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Wind & Hydropower Technologies Program

Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007

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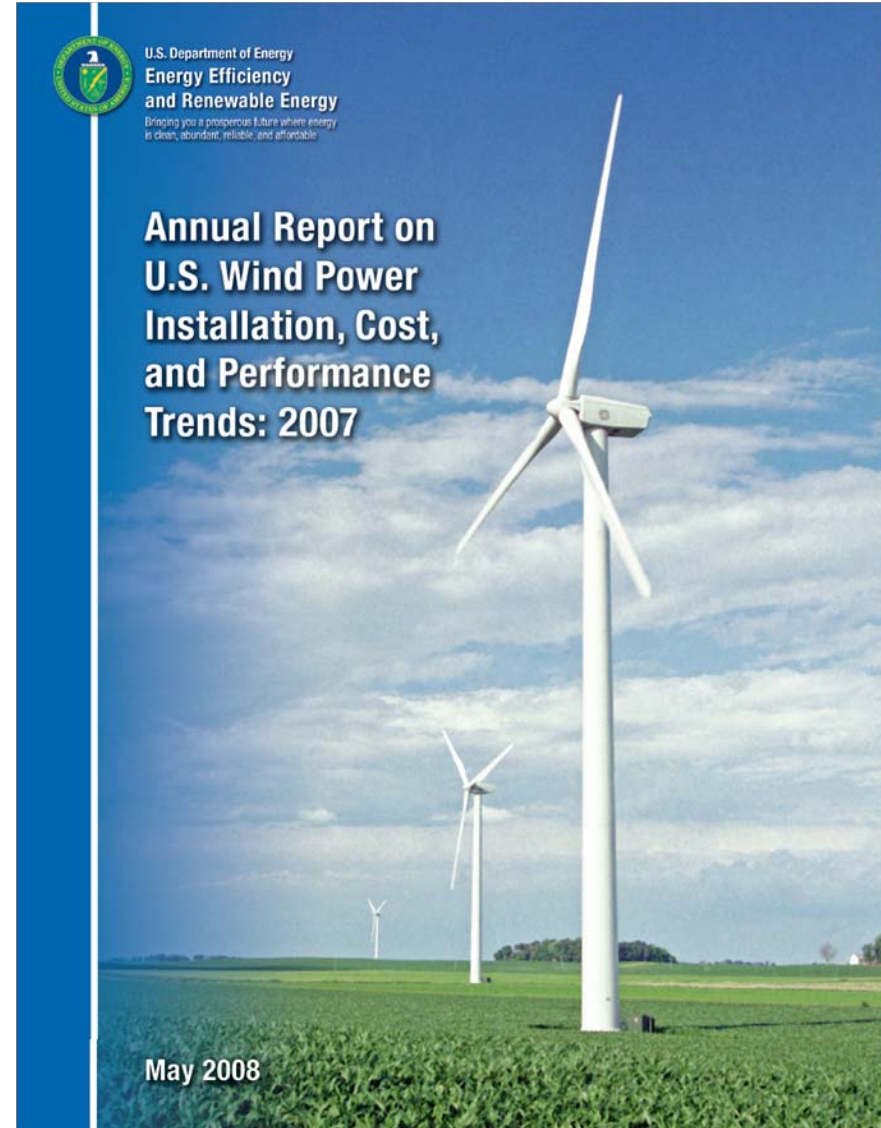
- Report Summary -

May 2008



Presentation Overview

- Introduction to 2007 edition of U.S. wind market data report
- Wind installation trends
- Wind industry trends
- Evolution of wind pricing
- Installed wind project costs
- Wind turbine transaction prices
- Wind project performance
- O&M cost trends
- Integration/transmission/policy
- Coming up in 2008





2007 Annual Market Data Report

Purpose, Scope, and Data:

- With a focus on 2007, 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 trends
- Scope primarily includes wind turbines and projects over 50 kW in size
- Data sources include AWEA, EIA, FERC, SEC, etc. (*see full report*)

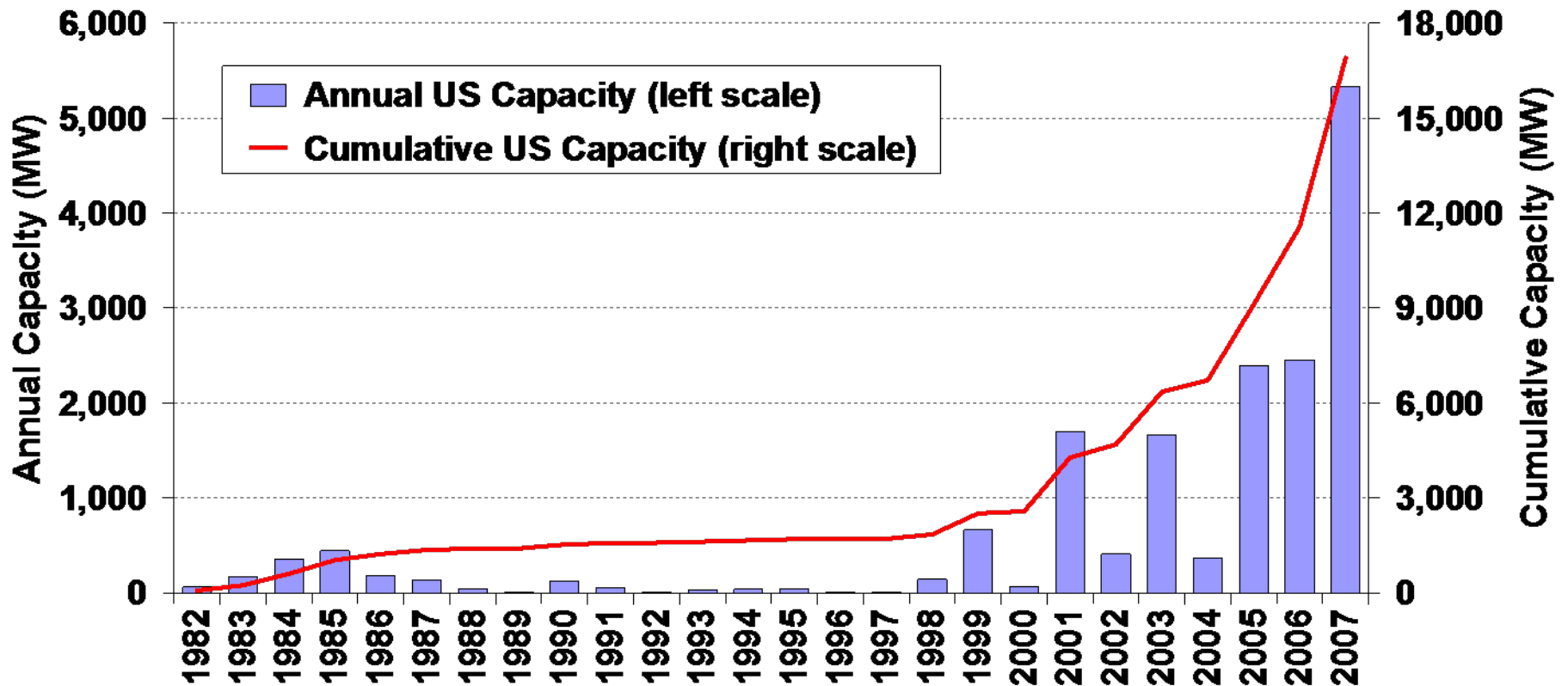
Report Authors:

- Primary Authors: R. Wiser and M. Bolinger, Berkeley Lab
- Contributions from others at Berkeley Lab, AWEA, NREL, DOE, Exeter Associates, George Washington University

Available at: <http://www1.eere.energy.gov/windandhydro/>



U.S. Wind Power Capacity Up 46% in 2007



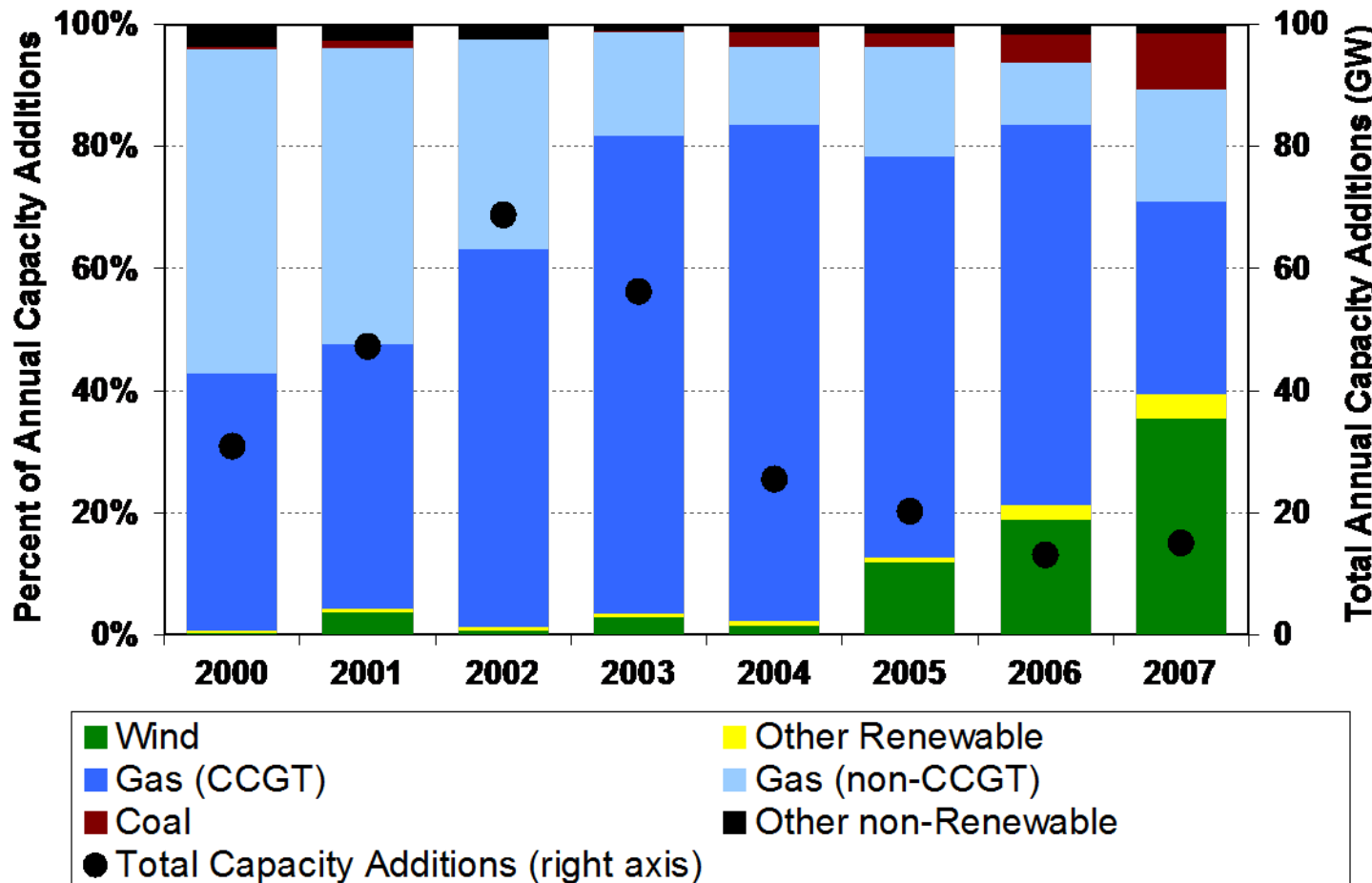
Source: AWEA

Record year for new U.S. wind capacity:

- 5,329 MW of wind added (*more than double* previous record)
- Roughly \$9 billion in investment



Wind Power Contributed 35% of All New Generating Capacity in the US in 2007



- Wind was the 2nd-largest resource added for the 3rd-straight year
- Up from 19% in 2006, 12% in 2005, and <4% in 2000-2004



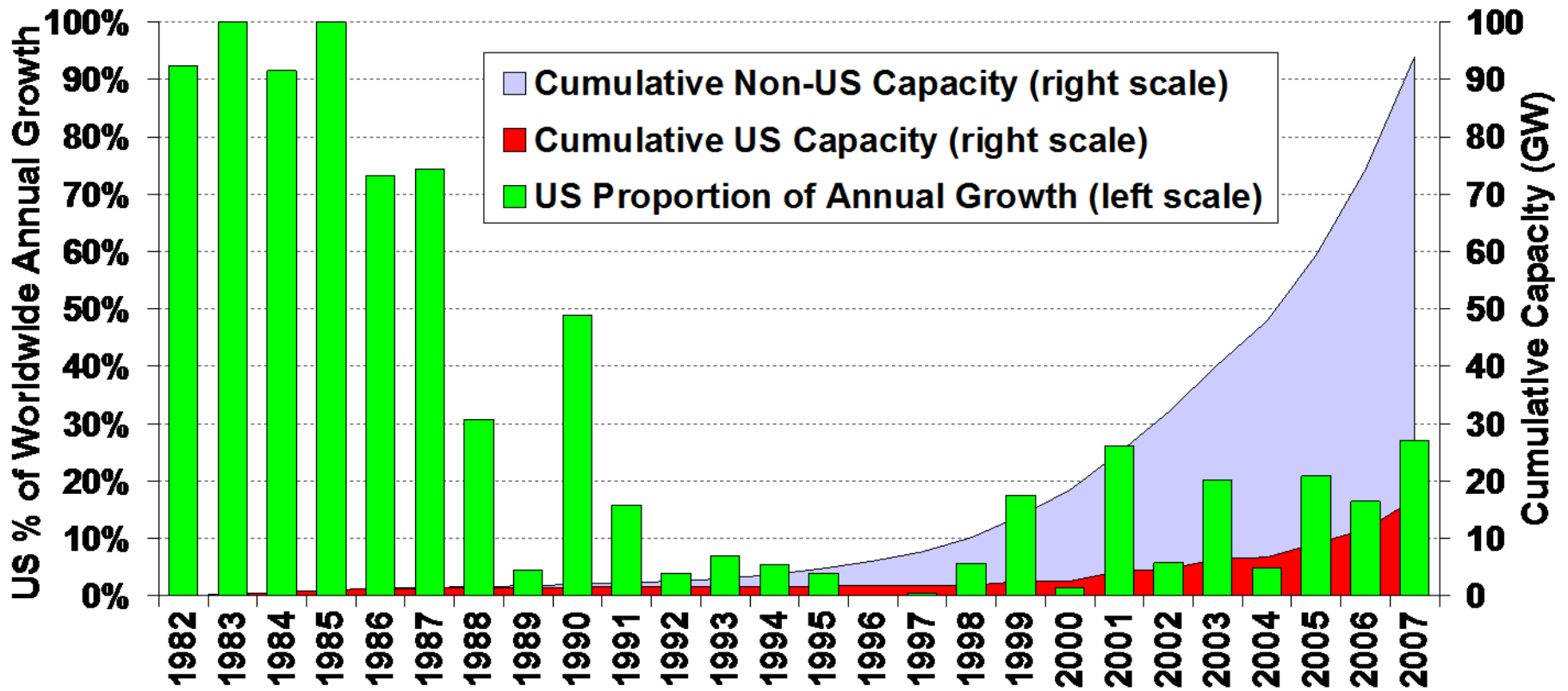
U.S. Led the World in 2007 Wind Capacity Additions; Second in Cumulative Capacity

Incremental Capacity (2007, MW)		Cumulative Capacity (end of 2007, MW)	
U.S.	5,329	Germany	22,277
China	3,287	U.S.	16,904
Spain	3,100	Spain	14,714
Germany	1,667	India	7,845
India	1,617	China	5,875
France	888	Denmark	3,088
Italy	603	Italy	2,721
Portugal	434	France	2,471
U.K.	427	U.K.	2,394
Canada	386	Portugal	2,150
<i>Rest of World</i>	2,138	<i>Rest of World</i>	13,591
TOTAL	19,876	TOTAL	94,030

