U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

# 2009 Wind Technologies Market Report

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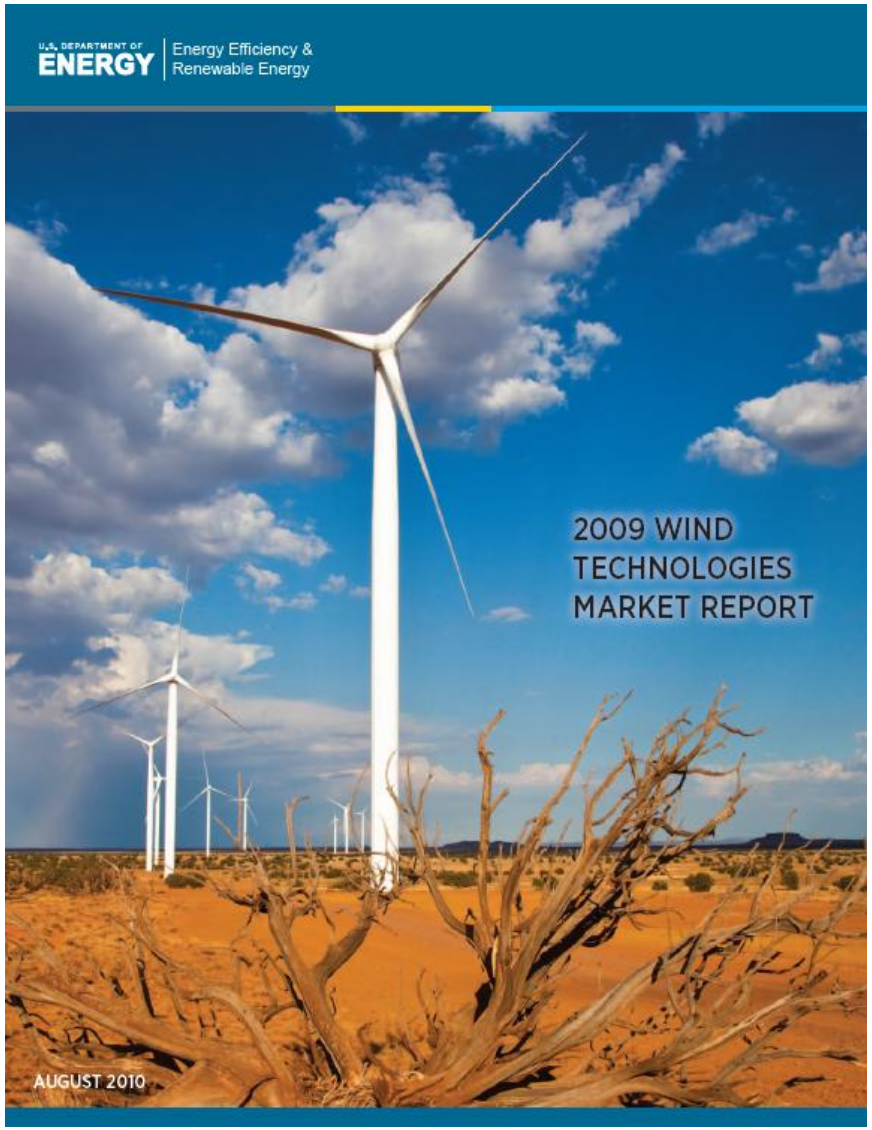
**Report Summary**

**August 2010**

# Presentation Overview

- Introduction to 2009 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



# 2009 Wind Technologies Market Report

## Purpose, Scope, and Data:

- With a focus on 2009, 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 100 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 Associates, NREL

