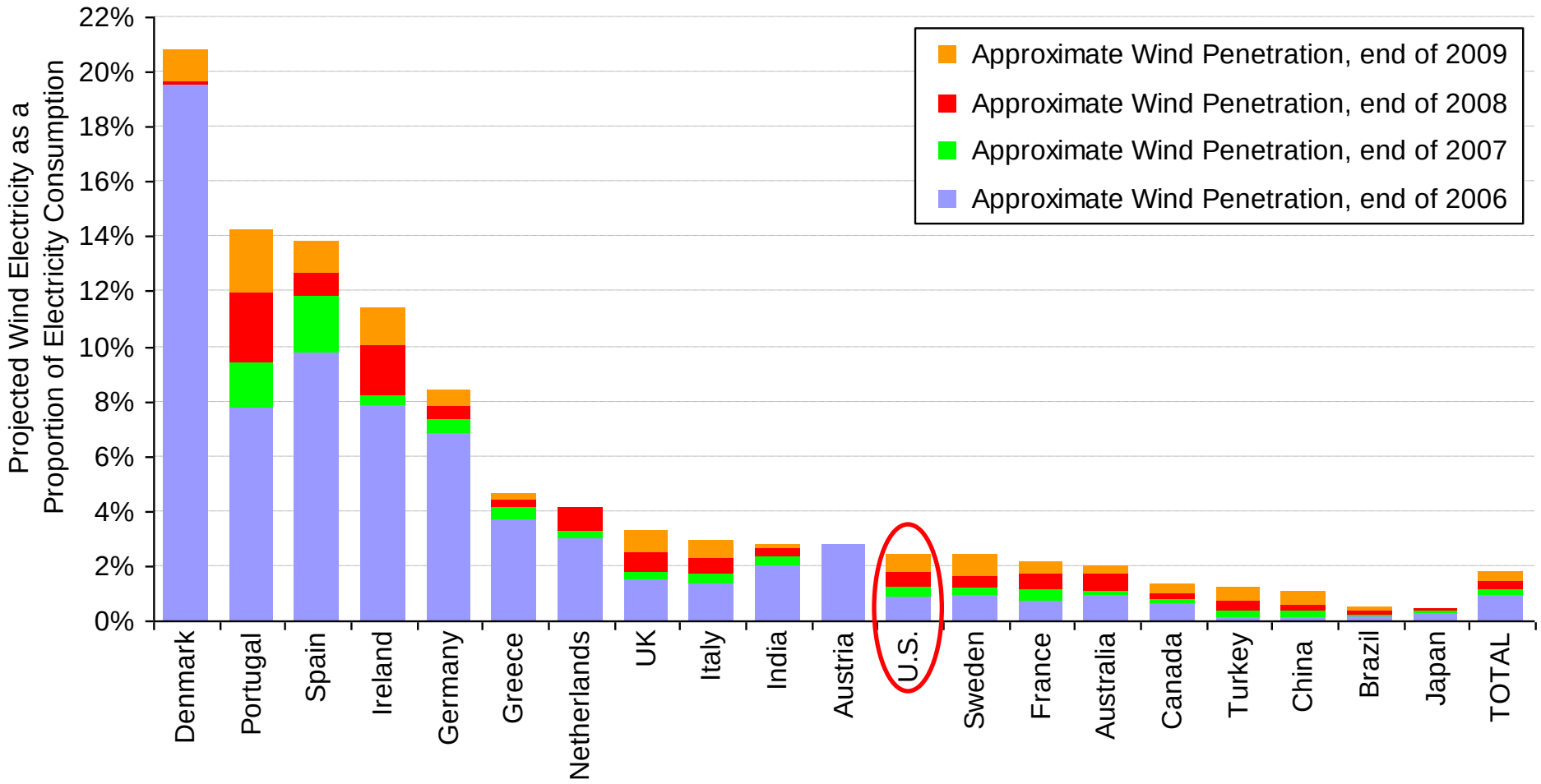
- Wind generation reached 1.8% of U.S. generation mix in 2009. This is an increase from 1.3% of generation at the end of 2008.

- All renewable energy sources provided 10.5% of the U.S. power mix in 2009.

- With the significant increase in renewable energy capacity over the past several years, the power mix is reflecting a slow but steady shift toward renewable energy.

Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

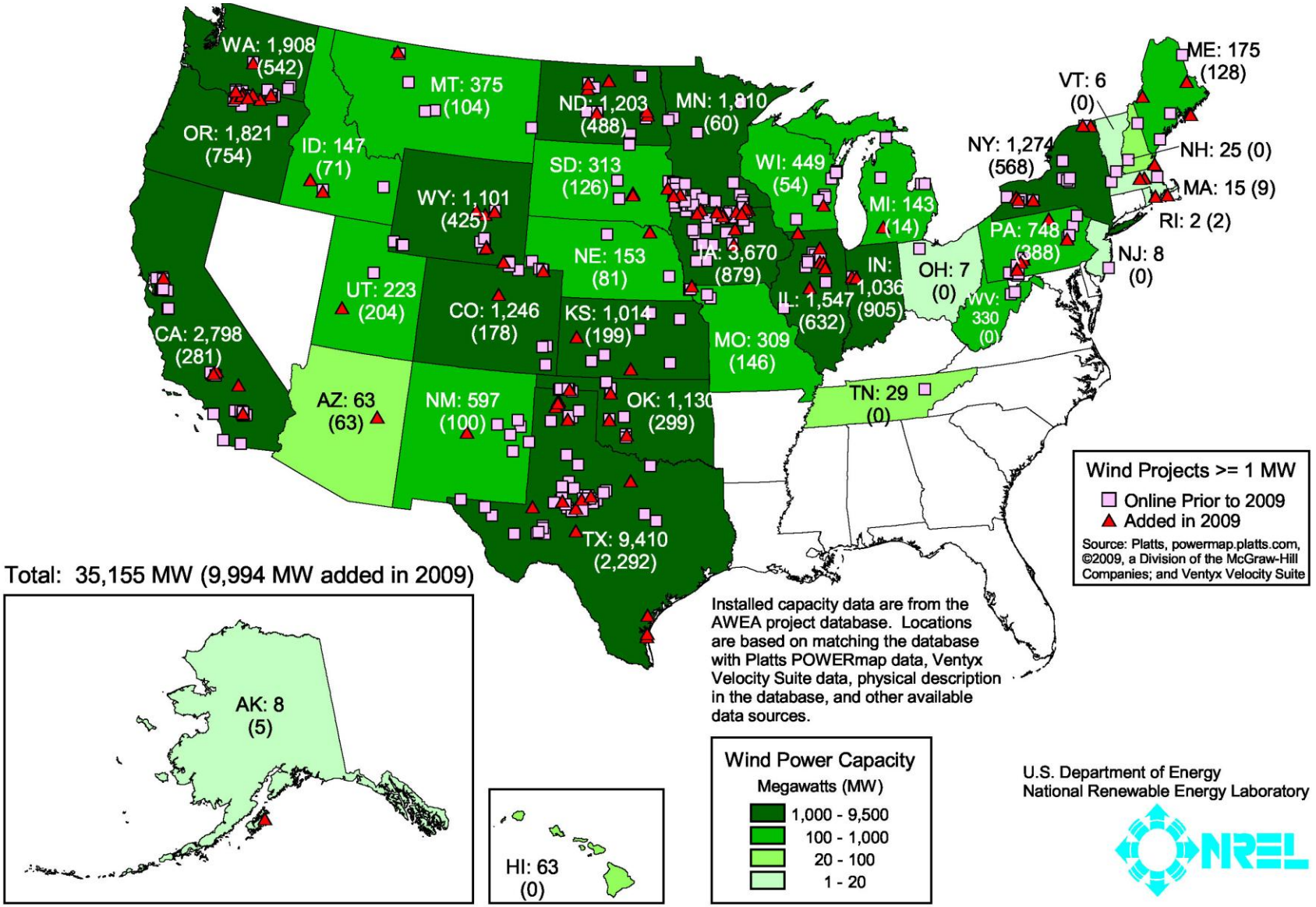
U.S Lagging Other Countries in Wind As a Percentage of Electricity Consumption