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



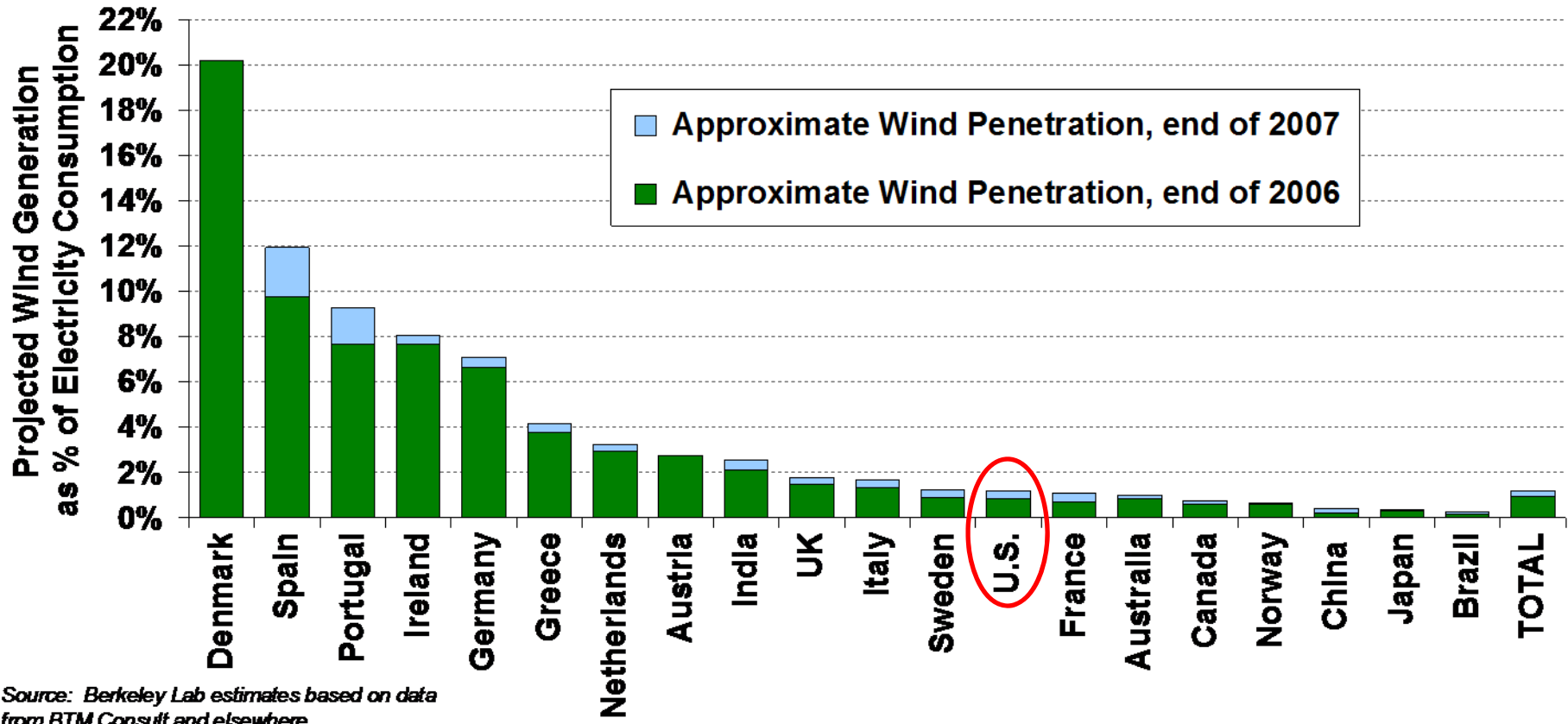
U.S. Share of Global Wind Capacity: 27% of 2007 Additions, 18% of Cumulative



Source: Earth Policy Institute, BTM Consult, AWEA



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

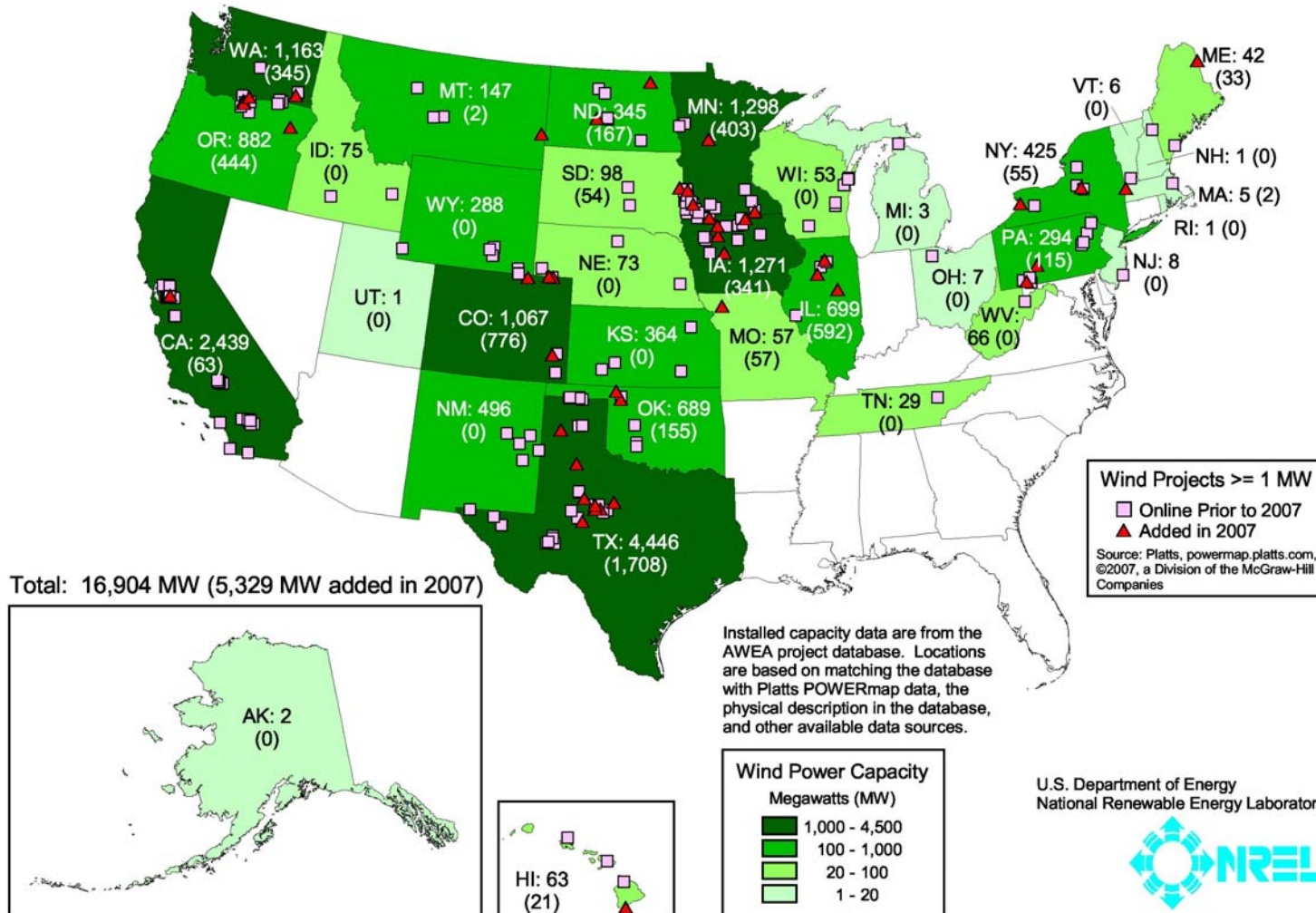


Source: Berkeley Lab estimates based on data from BTM Consult and elsewhere

Note: Figure only includes the 20 countries with the most installed wind capacity at the end of 2007



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





Texas Easily Exceeded Other States in Annual Capacity Growth

Incremental Capacity (2007, MW)		Cumulative Capacity (end of 2007, MW)		Estimated Percentage of In-State Generation	
Texas	1,708	Texas	4,446	Minnesota	7.5%
Colorado	776	California	2,439	Iowa	7.5%
Illinois	592	Minnesota	1,298	Colorado	6.1%
Oregon	444	Iowa	1,271	South Dakota	6.0%
Minnesota	403	Washington	1,163	Oregon	4.4%
Washington	345	Colorado	1,067	New Mexico	4.0%
Iowa	341	Oregon	882	North Dakota	3.8%
North Dakota	167	Illinois	699	Oklahoma	3.0%
Oklahoma	155	Oklahoma	689	Texas	3.0%
Pennsylvania	115	New Mexico	496	Washington	2.8%
California	63	New York	425	California	2.8%
Missouri	57	Kansas	364	Kansas	2.3%
New York	55	North Dakota	345	Hawaii	2.3%
South Dakota	54	Pennsylvania	294	Montana	1.9%
Maine	33	Wyoming	288	Wyoming	1.7%
Hawaii	21	Montana	147	Idaho	1.5%
Massachusetts	2	South Dakota	98	Illinois	0.8%
Montana	2	Idaho	75	Maine	0.8%
		Nebraska	73	New York	0.7%
		West Virginia	66	Nebraska	0.7%
Rest of U.S.	0	Rest of U.S.	277	Rest of U.S.	0.05%
TOTAL	5,329	TOTAL	16,904	TOTAL	1.1%

- 16 states had >100 MW of wind capacity at the end of 2007 (9 had >500 MW)
- TX widened its lead over CA in cumulative wind capacity
- Neither TX nor CA was in the top tier of states for wind as a % of in-state generation
- 6 states have in-state wind generation that exceeds 4% of total in-state generation: MN, IA, CO, SD, OR, NM

Source: AWEA project database, EIA, Berkeley Lab estimates.



Wind Now >10% of Some Utilities' Sales

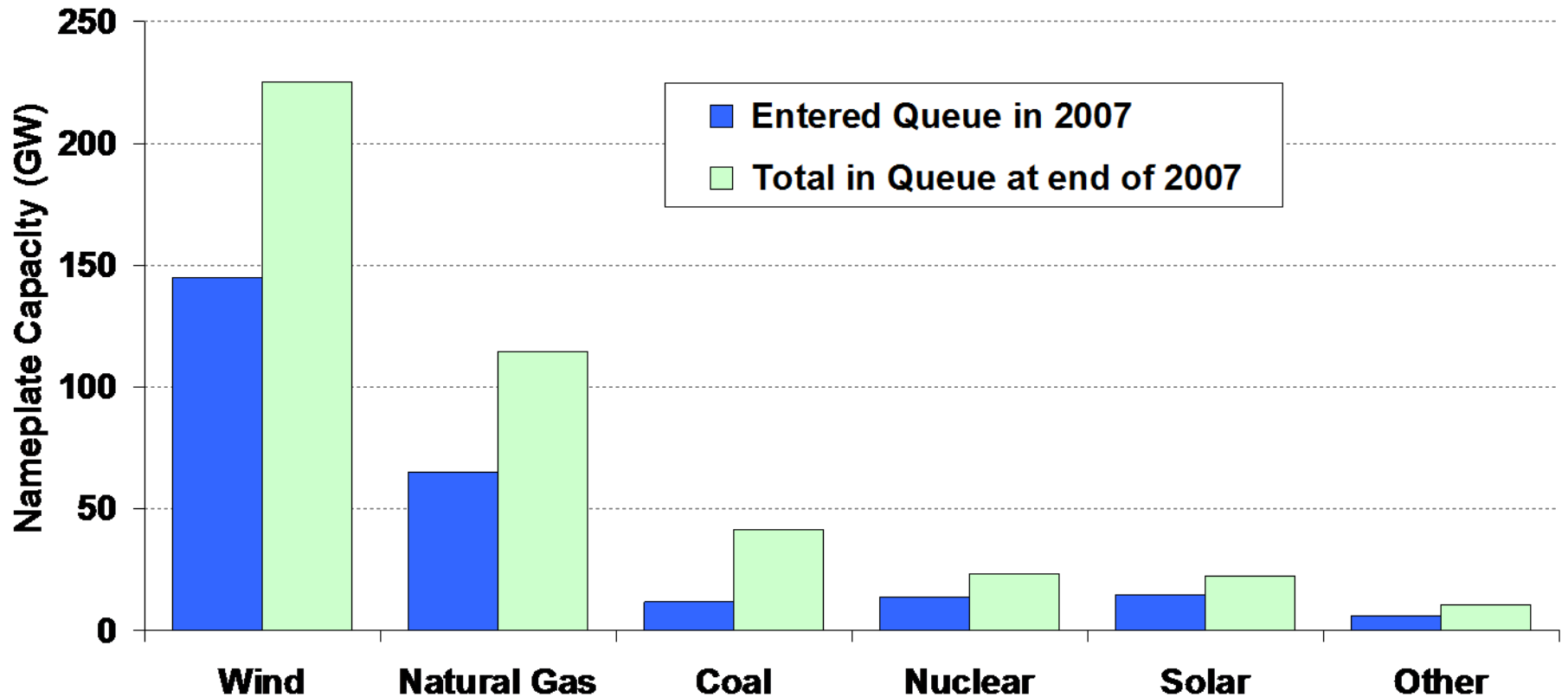
Total Wind Capacity (end of 2007, MW)		Estimated Percentage of Retail Sales (for utilities with > 50 MW of wind)	
Xcel Energy	2,635	Minnkota Power Cooperative	11.2%
MidAmerican Energy	1,201	Empire District Electric Company	10.2%
Southern California Edison	1,026	Last Mile Electric Cooperative	10.0%
Pacific Gas & Electric	878	Xcel Energy	9.3%
Luminant	704	MSR Public Power Agency	8.4%
American Electric Power	543	Public Service New Mexico	7.5%
CPS Energy	501	Oklahoma Municipal Power Authority	7.2%
Puget Sound Energy	428	CPS Energy	7.1%
Alliant Energy	378	Northwestern Energy	7.0%
Exelon Energy	342	Austin Energy	6.6%
Austin Energy	274	Otter Tail Power	6.4%
Portland General Electric	225	Great River Energy	6.3%
Great River Energy	218	Nebraska Public Power District	6.0%
Last Mile Electric Cooperative	205	Puget Sound Energy	5.2%
Public Service New Mexico	204	Seattle City Light	5.0%
MSR Public Power Agency	200	MidAmerican Energy	4.7%
Reliant Energy	199	Alliant Energy	4.2%
Seattle City Light	175	Western Farmers' Electric Cooperative	3.8%
Oklahoma Gas & Electric	170	Luminant Energy	3.6%
Empire District Electric Company	150	Minnesota Power	3.5%

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

Source: AWEA, EIA, Berkeley Lab estimates.