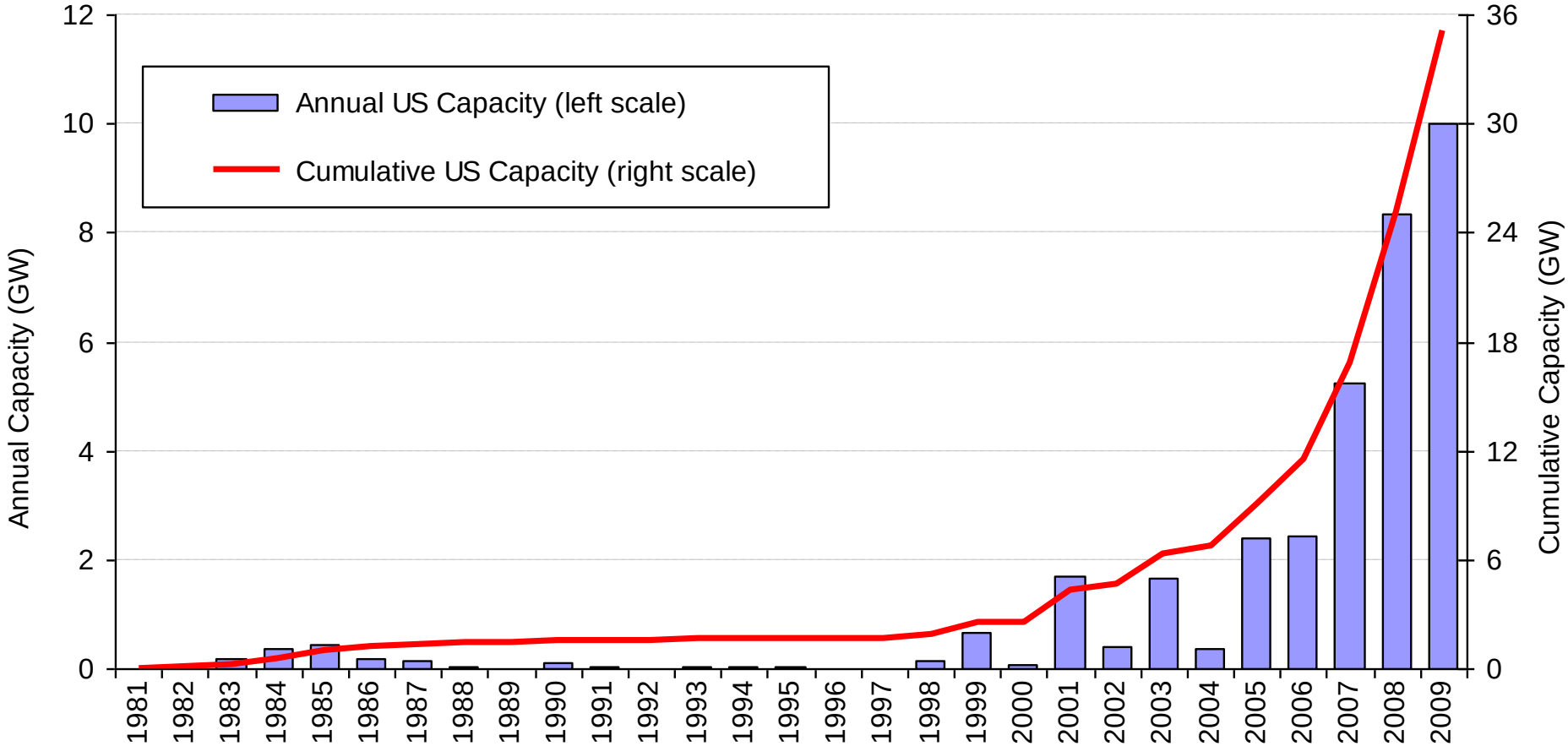
**Available at:** http://windandwater.energy.gov/

# New to the 2009 Edition of the Report

- Turbine and component imports into the U.S., and import share
- Trends in hub height and rotor diameter of installed projects
- Expanded discussion of the offshore wind energy sector
- Data on wind power curtailment in Texas and the Midwest
- Impact of the *Recovery Act* on the U.S. wind power industry

# Installation Trends

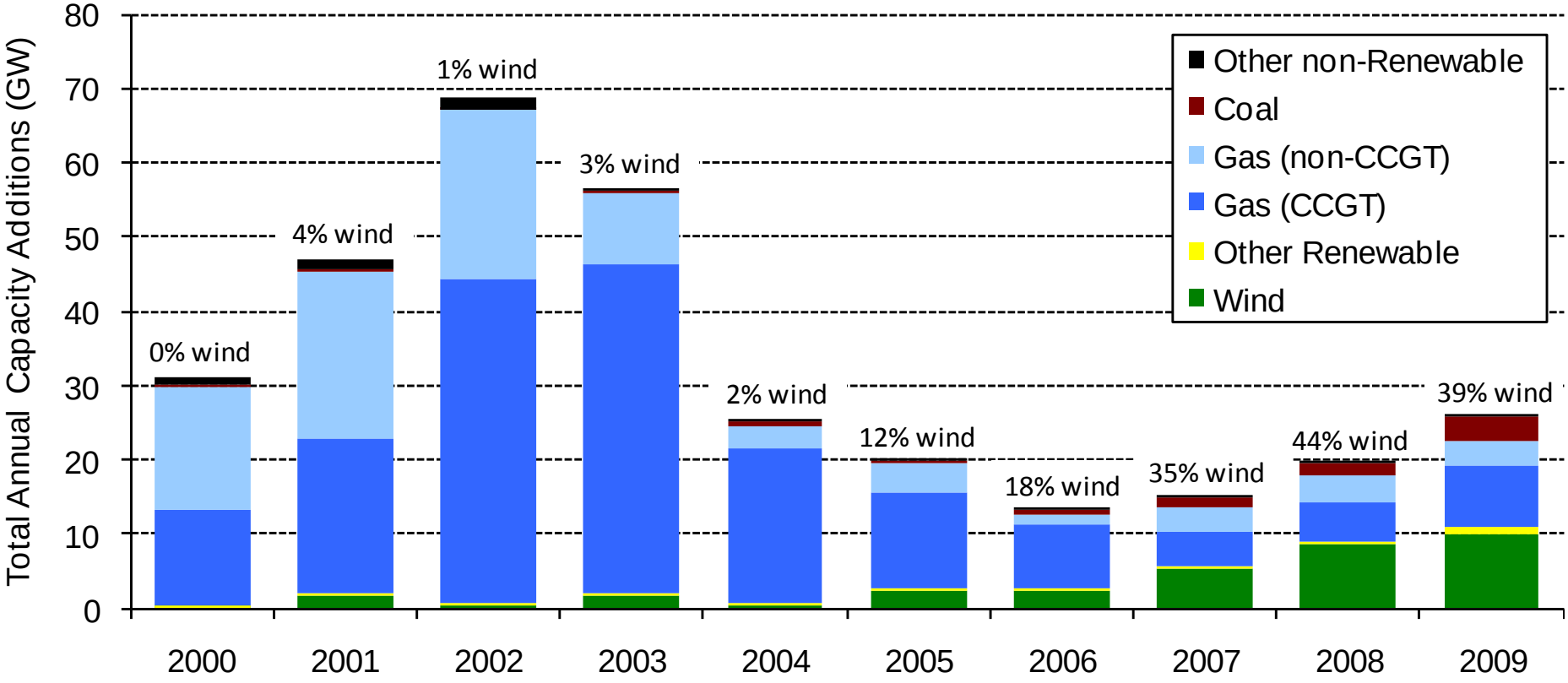
# U.S. Wind Power Capacity Up >40% in 2009