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

Source: DOE 2009 Wind Technologies Market Report

Geographic Spread of Wind Power Projects in the United States Is Reasonably Broad



Source: DOE 2009 Wind Technologies Market Report

Texas Easily Led Other States in Both Annual and Cumulative Capacity

Annual Capacity (2009, MW)		Cumulative Capacity (end of 2009, MW)		Estimated Percentage of In-State Generation	
Texas	2,292	Texas	9,410	Iowa	19.7%
Indiana	905	Iowa	3,670	South Dakota	13.3%
Iowa	879	California	2,798	North Dakota	11.9%
Oregon	754	Washington	1,908	Minnesota	10.7%
Illinois	632	Oregon	1,821	Oregon	9.0%
New York	568	Minnesota	1,810	Colorado	7.7%
Washington	542	Illinois	1,547	Kansas	7.4%
North Dakota	488	New York	1,274	Texas	6.8%
Wyoming	425	Colorado	1,246	Wyoming	6.7%
Pennsylvania	388	North Dakota	1,203	Oklahoma	5.0%
Oklahoma	299	Oklahoma	1,130	Montana	4.9%
California	281	Wyoming	1,101	Washington	4.9%
Utah	204	Indiana	1,036	New Mexico	4.6%
Kansas	199	Kansas	1,014	California	3.4%
Colorado	178	Pennsylvania	748	Maine	3.1%
Missouri	146	New Mexico	597	Idaho	3.0%
Maine	128	Wisconsin	449	Indiana	2.7%
South Dakota	126	Montana	375	New York	2.2%
Montana	104	West Virginia	330	Hawaii	2.2%
New Mexico	100	South Dakota	313	Illinois	2.1%
Rest of U.S.	358	*Rest of U.S.*	1,376	*Rest of U.S.*	0.3%
TOTAL	**9,994**	**TOTAL**	**35,155**	**TOTAL**	**2.5%**

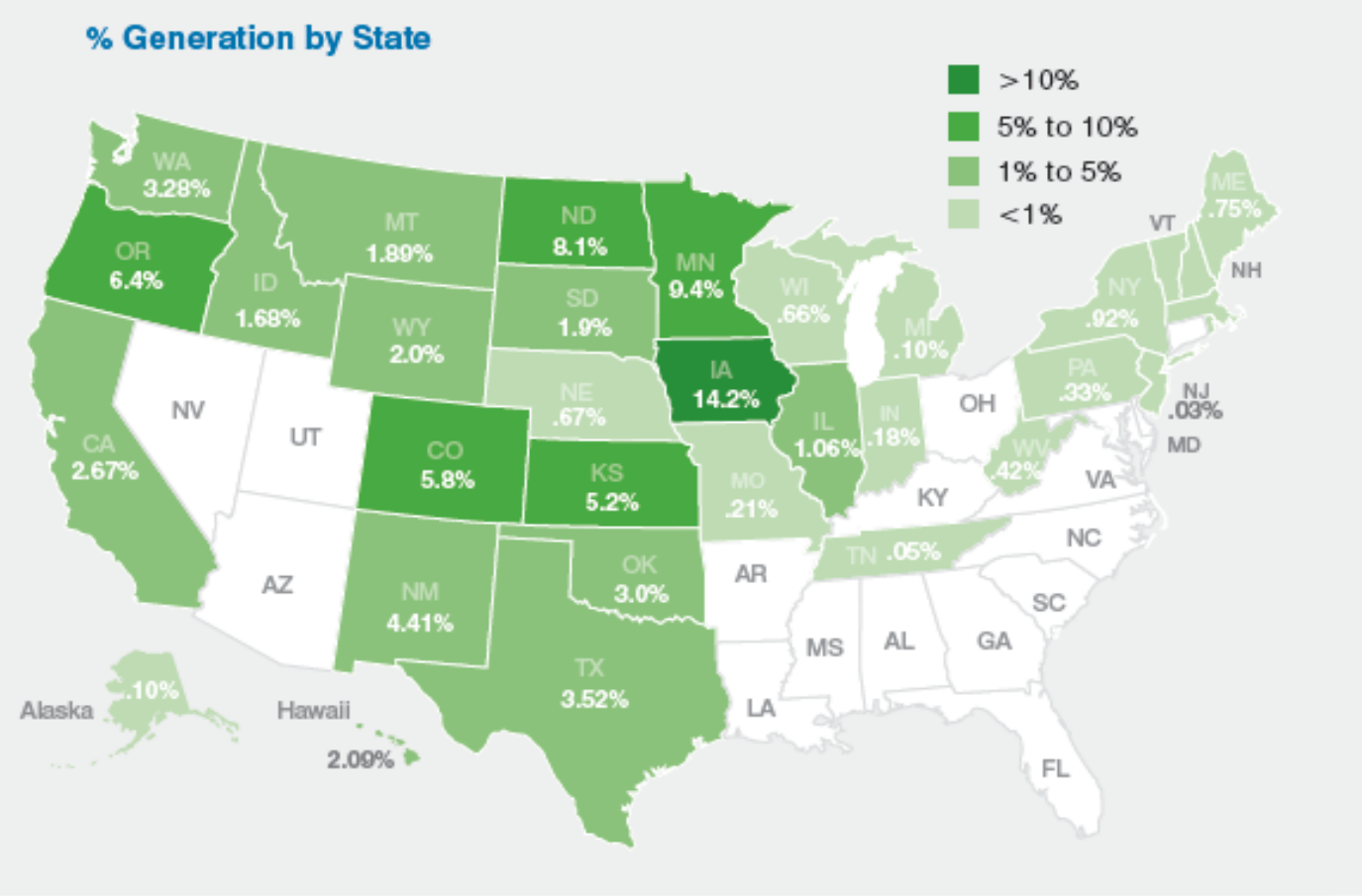
Source: AWEA project database, EIA, Berkeley Lab estimates

- 14 states had >1000 MW of wind capacity at the end of 2009 (3 had >2000 MW)
- 4 states have in-state wind generation that exceeds 10% of total in-state generation (10 states exceed 5%)

Source: DOE 2009 Wind Technologies Market Report

Percentage of Generation by State

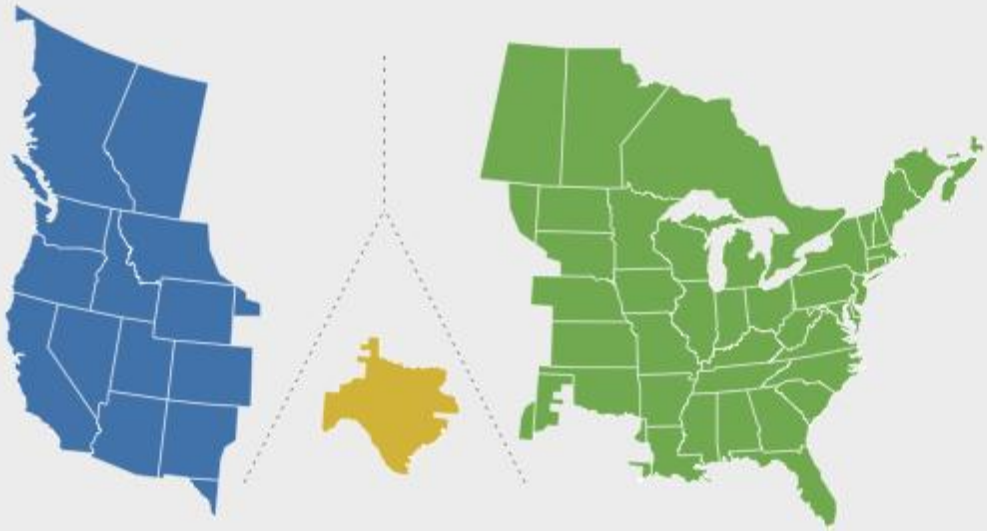
6 states receive more than 5% of their electricity from wind. Iowa is first state to exceed 10% wind energy generation on an annual basis, reaching 14.2% in 2009.