>225 GW of Wind in Interconnection Queues



Source: Exeter Associates review of interconnection queues

- MISO (66 GW), ERCOT (41 GW), and PJM (35 GW) make up 2/3 of total
- Twice as much wind as next largest resource (natural gas) in queues
- ***Not all of this capacity will be built....***



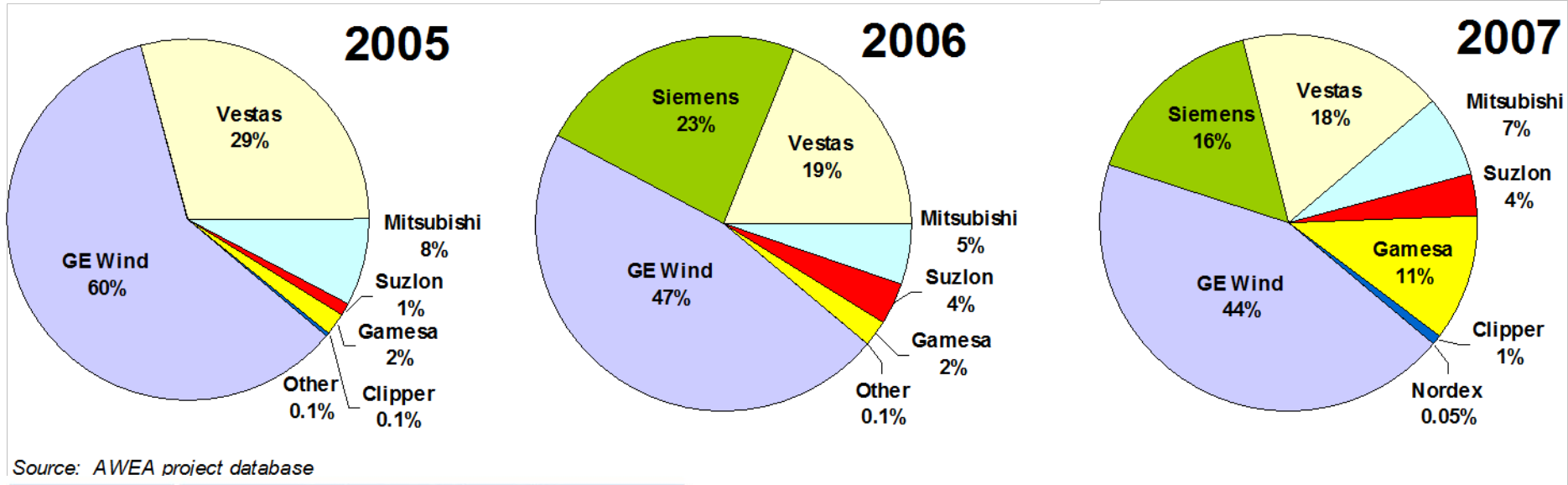
Interest in Offshore Wind Continues in the U.S., but No Such Projects Are Yet Online

State	Proposed Offshore Wind Capacity
Massachusetts	783 MW
Delaware	450 MW
New Jersey	350 MW
New York	160 MW
Texas	150 MW
Ohio	20 MW
Georgia	10 MW
TOTAL	1,923 MW

- All wind projects installed in the U.S. to date are land-based
- Some interest exists in offshore wind in several parts of the U.S.
- Several projects were put at risk in 2007 due to concerns about high and uncertain costs
- Projects presented in table to right are in various stages of development



GE Remained the Dominant Turbine Vendor



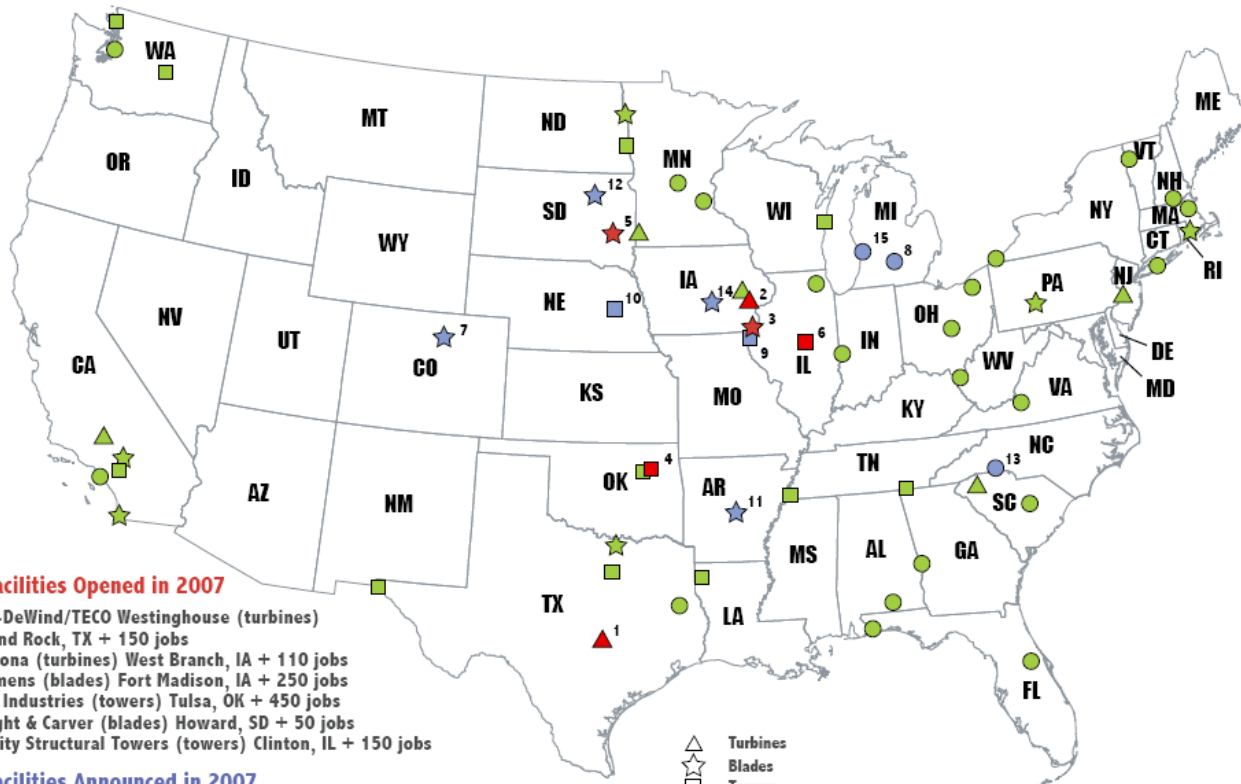
Source: AWEA project database

Manufacturer	Turbine Installations (MW)		
	2005	2006	2007
GE Wind	1,433	1,146	2,342
Vestas	700	463	948
Siemens	0	573	863
Gamesa	50	50	574
Mitsubishi	190	128	356
Suzlon	25	92	197
Clipper	2.5	0	47.5
Nordex	0	0	2.5
Other	2	2	0
TOTAL	2,402	2,454	5,329

- Although the three largest vendors lost U.S. market share in 2007...
- ...all vendors saw U.S. installations of their turbines grow in 2007



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



New Facilities Opened in 2007

1. CTC-DeWind/TECO Westinghouse (turbines) Round Rock, TX + 150 jobs
2. Acciona (turbines) West Branch, IA + 110 jobs
3. Siemens (blades) Fort Madison, IA + 250 jobs
4. DMI Industries (towers) Tulsa, OK + 450 jobs
5. Knight & Carver (blades) Howard, SD + 50 jobs
6. Trinity Structural Towers (towers) Clinton, IL + 150 jobs

New Facilities Announced in 2007

7. Vestas (blades) Windsor, CO + 650 jobs
8. Dowding Industries (turbine components) Eaton Rapids, MI + 200 jobs
9. Hendricks Industries (towers) Keokuk, IA + 350 jobs
10. Katana Summit (towers) Columbus, NE + 120 jobs
11. LM Glasfiber (blades) Little Rock, AR + 1,000 jobs
12. Molded Fiberglass (blades) Aberdeen, SD + 750 jobs
13. PPG Industries (fiberglass) Shelby, NC + not available
14. TPI Composites (blades) Newton, IA + 500 jobs
15. Genzink Steel (nacelles) Holland, MI + 10 jobs

- △ Turbines
- ☆ Blades
- Towers
- Other
- Existing facilities online prior to 2007
- New facilities opened in 2007
- New facilities announced in 2007

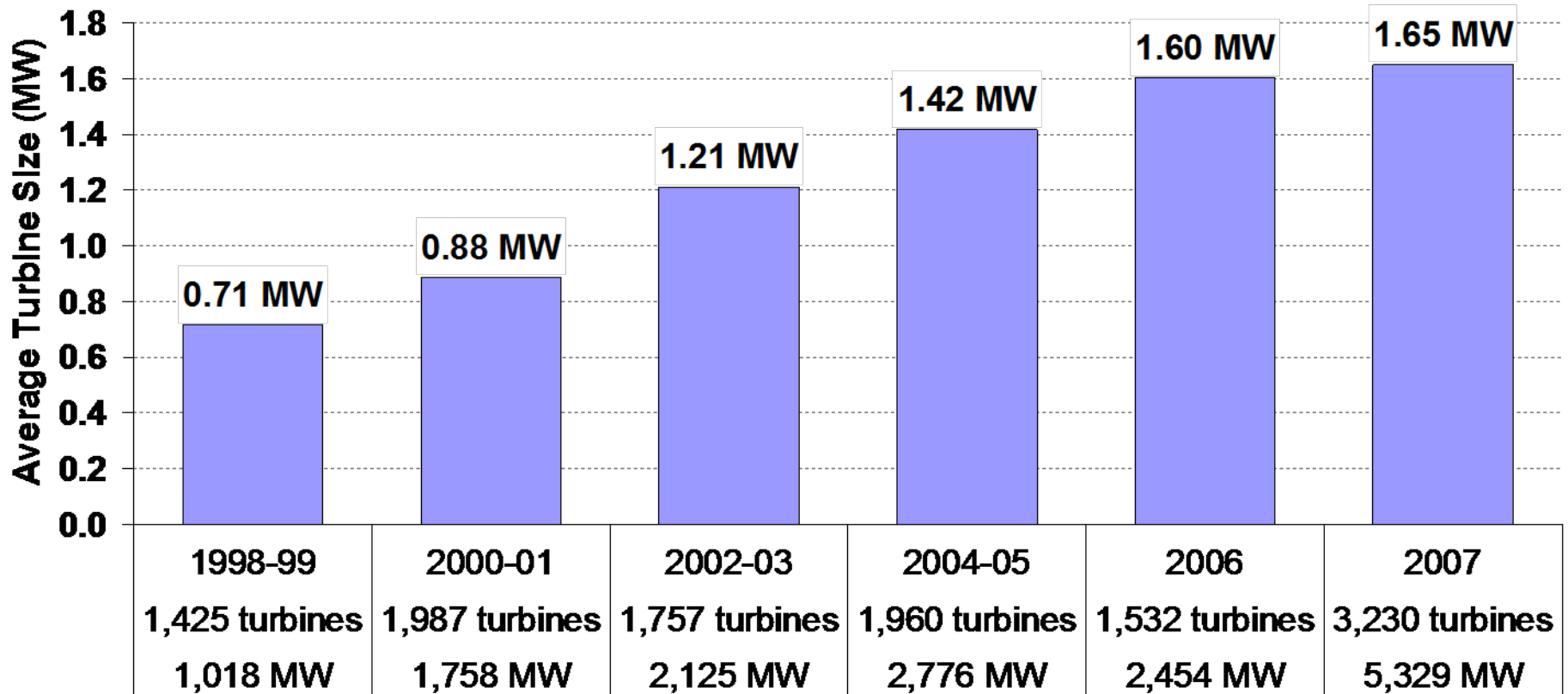
Figure includes wind turbine and component manufacturing facilities, as well as other supply chain facilities, and excludes corporate headquarters and service-oriented facilities. The facilities highlighted here are not intended to be exhaustive. Those facilities designated as "turbines" may include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



Note: Map is not intended to



Average Turbine Size Continued to Grow

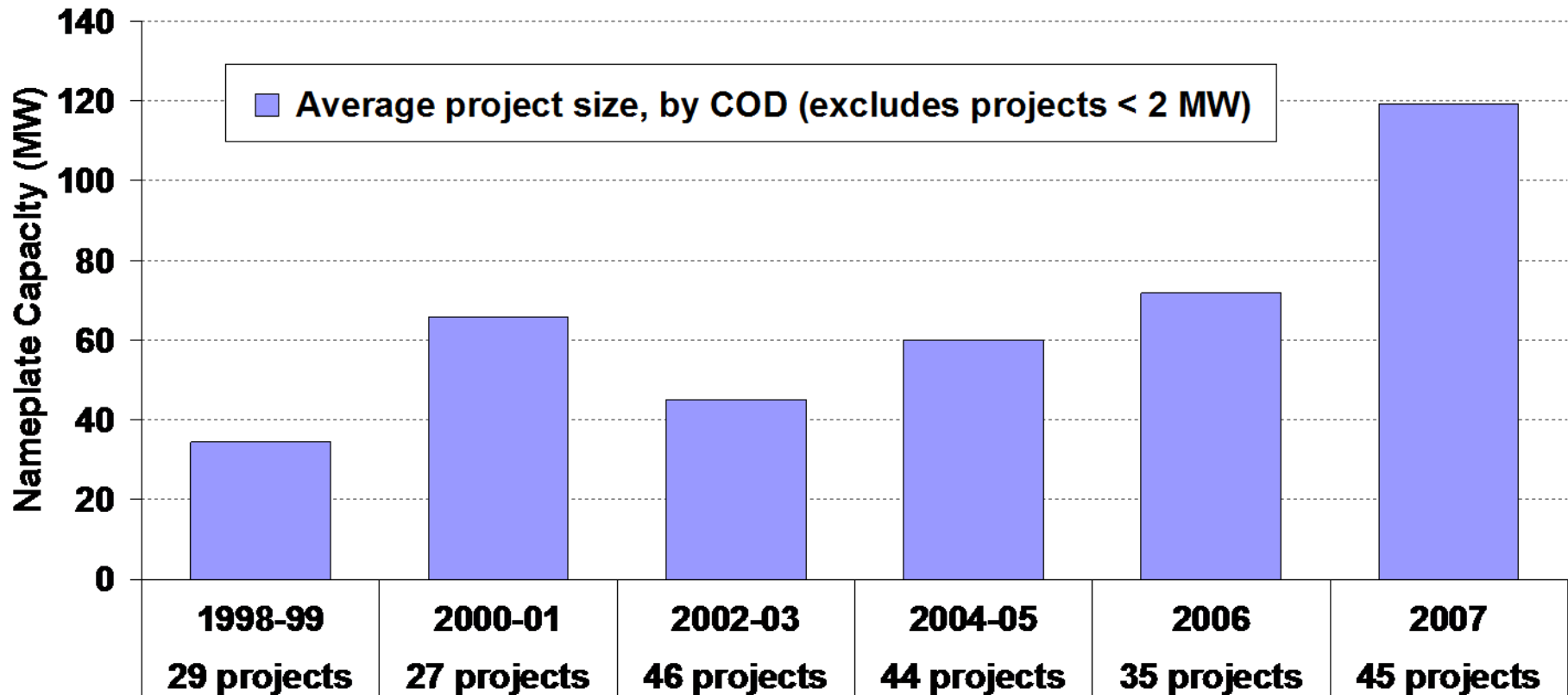


Source: AWEA project database

40% of turbines installed in 2007 were larger than 1.5 MW, up from 34% in 2006 and 24% in 2004/2005



Average Project Size Approached 120 MW



Source: Berkeley Lab analysis of AWEA project database

Average project size has doubled since 2004-2005, and tripled since 1998-1999



Developer Consolidation Continued at a Torrid Pace

- Acquisition and investment activity continued strong trend that began in 2005

2007: 11 deals = 37 GW of wind development pipeline

2006: 12 deals = 34 GW

2005: 8 deals = 12 GW

2002-04: 4 deals = 4 GW

- A number of large, foreign companies have entered the U.S. wind development business in recent years

Investor	Transaction Type	Developer	Announced
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

* Select list of announced transactions; excludes joint development activity.
 Source: Berkeley Lab.