**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

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



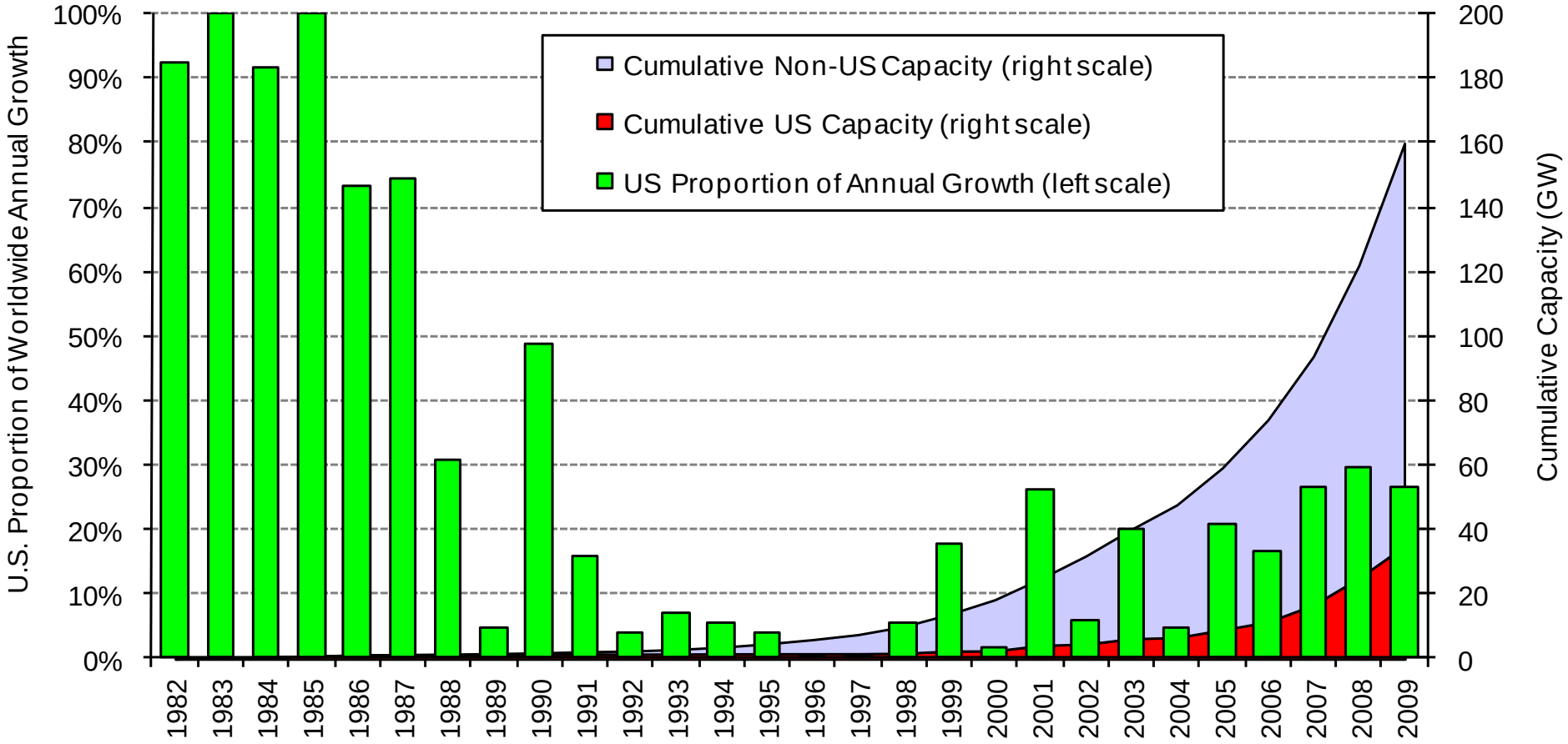

Wind was the 2nd-largest resource added for the 5th-straight year

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

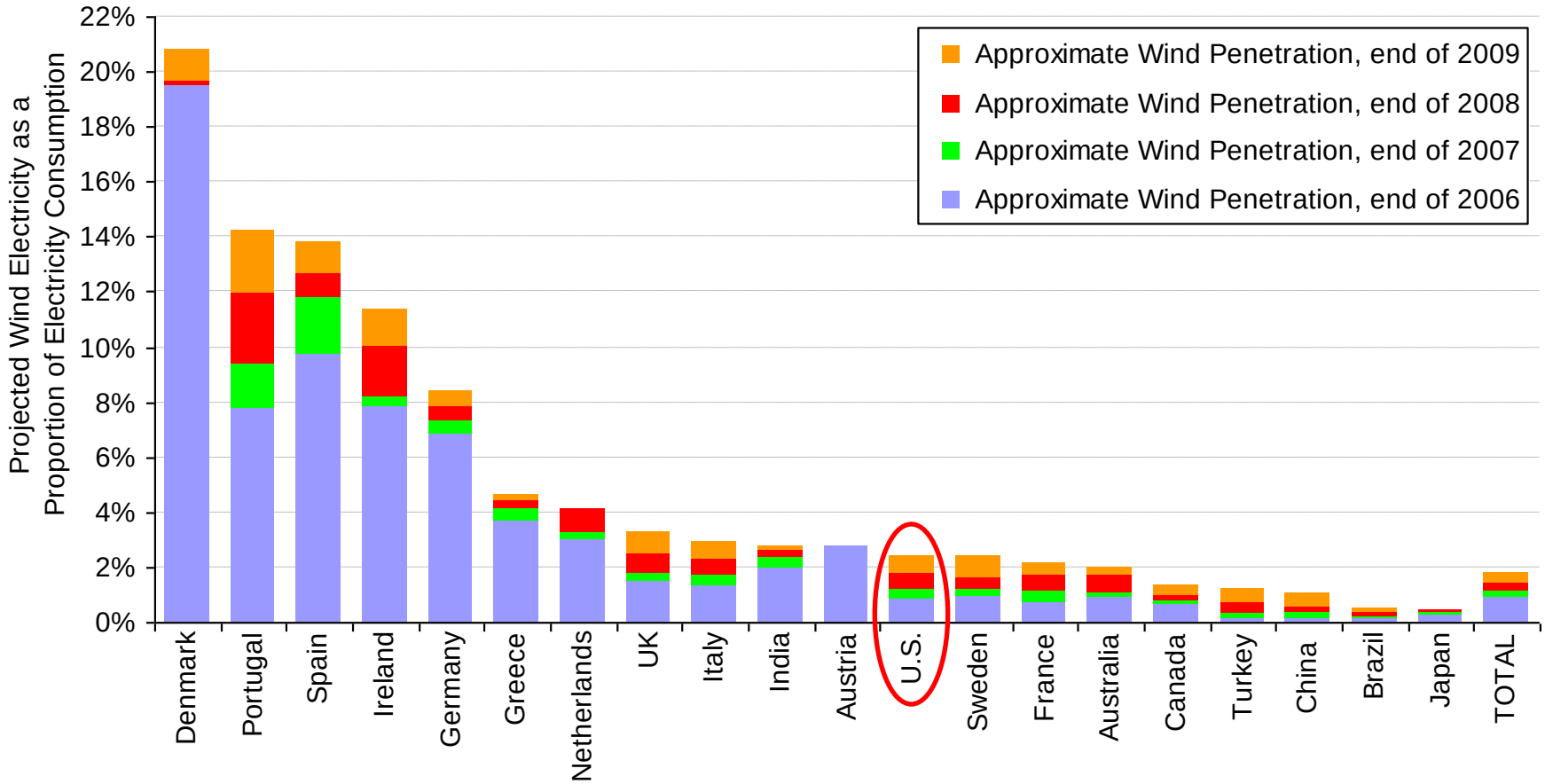
| Annual Capacity (2009, MW) | | Cumulative Capacity (end of 2009, MW) | |
|---|---|---|---|
| China | 13,750 | **U.S.** | **35,155** |
| **U.S.** | **9,994** | China | 25,853 |
| Spain | 2,331 | Germany | 25,813 |
| Germany | 1,917 | Spain | 18,784 |
| India | 1,172 | India | 10,827 |
| Italy | 1,114 | 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. Share of Global Wind Power Capacity: 26% of 2009 Additions, 22% of Cumulative

