2008 Wind Technologies Market Report

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Lawrence Berkeley National Laboratory

- Report Summary -

July 2009

Presentation Overview

- Introduction to 2008 edition of U.S. wind energy market report
- Wind installation trends
- Wind industry trends
- Price, cost, and performance trends
  - Power sales prices
  - Installed wind project costs
  - Wind turbine transaction prices
  - Wind project performance
  - O&M cost trends
- Policy and market drivers
- Future outlook

2008 Wind Technologies Market Report

Purpose, Scope, and Data:

- With a focus on 2008, summarize trends in the U.S. wind power market, including information on wind installations, industry developments, power sales prices, project costs, performance, O&M costs, policy/market trends
- Scope primarily includes wind turbines and projects over 50 kW in size
- Data sources include AWEA, EIA, FERC, SEC, etc. *(see full report)*

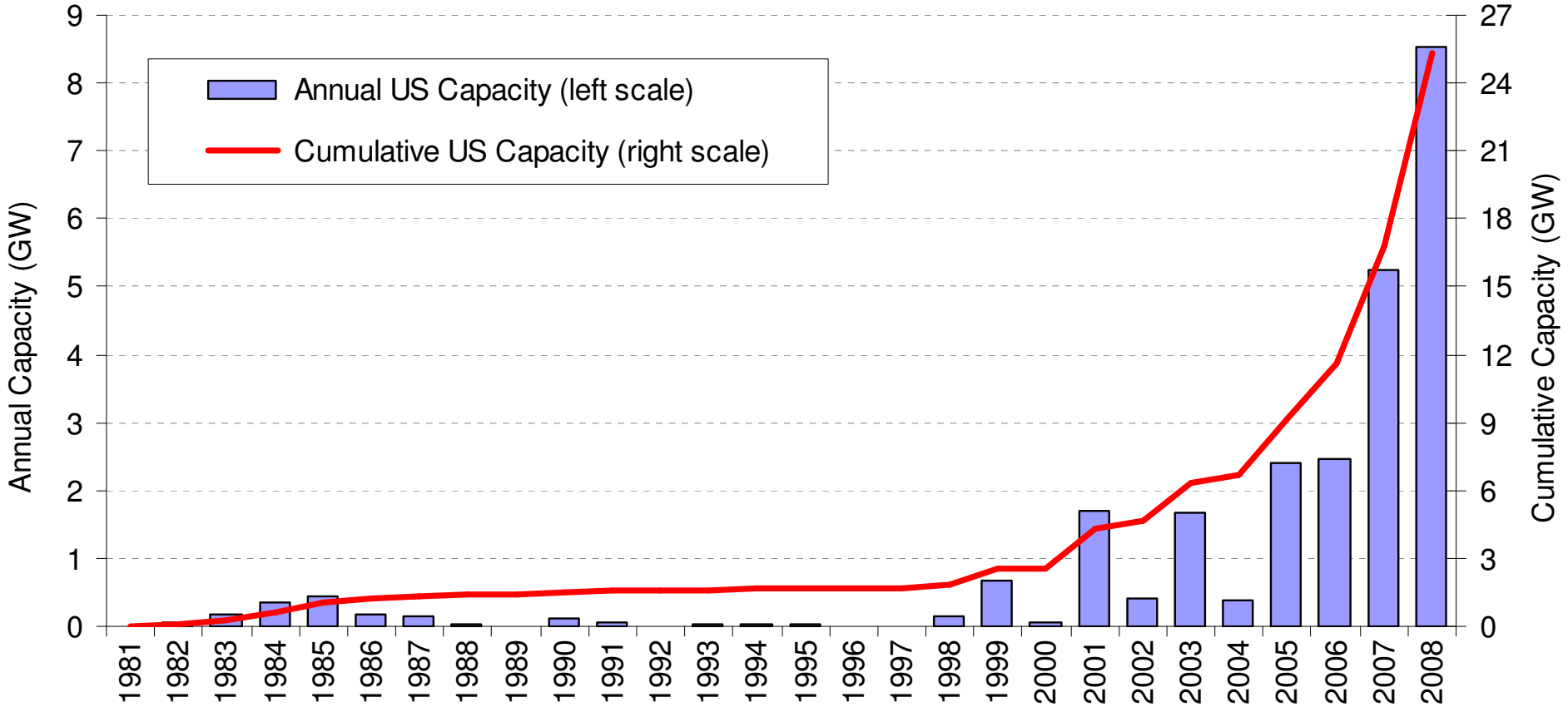
Report Authors:

- Primary authors: Ryan Wiser and Mark Bolinger, Berkeley Lab
- Contributions from others at Berkeley Lab, Exeter Assoc., NREL, AWEA

Available at: http://www1.eere.energy.gov/windandhydro/wind_pubs.html

Installation Trends

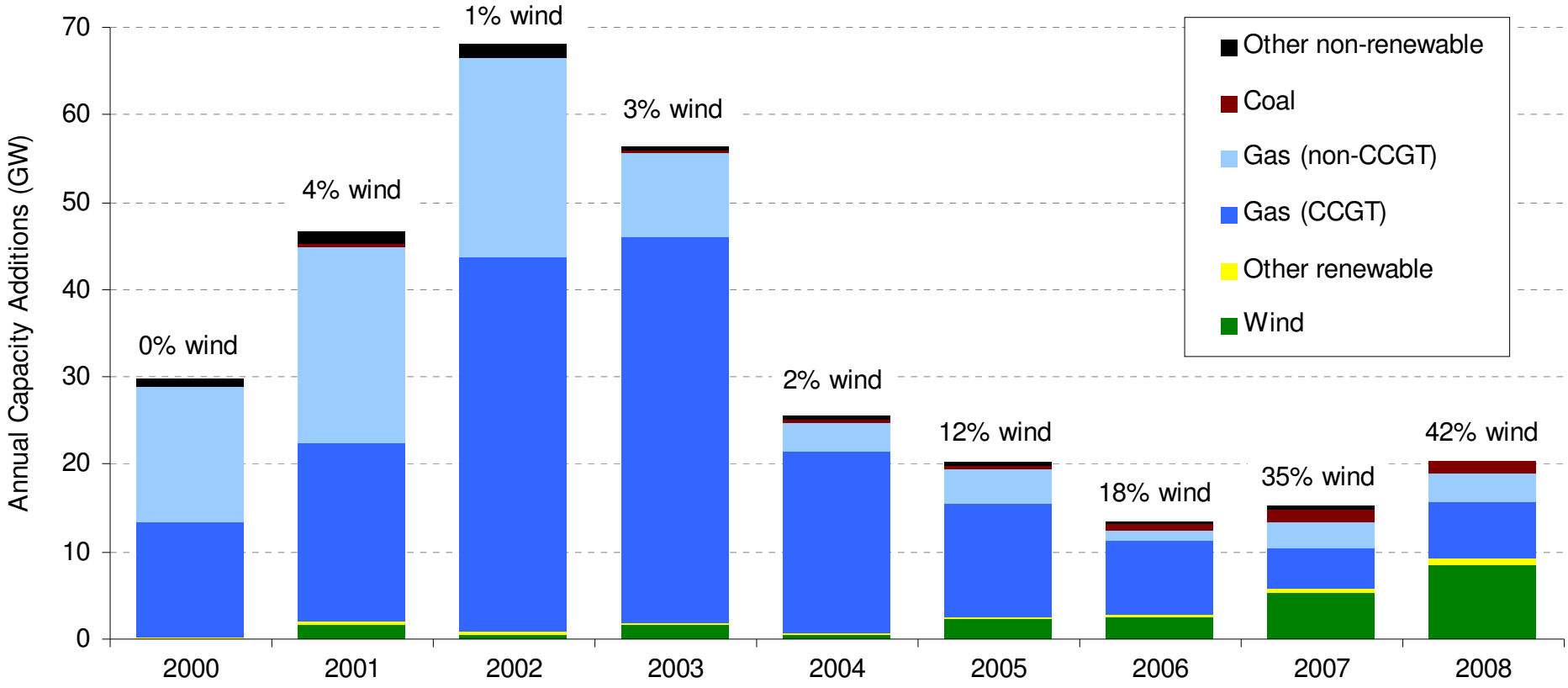
U.S. Wind Power Capacity Up >50% in 2008



Record year for new U.S. wind capacity:

- 8,558 MW of wind added in 2008, bringing total to 25,369 MW
- Roughly $16.4 billion in 2008 project investment

Wind Power Contributed 42% of All New Generating Capacity in the US in 2008



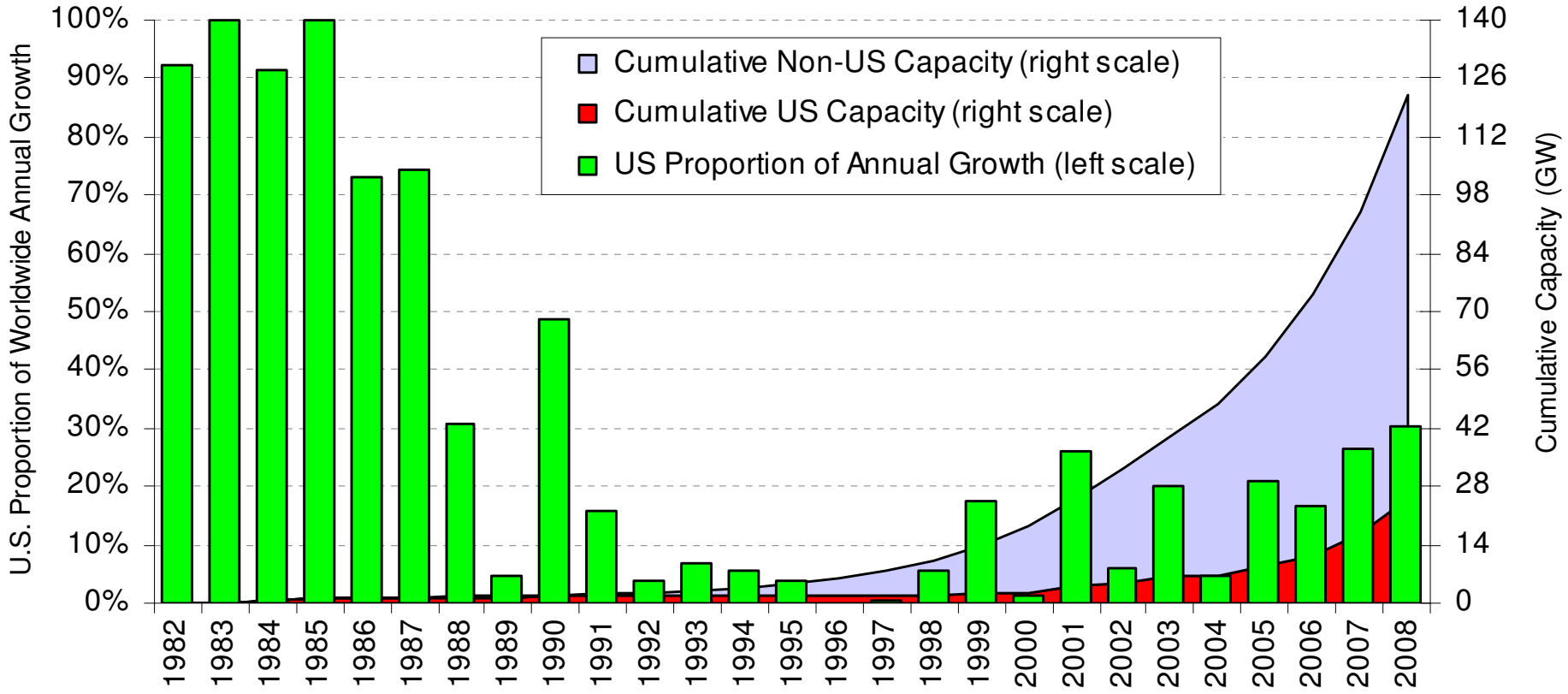
- Wind was the 2nd-largest resource added for the 4th-straight year

The U.S. Led the World in Annual Capacity Growth and Cumulative Wind Capacity

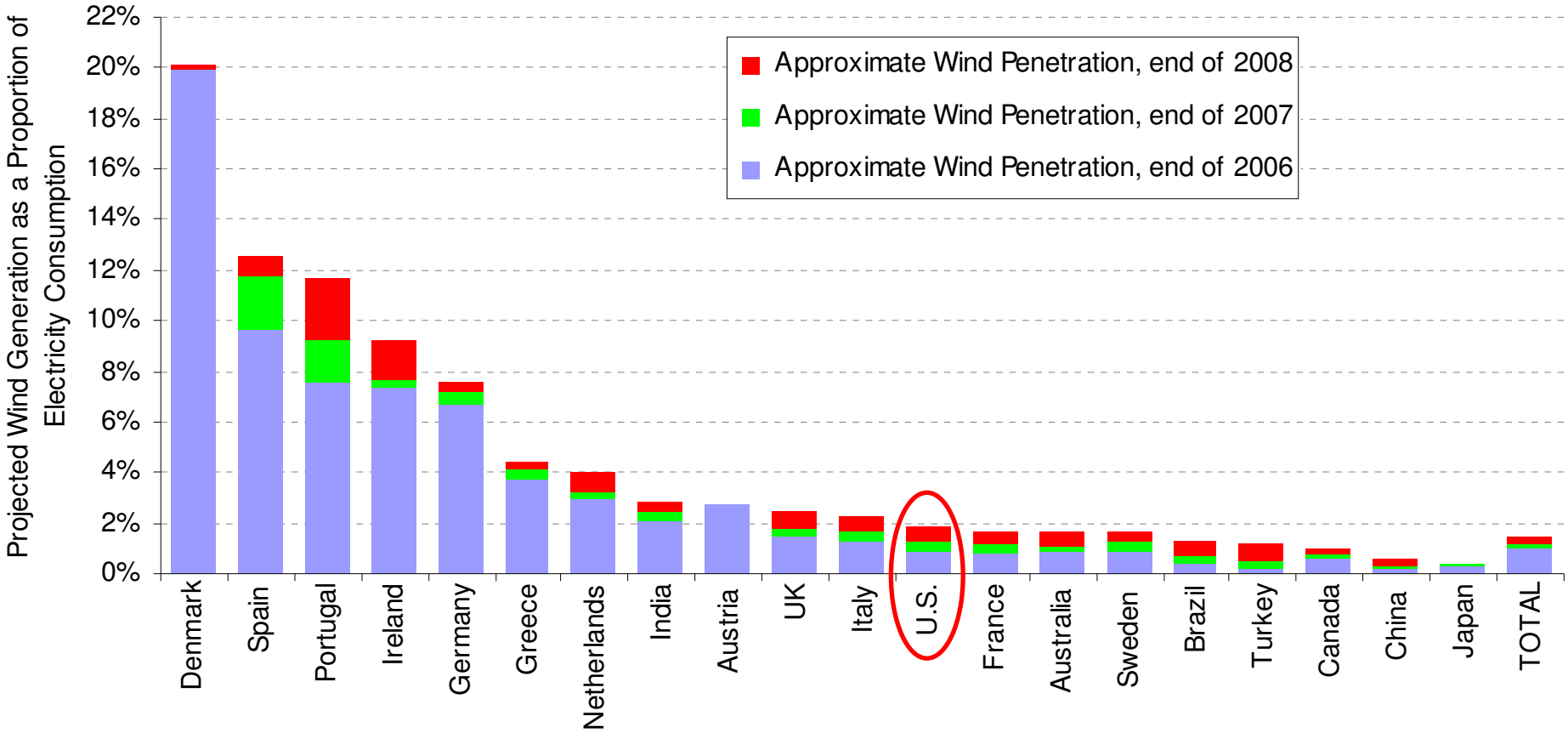
Annual Capacity (2008, MW)		Cumulative Capacity (end of 2008, MW)	
U.S.	**8,558**	**U.S.**	**25,369**
China	6,246	Germany	23,933
India	1,810	Spain	16,453
Spain	1,739	China	12,121
Germany	1,665	India	9,655
France	1,200	Italy	3,731
Italy	1,010	France	3,671
U.K.	869	U.K.	3,263
Portugal	679	Denmark	3,159
Australia	615	Portugal	2,829
Rest of World	3,999	*Rest of World*	18,106
TOTAL	**28,390**	**TOTAL**	**122,290**