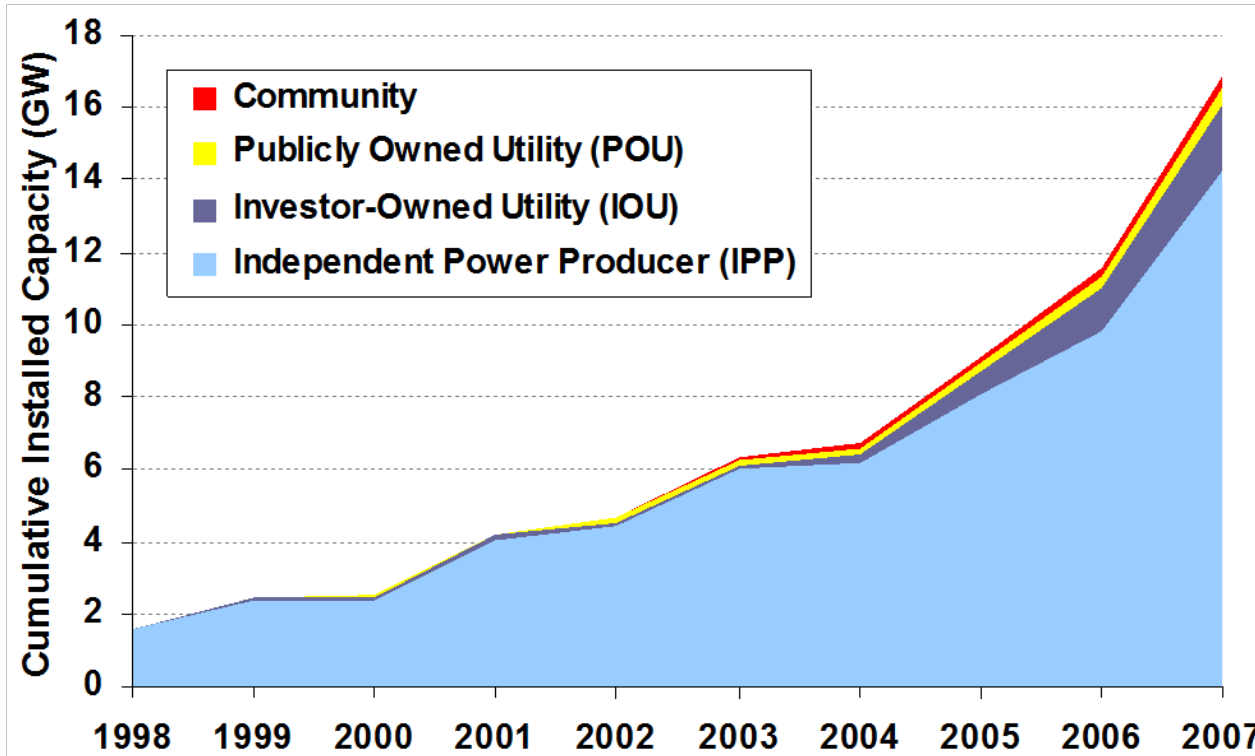


Comfort With and Use of Innovative Financing Structures Increased

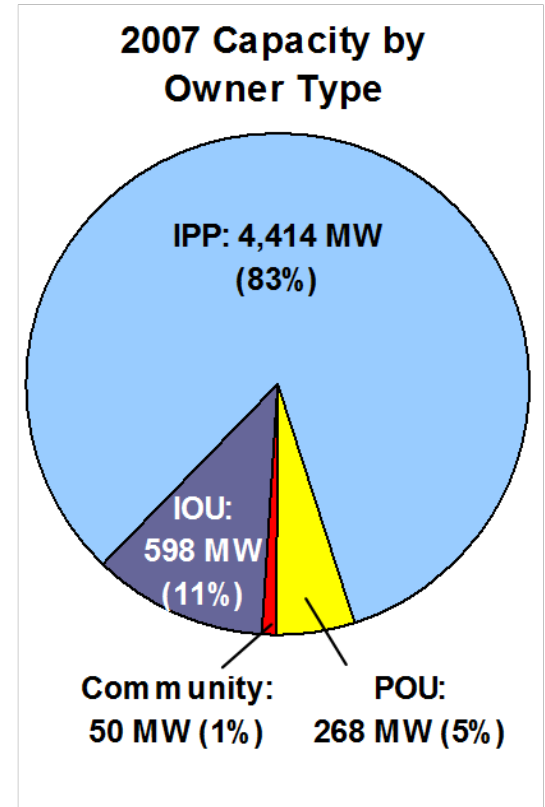
- IRS Revenue Procedure 2007-65 provides “safe harbor” guidelines for wind projects using “institutional investor flip” structure
 - More than a dozen institutional tax investors active in 2007
 - Some tax investors becoming comfortable with project-level debt
- 2007 also saw a first-of-its-kind tax equity structure geared towards municipal utilities and cooperatives (White Creek)
- But...growing dependence on 3rd-party tax investors has left the U.S. wind sector vulnerable to the global credit crisis
 - Institutional tax investors lately have fewer profits to shelter
 - Demand for affordable housing tax credits drying up, driving yields sharply higher – will this spillover into wind?



IPP Project Ownership Remained Dominant



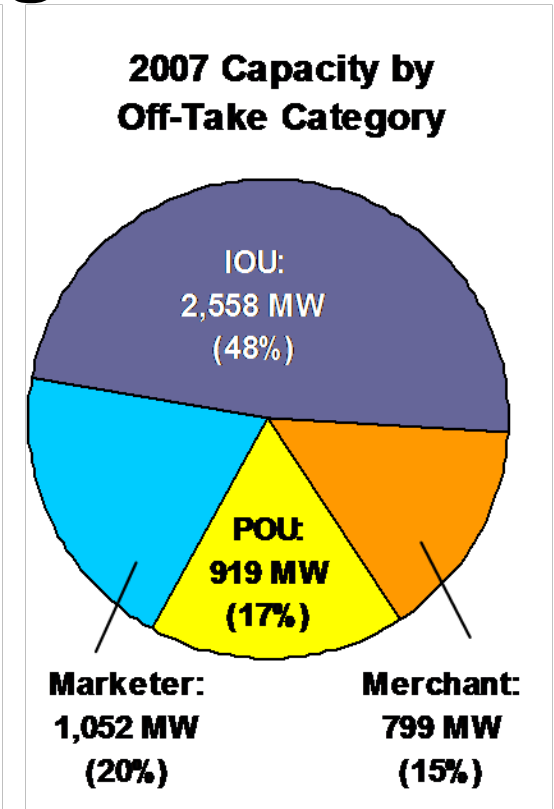
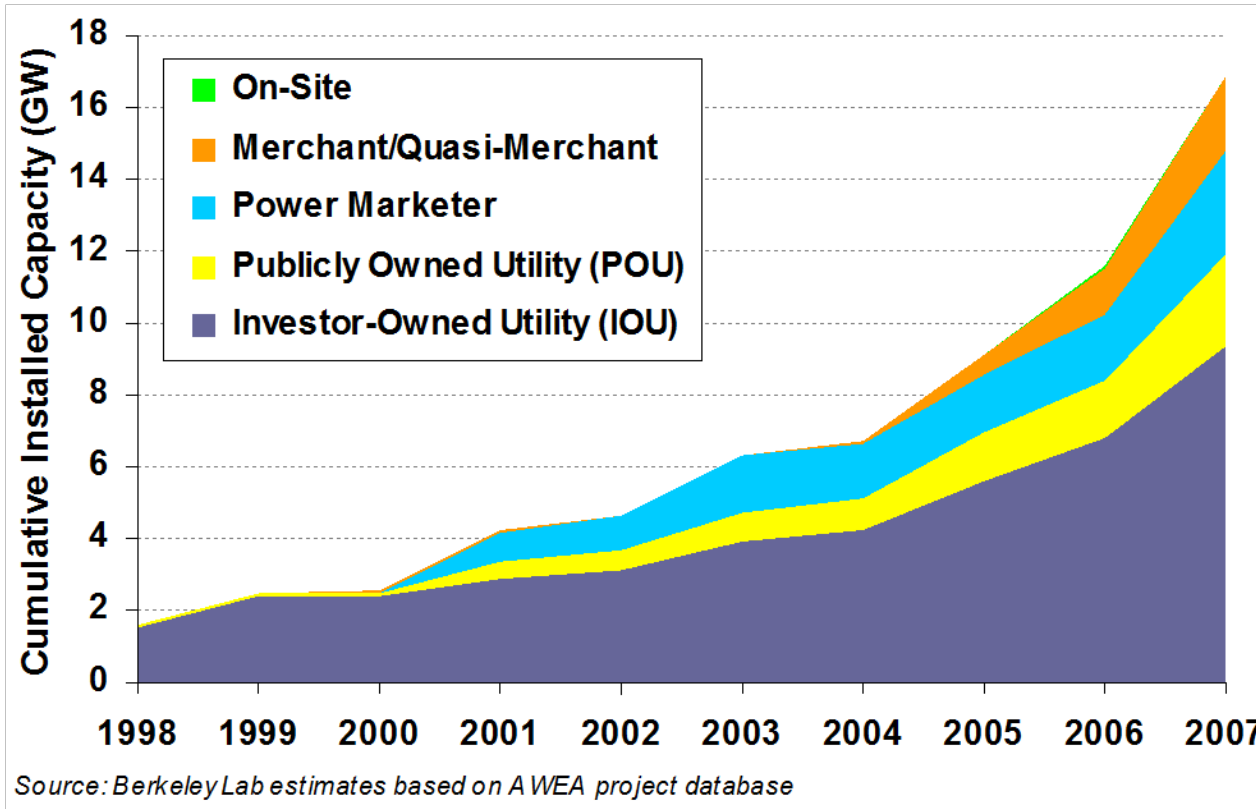
Source: Berkeley Lab estimates based on AWEA project database



- Utility ownership (both IOU and POU) gained some ground
- Community wind lost market share



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



- But sales to power marketers are becoming more prevalent
- So are “merchant” plants – primarily in TX and NY

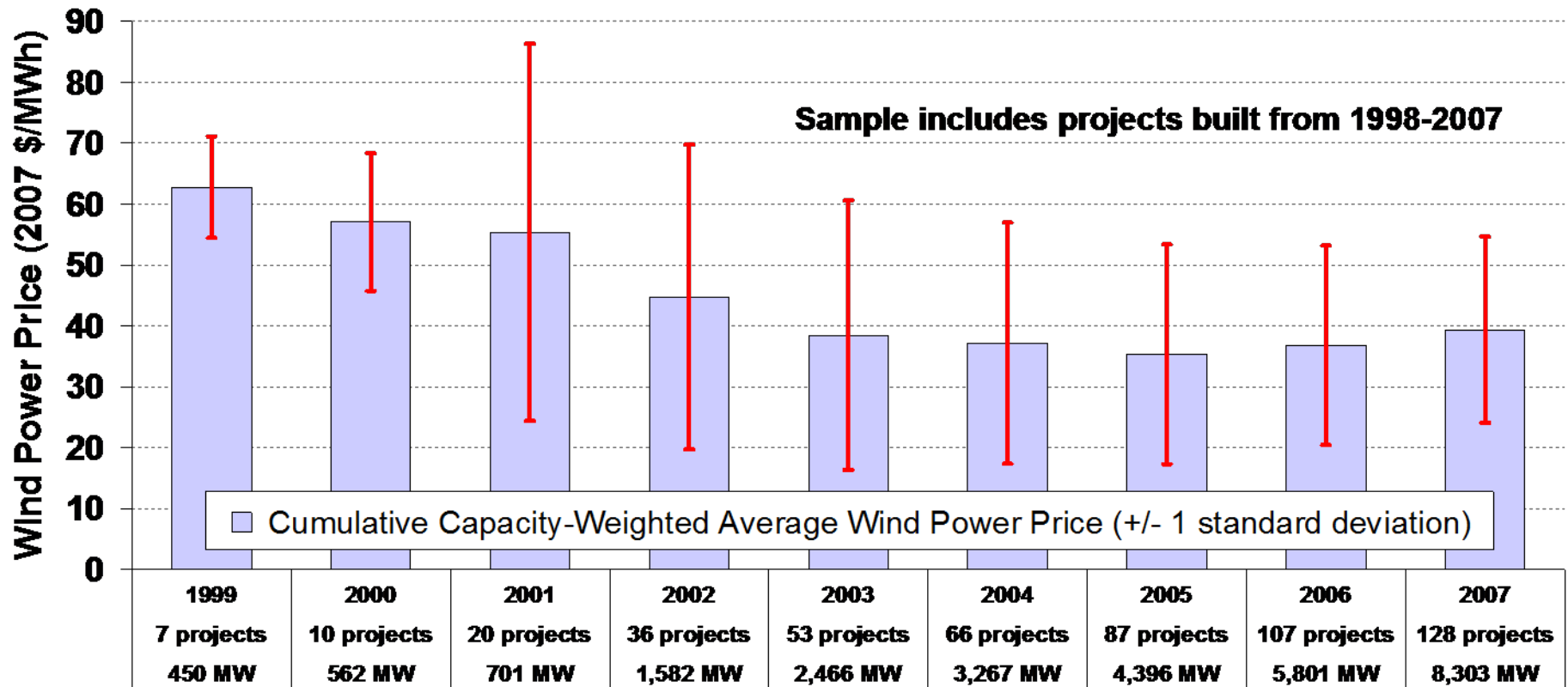


Upward Pressure on Wind Power Prices Continued in 2007

- Berkeley Lab maintains a database of wind power sales prices; next few slides present data from that database
- Sample includes 128 wind projects installed from 1998-2007, totaling 8,303 MW (55% of total added capacity over that timeframe)
- Prices reflect price of electricity as sold by project owner (i.e., busbar energy prices)
 - Prices reduced by receipt of state/federal incentives (e.g., the PTC) and by any value gained through separate sale of RECs (though only 10 of 128 projects appear to receive additional REC revenue)
 - As a result, prices do not reflect wind energy generation costs; prices would be higher were state/federal incentives and RECs not available



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

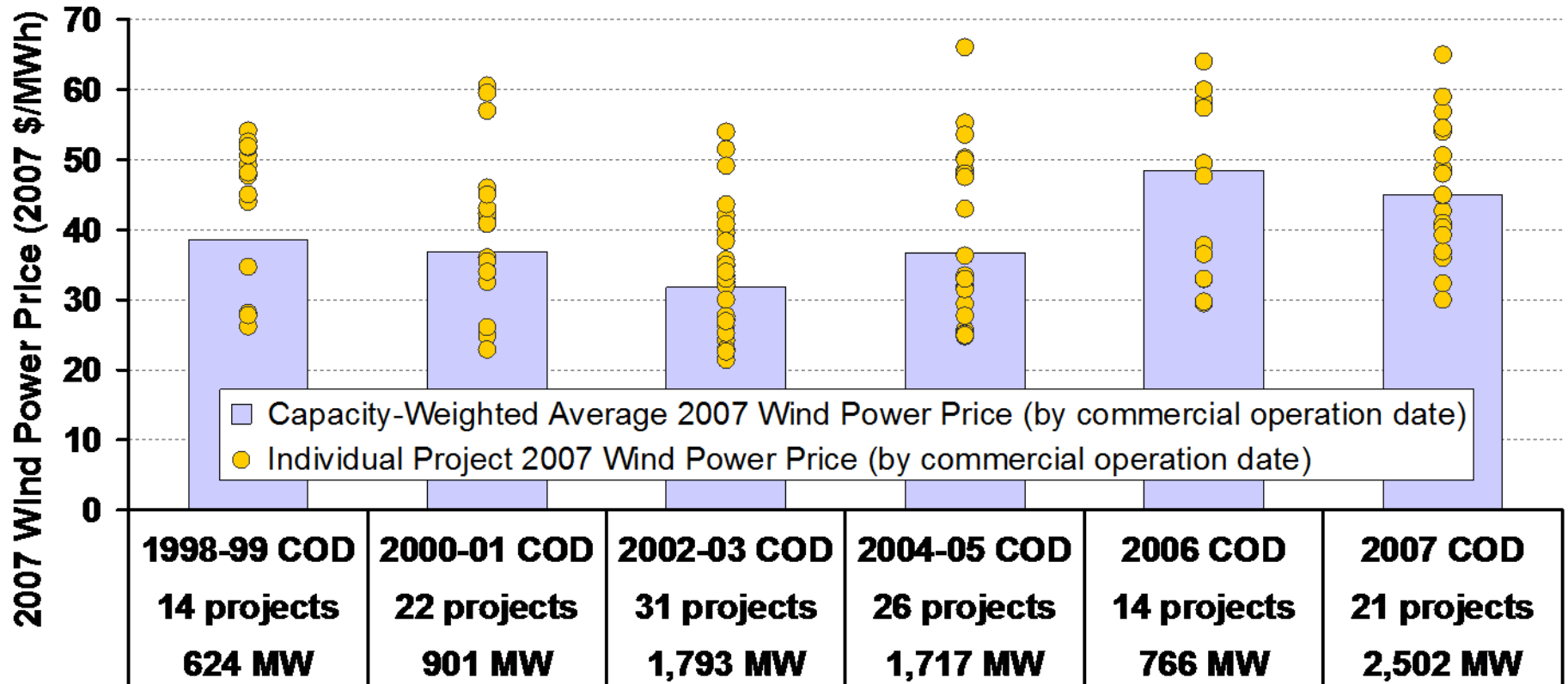


Source: Berkeley Lab database

Small increases in 2006 and 2007 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