% of wind generation compared to all generation in state as reported in DOE EIA Electric Power Monthly

Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

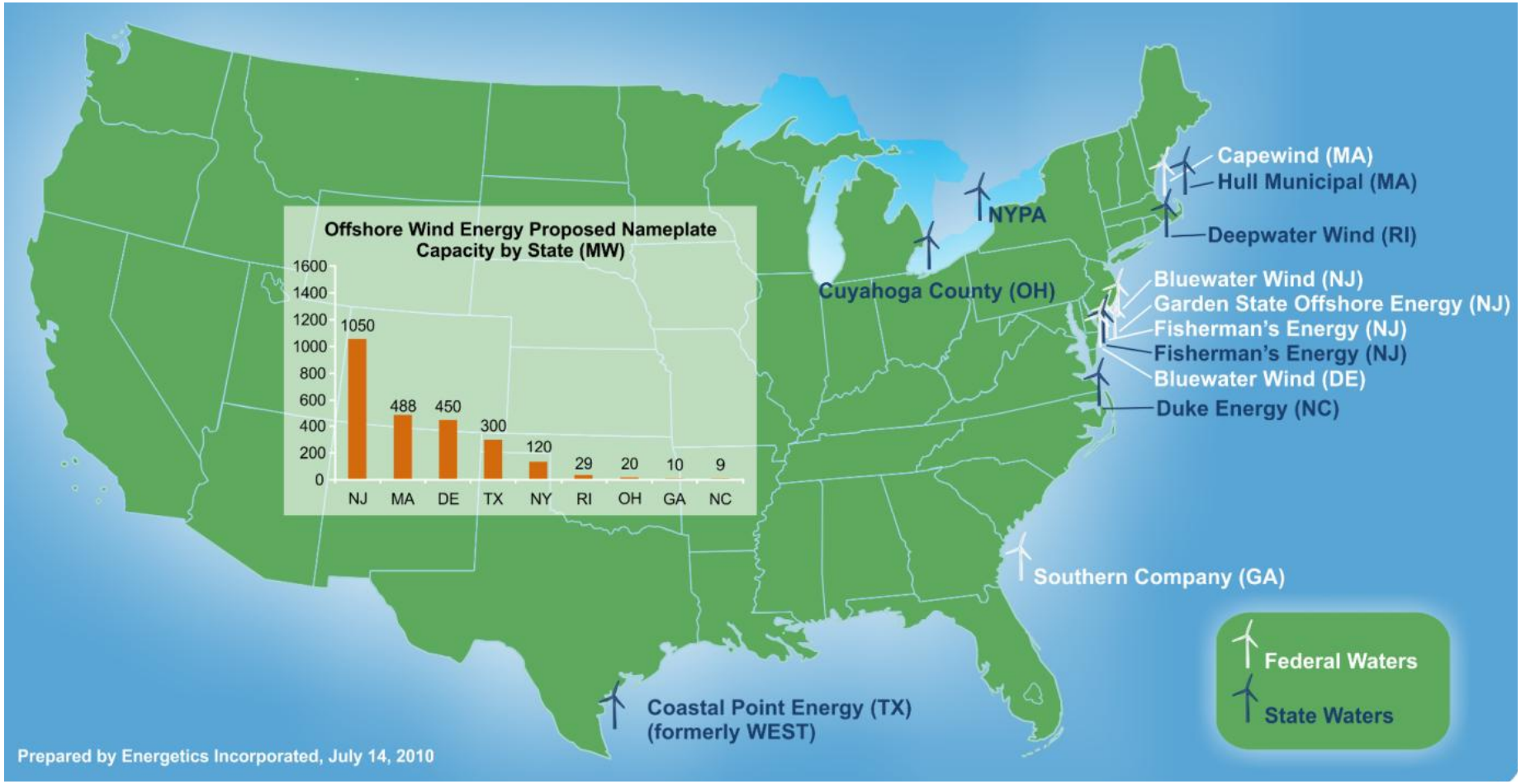
Installed U.S. Wind Capacity by Interconnection



	Capacity Installed (MW)
Eastern Interconnection	16,180
Western Interconnection	10,115
ERCOT (Electric Reliability Council of Texas)	8,745

Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

No Offshore Projects Have Been Built in the U.S.



- 13 projects are at a more-advanced permitting/development stage
- Three projects have signed or proposed power purchase agreements
- Cape Wind granted approval by Department of Interior in April 2010

Source: DOE 2009 Wind Technologies Market Report

Small Wind Turbine Market Continued to Grow in 2009

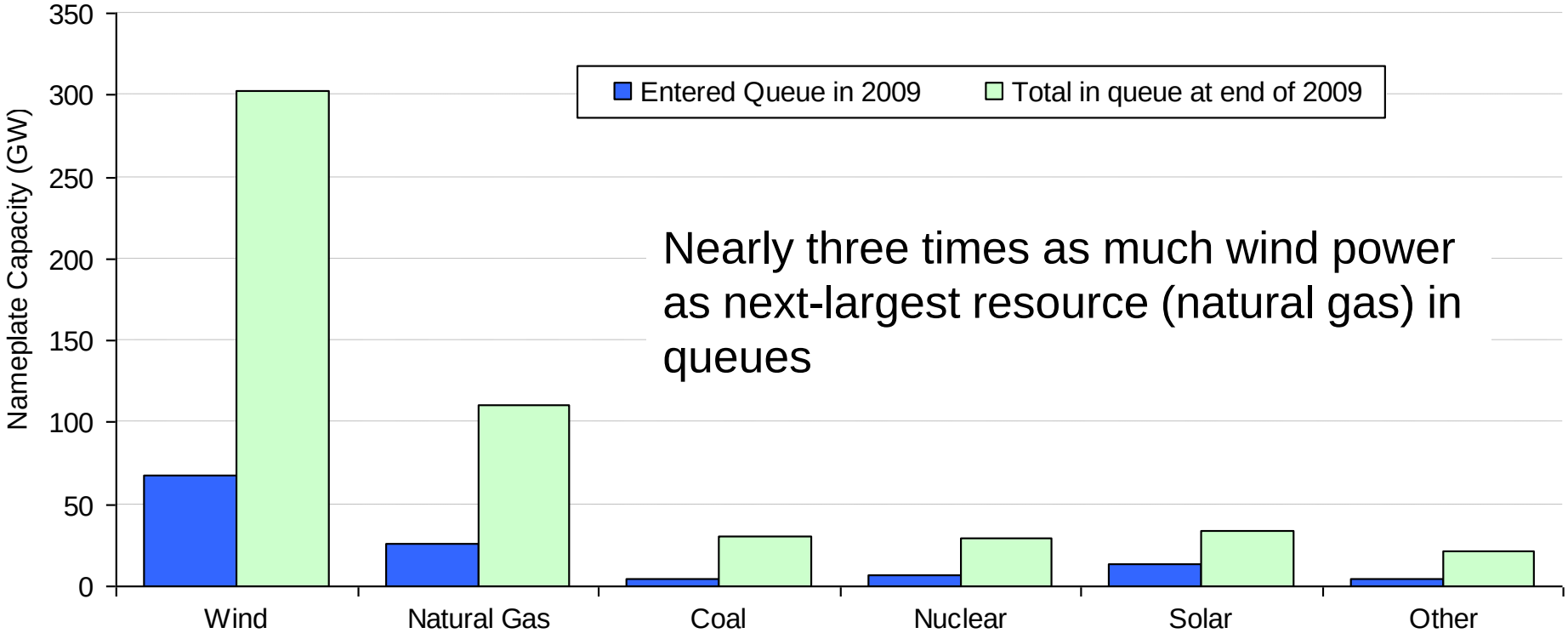
Year	Annual Sales of Small Wind Turbines into the United States		
	Number of Turbines	Capacity Additions	Sales Revenue
2005	4,324	3.3 MW	$10 million
2006	8,329	8.6 MW	$33 million
2007	9,092	9.7 MW	$42 million
2008	10,386	17.4 MW	$73 million
2009	9,800	20.3 MW	$82 million

Source: AWEA (2010b)

- Sales of small wind turbines (turbine size to 100 kW) in the U.S. equaled 20.3 MW in 2009, or $82 million
- Roughly 15% growth in annual sales (in capacity terms), relative to 2008, yielding cumulative capacity of roughly 100 MW

Source: DOE 2009 Wind Technologies Market Report

Roughly 300 GW of Wind Power Capacity in Transmission Interconnection Queues



Not all of this capacity will be built….