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

U.S. Share of Global Wind Capacity: 30% of 2008 Additions, 21% of Cumulative

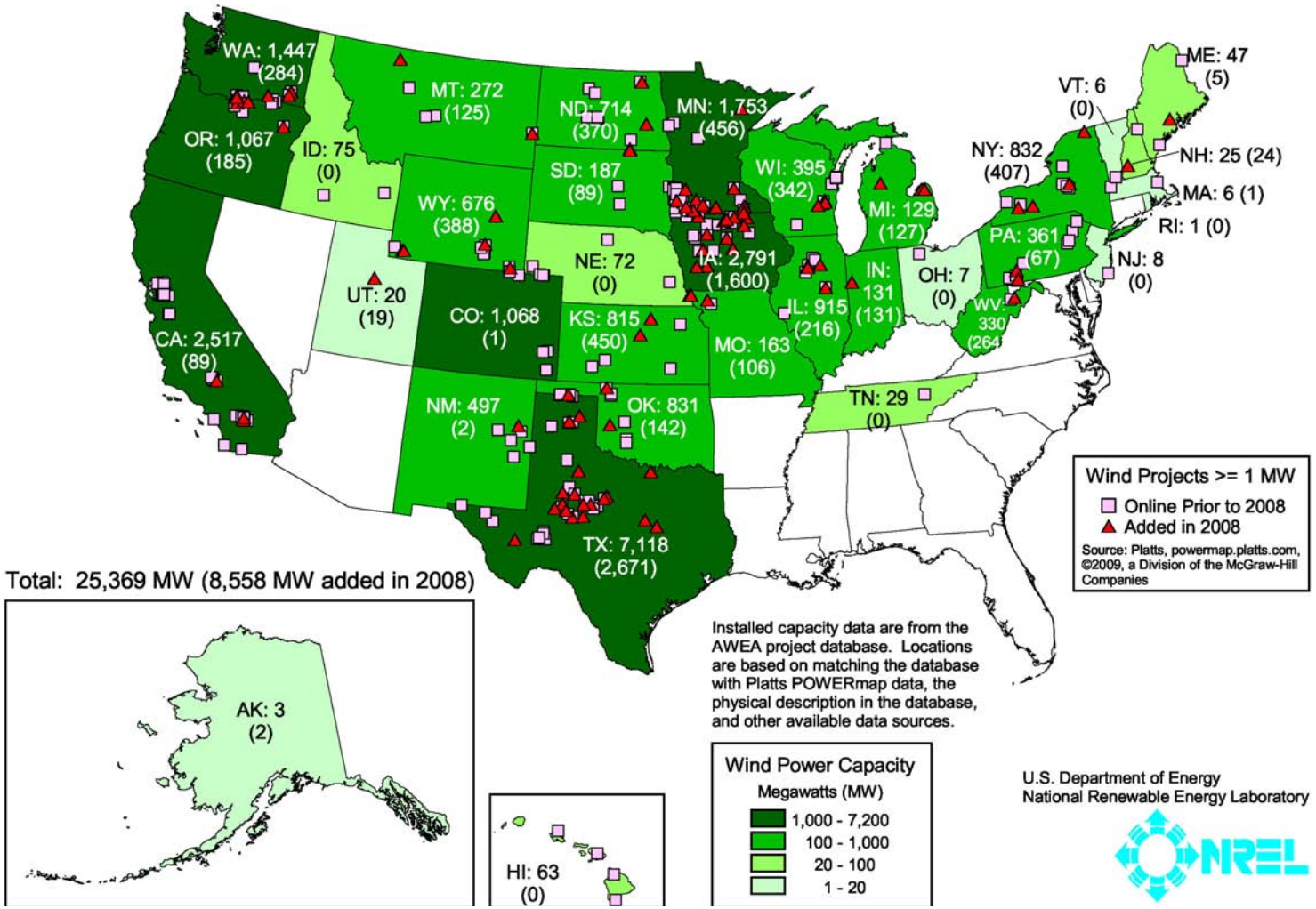


U.S Lagging Other Countries in Wind As a Percentage of Electricity Consumption



Note: Figure only includes the 20 countries with the most installed wind capacity at the end of 2008

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



Texas Easily Led Other States in Both Annual and Cumulative Capacity

Annual Capacity (2008, MW)		Cumulative Capacity (end of 2008, MW)		Estimated Percentage of In-State Generation	
Texas	2,671	Texas	7,118	Iowa	13.3%
Iowa	1,600	Iowa	2,791	Minnesota	10.4%
Minnesota	456	California	2,517	South Dakota	8.8%
Kansas	450	Minnesota	1,753	North Dakota	7.1%
New York	407	Washington	1,447	Kansas	6.7%
Wyoming	388	Colorado	1,068	Colorado	6.6%
North Dakota	370	Oregon	1,067	Oregon	5.4%
Wisconsin	342	Illinois	915	Texas	5.3%
Washington	284	New York	832	New Mexico	4.5%
West Virginia	264	Oklahoma	831	Wyoming	4.1%
Illinois	216	Kansas	815	Washington	3.9%
Oregon	185	North Dakota	714	Oklahoma	3.7%
Oklahoma	142	Wyoming	676	Montana	3.4%
Indiana	131	New Mexico	497	California	3.1%
Michigan	127	Wisconsin	395	Hawaii	2.2%
Montana	125	Pennsylvania	361	Idaho	1.6%
Missouri	106	West Virginia	330	New York	1.4%
South Dakota	89	Montana	272	Illinois	1.4%
California	89	South Dakota	187	Wisconsin	1.3%
Pennsylvania	67	Missouri	163	West Virginia	0.9%
Rest of U.S.	52	*Rest of U.S.*	622	*Rest of U.S.*	0.2%
TOTAL	**8,558**	**TOTAL**	**25,369**	**TOTAL**	**1.8%**

Source: AWEA project database, EIA, Berkeley Lab estimates

- 13 states had >500 MW of wind capacity at the end of 2008 (7 had >1000 MW, 3 had >2500 MW)
- 2 states (IA and MN) have in-state wind generation that exceeds 10% of total in-state generation (6 other states exceed 5%)

Wind Now >20% of Some Utilities' Sales

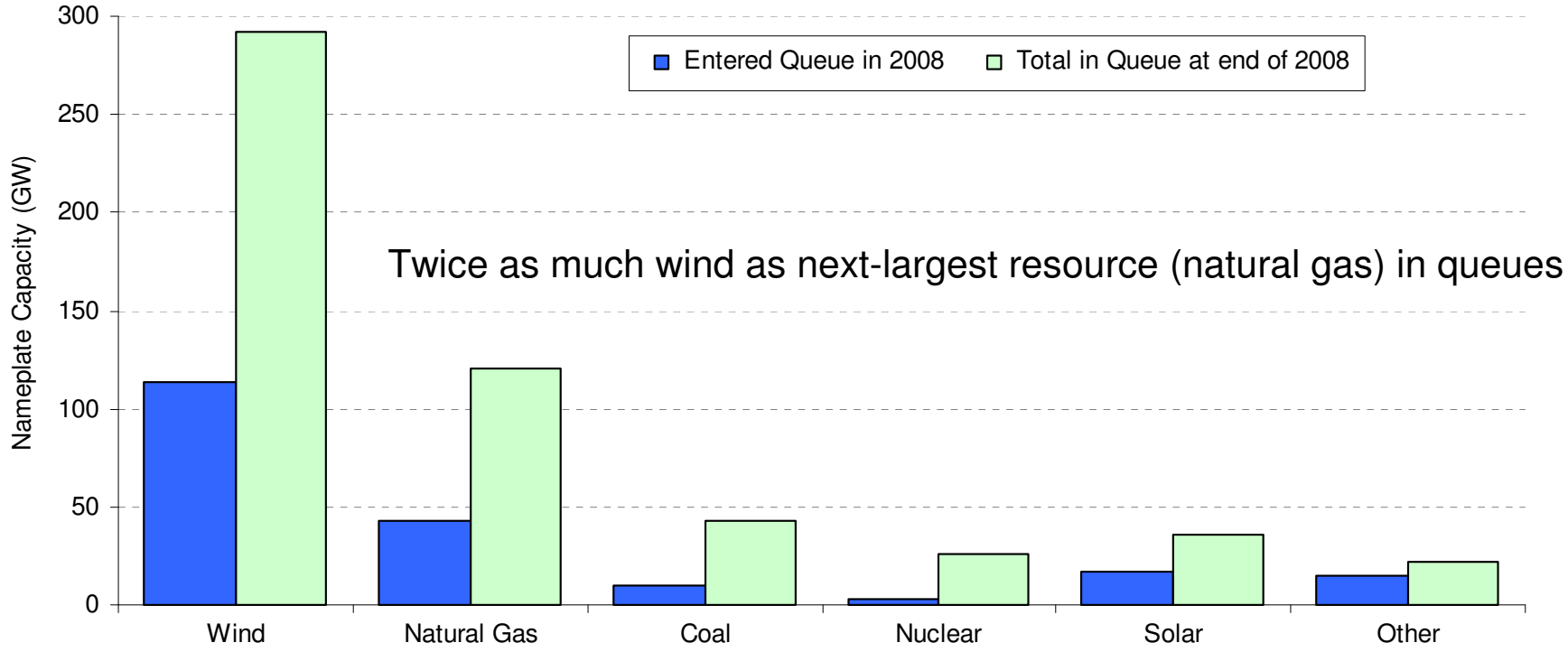
Total Wind Capacity (end of 2008, MW)	
Xcel Energy	2,906
MidAmerican Energy	2,363
Southern California Edison	1,137
Pacific Gas & Electric	981
Luminant	913
City Public Service of San Antonio	502
American Electric Power	468
Alliant Energy	446
Austin Energy	439
Puget Sound Energy	435
Exelon Energy	351
Great River Energy	319
Empire District Electric Company	255
First Energy	244
San Diego Gas & Electric	239
Portland General Electric	225
Public Service New Mexico	204
MSR Public Power Agency	200
Reliant Energy	199
Minnkota Power Cooperative	193

Estimated Percentage of Retail Sales (for utilities with > 100 MW of wind)	
Minnkota Power Cooperative	22.6%
Empire District Electric Company	20.7%
Otter Tail Power	14.9%
Southern Minn. Muni. Power Authority	13.0%
Austin Energy	11.7%
Xcel Energy	10.7%
MSR Public Power Agency	9.3%
Great River Energy	9.1%
City Public Service of San Antonio	8.2%
MidAmerican Energy	8.1%
Public Service New Mexico	6.2%
Luminant	5.6%
Alliant Energy	5.4%
Puget Sound Energy	5.3%
Seattle City Light	5.3%
Northwestern Energy	5.0%
Minnesota Power	4.6%
Aquila	3.9%
Portland General Electric	3.3%
Southern California Edison	3.1%

Source: AWEA, EIA, Berkeley Lab estimates

See full report for the many assumptions used to generate the data in this table

Nearly 300 GW of Wind in Transmission Interconnection Queues



- MISO (64 GW), ERCOT (52 GW), SPP (48), and PJM (43 GW) account for >70% of total wind in queues
- ***Not all of this capacity will be built….***

Interest in Offshore Wind Continues in the U.S., but No Such Projects Are Yet Online

State	Proposed Offshore Wind Capacity (Advanced-Stage Only)
Massachusetts	783 MW
Rhode Island	412 MW
Delaware	350 MW
New Jersey	350 MW
Texas	150 MW
Ohio	20 MW
Georgia	10 MW
TOTAL	**2,075 MW**

Source: NREL

- Table at left contains only project proposals that are considered to be in an "advanced stage," in that they plan to use proven technology and recognized design standards, and have commenced with feasibility studies for a defined amount of capacity at a specific site
- Nevertheless, these projects are in various stages of development, and may not all be built as planned

Distributed Wind Power Market Continues to Grow

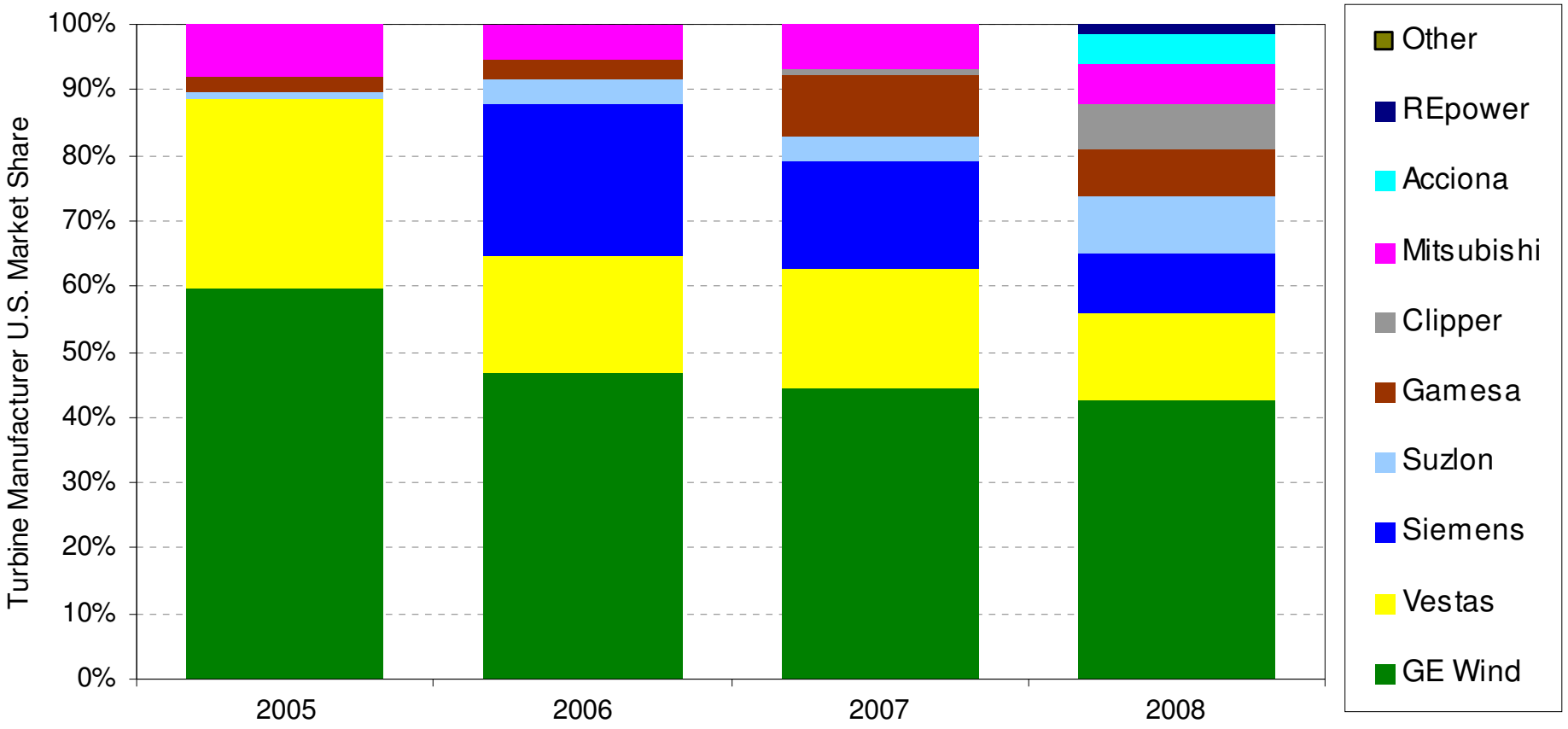
Application	Distributed Wind Power, Annual Sales in 2008		
	Number of Turbines	Capacity Additions	Sales Revenue
Off-grid	7,402	3.8 MW	$15 million
On-grid	2,984	13.6 MW	$62 million
TOTAL	**10,386**	**17.4 MW**	**$77 million**

Source: AWEA

- Sales of wind turbines into the distributed wind market (turbine size range of 300 W to 100 kW) in the U.S. equaled 17.4 MW in 2008, or $77 million
- 78% growth in annual sales (in capacity terms), relative to 2007, yielding cumulative capacity of 80 MW