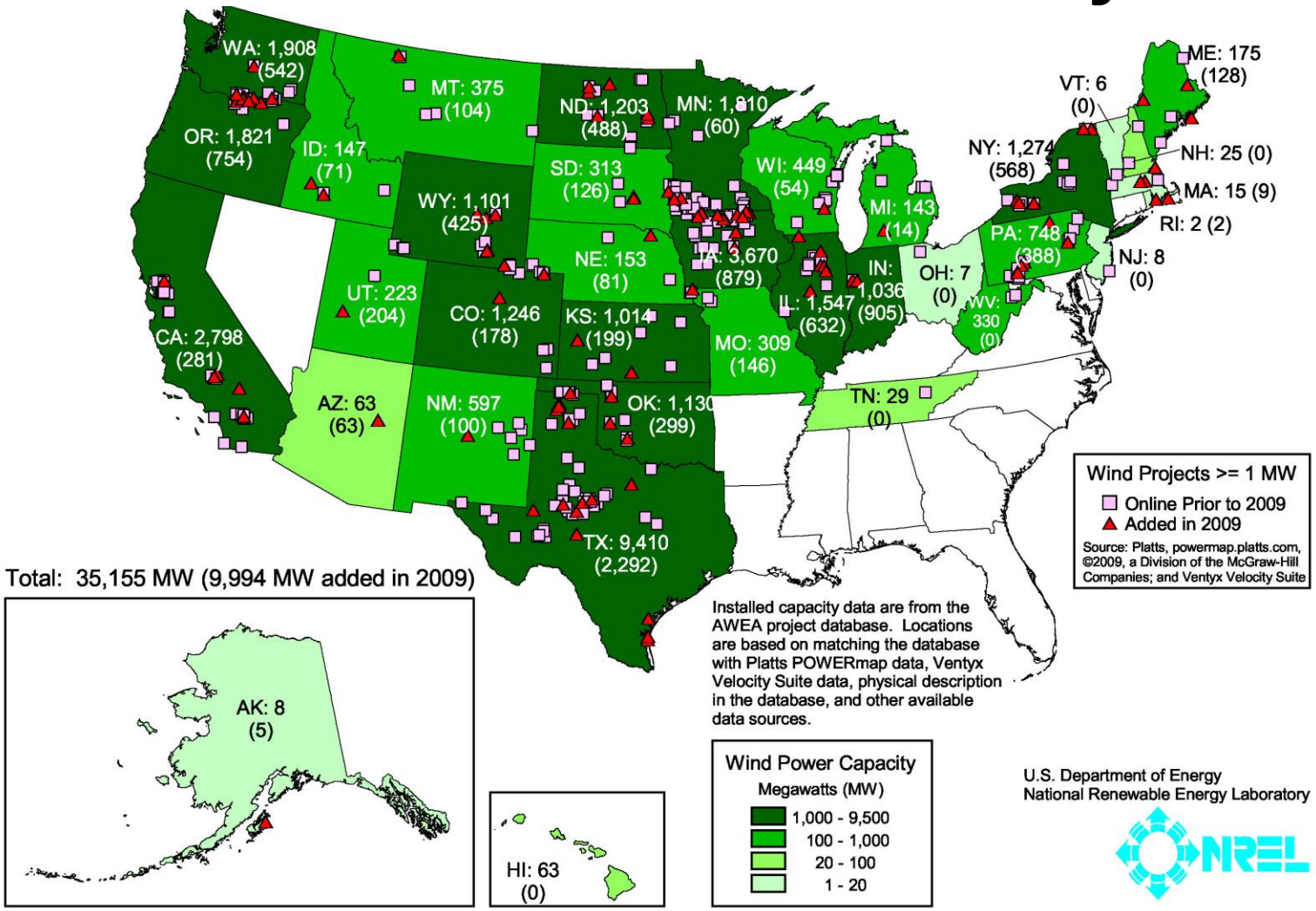


# U.S Lagging Other Countries in Wind As a Percentage of Electricity Consumption




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

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



# 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%)

# Wind Now >10% of Nine Utilities' Sales

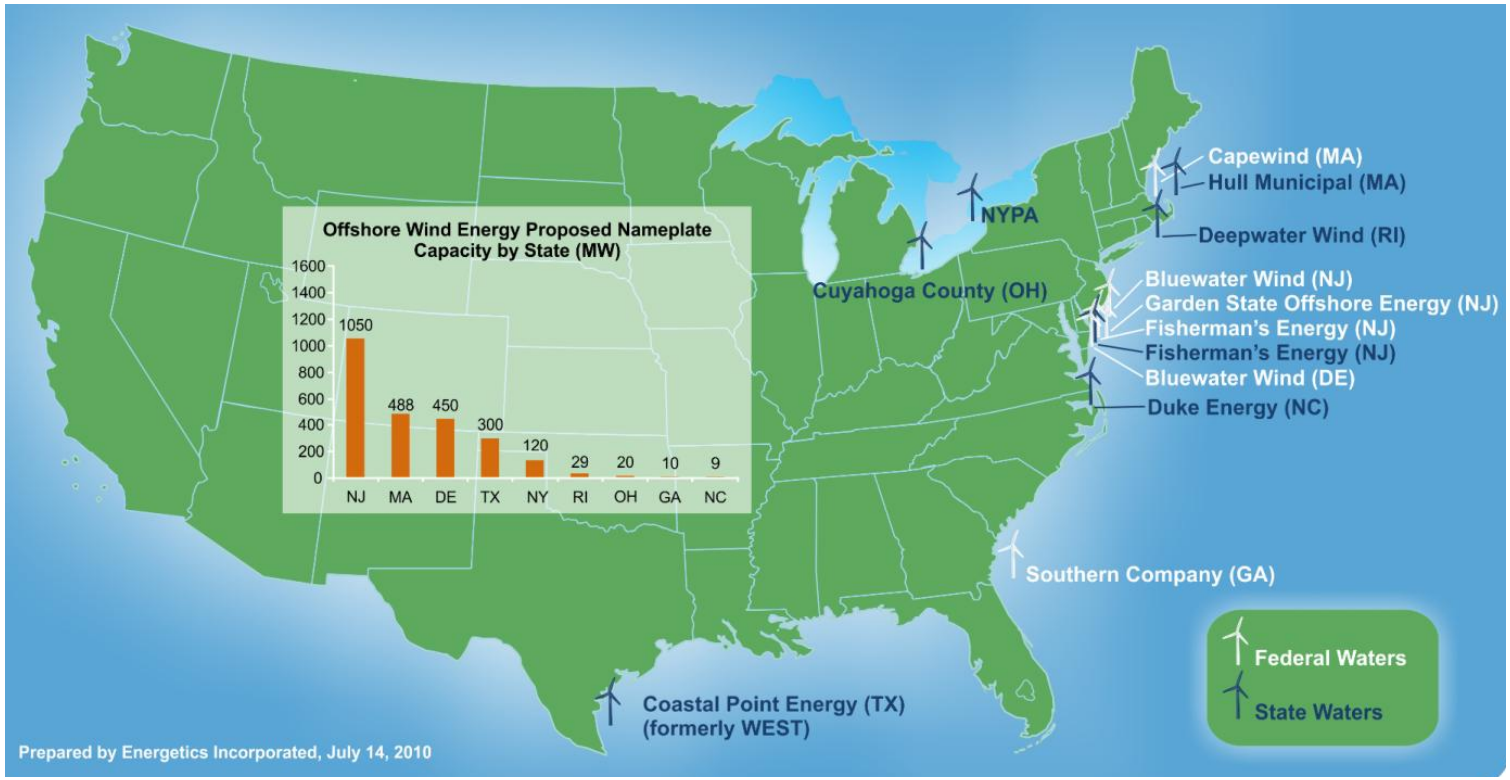
| Total Wind Capacity (end of 2009, MW) | |
|---|---|
| Xcel Energy | 3,176 |
| MidAmerican Energy | 2,923 |
| Southern California Edison | 1,772 |
| American Electric Power | 1,196 |
| Pacific Gas & Electric | 1,131 |
| Luminant | 913 |
| Alliant Energy | 645 |
| City Public Service of San Antonio | 579 |
| Puget Sound Energy | 479 |
| Austin Energy | 439 |
| First Energy | 376 |
| Portland General Electric | 375 |
| Minnkota Power Cooperative | 357 |
| Basin Electric | 352 |
| SDG&E | 342 |
| Great River Energy | 319 |
| Westar | 295 |
| Oklahoma Gas & Electric | 272 |
| Empire District Electric Company | 255 |
| SCPPA (not including LADWP) | 233 |

| Estimated Percentage of Retail Sales (for utilities with > 100 MW of wind) | |
|---|---|
| Minnkota Power Cooperative | 38.0% |
| Empire District Electric Company | 18.1% |
| Turlock Irrigation District | 18.0% |
| Otter Tail Power | 14.0% |
| Sunflower Electric Power Corp. | 13.2% |
| Xcel Energy | 11.1% |
| Austin Energy | 10.3% |
| Great River Energy | 10.1% |
| Westar | 10.1% |
| Western Farmers' Electric Cooperative | 9.8% |
| MidAmerican Energy | 9.6% |
| Snohomish PUD | 8.5% |
| MSR Public Power Agency | 8.4% |
| City Public Service of San Antonio | 8.4% |
| Public Service New Mexico | 6.8% |
| Cowlitz PUD | 6.5% |
| WPPI Energy | 6.4% |
| Alliant Energy | 5.9% |
| Puget Sound Energy | 5.4% |
| Northwestern Energy | 5.3% |