Source: DOE 2009 Wind Technologies Market Report

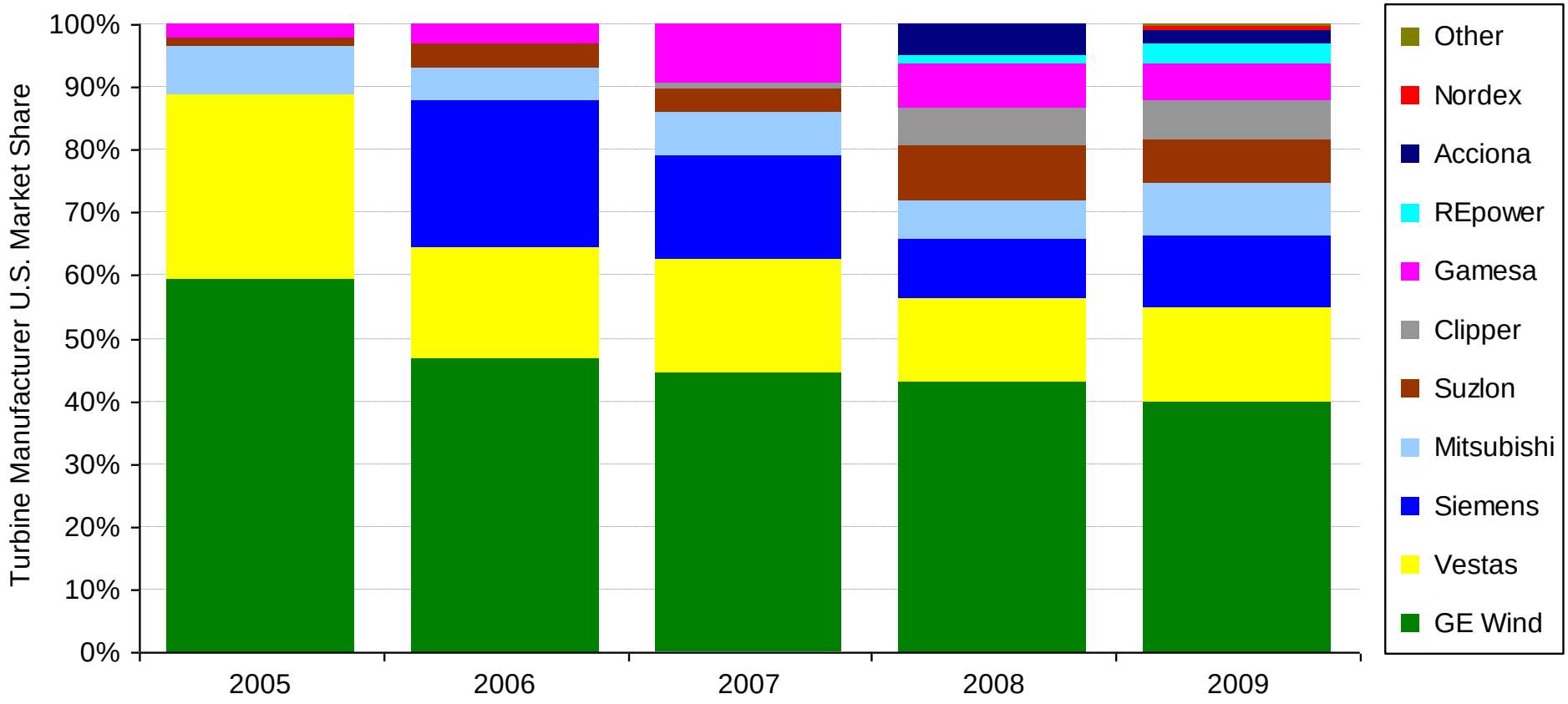
New Transmission Lines Proposed in U.S.

Transmission Project Name & Location	Voltage (kV)	MW Expected	Year Online
Populus-Terminal (ID, UT)	Double 345	1,600	2010
Walla Walla-McNary (OR, WA)	235	400	2010
Southwest Intertie (ID, NV)	500	1,850	2011
Northeast Energy Link (ME, NH, MA)	(DC) 320	1,000-2,000	2012
BPA lines from Open Season (WA, OR)	500	2,800	2012
CREZ (TX)	345	9,859	2012-2013
CO-WY intertie (WY)	345	900	2012-2013
CapX (MN, SD, ND)	345	2,275	2012-2014
Tallgrass/Prairie Wind (KS, OK)	765	5,800	2013
Tehachapi (CA)	500	4,500	2013
Pawnee-Smoky Hill upgrade (CO)	345	500	2013
Total		~32,000 MW	

Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

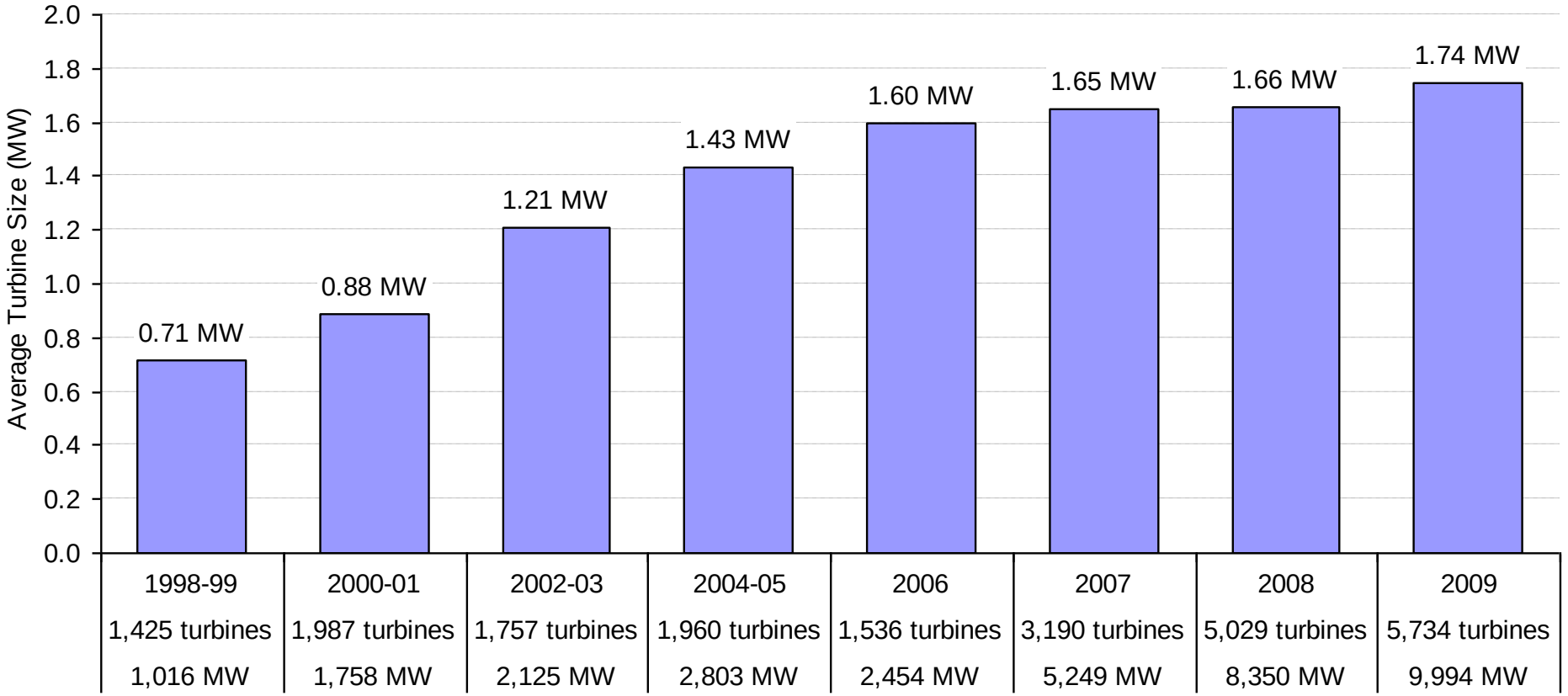
GE Remained the Top Turbine Vendor in the U.S. Market