Industry Trends

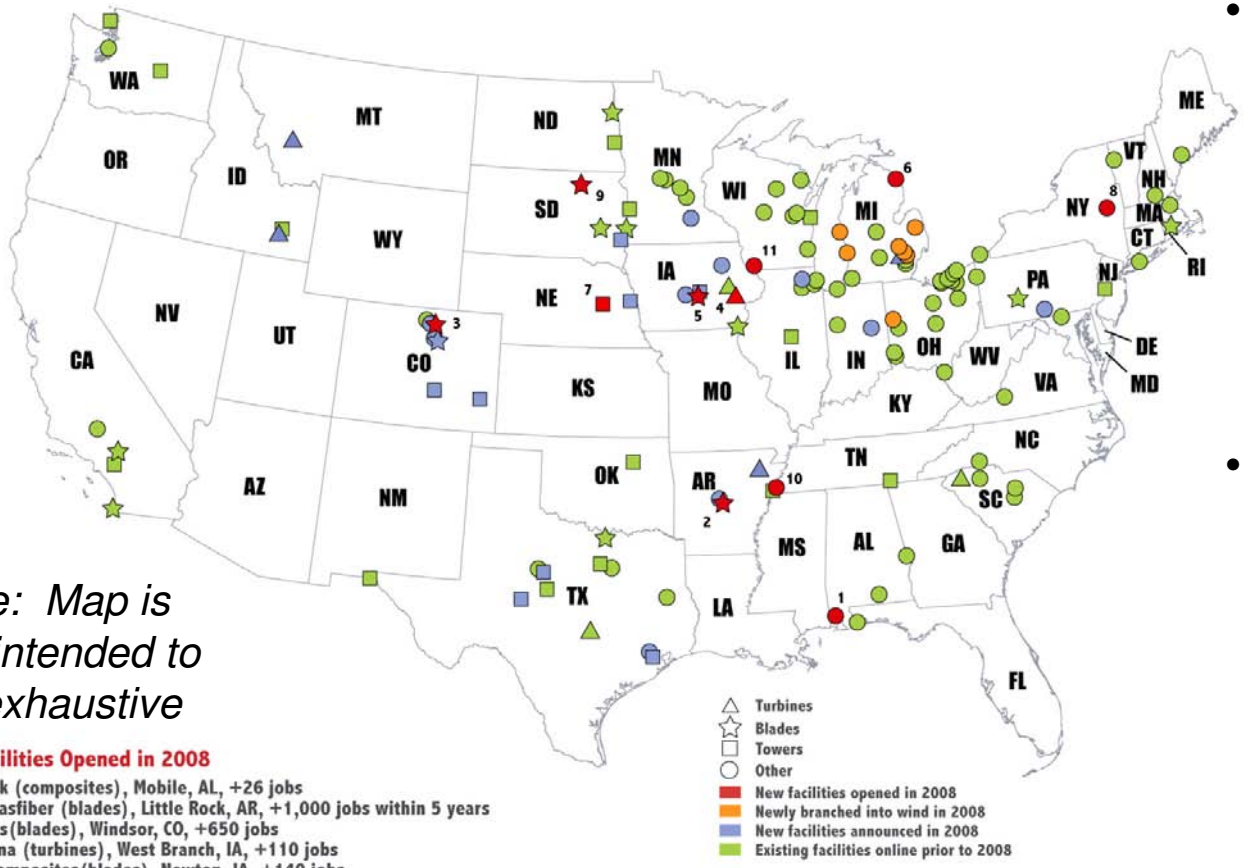
GE Remained the Top Turbine Vendor in the U.S. Market, But a Growing Number of Other Manufacturers are Capturing Market Share



Nearly Every Turbine Vendor Active in the U.S. Market Saw Growth in 2008

Manufacturer	Turbine Installations (MW)			
	2005	**2006**	**2007**	**2008**
GE Wind	1,433	1,146	2,342	3,657
Vestas	700	439	948	1,120
Siemens	0	573	863	791
Suzlon	25	92	197	738
Gamesa	50	74	494	616
Clipper	2.5	0	47.5	595
Mitsubishi	190	128	356	516
Acciona	0	0	0	410
REpower	0	0	0	102
Other	2	2	3	13
TOTAL	**2,402**	**2,454**	**5,329**	**8,558**

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



Note: Map is not intended to be exhaustive

New Facilities Opened in 2008

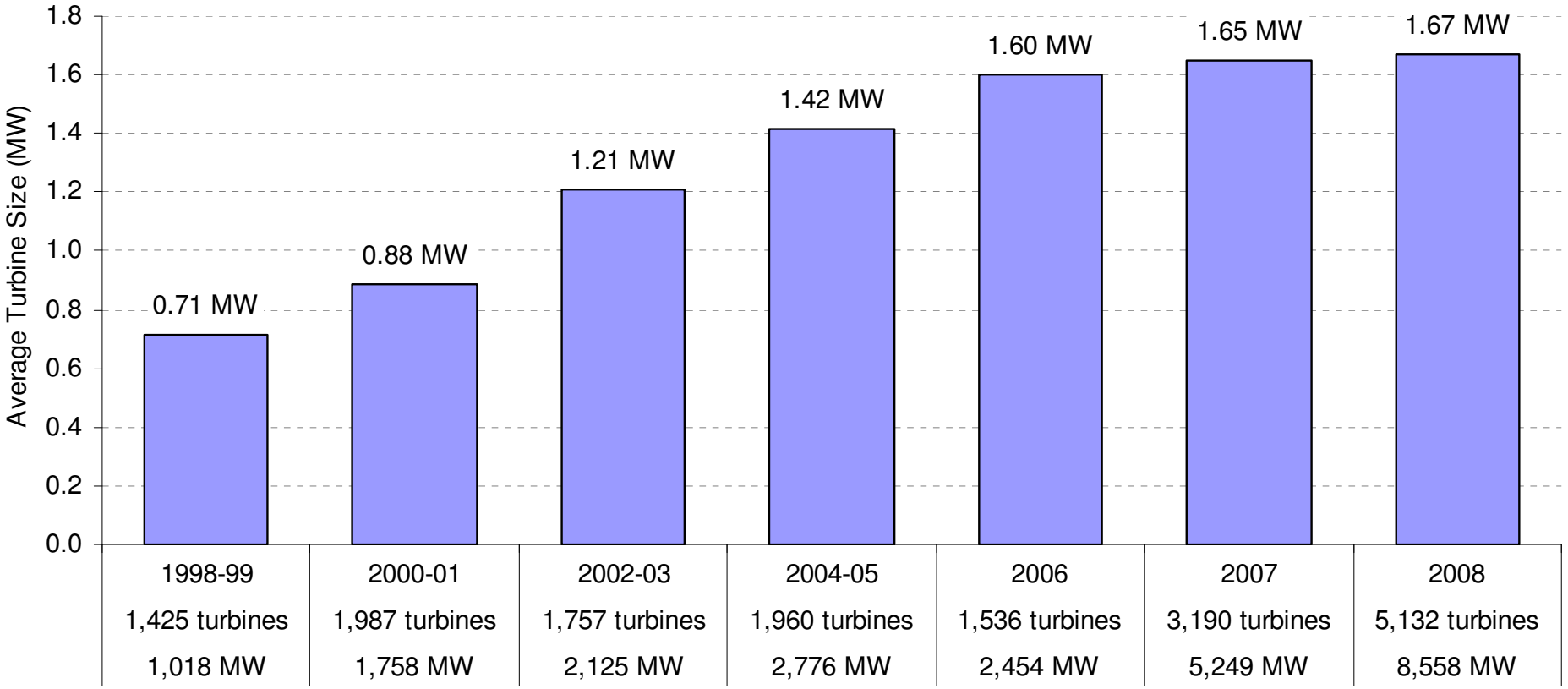
1. Evonik (composites), Mobile, AL, +26 jobs
2. LM Glasfiber (blades), Little Rock, AR, +1,000 jobs within 5 years
3. Vestas(blades), Windsor, CO, +650 jobs
4. Acciona (turbines), West Branch, IA, +110 jobs
5. TPI Composites(blades), Newton, IA, +140 jobs
6. ATI Casting Services (casting and foundry), Alpena, MI, +20 jobs
7. Katana Summit (towers), Columbus, NE
8. GE (parts fulfillment center), Schenectady, NY
9. Molded Fiberglass (blades), Aberdeen, SD, +up to 750 jobs
10. GE (parts operation center), Memphis, TN
11. Wausaukee Composites (housings), Cuba City, WI, +61 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 and blades.

NREL
This map was created by The National Renewable Energy Laboratory for the U.S. Department of Energy May 18, 2009

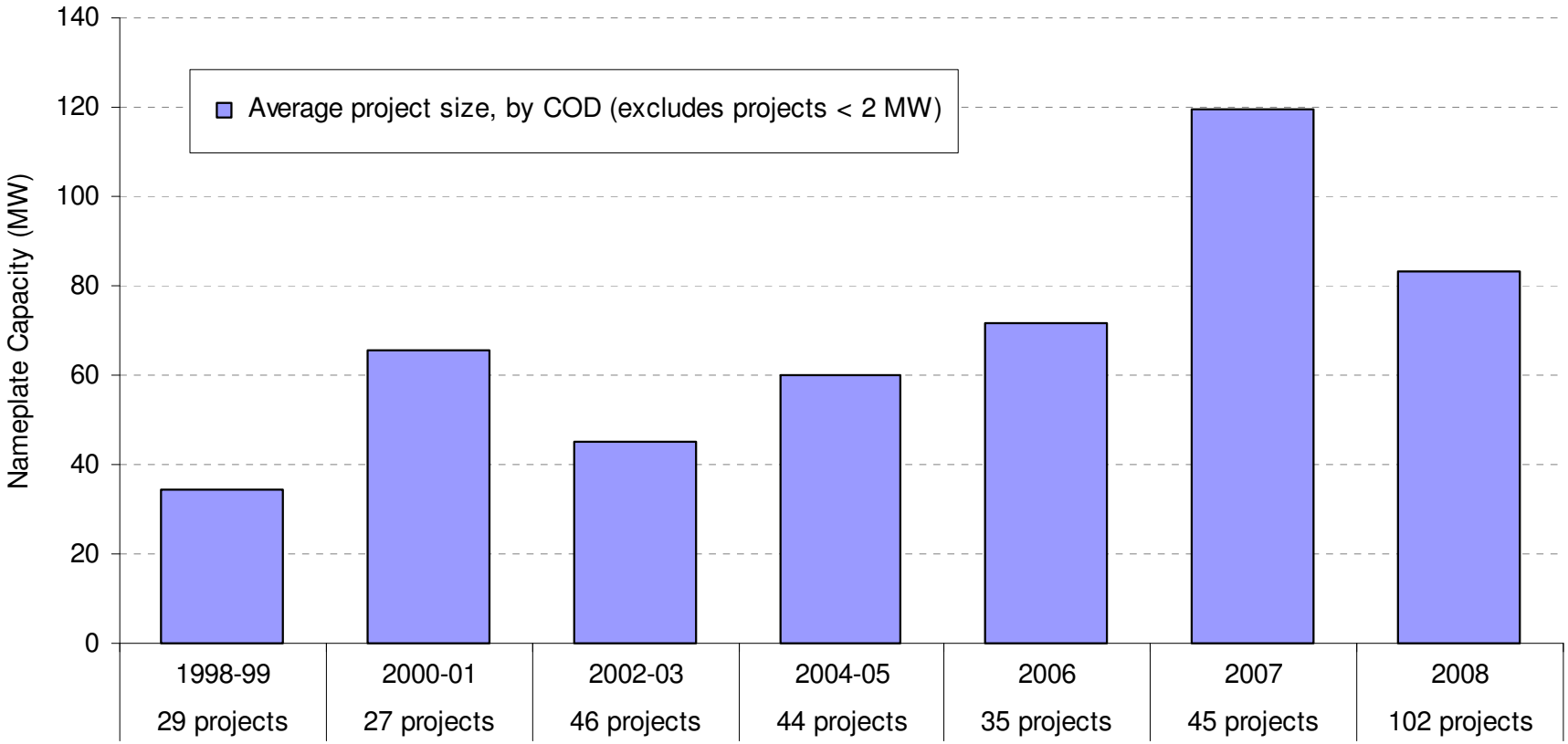
- AWEA estimates that roughly 8,400 new domestic manufacturing jobs were added in the U.S. wind sector in 2008 (total U.S. wind employment growth in 2008 = 35,000)
- The # of utility-scale turbine vendors assembling nacelles in the U.S. rose from just one in 2004 (GE) to five in 2008 (GE, Gamesa, Clipper, Acciona, CTC/DeWind)

Average Turbine Size Inched Higher in 2008



~20% of turbines installed in 2008 were larger than 2.0 MW, up from ~16% in 2006 and 2007, and just 0.1% in 2004-2005

Average Project Size Declined in 2008, Bucking Longer-Term Trend



Despite retreat in 2008, the average 2008 project size was still larger than in any other period (other than 2007)

Developer Consolidation Slowed in 2008

- Acquisitions and investments fell below 2006-2007 pace:
  - **2008:** 5 deals = 19 GW of wind development pipeline
  - **2007:** 11 deals = 37 GW
  - **2006:** 12 deals = 34 GW
  - **2005:** 8 deals = 12 GW
  - **2002-04:** 4 deals = 4 GW
- Slackening might reflect the financial crisis, and that many of the prime targets for investment and/or acquisition had already been acquired in previous years

Investor	Transaction Type	Developer	Announcement Date
EDF (SIIF Energies)	Acquisition	enXco	May-02
Gamesa	Investment	Navitas	Oct-02
AES	Investment	US Wind Force	Sep-04
PPM (Scottish Power)	Acquisition	Atlantic Renewable Energy Corp.	Dec-04
AES	Acquisition	SeaWest	Jan-05
Goldman Sachs	Acquisition	Zilkha (Horizon)	Mar-05
JP Morgan Partners	Investment	Noble Power	Mar-05
Arclight Capital	Investment	CPV Wind	Jul-05
Diamond Castle	Acquisition	Catamount	Oct-05
Pacific Hydro	Investment	Western Wind Energy	Oct-05
EIF U.S. Power Fund II	Investment	Tierra Energy, LLC	Dec-05
Airtricity	Acquisition	Renewable Generation Inc.	Dec-05
Babcock & Brown	Acquisition	G3 Energy LLC	Jan-06
Iberdrola	Acquisition	Community Energy Inc.	Apr-06
Shaw/Madison Dearborn	Investment	UPC Wind	May-06
NRG	Acquisition	Padoma	Jun-06
CPV Wind	Acquisition	Disgen	Jul-06
BP	Investment	Clipper	Jul-06
BP	Acquisition	Greenlight	Aug-06
Babcock & Brown	Acquisition	Superior	Aug-06
Enel	Investment	TradeWind	Sep-06
Iberdrola	Acquisition	Midwest Renewable Energy Corp.	Oct-06
Iberdrola	Acquisition	PPM (Scottish Power)	Dec-06
BP	Acquisition	Orion Energy	Dec-06
Naturener	Acquisition	Great Plains Wind & Energy, LLC	Feb-07
HSH Nordbank	Investment	Ridgeline Energy	Feb-07
Energias de Portugal	Acquisition	Horizon	Mar-07
Iberdrola	Acquisition	CPV Wind	Apr-07
Duke Energy	Acquisition	Tierra Energy, LLC	May-07
Acciona	Acquisition	EcoEnergy, LLC	Jun-07
Babcock & Brown	Acquisition	Bluewater Wind	Sep-07
Good Energies	Investment	EverPower	Sep-07
E.ON AG	Acquisition	Airtricity North America	Oct-07
Wind Energy America	Acquisition	Boreal	Oct-07
Marubeni	Investment	Oak Creek Energy Systems	Dec-07
NTR	Investment	Wind Capital Group	Apr-08
Canadian Pension Plan	Investment	Noble Power	Apr-08
ArcLight and Terra-Gen	Acquisition	Allco Wind Energy	Jun-08
Duke Energy	Acquisition	Catamount	Jun-08
Veolia	Acquisition	Ridgeline Energy	Oct-08

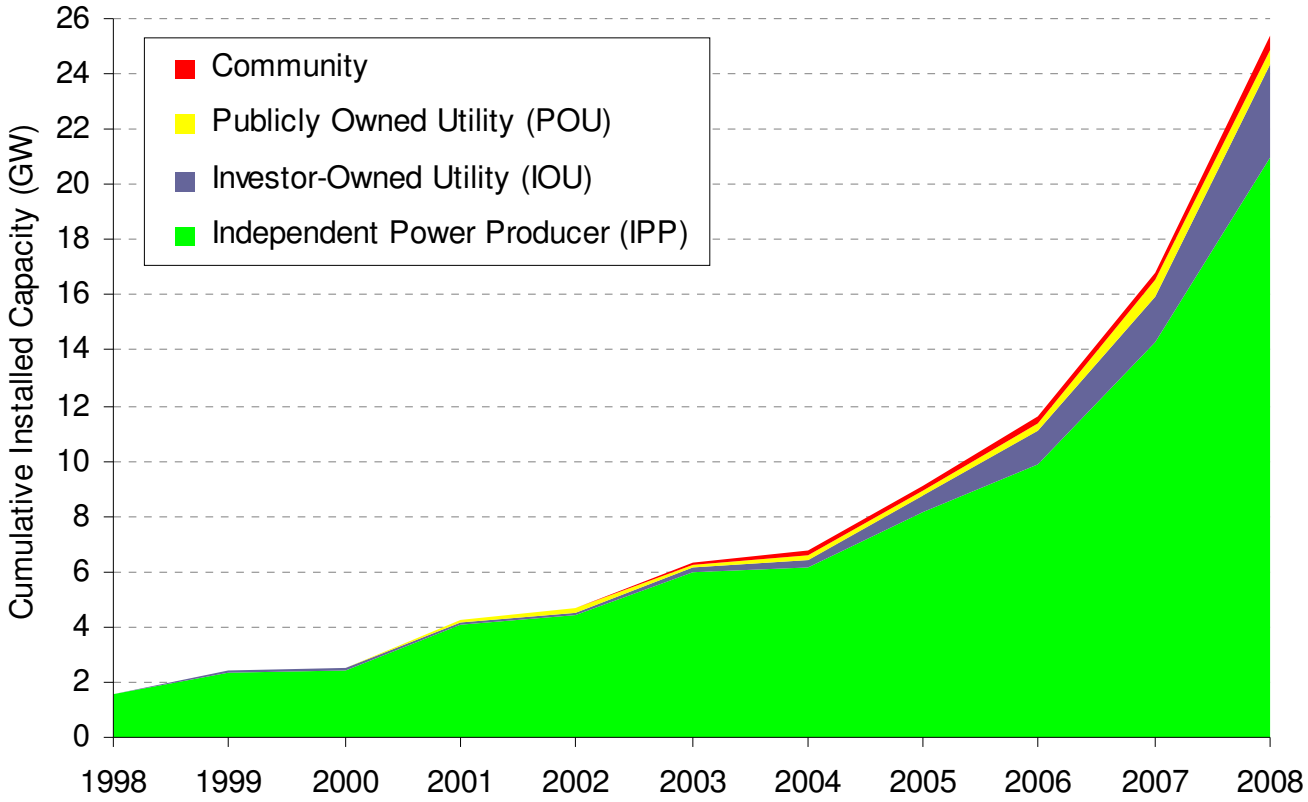
* Select list of announced transactions; excludes joint development activity