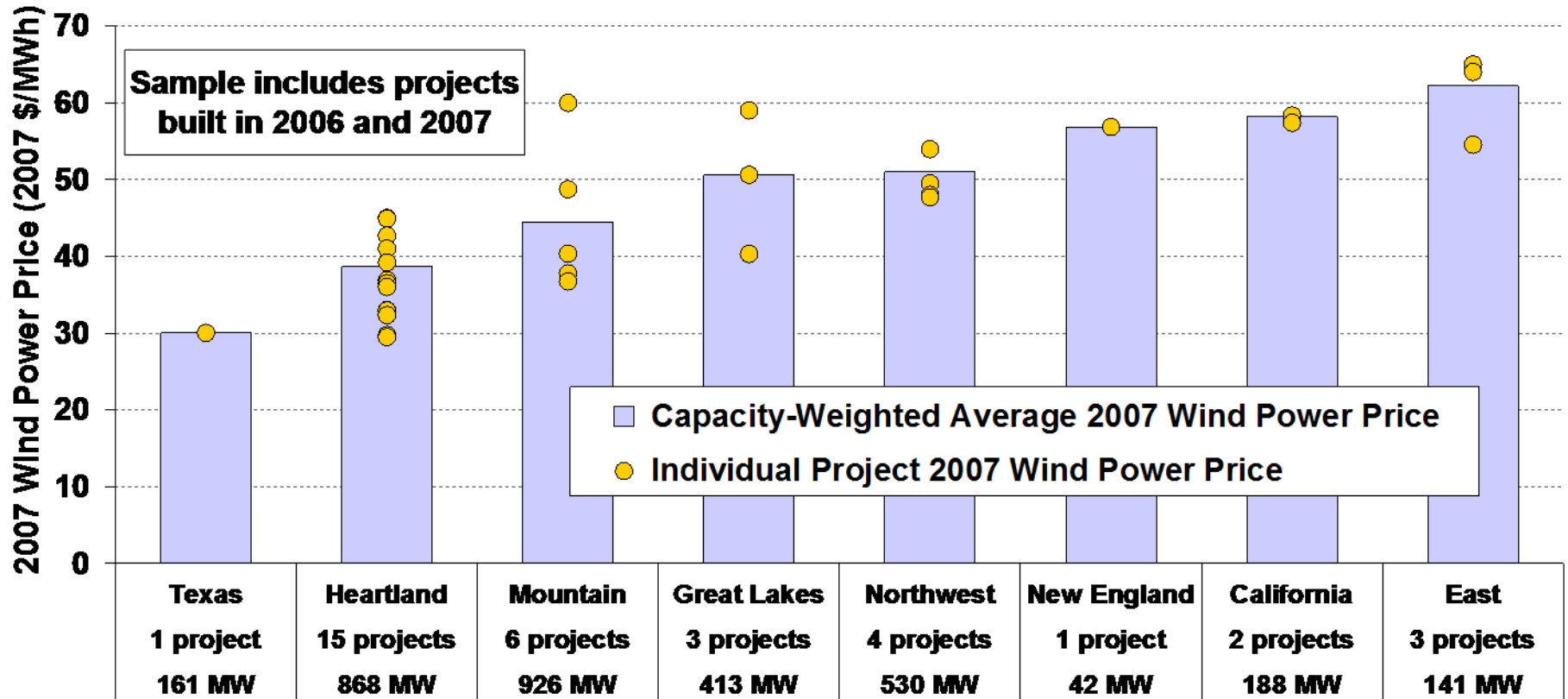


Source: Berkeley Lab database

- Graphic shows prices in 2007 from projects built from 1998-2007
- Prices will likely rise further to more fully reflect turbine price increases



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

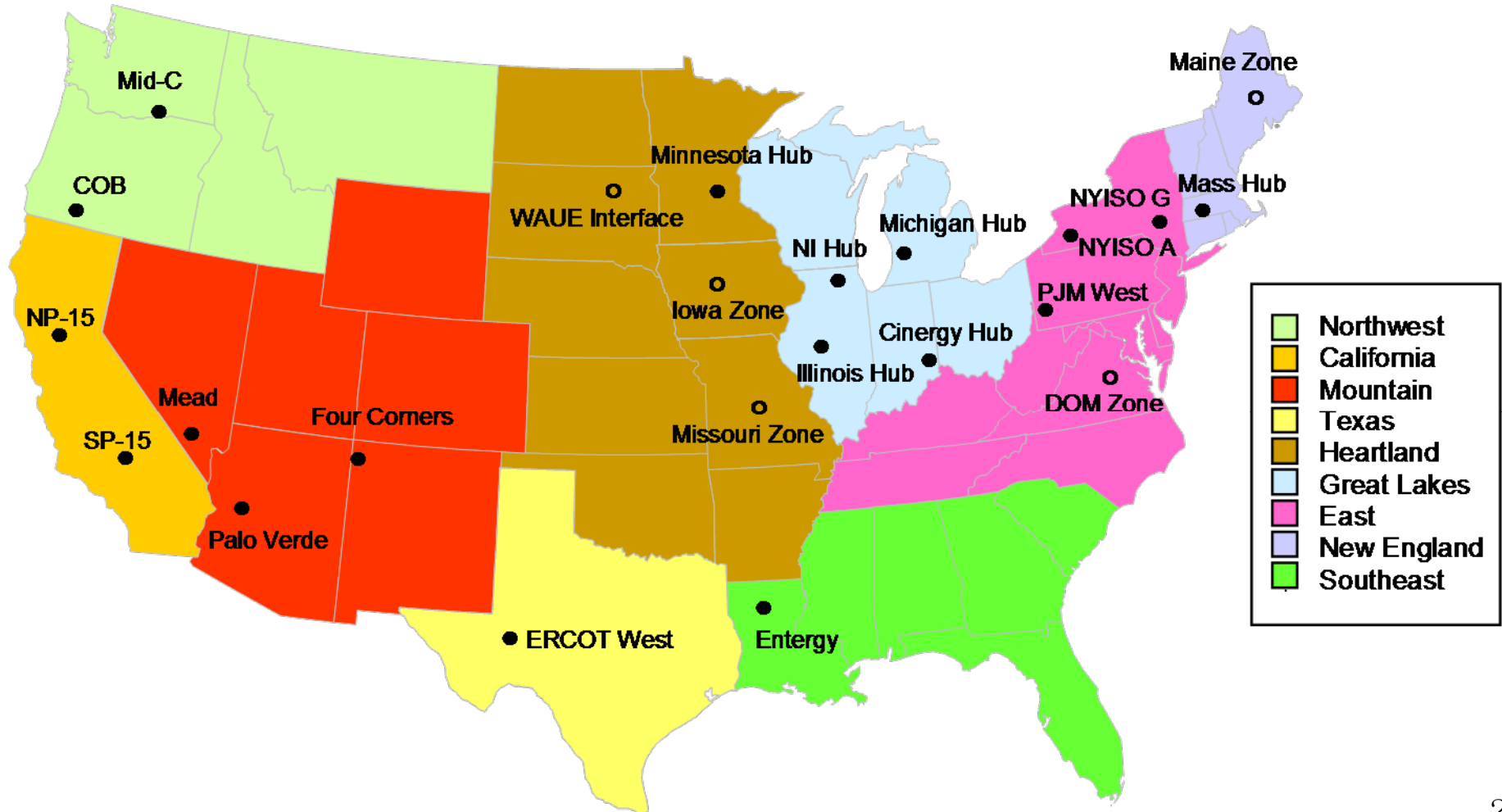


Source: Berkeley Lab database

Texas and the Heartland are lower-price regions, while California and the East are higher-price regions (sample size is problematic in many regions)

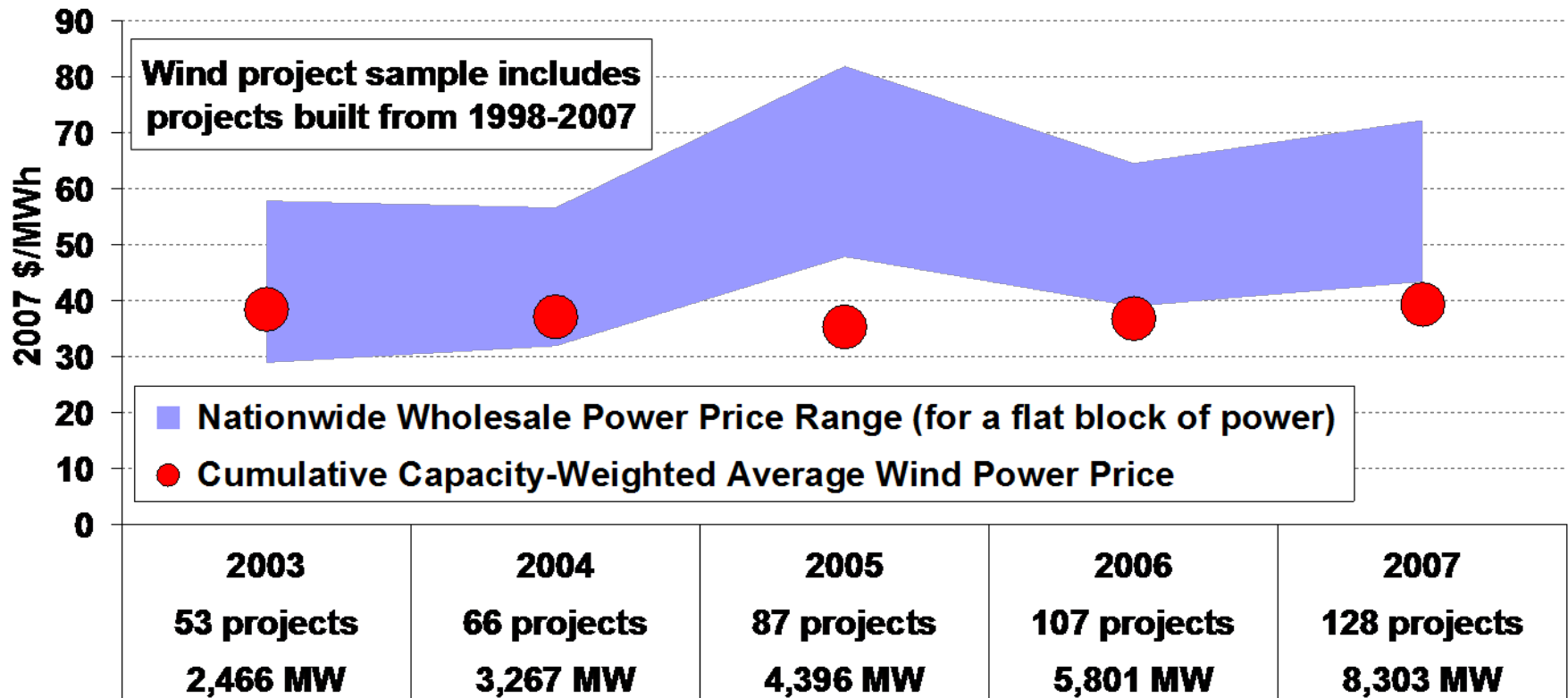


Regions and Wholesale Price Hubs Used in Analysis





Wind Has Been Competitive with Wholesale Power Prices in Recent Years

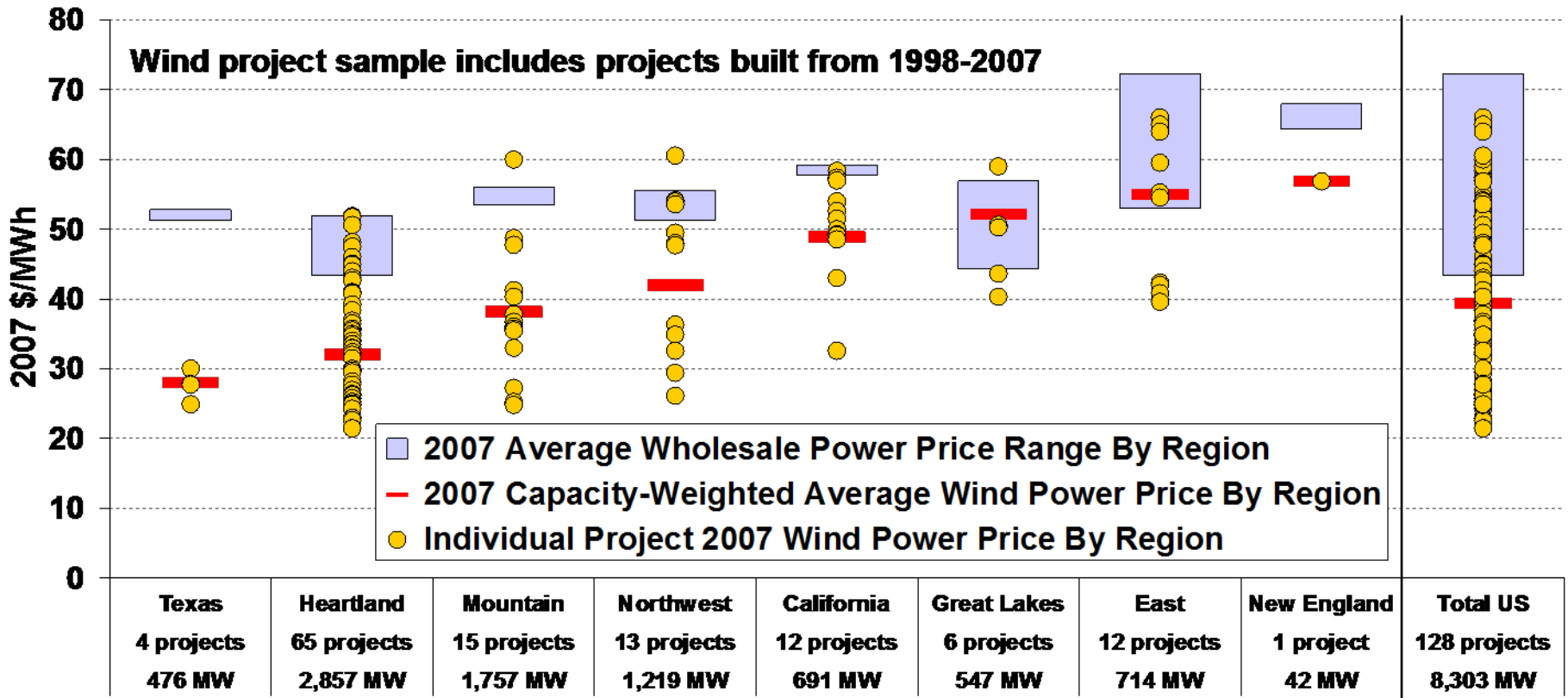


Source: FERC 2006 and 2004 "State of the Market" reports, Berkeley Lab database, Ventyx

- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- Wind prices are capacity-weighted averages from cumulative project sample



Wind Built After 1997 Was Competitive with Wholesale Prices in Most Regions in 2007

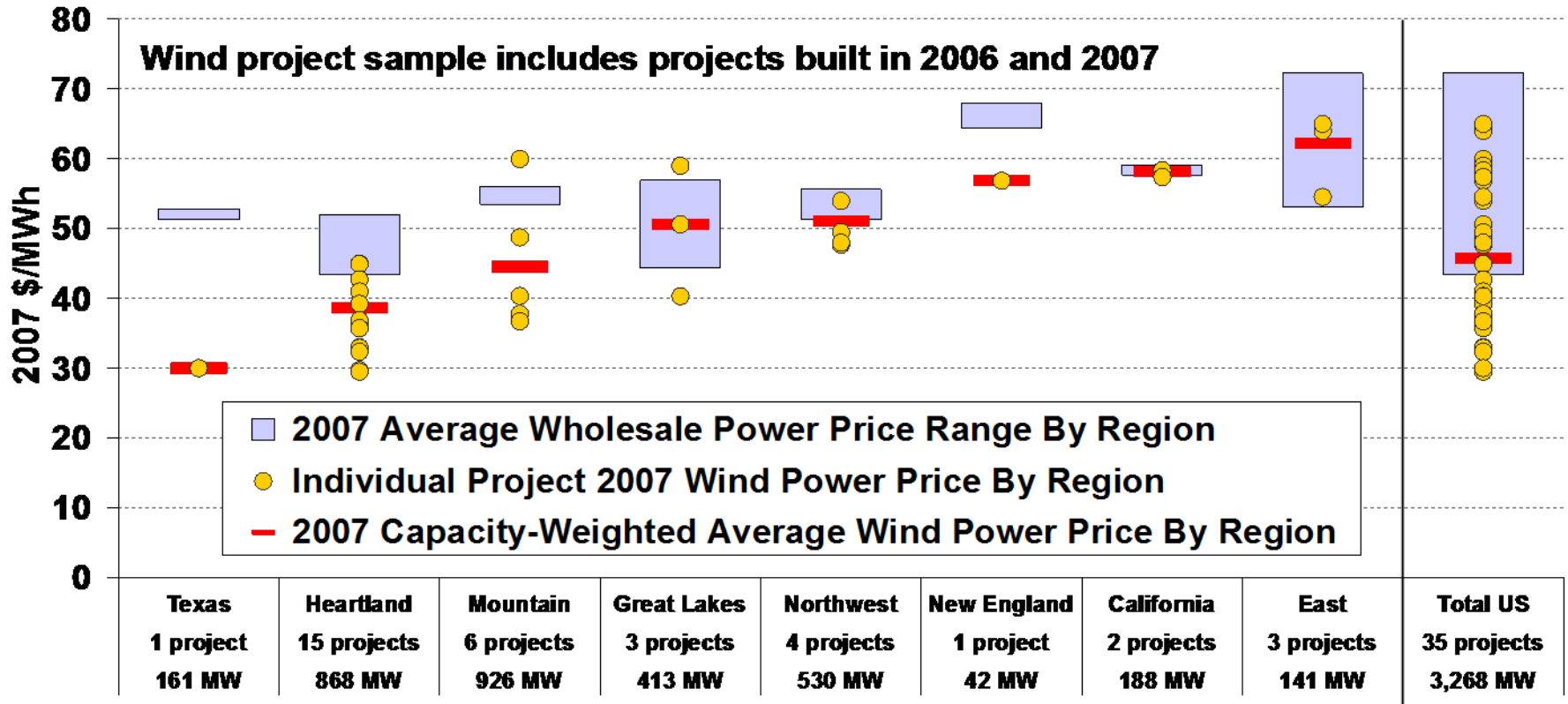


Source: Berkeley Lab database, Ventyx

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



Focusing Just on Wind Projects Built in 2006 and 2007 Tells a More Cautious Story



Source: Berkeley Lab database, Ventyx

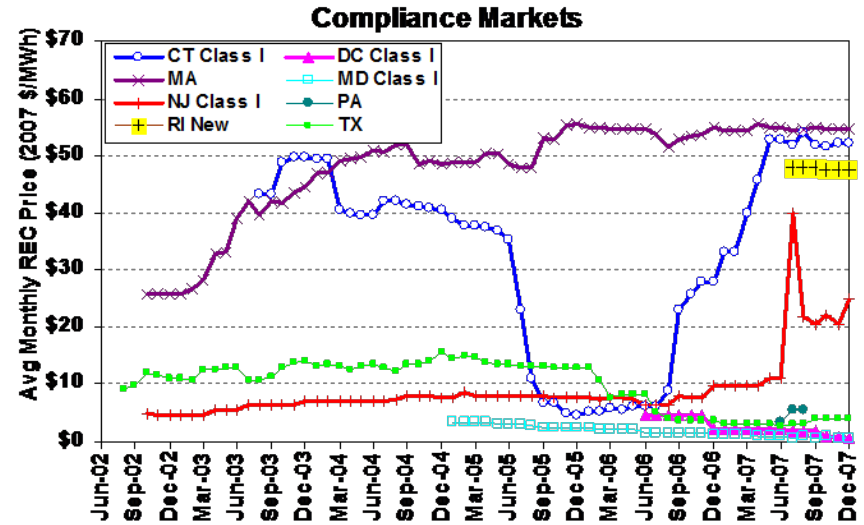
The recent rise in wind prices is making wind somewhat less competitive in wholesale markets throughout the U.S., though wind prices remain at the lower end of the wholesale price range



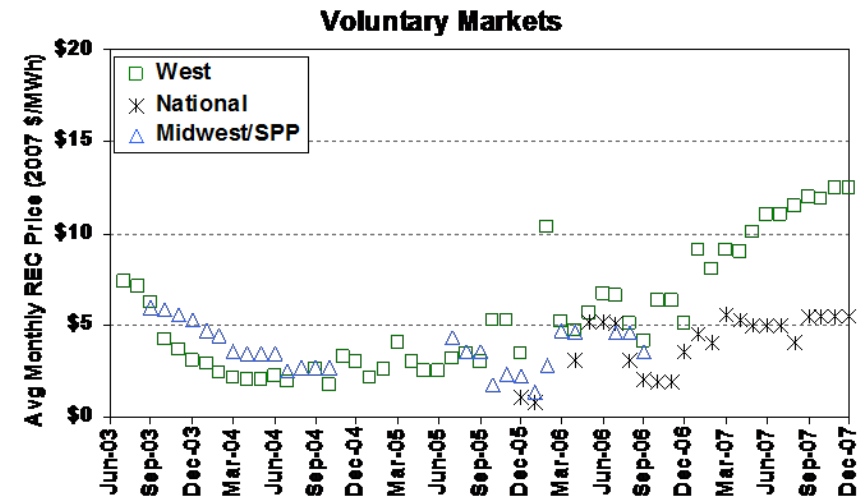
REC Markets Remain Fragmented and Volatile

Renewable energy certificate (REC) markets have experienced significant price variations by:

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



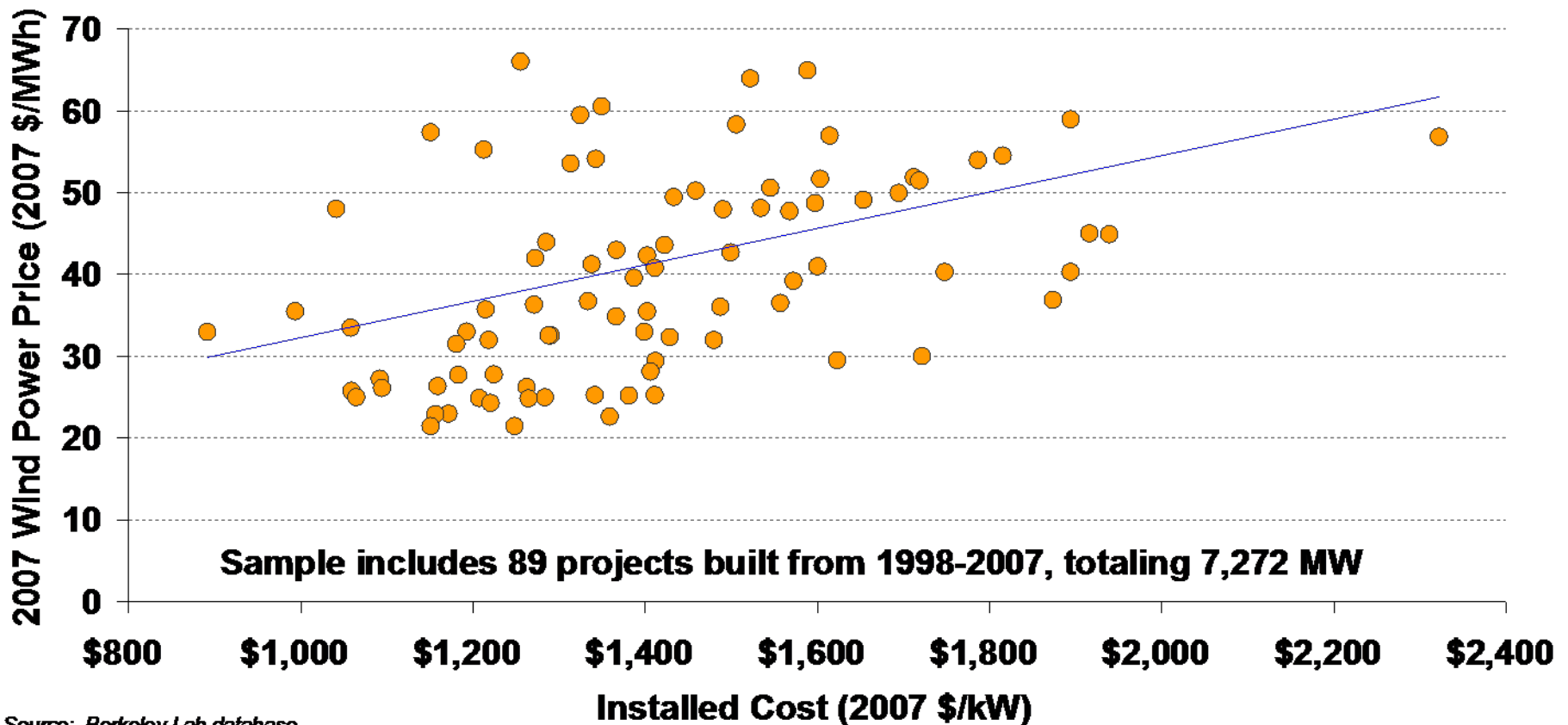
Source: EvolutionMarkets



Source: EvolutionMarkets



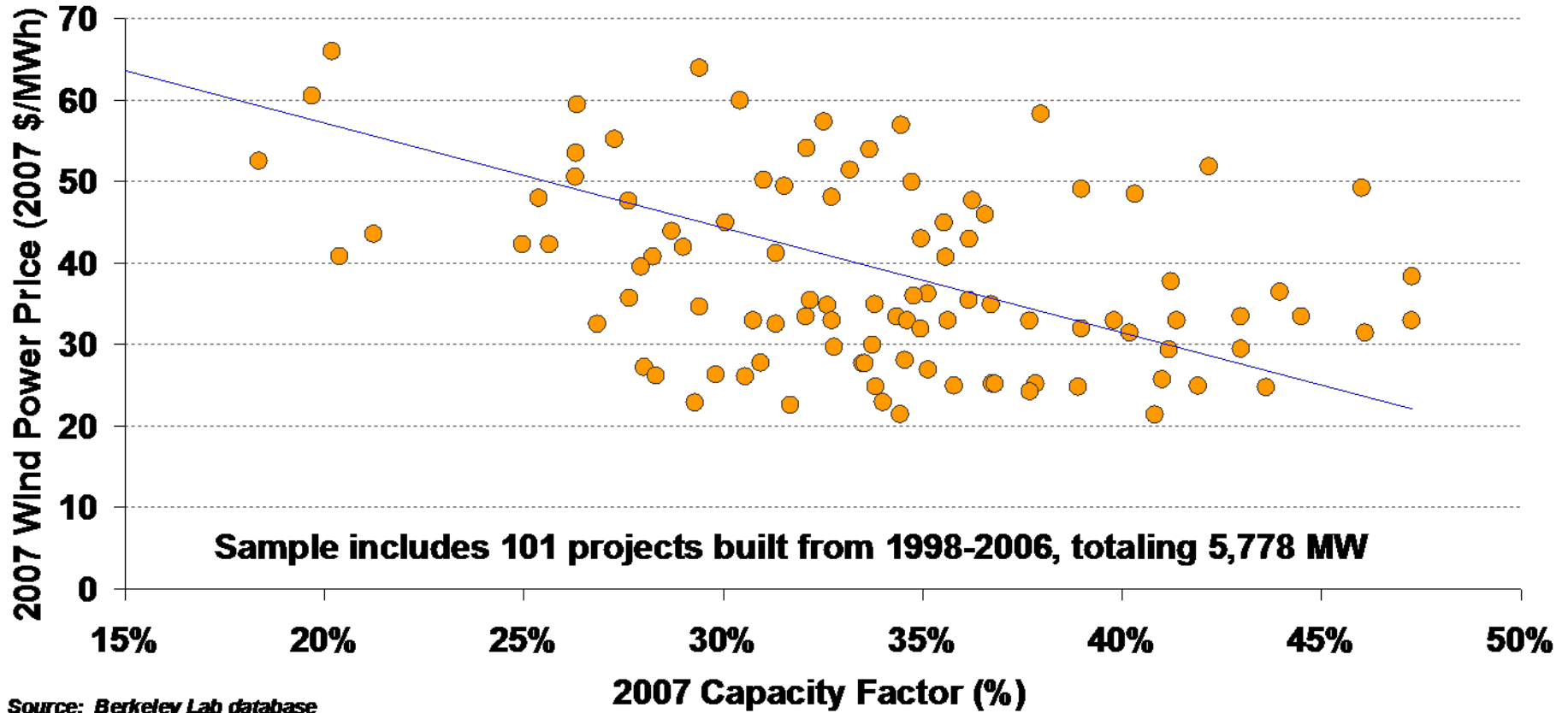
Wind Power Sales Prices Are Affected by Installed Project Costs...