But a Growing Number of Other Manufacturers Are Capturing Market Share



Source: DOE 2009 Wind Technologies Market Report

Average U.S Utility-scale Turbine Size Larger in 2009

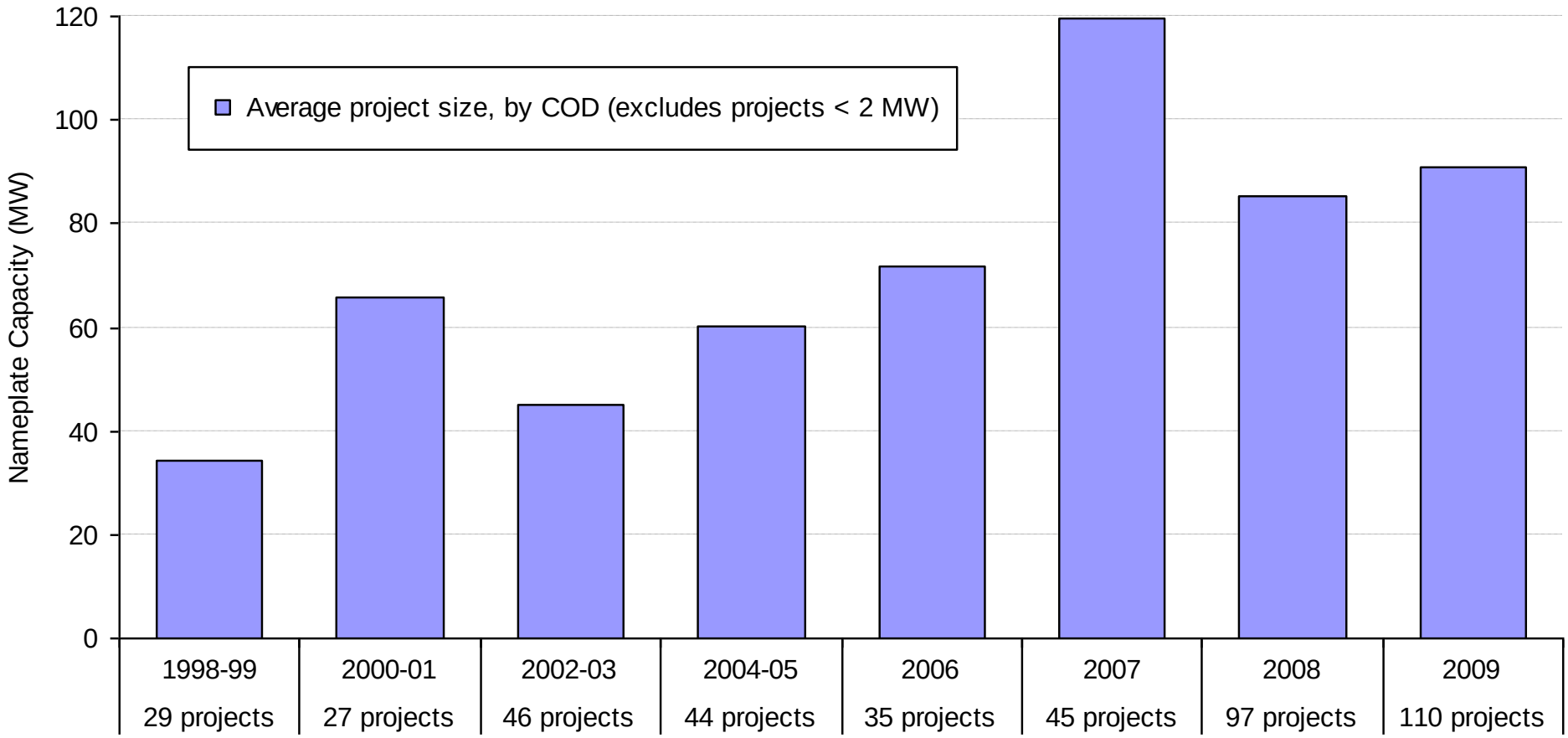


25% of turbines installed in 2009 were larger than 2.0 MW

- Up from 19% in 2008, 16% in 2006 & 2007, and just 0.1% in 2004-05

Source: DOE 2009 Wind Technologies Market Report

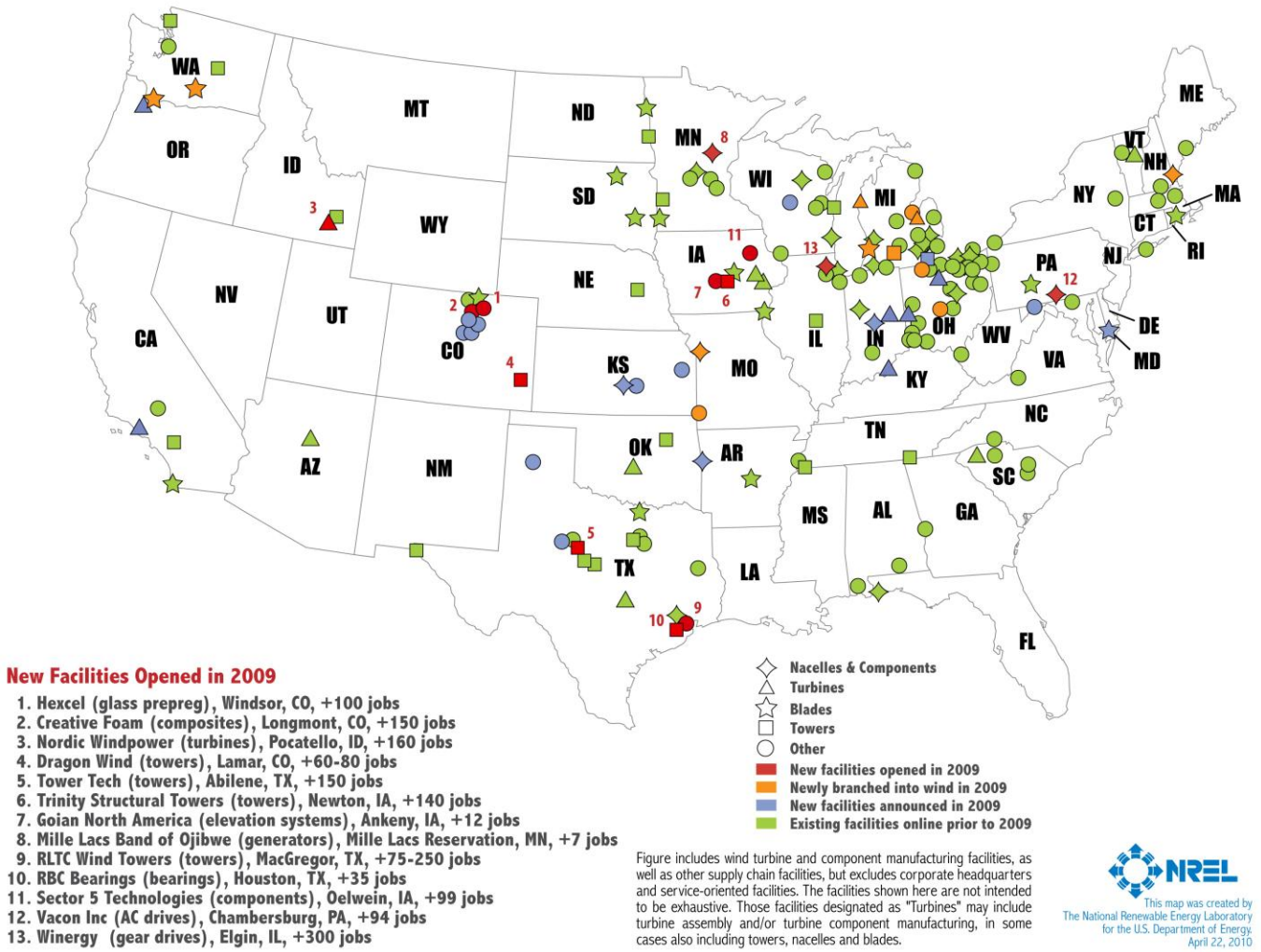
Average Wind Power Project Size in U.S. Continued Upward Trend in 2009