*Source: AWEA, EIA, Berkeley Lab estimates*

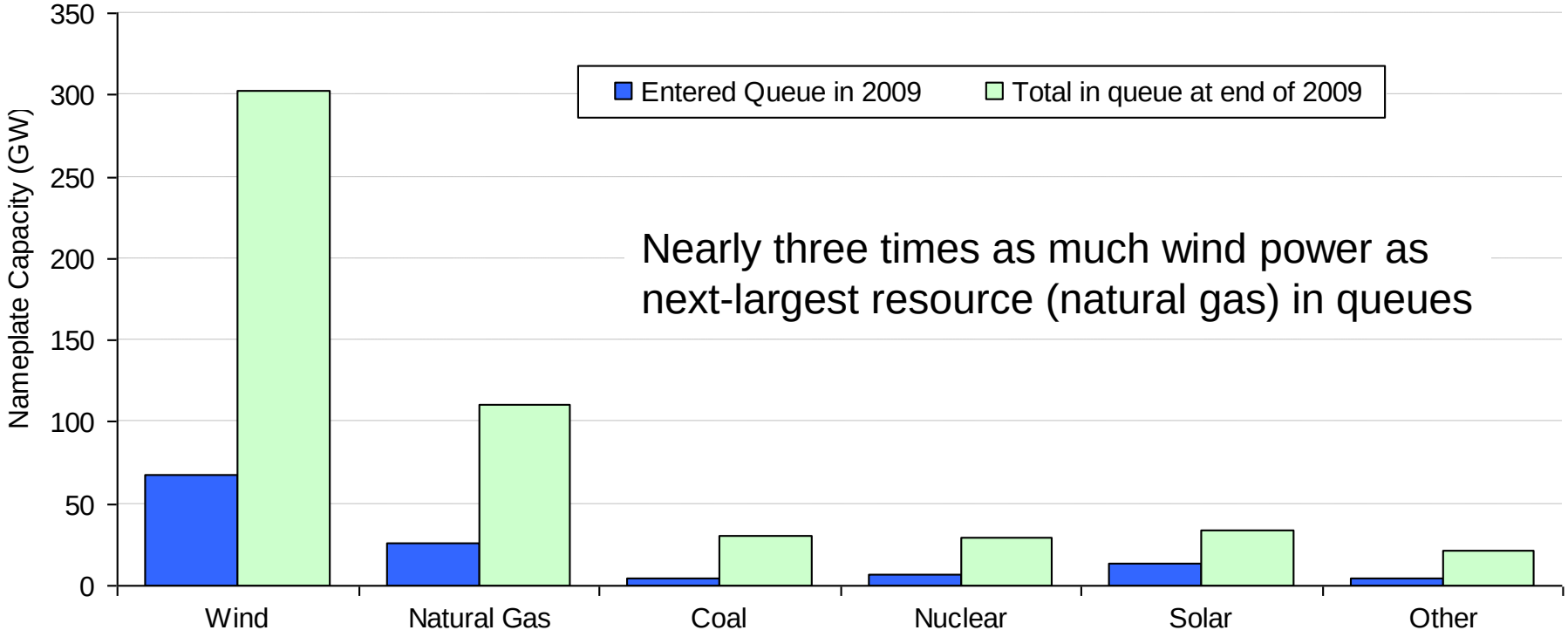
*See full report for the many assumptions used to generate the data in this table*

# No Offshore Projects Have Been Built in the U.S., But 13 Projects Are At a More-Advanced Permitting/Development Stage



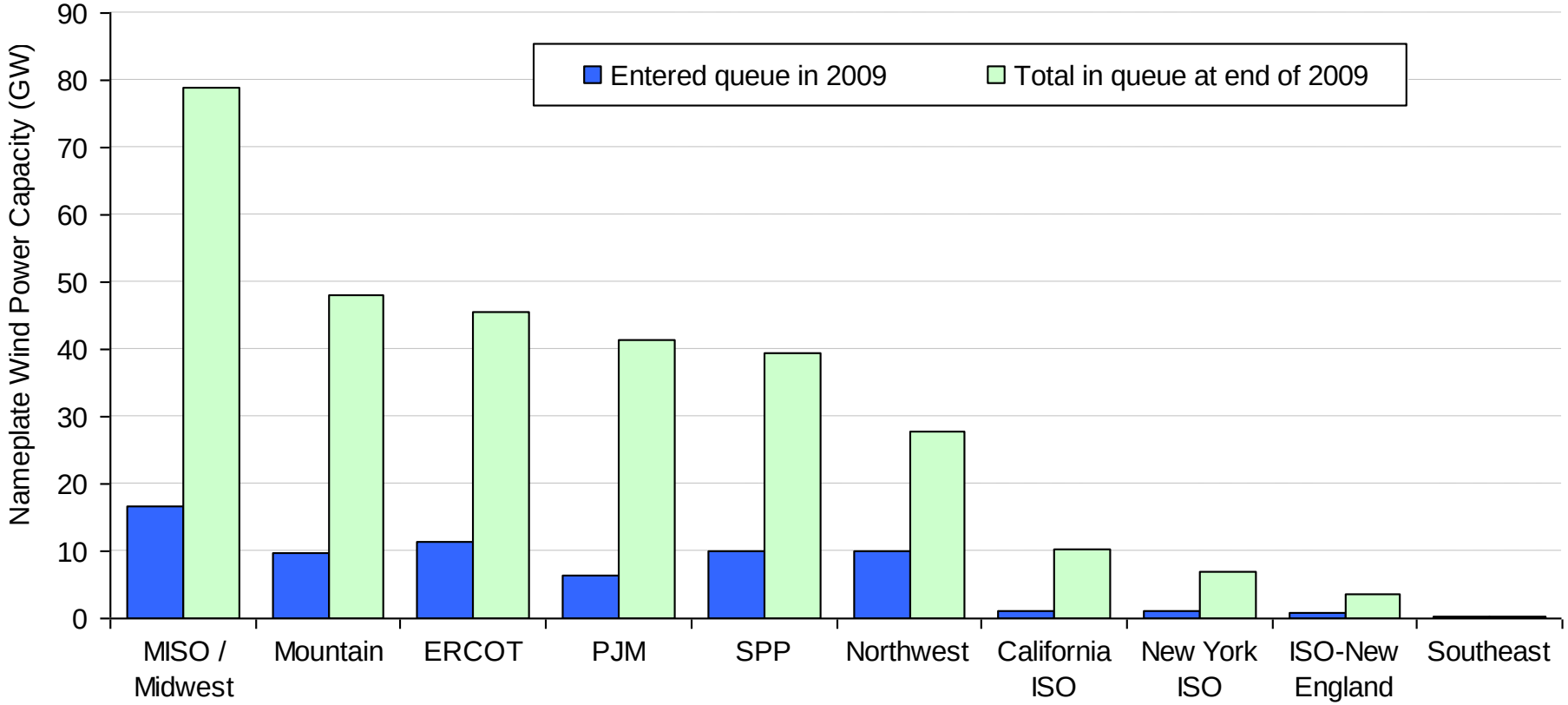

- Three projects have signed or proposed power purchase agreements
- Cape Wind granted approval by Department of Interior in April 2010