Source: Berkeley Lab database



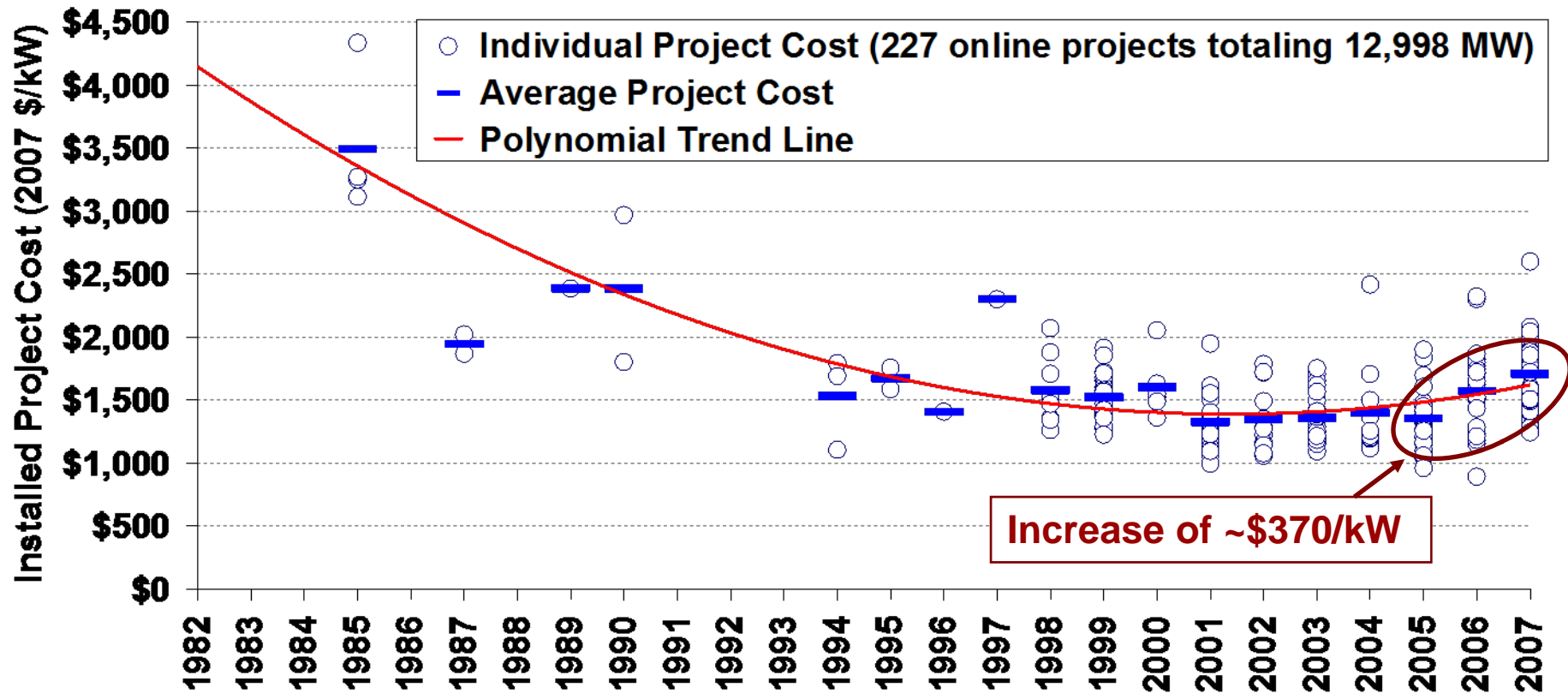
...and by Project Performance



Source: Berkeley Lab database



Installed Project Costs Are On the Rise, After a Long Period of Decline

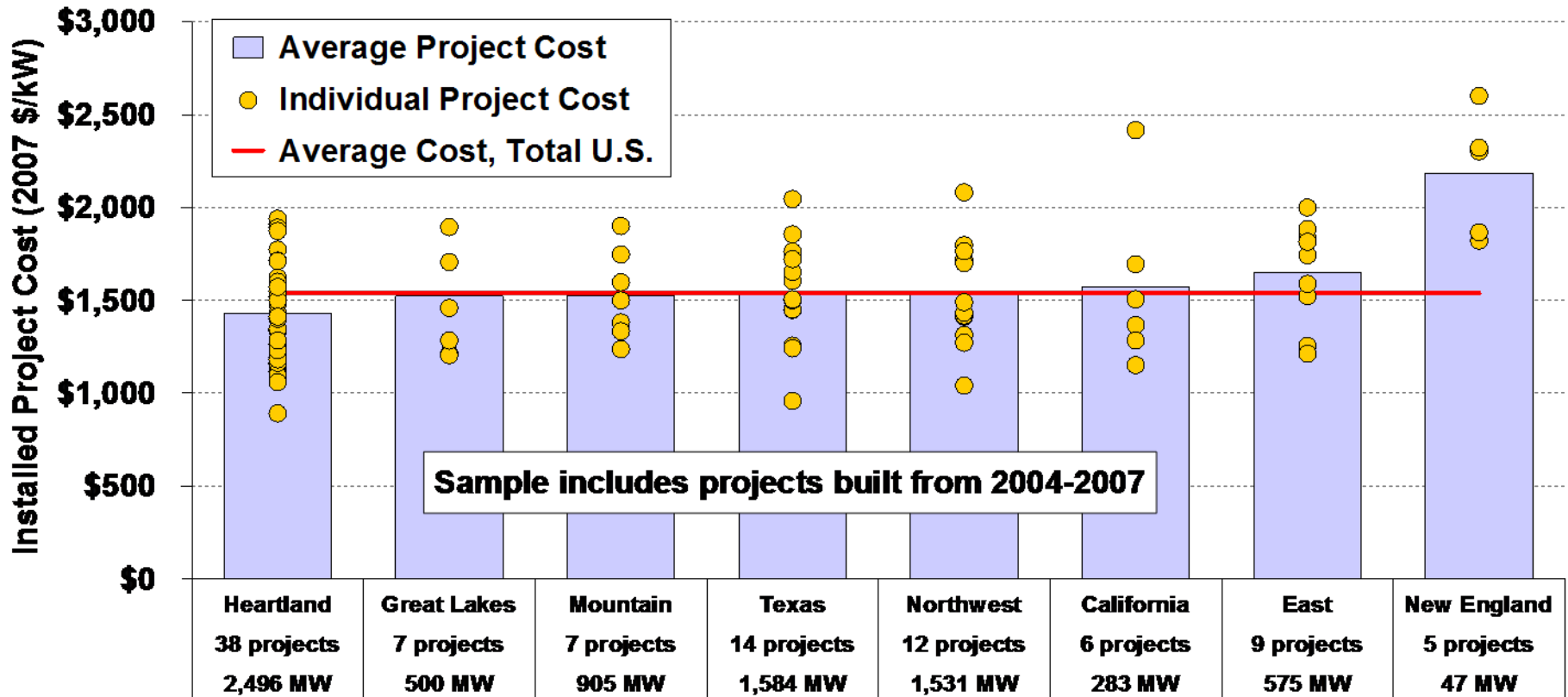


Source: Berkeley Lab database (some data points suppressed to protect confidentiality)

Projects proposed for construction in 2008 (not shown in graphic) are ~\$210/kW higher still (averaging ~\$1,920/kW)



Regional Differences in Wind Project Costs Are Apparent

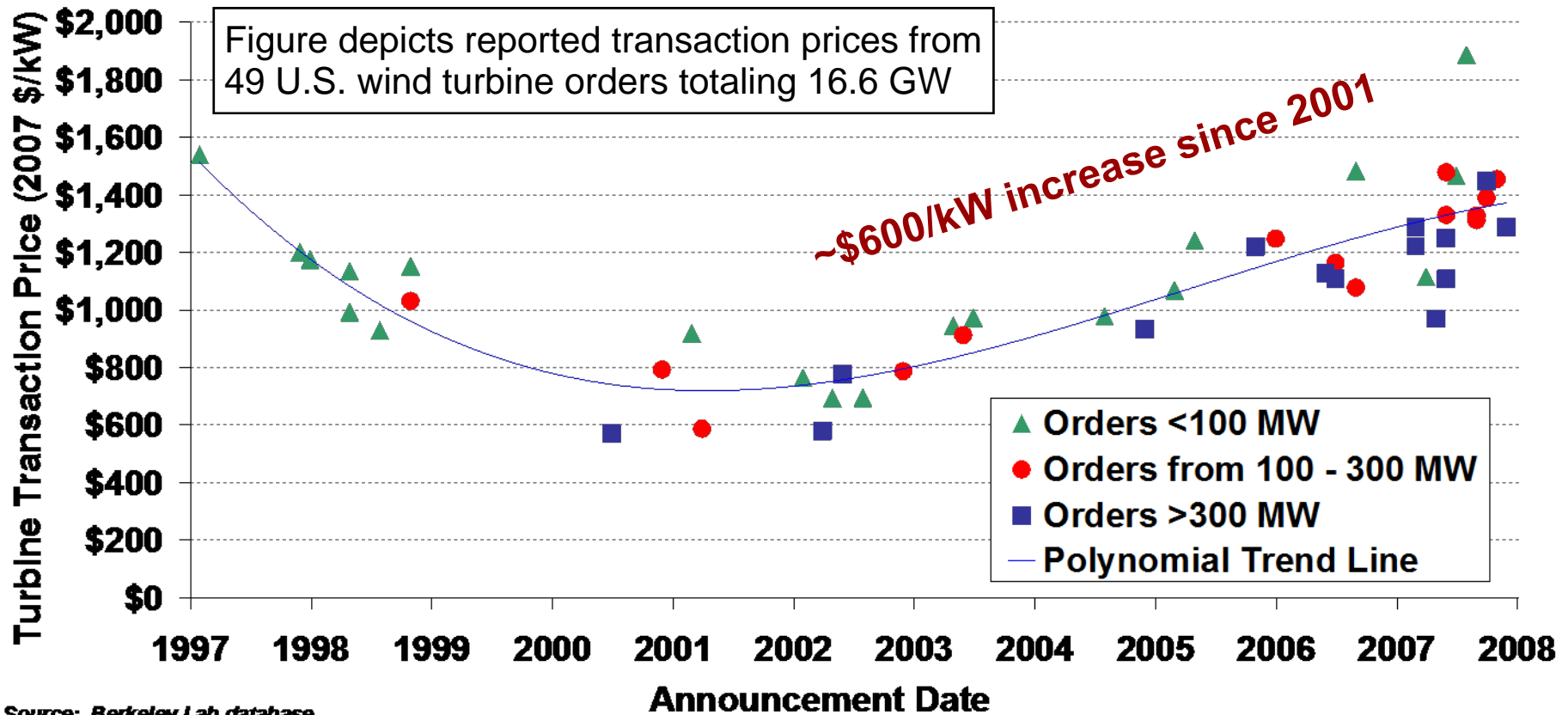


Source: Berkeley Lab database

Heartland low-cost region, East and New England high-cost



Project Cost Increases Are a Function of Wind Turbine Prices

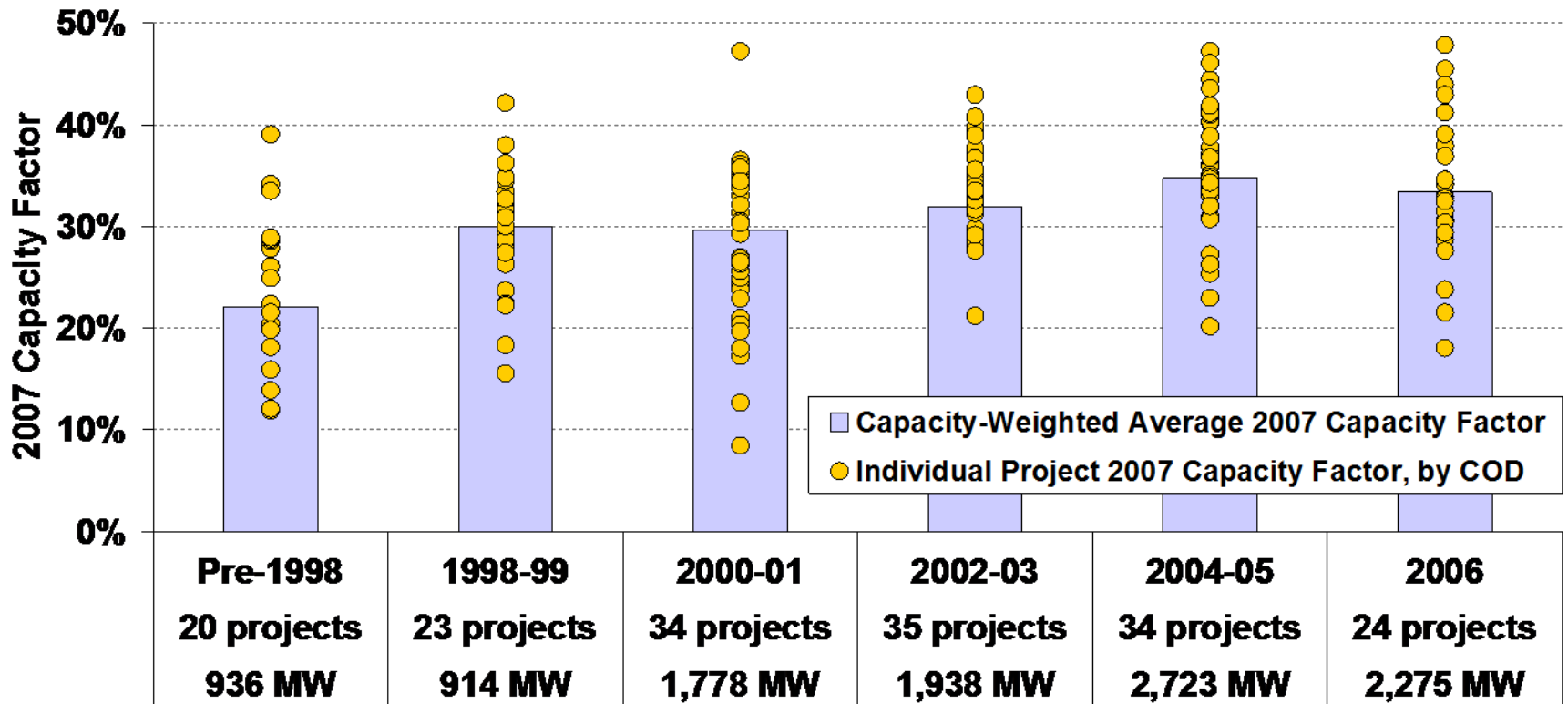


Source: Berkeley Lab database

Since turbines are often ordered 12 or more months in advance, further project cost increases are expected



Wind Project Performance Is Improving



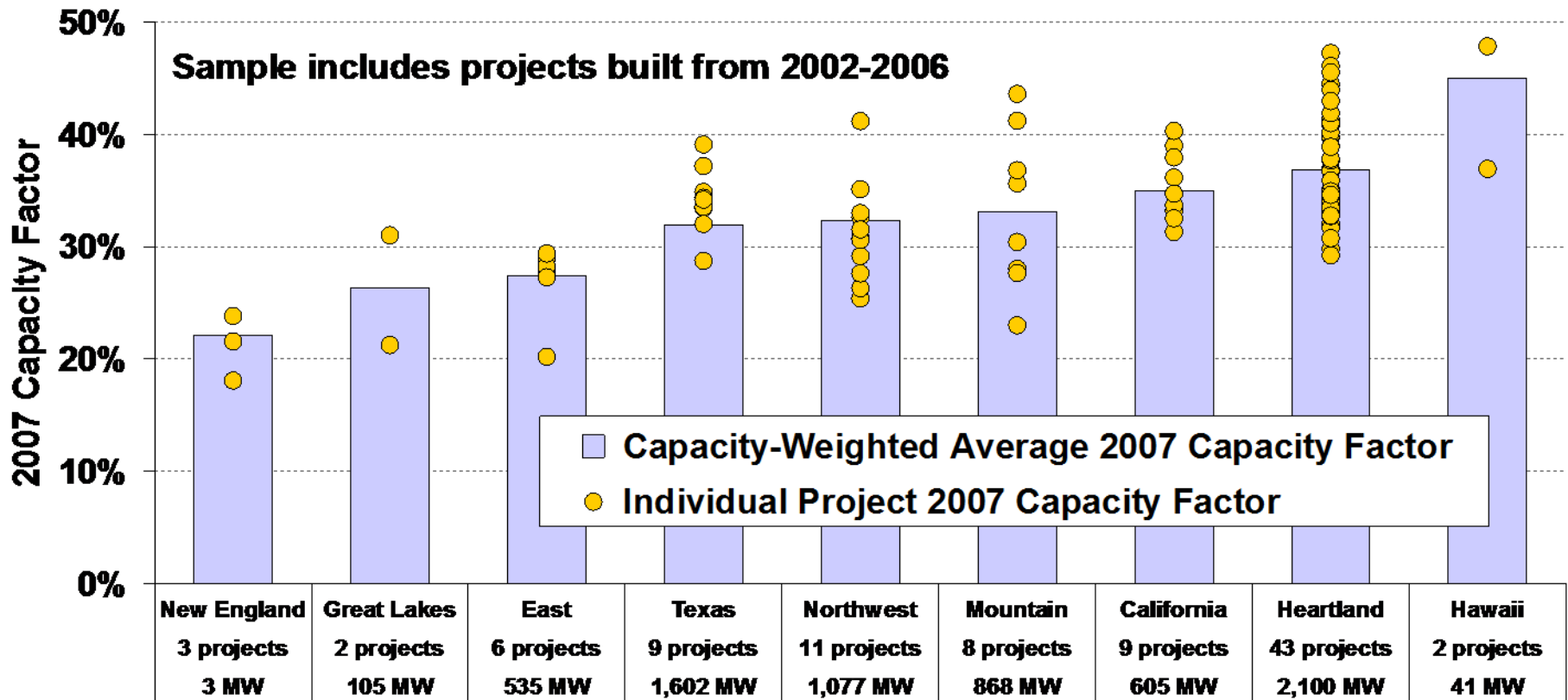
Source: Berkeley Lab database

Of the projects installed prior to 2004, 3.6% had capacity factors in excess of 40%; of the projects installed from 2004-2006, 25.9% had capacity factors in excess of 40%