The average project size in 2009 was about the same as in 2008 – over 80 MW per project

Source: DOE 2009 Wind Technologies Market Report

U.S. Wind Turbine Manufacturing Strong

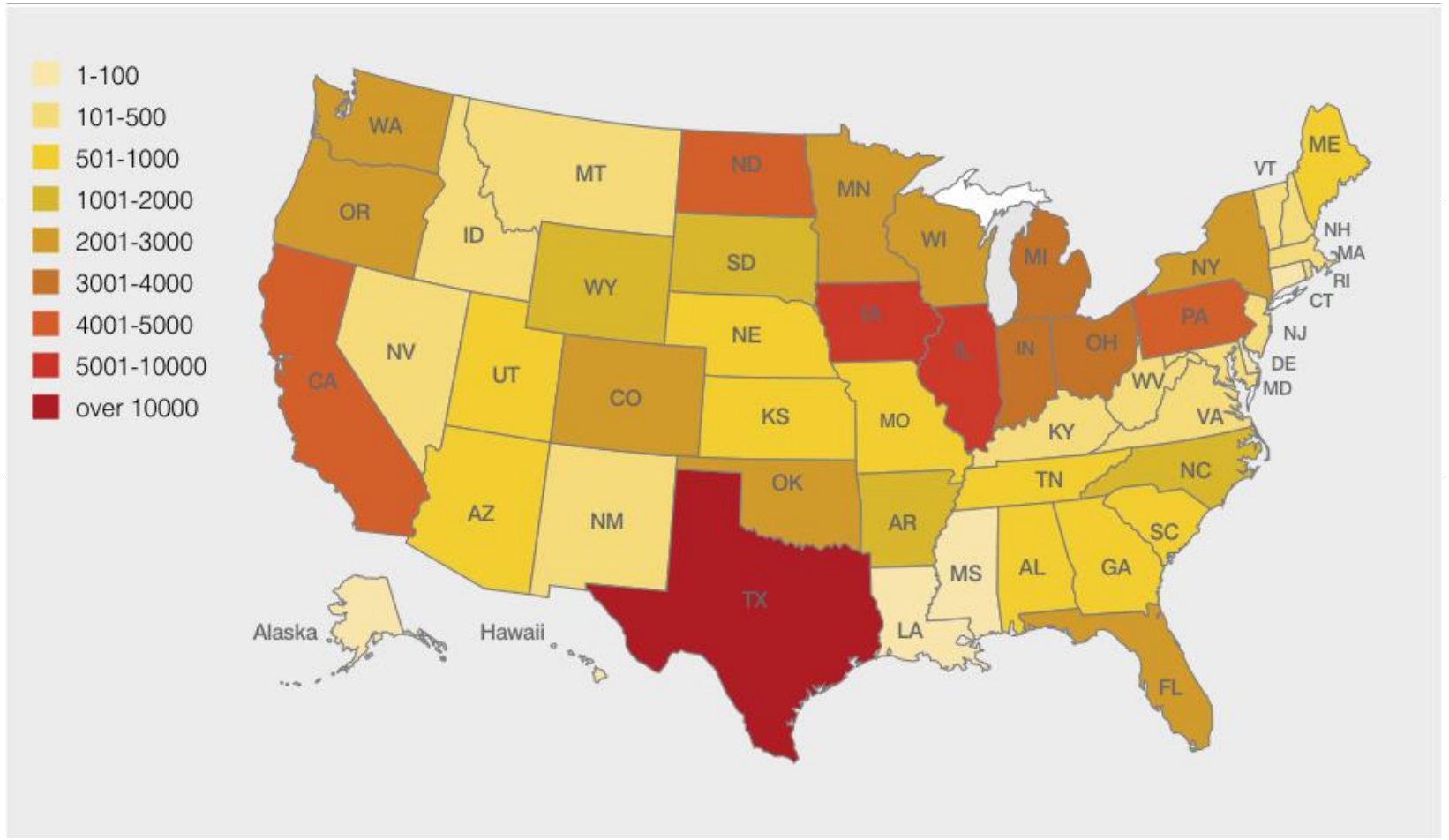


- AWEA estimates that the wind power sector provided roughly 85,000 full-time jobs in the U.S. at the end of 2009 (18,500 of which were in manufacturing)
- 7 of the 10 wind turbine vendors with the largest share of the U.S. market in 2009 have one or more manufacturing facilities operating in the U.S., while 2 of the remaining 3 have announced specific plans to open facilities in the future

Note: map is not intended to be exhaustive

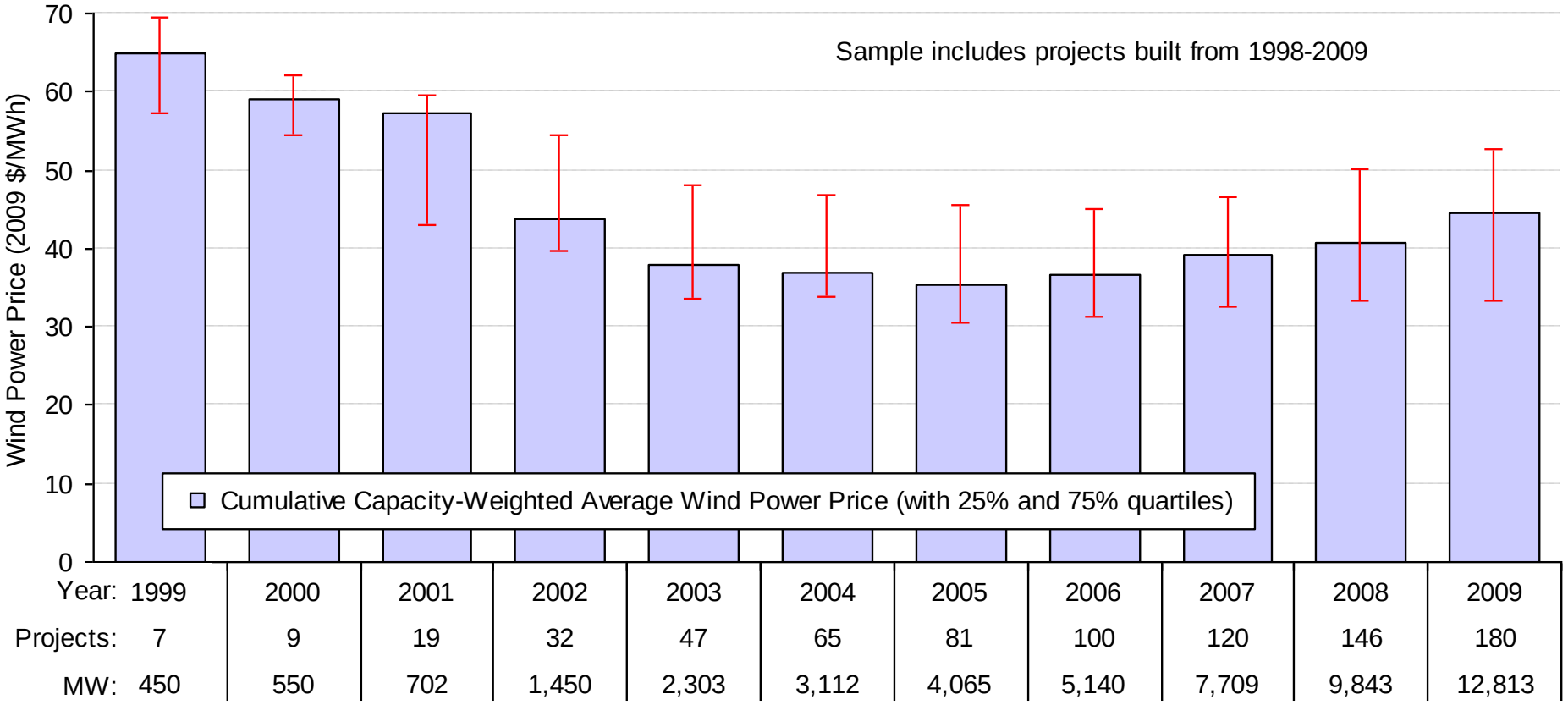
Source: DOE 2009 Wind Technologies Market Report