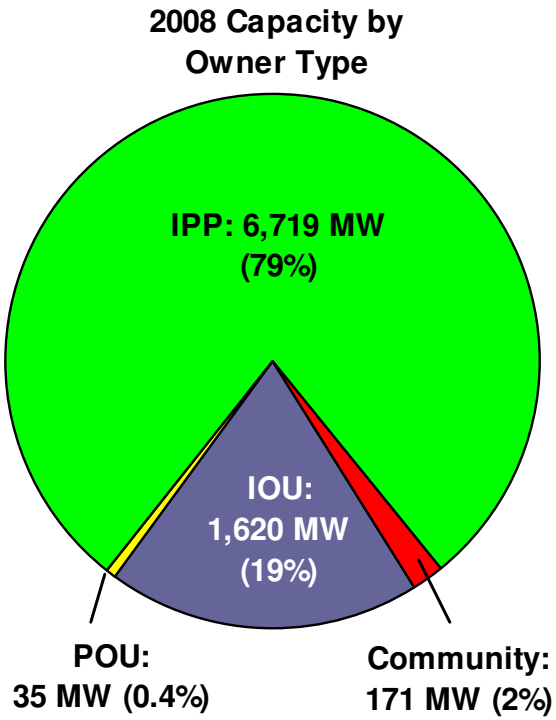
Source: Berkeley Lab

The Global Credit Crisis Caught Up With the Wind Sector in 2008

- By the end of 2008, only a handful of tax equity investors – out of a previously growing stable that had numbered in the teens – remained in the market, and those that remained were charging significantly more for the use of their tax base
- As a result, tax equity investment in the U.S. wind market actually *declined* in 2008, despite the record-shattering growth in installed wind capacity
- Other sources of financing – e.g., bank debt and IPOs – were similarly hit hard in 2008
- ARRA 2009 provides temporary policy changes intended to lessen the dependence on tax equity (e.g., the ability to elect a cash grant in lieu of the PTC or ITC)
- Early signs of a credit thaw began to emerge in mid-2009

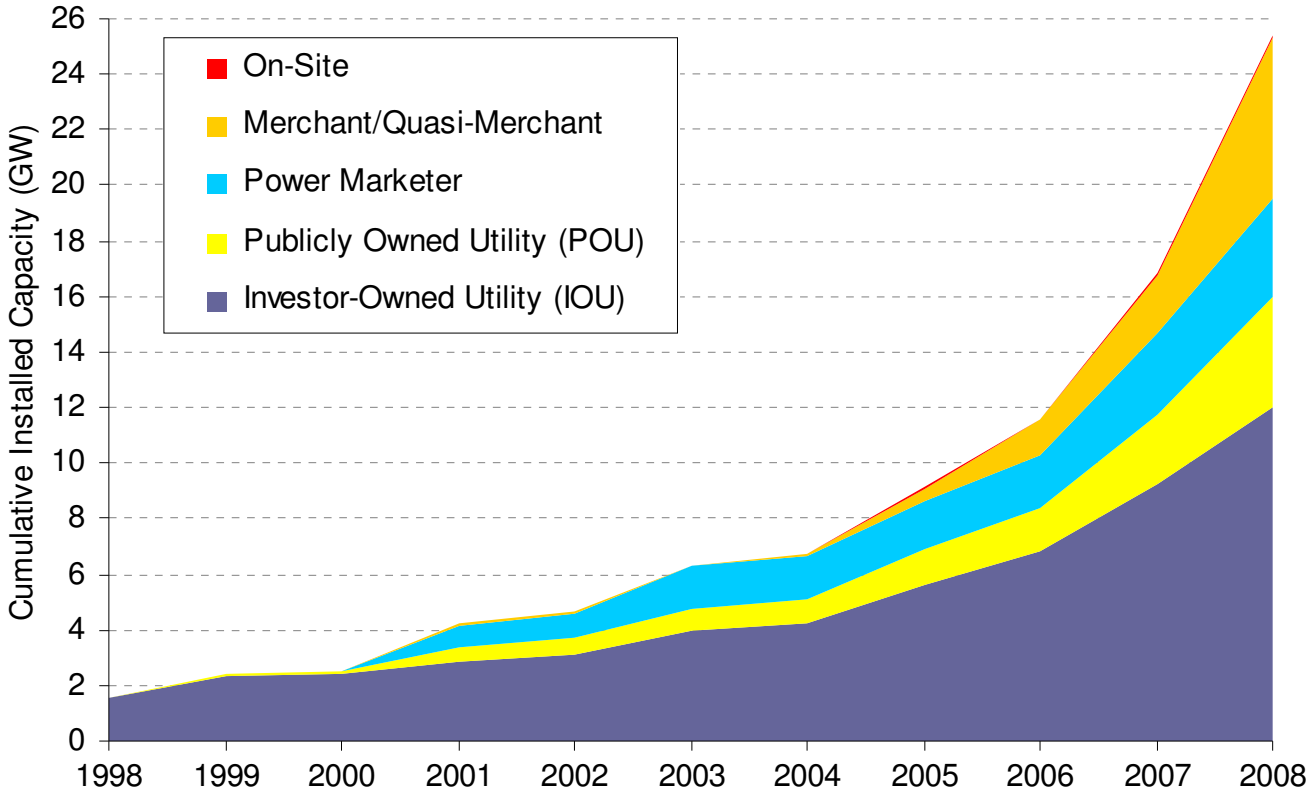
IPP Project Ownership Remained Dominant

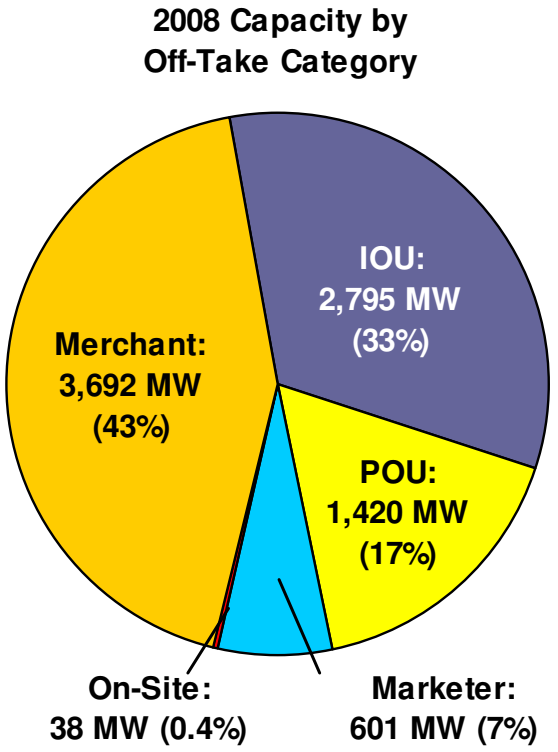




- Utility ownership (IOU) gained some ground
- Community wind market share stagnant since 2004

Contracted Sales to Utilities Remained the Most Common Off-Take Arrangement





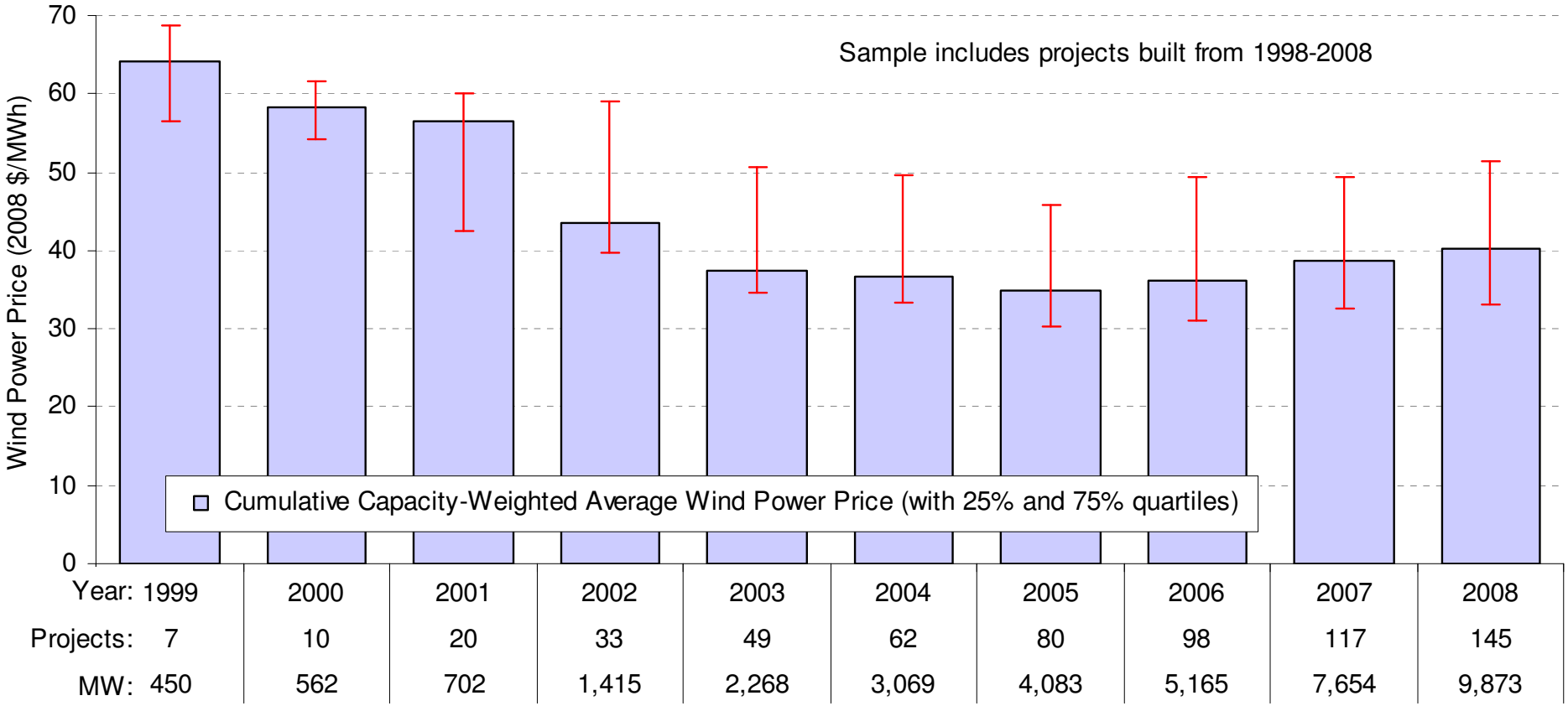
But “merchant” plants were very popular in 2008 (unlikely to be as popular in 2009, due to credit freeze and lower wholesale power prices)

Price, Cost, and Performance Trends

Upward Pressure on Wind Power Prices Continued in 2008

- Berkeley Lab maintains a database of wind power sales prices; next few slides present data from that database
- Sample includes 145 projects built from 1998-2008, totaling 9,873 MW (42% of all wind capacity added in that period)
- Prices reflect the bundled price of electricity and RECs as sold by the project owner under a power purchase agreement
  - Dataset excludes merchant plants and projects that sell renewable energy certificates (RECs) separately
  - Prices reflect receipt of state and federal incentives (e.g., the PTC); as a result, prices do not reflect wind energy generation costs - prices would be higher were state/federal incentives not available

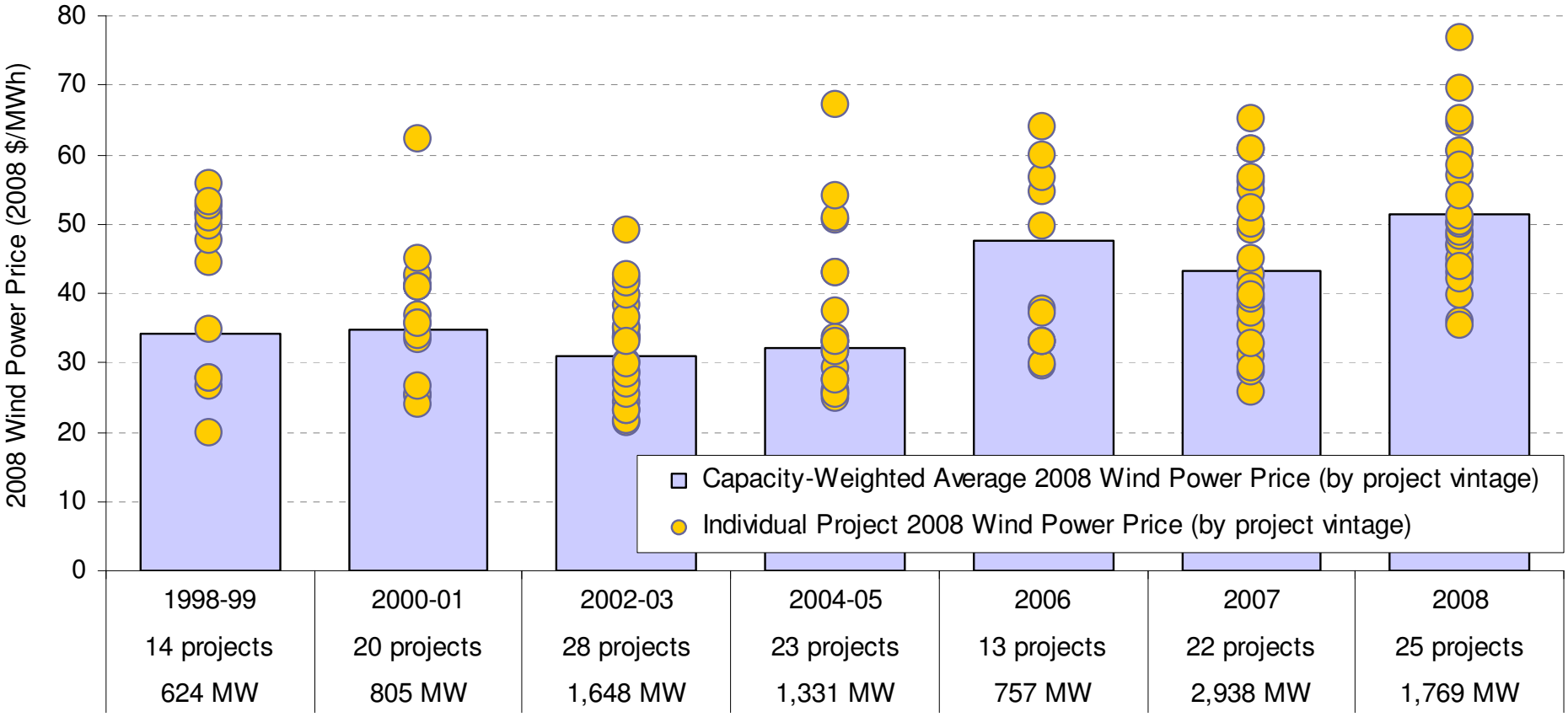
Cumulative Average Sales Price for Sample of Projects Built After 1997 Remains Low



Year:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Projects:	7	10	20	33	49	62	80	98	117	145
MW:	450	562	702	1,415	2,268	3,069	4,083	5,165	7,654	9,873