Note: Sample consists of 170 wind projects built from 1983-2006, totaling 10,564 MW (91% of nationwide capacity at end of 2006)



Regional Performance Differences Are Apparent

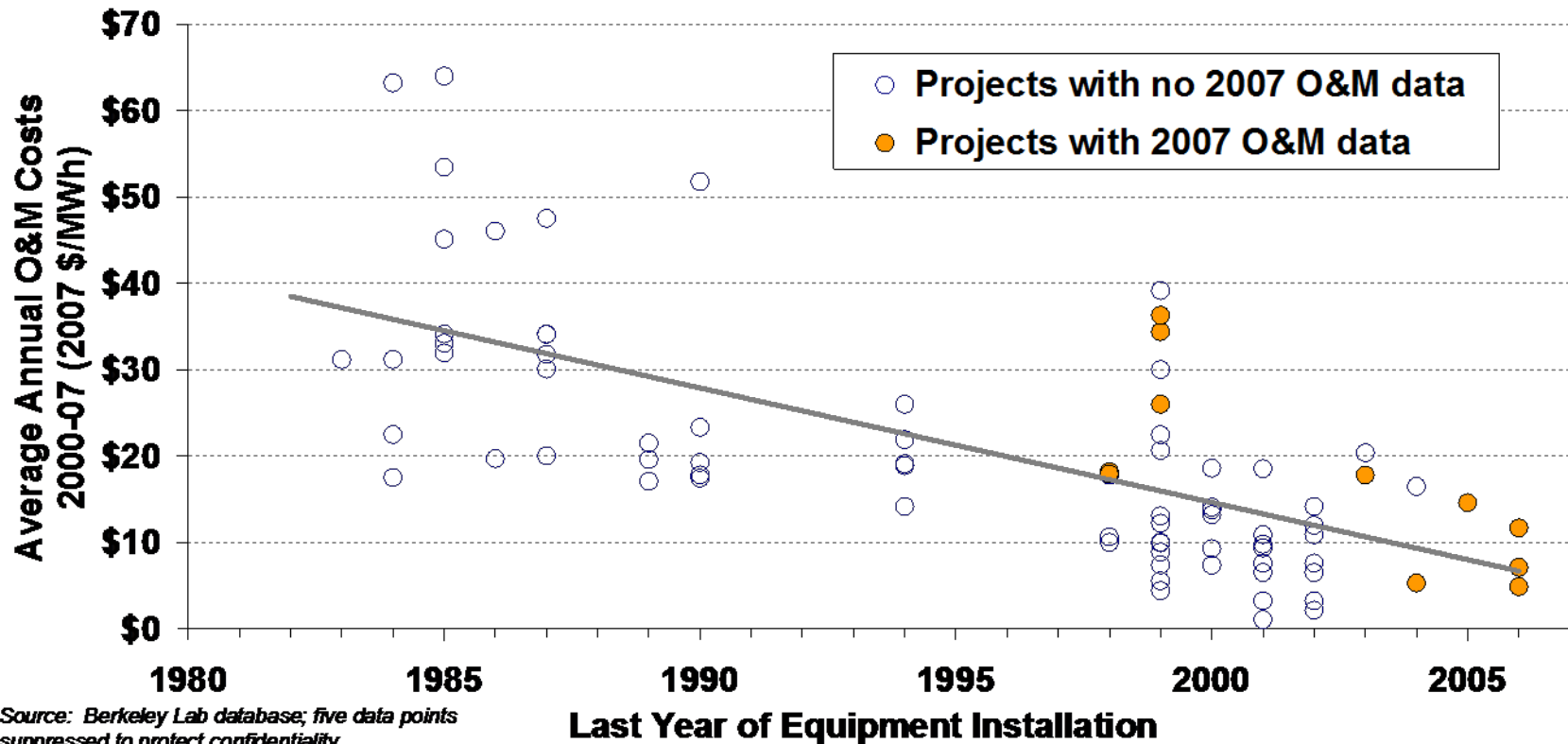


Source: Berkeley Lab database

- Sample size is problematic in several regions (New England, Great Lakes, Hawaii)
- Texas' relatively low average is heavily influenced by a single large project



Average Wind Project O&M Costs from 2000-07 Are Affected By Year of Installation



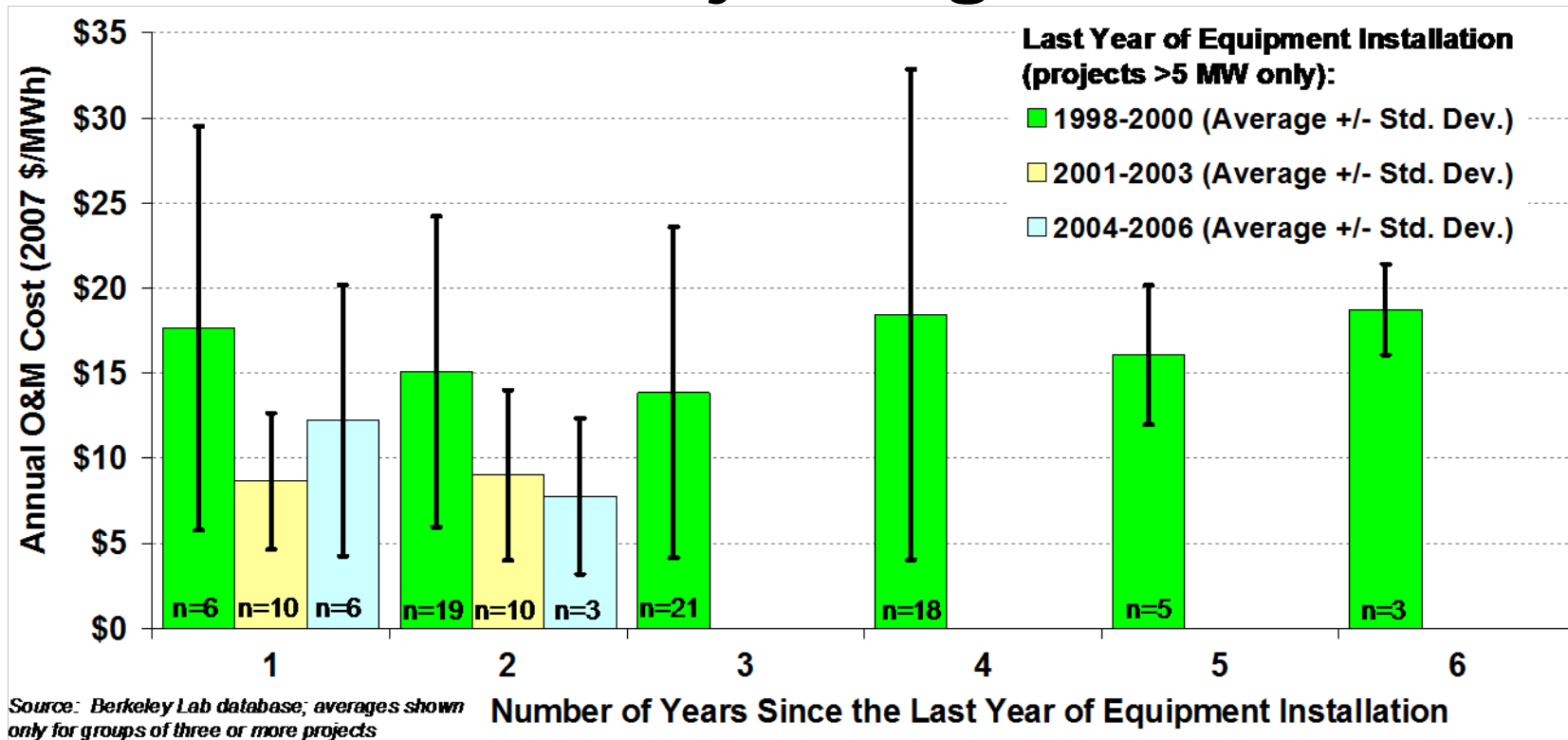
Source: Berkeley Lab database; five data points suppressed to protect confidentiality.

Capacity-weighted average 2000-07 O&M costs for projects built in 1980s equal **\$30/MWh**, dropping to **\$20/MWh** for projects built in 1990s, and to **\$9/MWh** for projects built in 2000s

Note: Sample is limited, and consists of 95 wind projects totaling 4,319 MW; few projects in sample have complete records of O&M costs from 2000-07



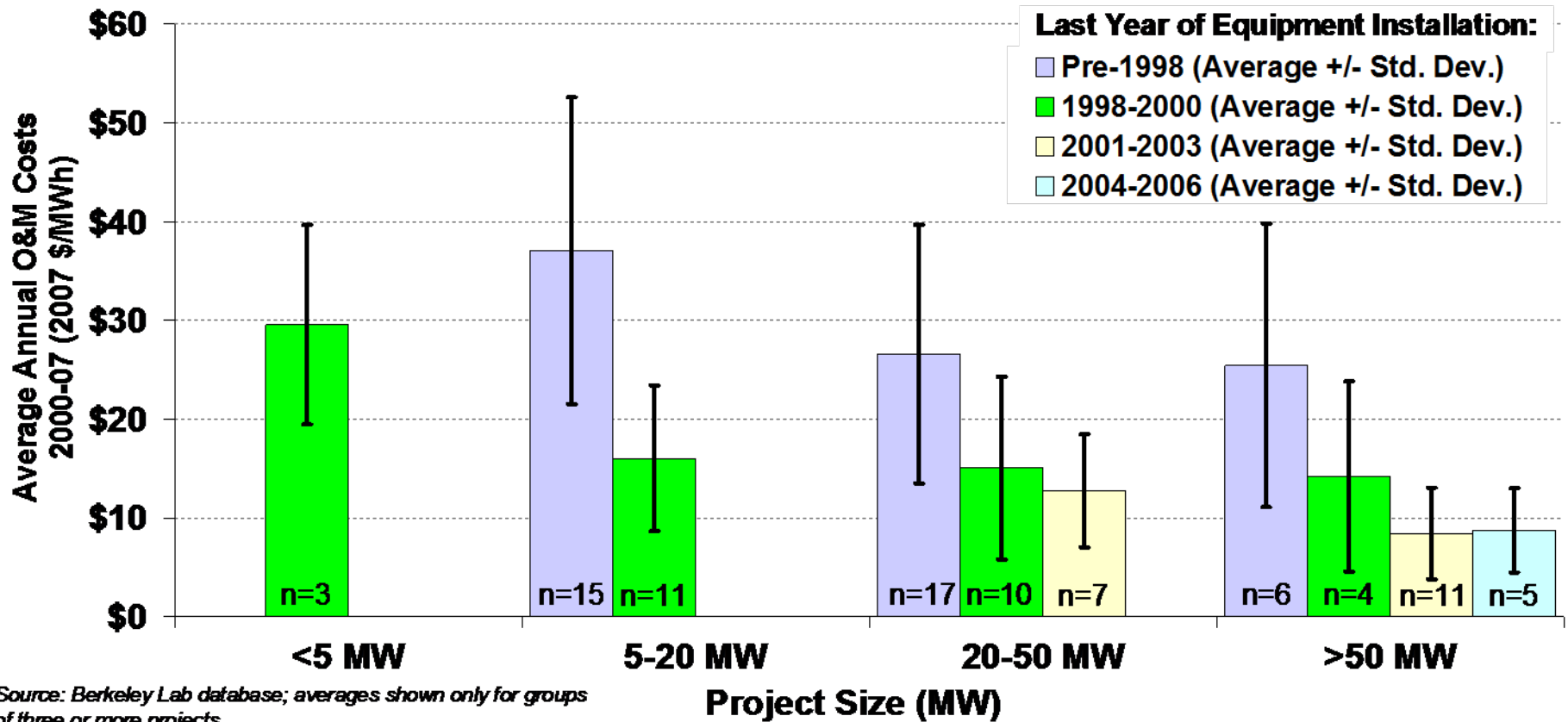
O&M Costs Appear to Decrease for Recently Constructed Projects, and Increase with Project Age



Note: Sample size is extremely limited; figure only includes projects over 5 MW in size and built from 1998-2006



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



Note: Sample size is extremely limited



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

Date	Study	Wind Capacity Penetration	Cost (\$/MWh)				
			Regulation	Load Following	Unit Commitment	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	20%	0	1.60	3.00	na	4.60
2006	CA RPS (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	10%	na	na	na	na	5.50
2007	Arizona Public 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

* regulation costs represent 3-year average

** highest over 3-year evaluation period

*** unit commitment includes cost of wind forecast error

Source: Berkeley Lab based, in part, on data from NREL.

- 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



Solutions to Transmission Barriers Began to Emerge in 2007, but Constraints Remain

- U.S. DOE *National Electric Transmission Congestion Report* designated two “national interest” corridors, in Southwest and Mid-Atlantic
- FERC issued Order 890 in February 2007
 - Adopts cost-based energy imbalance policy
 - Requires transmission providers to participate in local/regional planning process
 - Requires transmission providers to examine re-dispatch and conditional firm service
- FERC approved California ISO proposal for new interconnection category for location-constrained resources
- Several states began to proactively develop transmission infrastructure for wind
 - Texas PUC designated 5 Competitive Renewable Energy Zones (CREZ), with a potential 23 GW of wind, to which transmission could be built in advance of generation
 - Colorado initiated a similar process to identify Energy Resource Zones (ERZ)
 - Likewise, California launched the Renewable Energy Transmission Initiative (RETI) to identify renewable energy zones and prepare transmission plans to them
- Large number of transmission projects planned that include wind



Federal and State Policy Efforts in 2007 Continued to Drive Wind Development

- Federal PTC currently in place through 2008
- \$170 million of Clean Renewable Energy Bonds to 102 wind projects
- \$2.7 million of USDA 9006 grant awards to 7 “large wind” projects (8.2 MW)
- Four new state RPS policies (IL, NH, NC, OR), and many revisions to existing state RPS policies (additional state RPS activity has occurred in 2008)
- State renewable funds, tax incentives, utility planning, green power, and growing interest in carbon regulation all also played a role in 2007



Coming Up in 2008

- Rising wind power prices, transmission availability, siting and permitting conflicts, and other barriers to wind development remain
- Nonetheless, 2008 is expected to be another banner year for the U.S. wind industry, with >5,000 MW projected
- Drivers include rising cost of fossil generation, mounting possibility of carbon regulation, increasing state support for wind, and looming PTC expiration
- Unless the PTC is soon extended beyond 2008, 2009 could be a year of retrenchment



For More Information...

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

- <http://www1.eere.energy.gov/windandhydro/>

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