Wind Industry Jobs in U.S. by State



Source: AWEA US Wind Industry Annual Market Report – Year Ending 2009

Cumulative Average Sales Price for Sample of Projects Built After 1997 Low But Rising

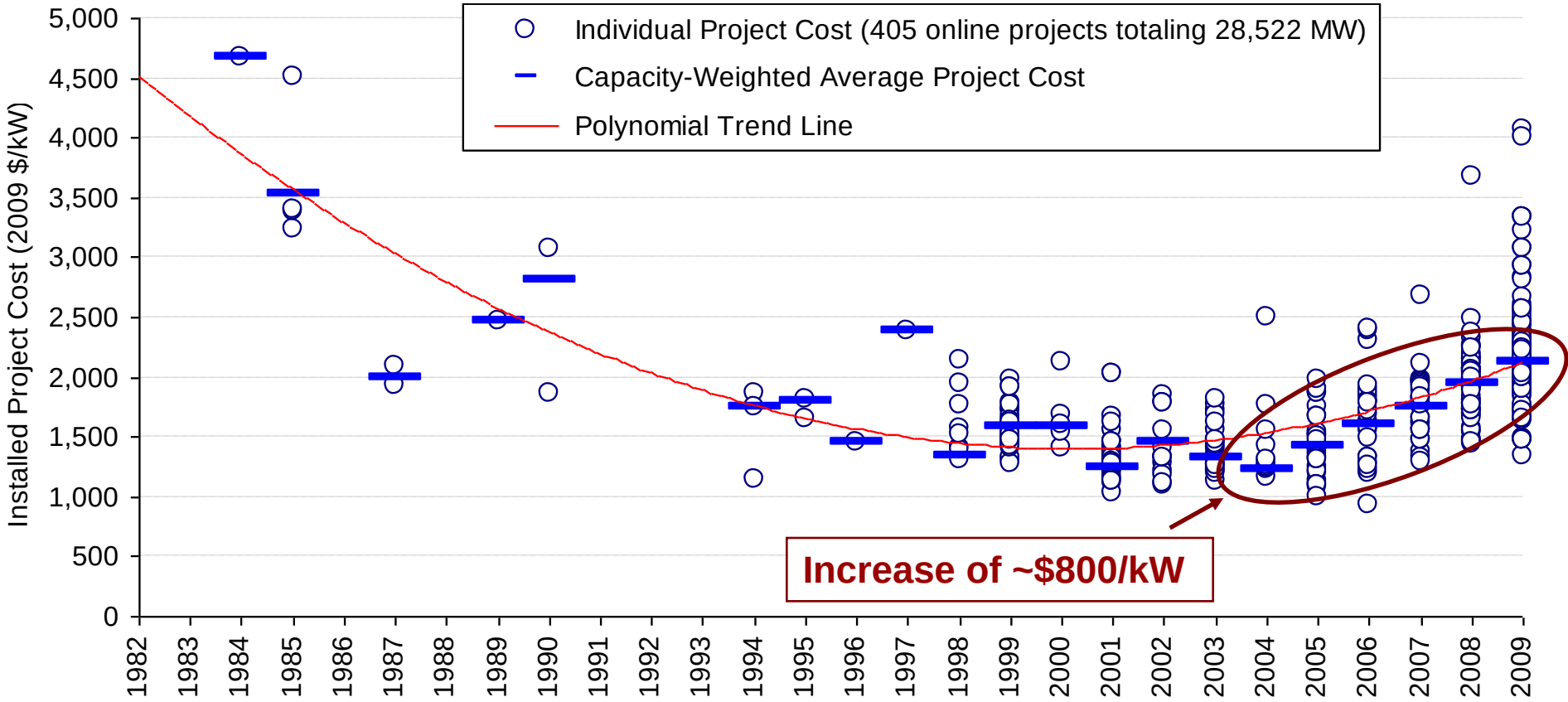


Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Projects:	7	9	19	32	47	65	81	100	120	146	180
MW:	450	550	702	1,450	2,303	3,112	4,065	5,140	7,709	9,843	12,813

Increase in prices since 2005 due to rising prices from newly built projects

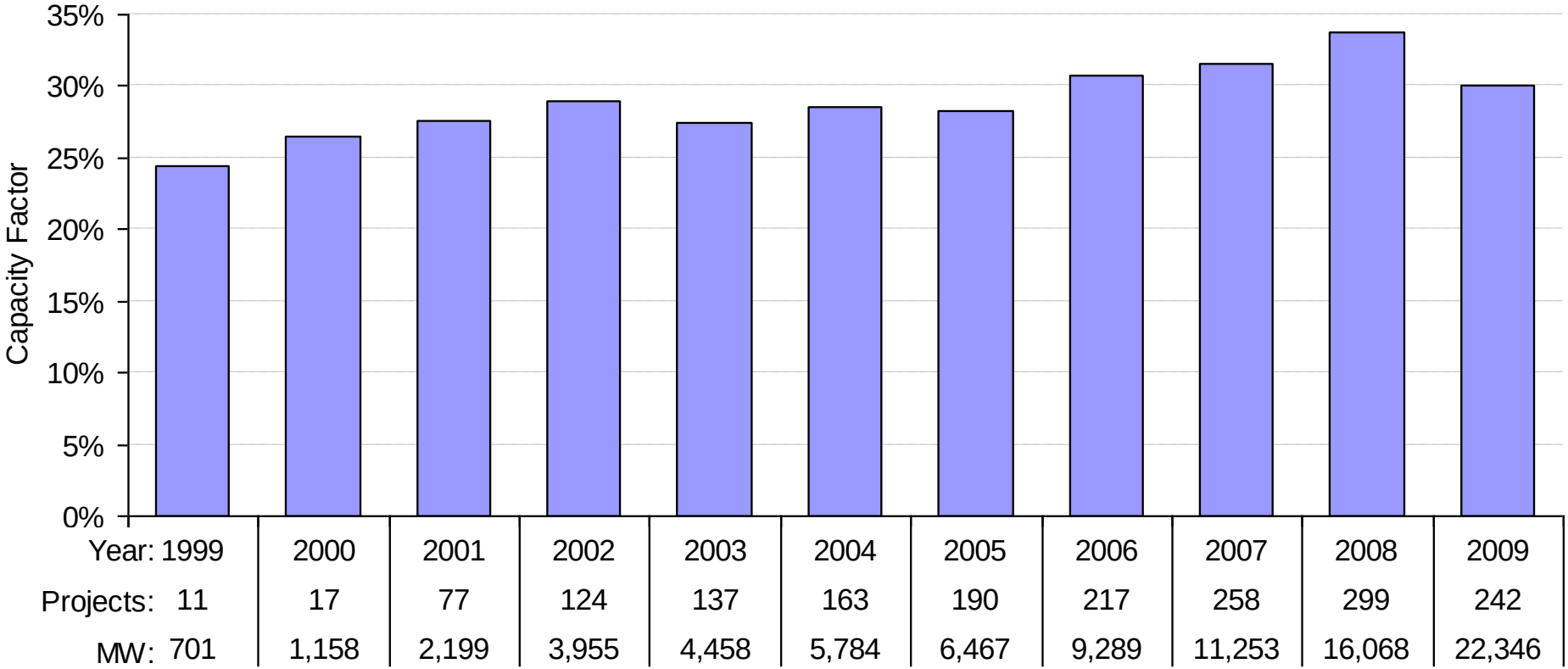
Source: DOE 2009 Wind Technologies Market Report