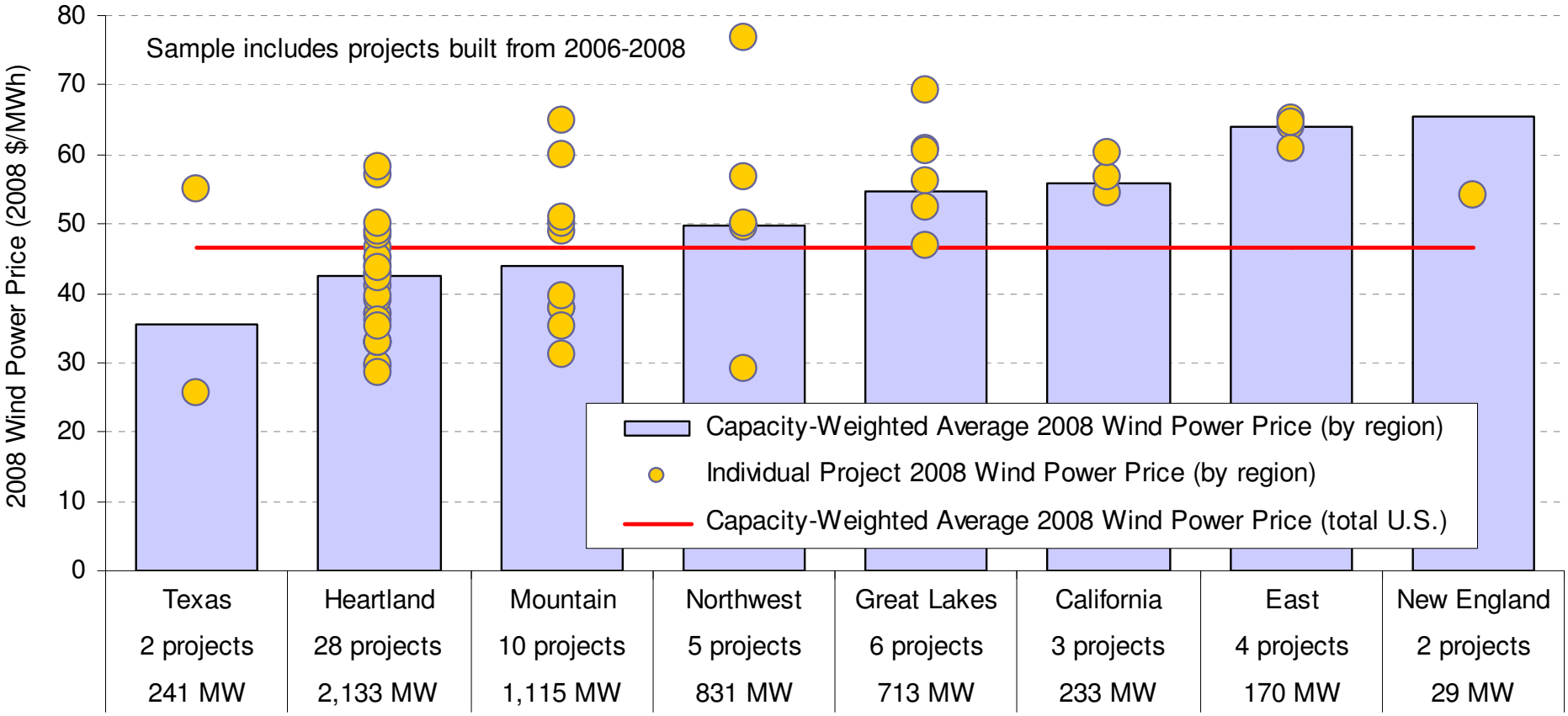
Small increases since 2005 are due to rising prices from newly built projects, but cumulative nature of graphic mutes degree of price increase

Binning by Commercial Operation Date Shows that Prices Have Increased Recently



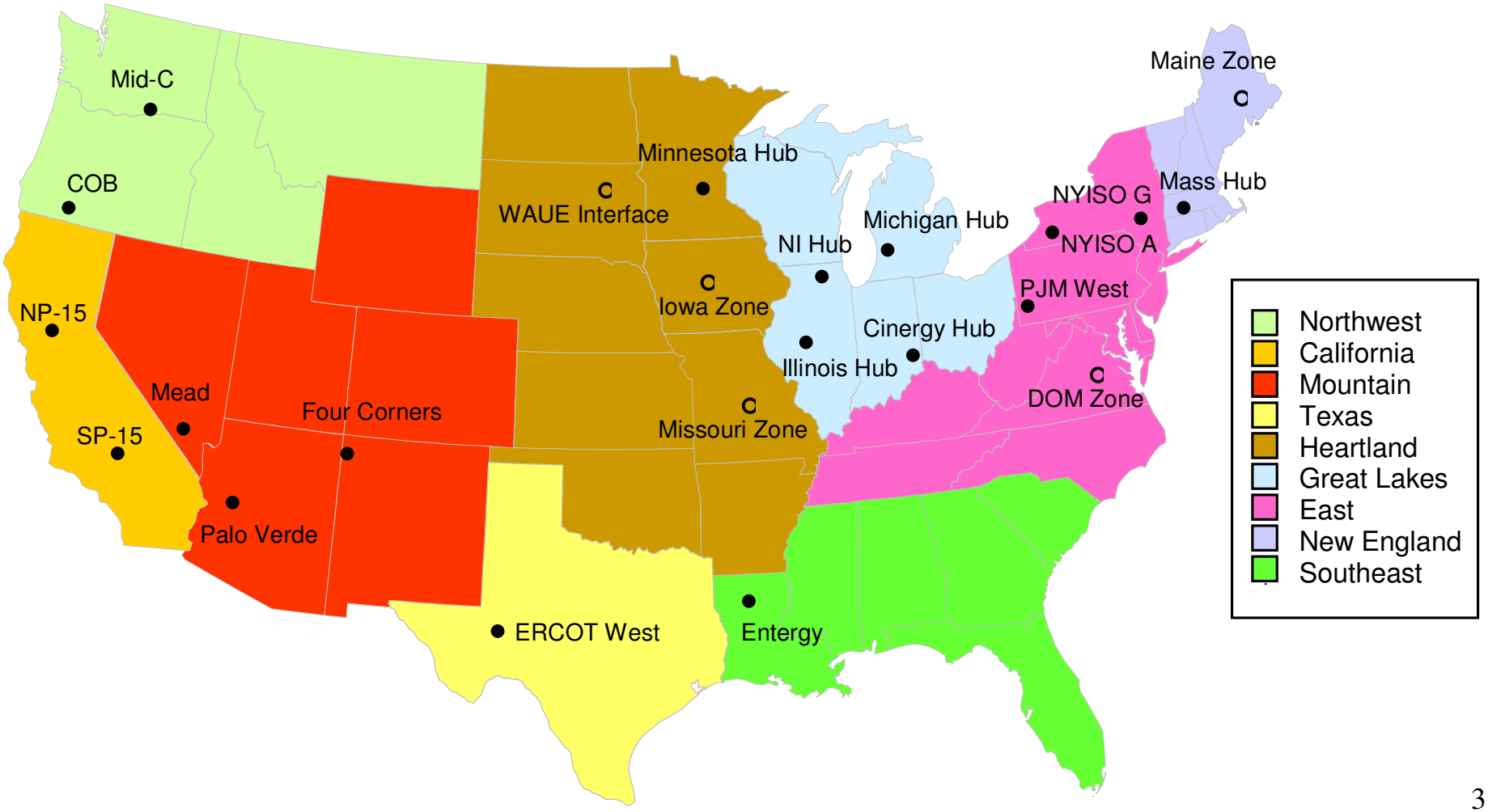
- Graphic shows prices in 2008 from projects built from 1998-2008

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

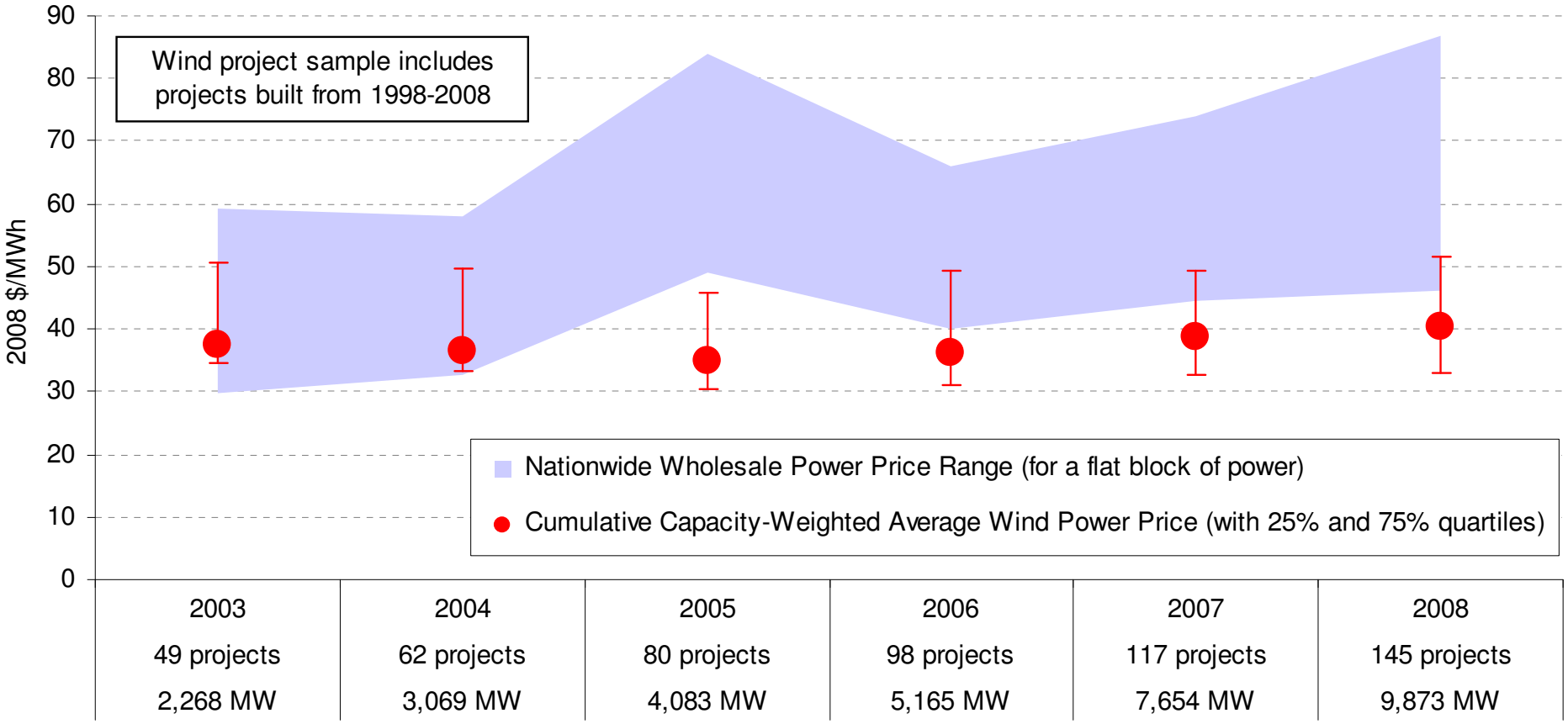


Texas and the Heartland are low-price regions, while the East and New England are high-price (note: sample size is problematic in many regions)

Regions and Wholesale Price Hubs Used in Analysis

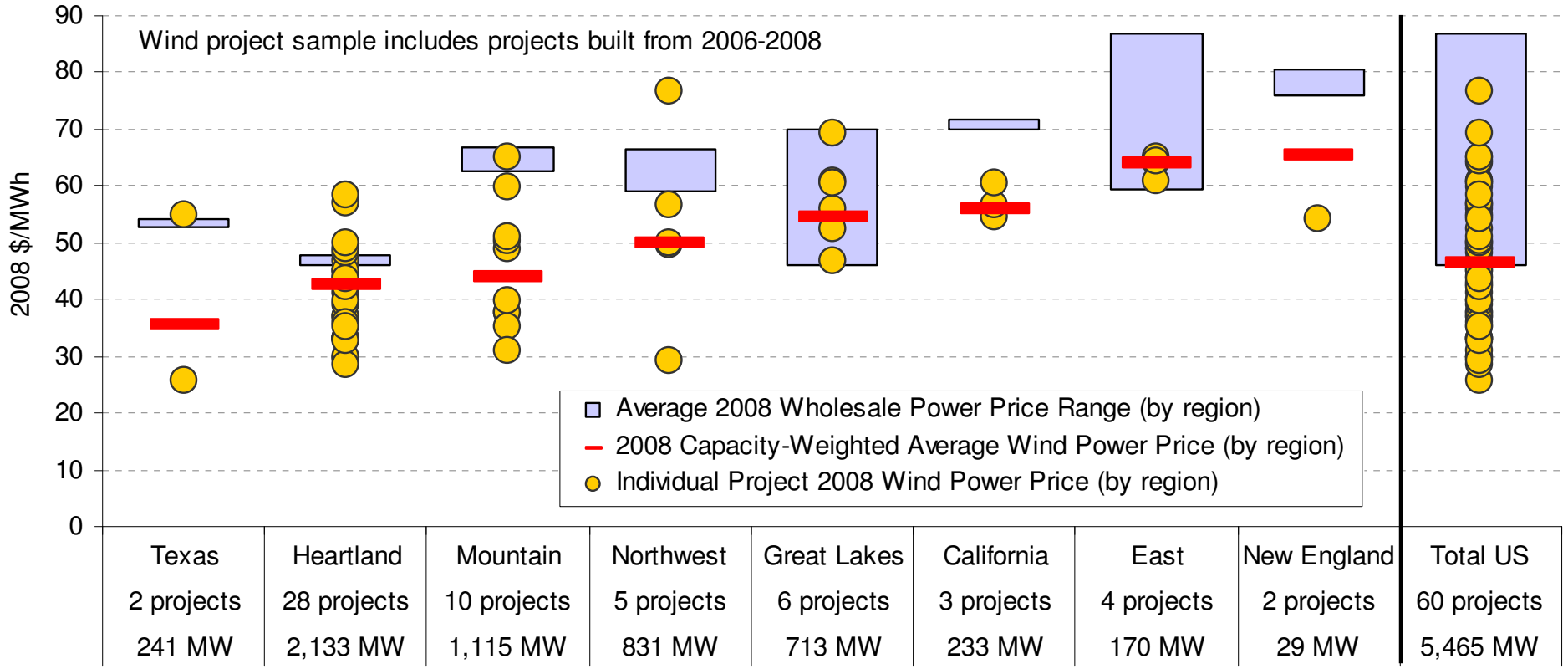


Wind Has Been Competitive with Wholesale Power Prices in Recent Years



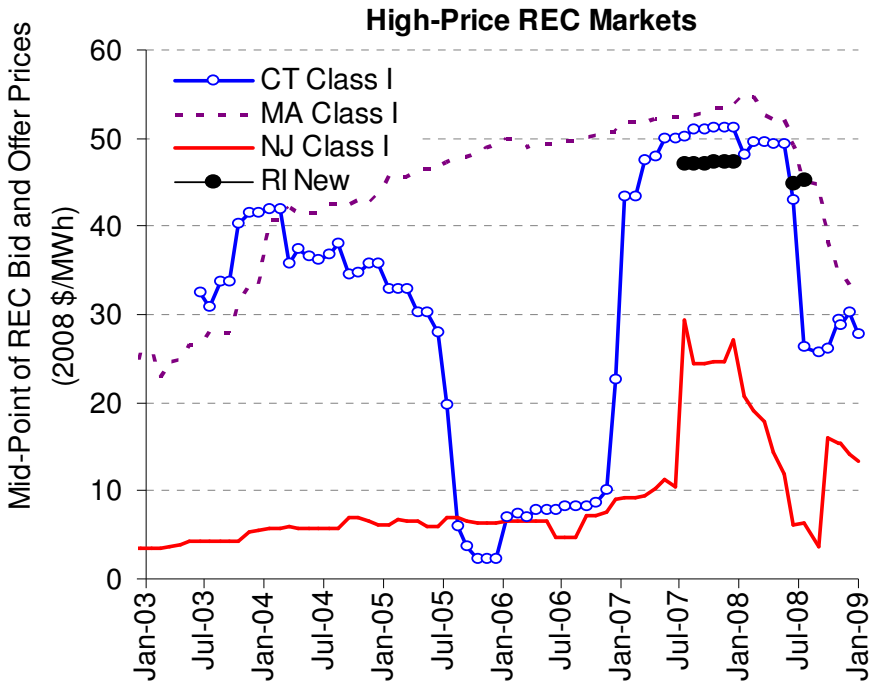
- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- 2009 to be far more challenging, as wholesale prices have dropped sharply since mid-2008

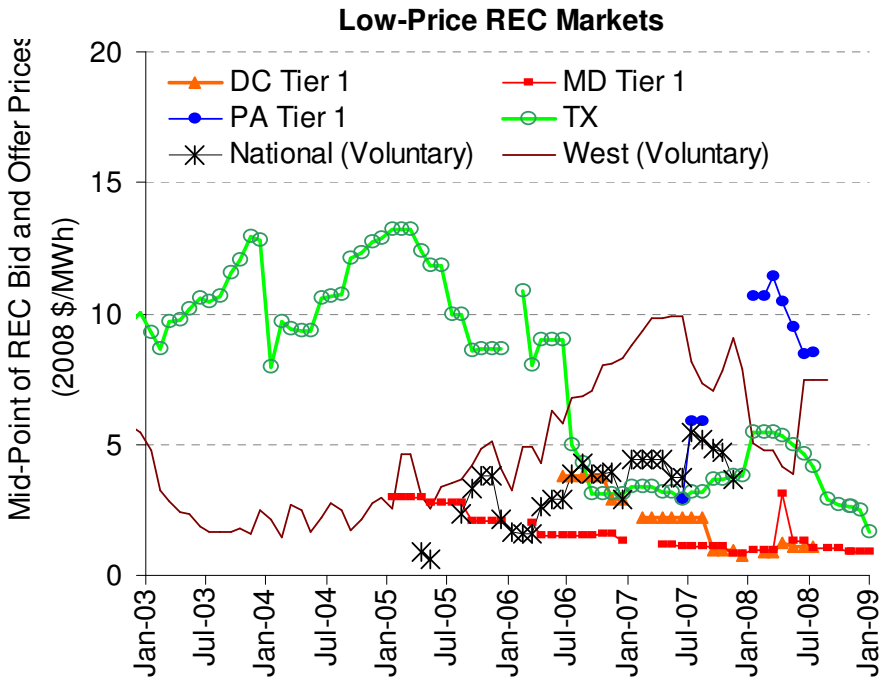
Even Among More-Recent Projects, Wind Was Competitive in Most Regions in 2008



Note: Within a region there are a range of wholesale power prices because multiple wholesale price hubs exist in each area (see earlier map)

Renewable Energy Certificate (REC) Markets Remain Fragmented and Volatile

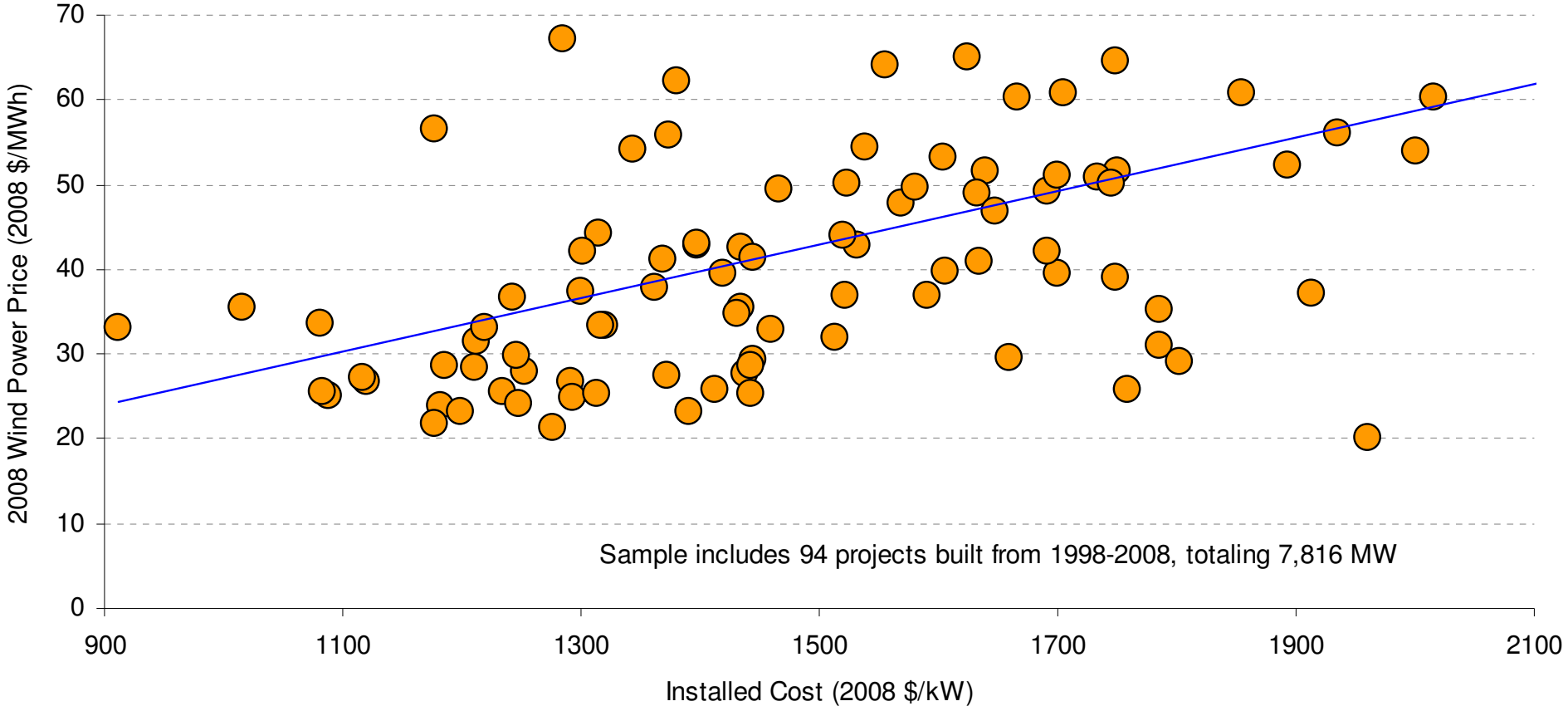




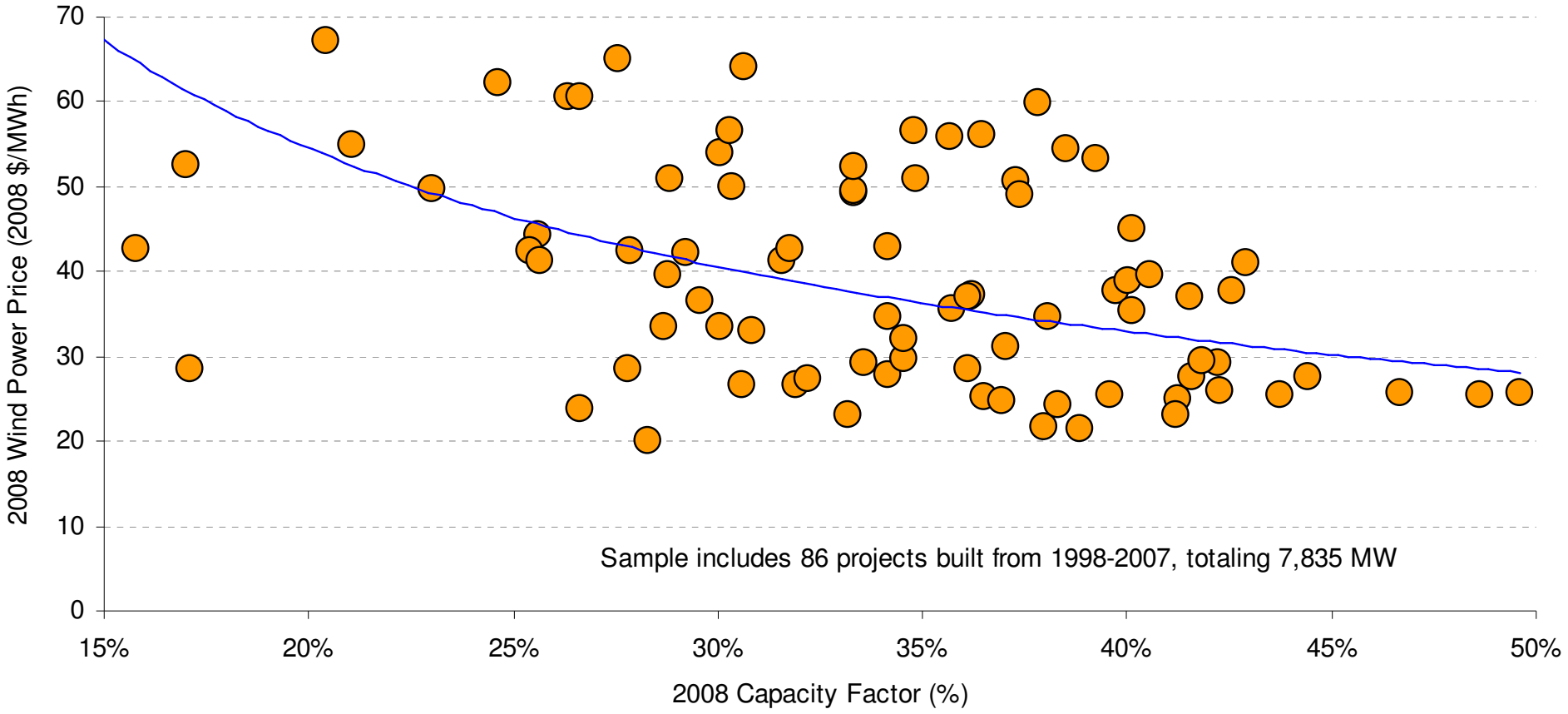
REC prices vary by:

- market type: compliance vs. voluntary
- geographic region
- specific design of state RPS policies

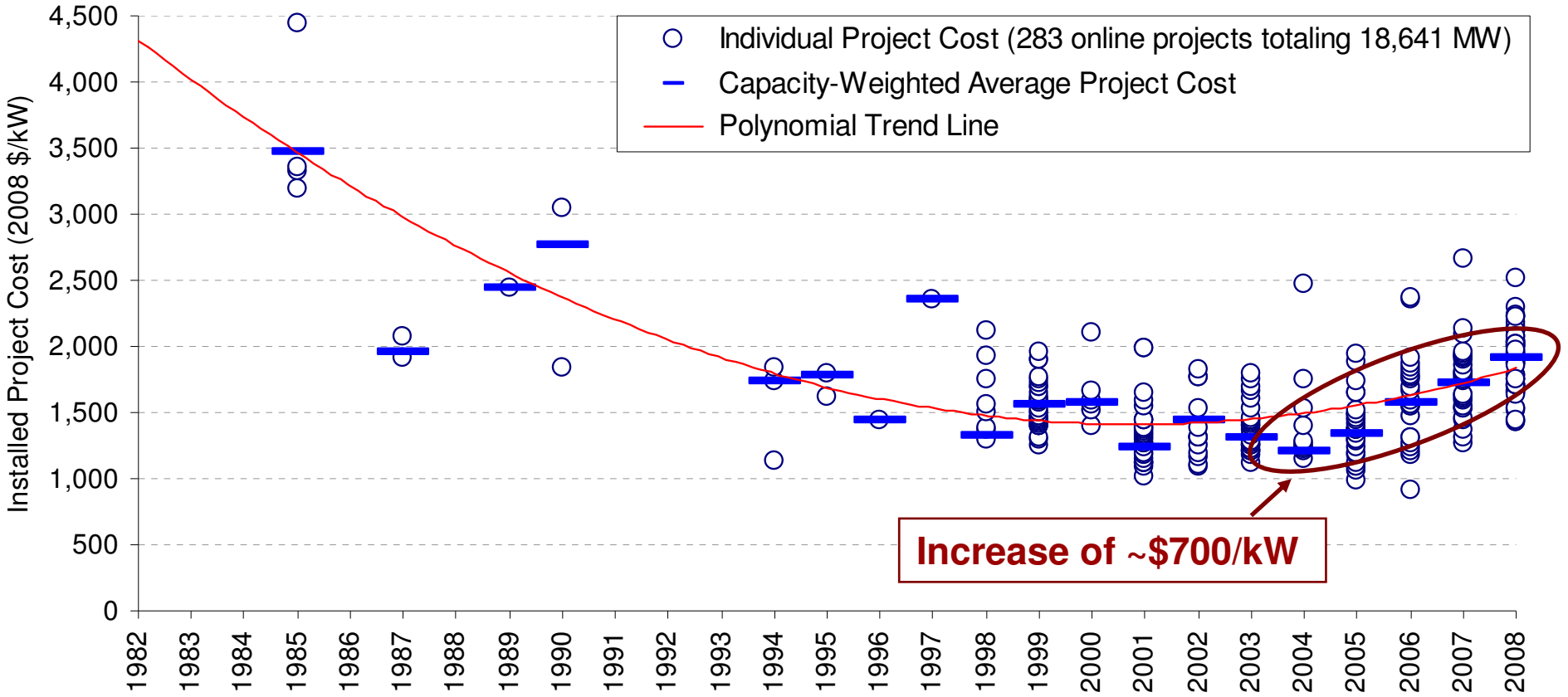
Wind Power Sales Prices Are Affected by Installed Project Costs...