Installed Project Costs Continued to Rise in 2009, After a Long Period of Decline



Source: DOE 2009 Wind Technologies Market Report

Average Wind Project Capacity Factors Have Improved Over Time, But Leveled Off in Recent Years



Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Projects:	11	17	77	124	137	163	190	217	258	299	242
MW:	701	1,158	2,199	3,955	4,458	5,784	6,467	9,289	11,253	16,068	22,346

- General improvement reflects increase in hub height and rotor diameter
- Inter-annual wind resource variation also plays a role: 2009 was a bad wind year
- Curtailment was another major factor in lower 2009 capacity factor

Source: DOE 2009 Wind Technologies Market Report

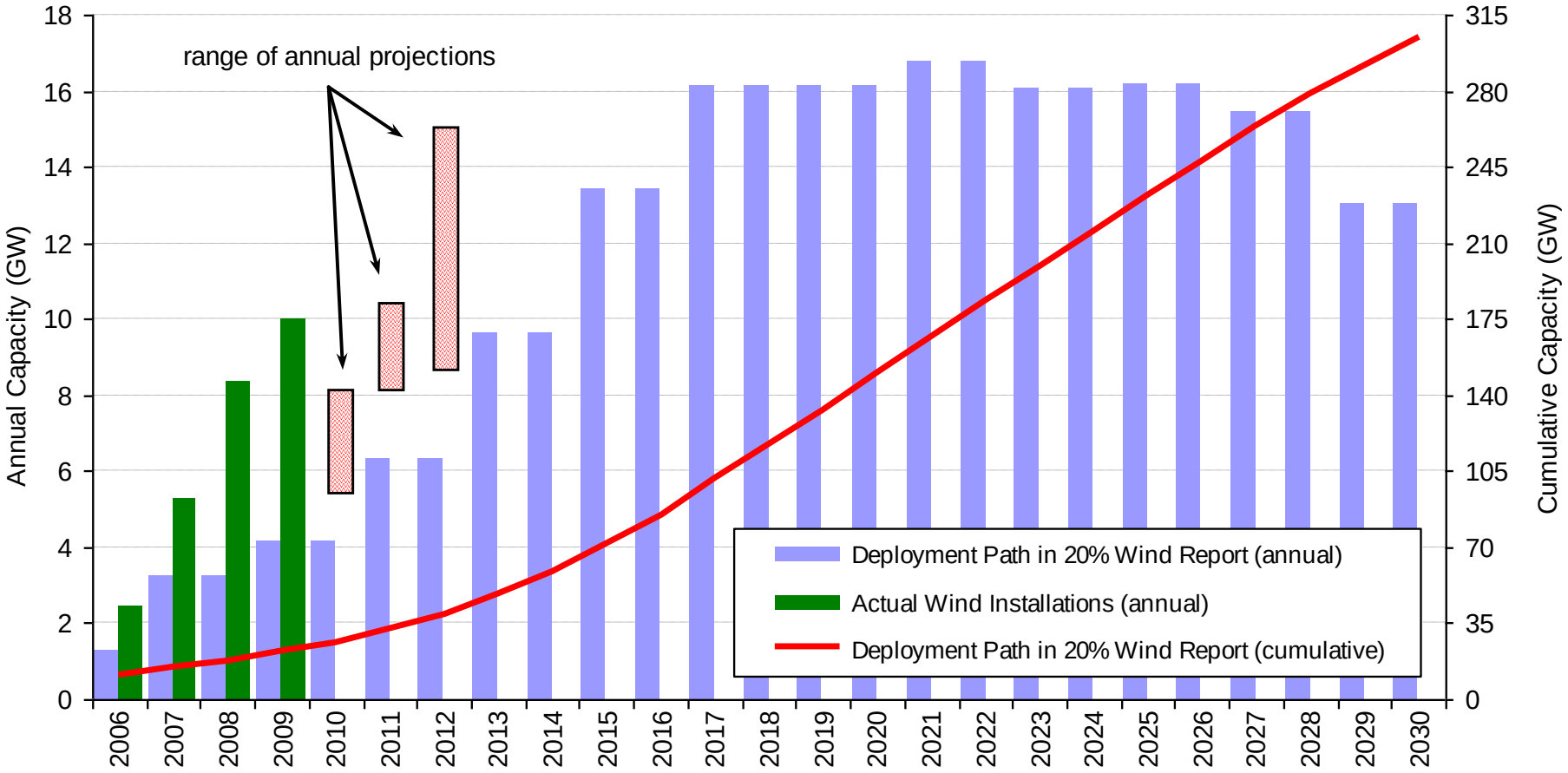
Forecasts Predict Slower 2010, with Resurgence in 2011 and 2012

- 2010 expected to be a slower year, due to reduced demand for wind (driven by weak economy and low wholesale prices); 2009 buoyed by projects planned for completion in 2008 but carried over as result of PTC extension
- Predictions for 2010 range from 5,500 MW to 8,000 MW; forecasts predict a market resurgence in 2011-2012
- U.S. expected to retain 2nd-largest market status, after China, from 2010-12
- Beyond 2012, federal policy is uncertain, complicating projections

Source	2010	2011	2012	Cumulative Additions 2010-2012
EIA	7,310	10,200	10,330	27,840
BTM	8,000	10,000	15,000	33,000
IHS EER	7,130	9,830	9,340	26,300
Bloomberg NEF	7,390	8,535	8,610	24,535
Macquarie	7,500	8,100	8,700	24,300
UBS	6,950	9,380	10,780	27,110
AWEA	5,500-7,500	--	--	--

Source: DOE 2009 Wind Technologies Market Report

U.S. Is on a Trajectory that May Lead to 20% of Electricity Coming from Wind



Ramping up further to ~16 GW/year and maintaining that pace for a decade is an enormous challenge, and is far from pre-determined

Source: DOE 2009 Wind Technologies Market Report

References

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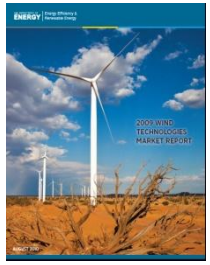

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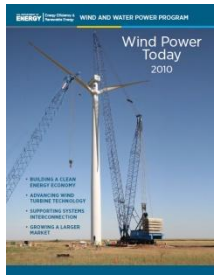

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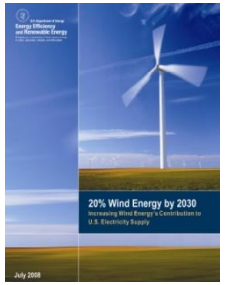

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Thank You!

Questions?

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