...and by Wind Project Performance

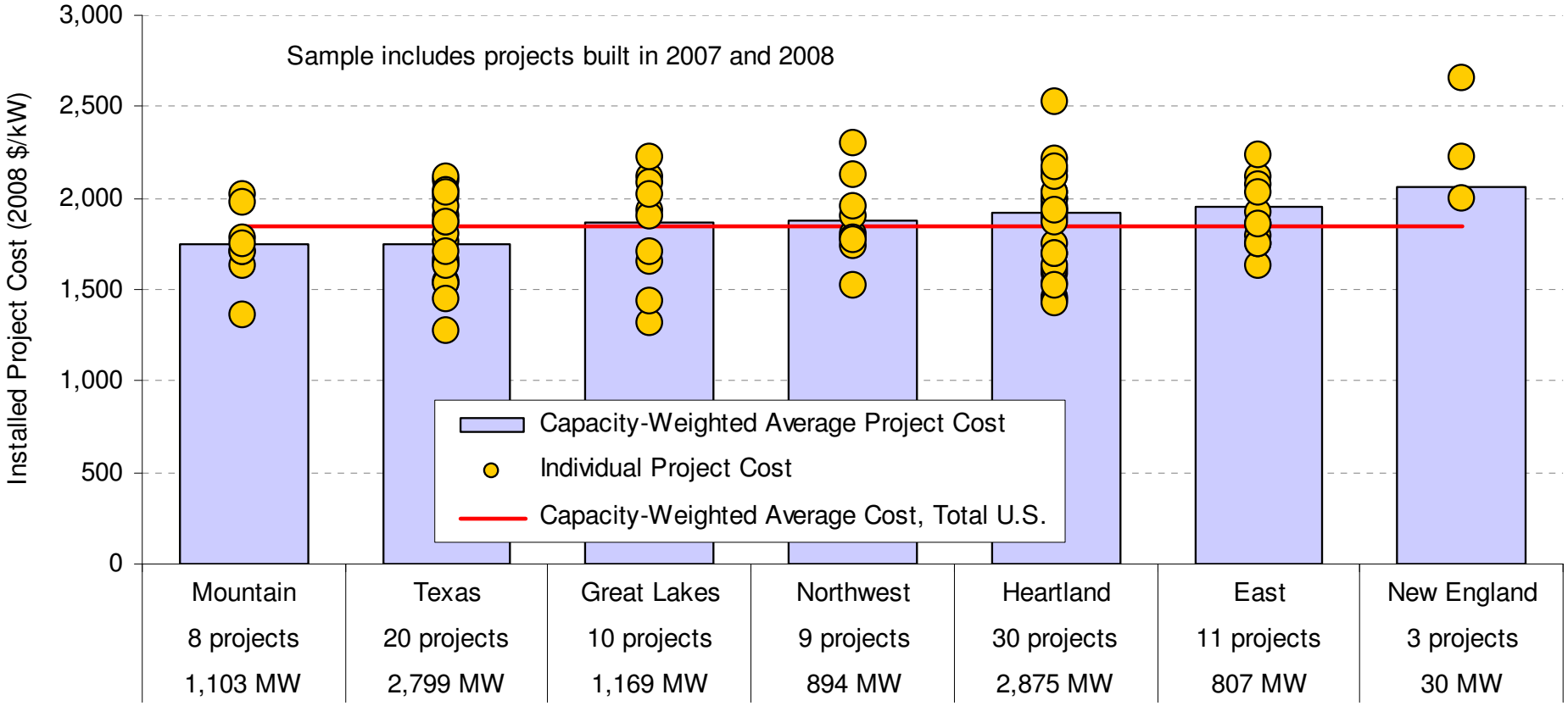


Installed Project Costs Rose Substantially, After a Long Period of Decline



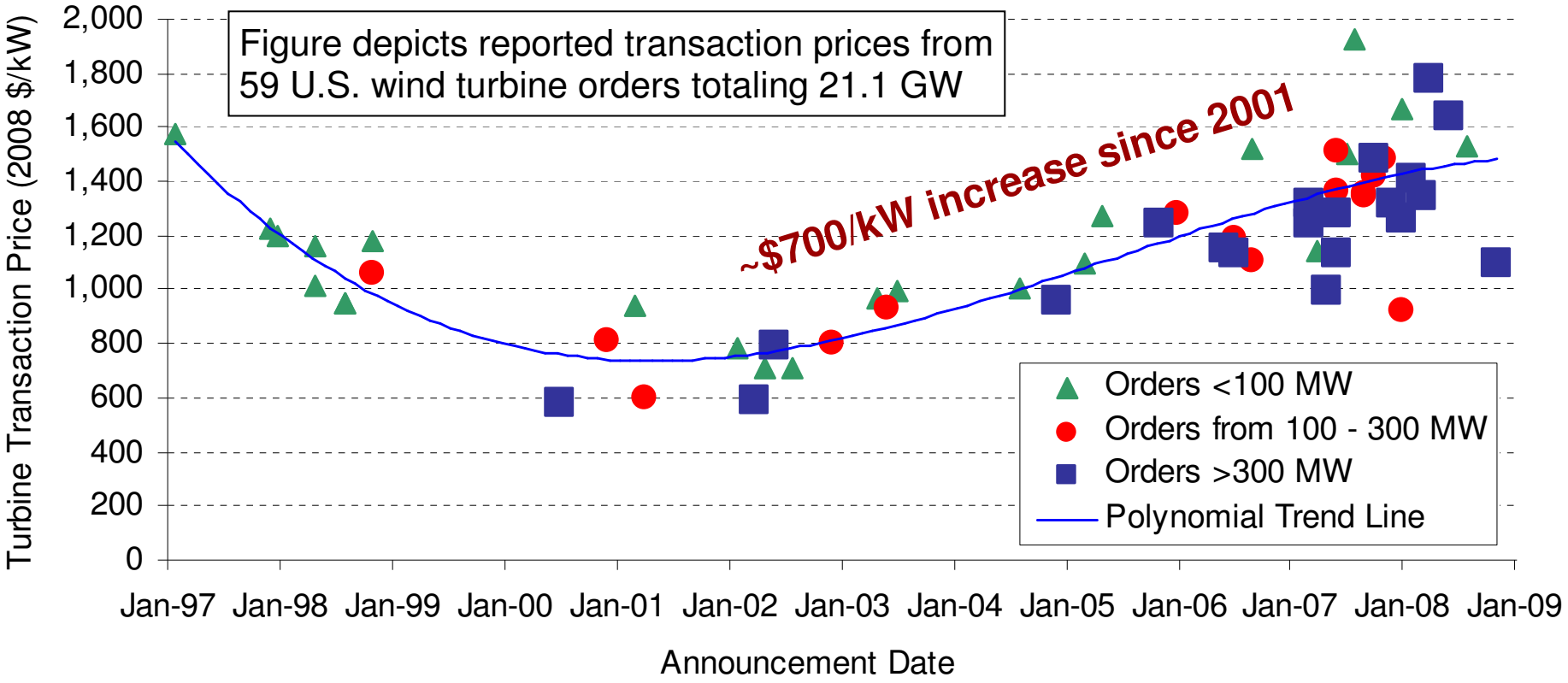
Sample of 3,600 MW of projects proposed for construction in 2009 (not shown in graphic) are ~$205/kW higher still (averaging ~$2,120/kW)

Some Regional Differences in Wind Project Costs Are Apparent



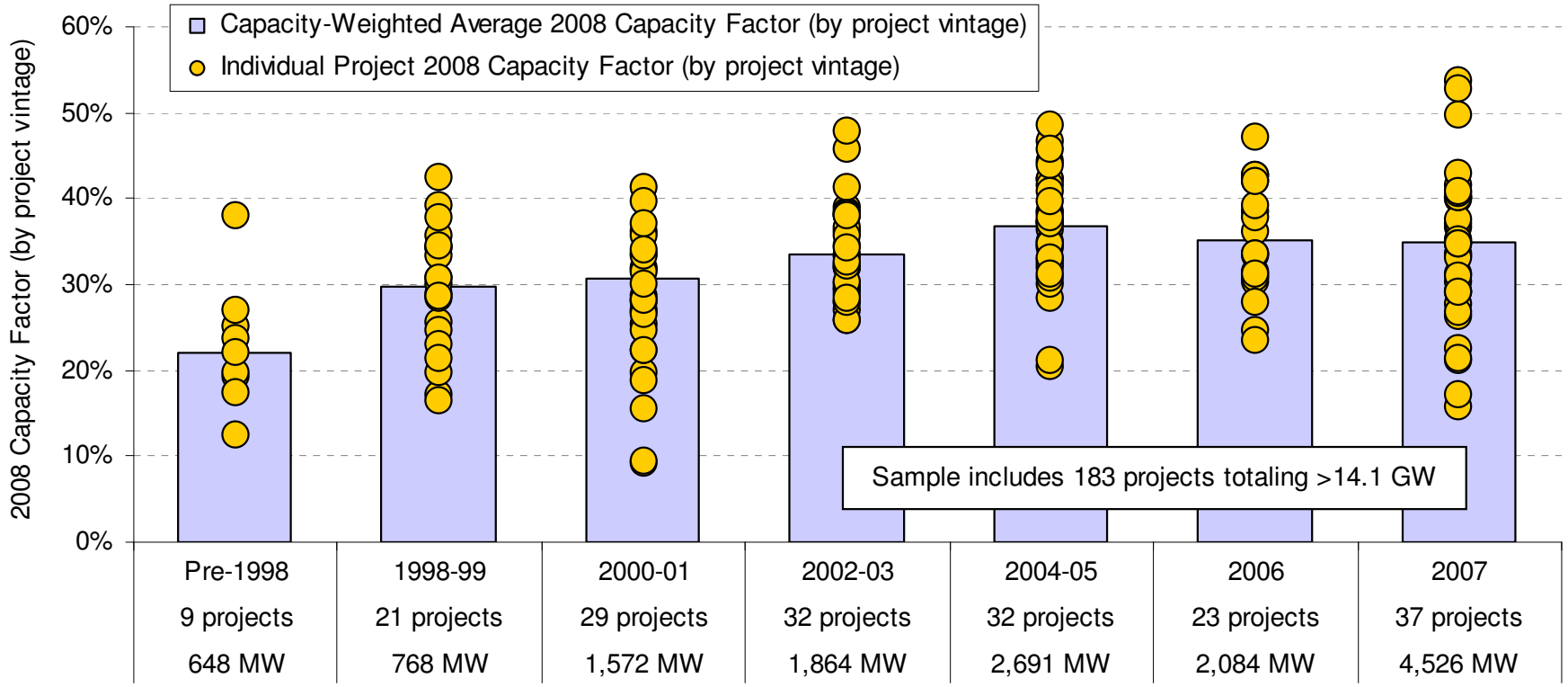
Mountain, Texas are low-cost regions; East, New England higher-cost

Project Cost Increases Are a Function of Wind Turbine Prices



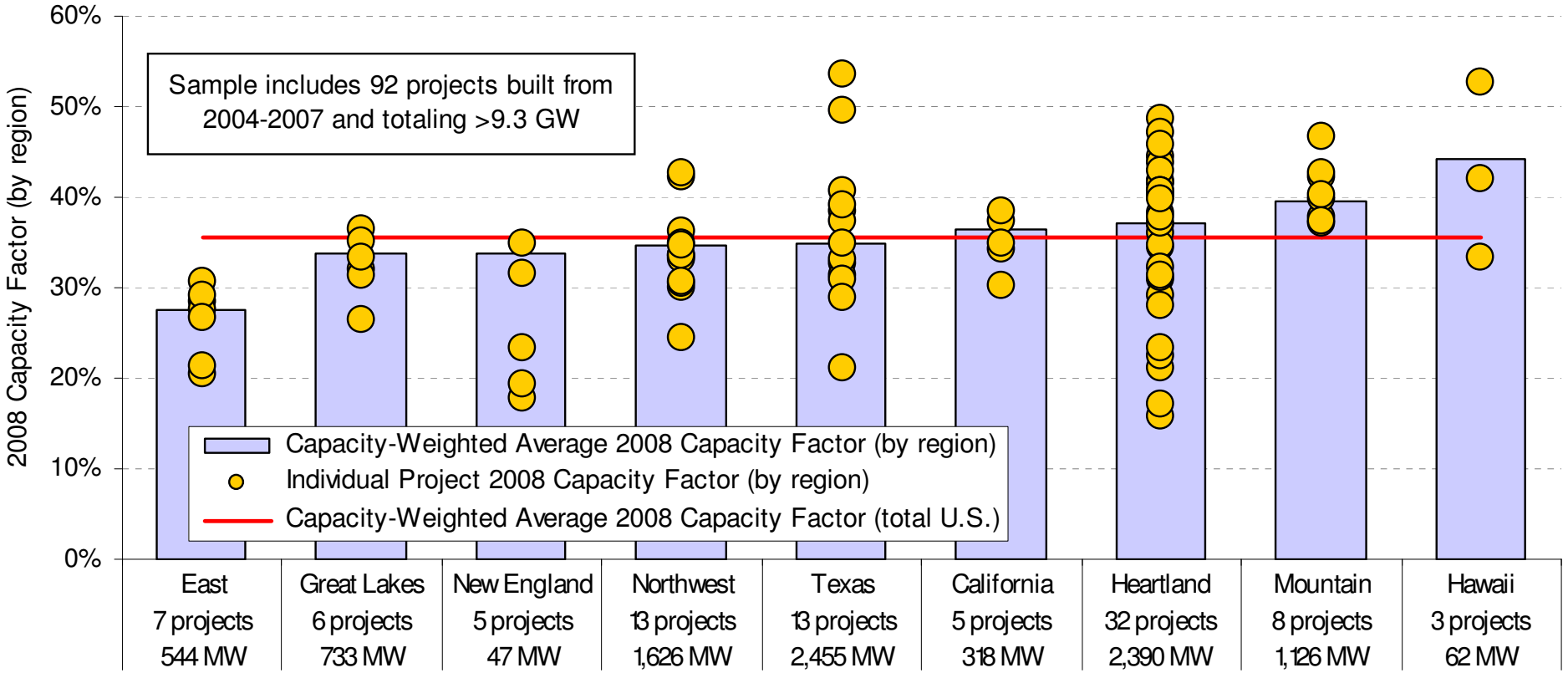
Though not shown in above graphic, spot turbine prices have softened as a result of the global recession and reversals in cost drivers, with 5-25% overall turbine price reductions seen through mid-2009

Average Wind Project Performance Has Improved Over Time, But Leveled Off in Recent Years



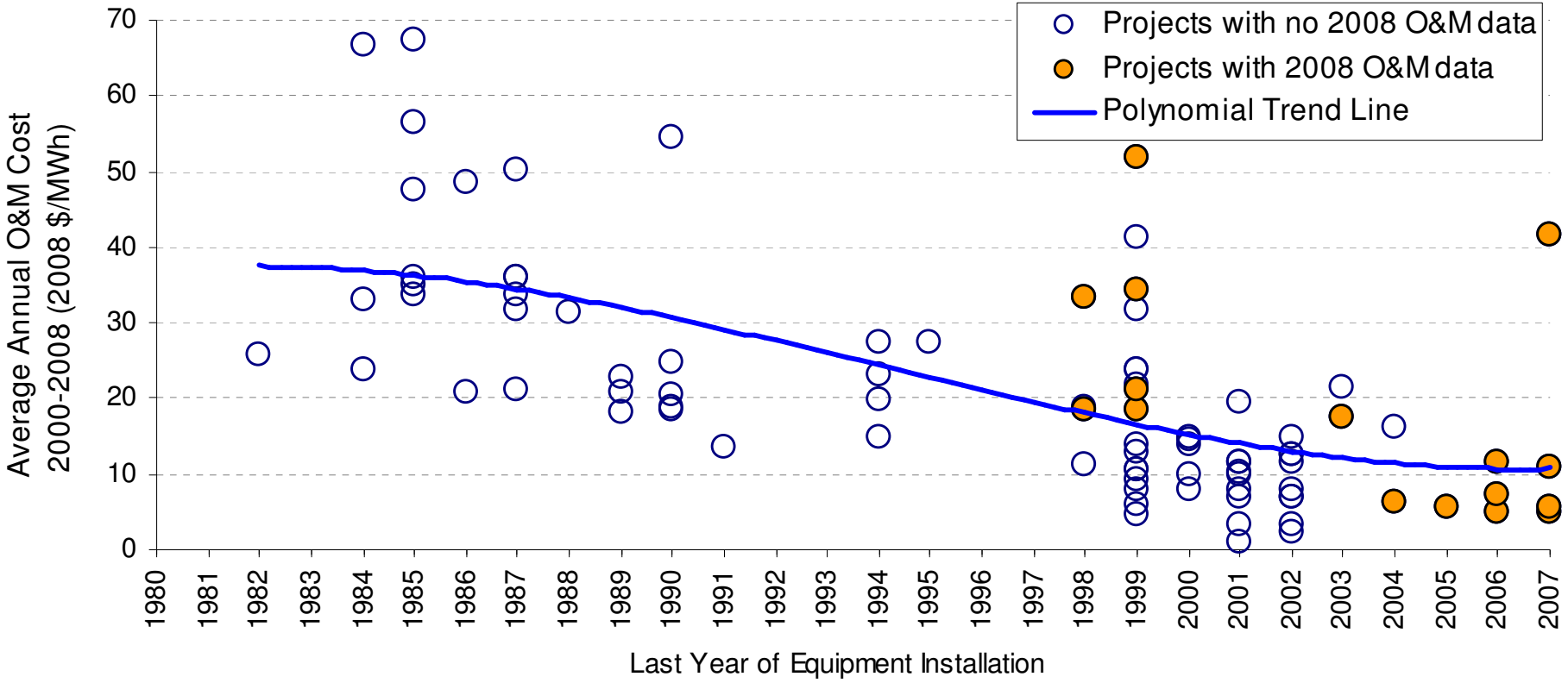
Of the projects installed prior to 2004, 5.5% had capacity factors in excess of 40%; of the projects installed from 2004-2007, 26.1% had capacity factors in excess of 40%

Regional Performance Differences Are Apparent



- Highest in Hawaii and the Mountain region, lowest in the East (all other regions are near the U.S. average)

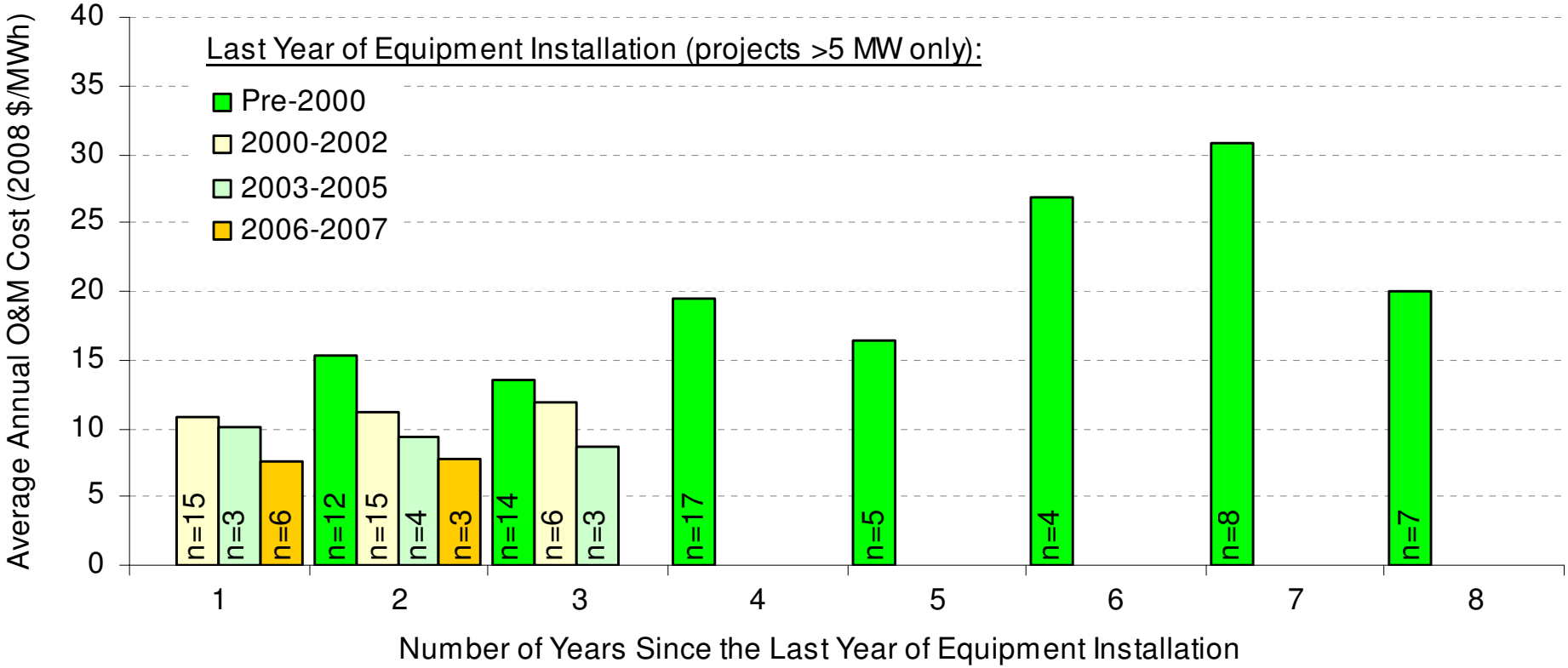
Average Wind Project O&M Costs from 2000-08 Are Affected By Year of Installation



Capacity-weighted average 2000-08 O&M costs for projects built in 1980s equal **$32/MWh**, dropping to **$22/MWh** for projects built in 1990s, and to **$8/MWh** for projects built in 2000s

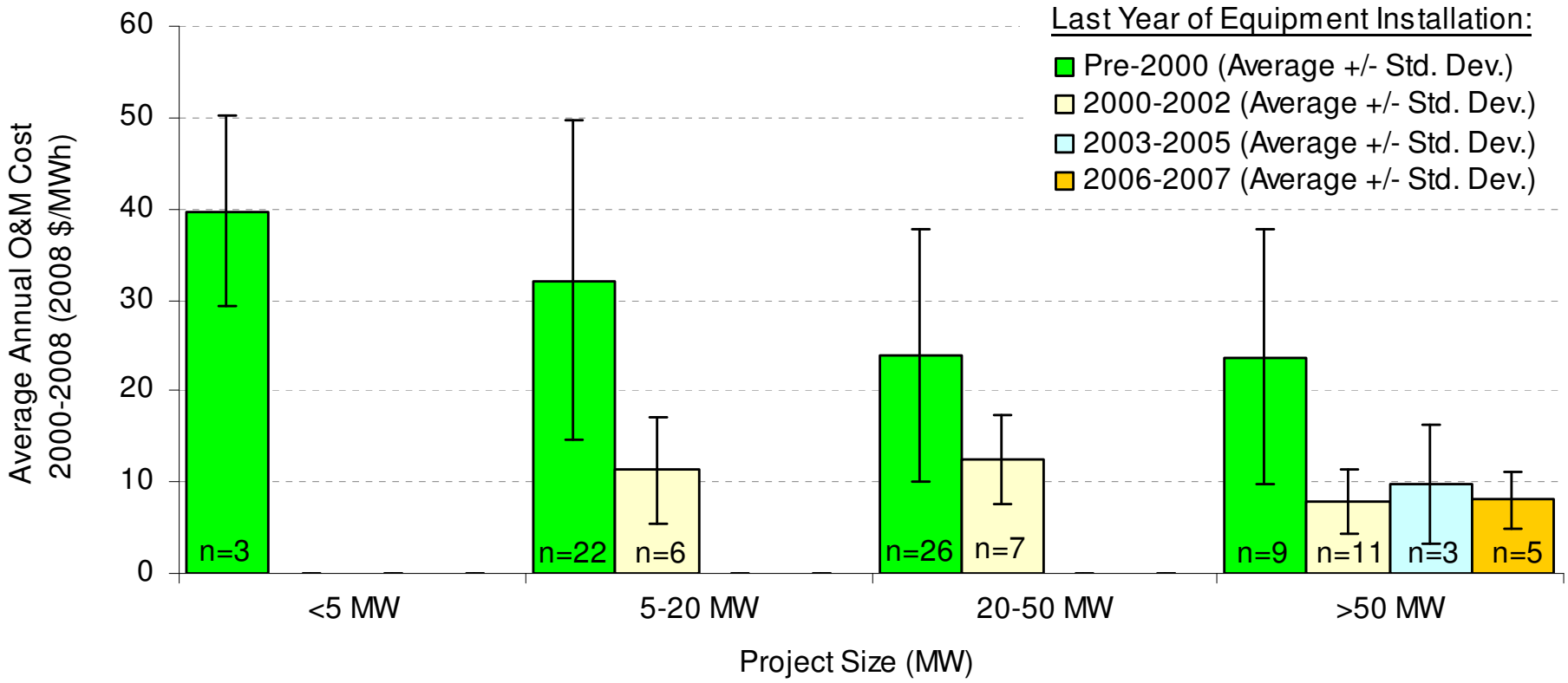
Note: Sample is limited, and consists of 99 wind projects totaling 4,751 MW; few projects in sample have complete records of O&M costs from 2000-08

O&M Costs Appear to Decrease for Recently Constructed Projects, and Increase with Project Age



Note: Sample size is extremely limited; figure only includes projects over 5 MW in size and built from 1998-2007

Smaller Projects Appear to Experience Higher O&M Costs, on a $/MWh Basis



Note: Sample size is extremely limited

Policy and Market Drivers

Policy Is Now More Favorable to Wind Than At Any Other Time in the Past Decade

- ARRA 2009 established a number of federal policies to support wind
- Federal PTC currently in place through 2012 (longest extension in history)
- Wind projects can elect a 30% ITC or a 30% cash grant in lieu of the PTC
- Subsidized financing double-dipping penalty removed for ITC / cash grant
- New allocations of Clean Renewable Energy Bonds
- Expansion and enhancement of Federal loan guarantee program
- Increased R&D funding
- Four new state RPS policies (MI, MO, OH, KS), and many revisions to existing state RPS policies (total is now 29 states plus Washington, D.C.)
- State renewable funds, tax incentives, utility planning, green power, and growing interest in carbon regulation all also played a role in 2008
- Efforts to pass an RPS and carbon regulation at the Federal level continue

Despite Progress on Overcoming Transmission Barriers, Constraints Remain

- U.S. Congress considering transferring additional transmission siting authority from states to FERC, and FERC itself has continued to press for modifications to interconnection queuing procedures
- States, grid operators, and regional entities also continue to take proactive steps to encourage transmission investment to access remote renewable resources
- Most notable among these is a growing list of entities engaged in identifying “renewable energy zones” to which transmission could be built proactively
- Progress was also made in 2008 on nearly twenty large transmission projects in the central and western U.S. that are designed, in part, to support wind power

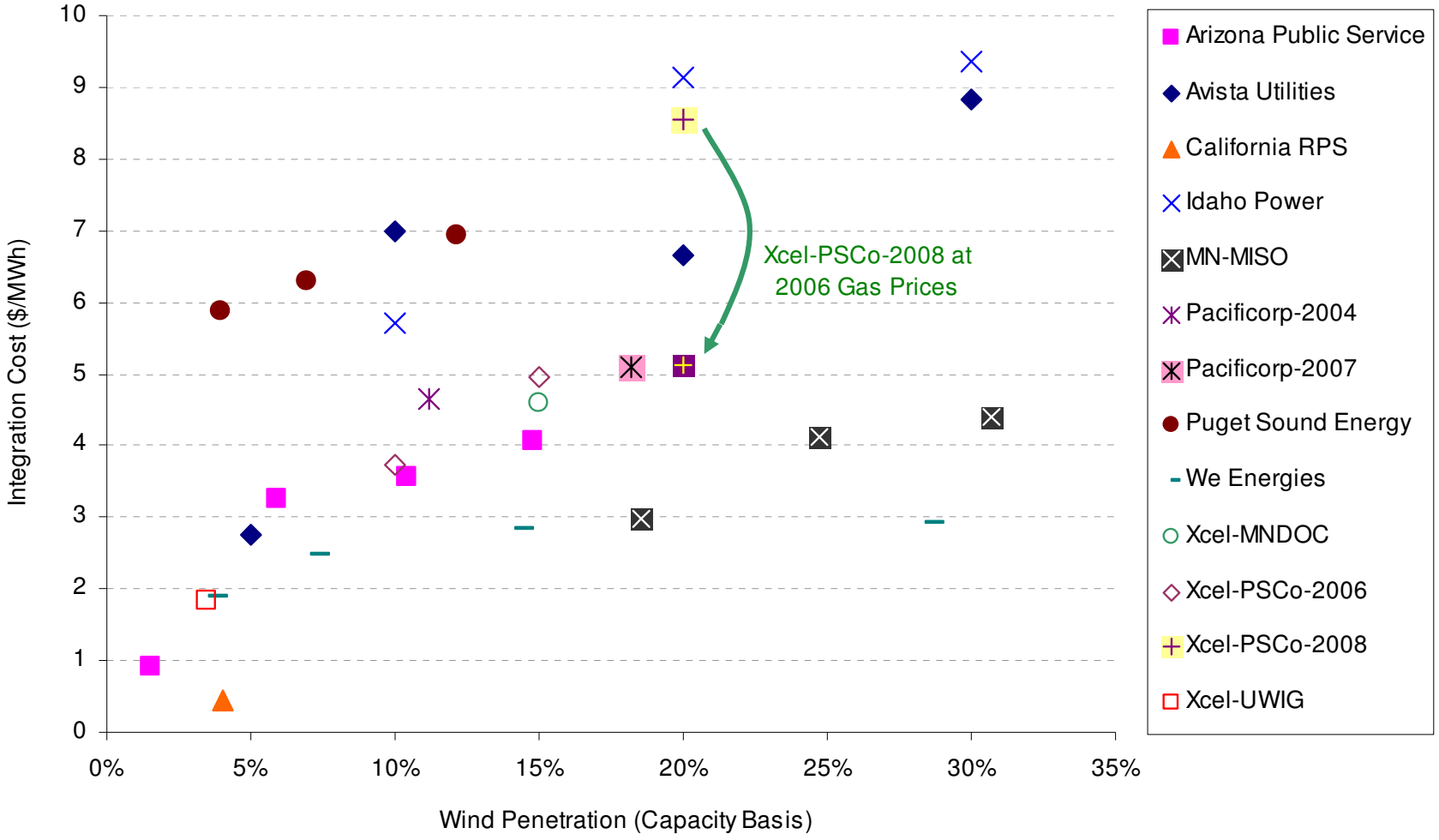
Studies Find that the Cost of Integrating Wind into Power Systems Is Manageable

Date	Study	Wind Capacity Penetration	Integration Cost ($/MWh)				
			Regulation	Load Following	Unit Commit.	Gas Supply	TOTAL
2003	Xcel-UWIG	3.5%	0	0.41	1.44	na	1.85
2003	We Energies	29%	1.02	0.15	1.75	na	2.92
2004	Xcel-MNDOC	15%	0.23	na	4.37	na	4.60
2005	PacifiCorp-2004	11%	0	1.48	3.16	na	4.64
2006	Calif. (multi-year)*	4%	0.45	trace	trace	na	0.45
2006	Xcel-PSCo	15%	0.20	na	3.32	1.45	4.97
2006	MN-MISO**	31%	na	na	na	na	4.41
2007	Puget Sound Energy	12%	na	na	na	na	6.94
2007	Arizona Pub. Service	15%	0.37	2.65	1.06	na	4.08
2007	Avista Utilities	30%	1.43	4.40	3.00	na	8.84
2007	Idaho Power	20%	na	na	na	na	7.92
2007	PacifiCorp-2007	18%	na	1.10	4.00	na	5.10
2008	Xcel-PSCo***	20%	na	na	na	na	8.56

* Regulation costs represent 3-year average.
** Highest over 3-year evaluation period.
*** This integration cost reflects a $10/MMBtu natural gas price scenario. This cost is much higher than the integration cost calculated for Xcel-PSCo in 2006, in large measure due to the higher natural gas price: had the gas price from the 2006 study been used in the 2008 study, the integration cost would drop to $5.13/MWh.

- Wind integration costs are < $10/MWh for capacity penetrations of up to ~30%
- Regulation impacts are small, load-following and unit commitment larger
- Larger balancing areas and use of wind forecasts ease integration challenges, and operators are increasingly relying on these strategies

Studies Find that the Cost of Integrating Wind Rises with Greater Wind Penetration



Future Outlook

Forecasts Predict Slow 2009, with Resurgence in 2010

- 2009 likely to be a slow year, due to impact of global recession; predictions in table below range from 4,400 MW to 6,800 MW
- Forecasts show a market resurgence in 2010, however, and continuing at least through 2012, as the policies established in ARRA 2009 come into full swing, and as financing constraints are relieved

Source	2009	2010	2011	2012	Cumulative Additions 2009-2012
EIA	4,400	10,400	11,900	13,700	40,400
BTM	6,000	8,500	10,000	13,000	37,500
EER	6,500	9,000	11,000	10,000	36,500
NEF	4,900 – 6,800	na	na	na	na
AWEA	> 5,000	na	na	na	na

Uncertainties in Market Growth in Near-Term Reflect Balance Among Countering Trends

Stronger Growth

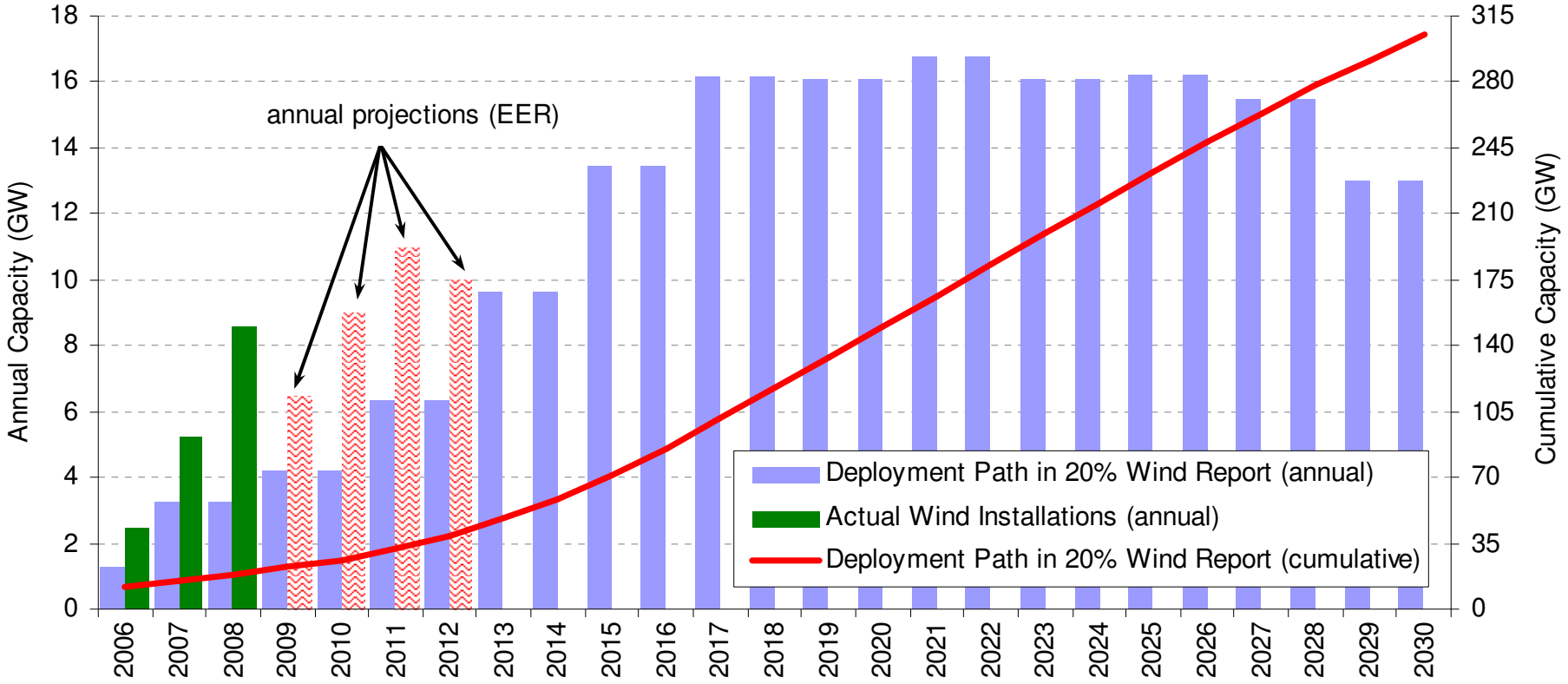
- Stronger federal and state policy support than at any point in last decade
- Expectations for further federal policy support through RPS, climate policy, and/or transmission policy
- Dropping wind turbine prices may improve comparative economics of wind, over time

Weaker Growth

- Duration of financial crisis uncertain, and degree to which ARRA will alleviate impacts on wind unclear
- Natural gas and wholesale power prices and price expectations have plummeted
- Inadequate transmission infrastructure beginning to constrain new builds
- Increased competition from other renewable energy sources, in some regions

U.S. Remains on Early Track To Meet 20% of Nation's Electricity with Wind by 2030

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



For More Information...

See full report for additional findings, a discussion of the sources of data, etc.:

- http://www1.eere.energy.gov/windandhydro/wind_pubs.html

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