# Roughly 300 GW of Wind Power Capacity in Transmission Interconnection Queues




***Not all of this capacity will be built….***

# >90% Planned for Midwest, Mountain, ERCOT, PJM, SPP, and Northwest Regions




***Not all of this capacity will be built….***

# Market for Small Wind Turbines Continued to Grow in 2009

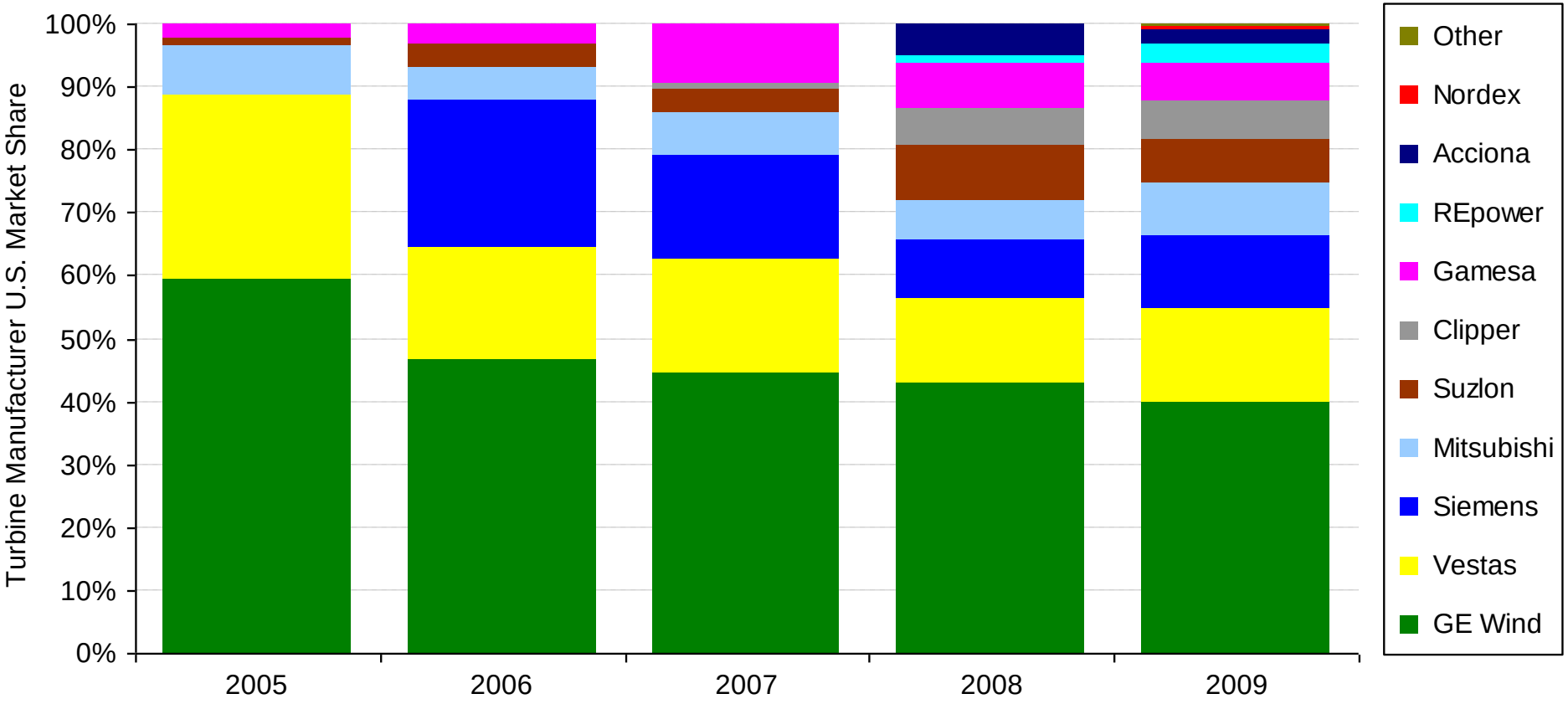
| Year | Annual Sales of Small Wind Turbines into the United States | | |
|---|---|---|---|
| | Number of Turbines | Capacity Additions | Sales Revenue |
| 2005 | 4,324 | 3.3 MW | $10 million |
| 2006 | 8,329 | 8.6 MW | $33 million |
| 2007 | 9,092 | 9.7 MW | $42 million |
| 2008 | 10,386 | 17.4 MW |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

# Industry Trends

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

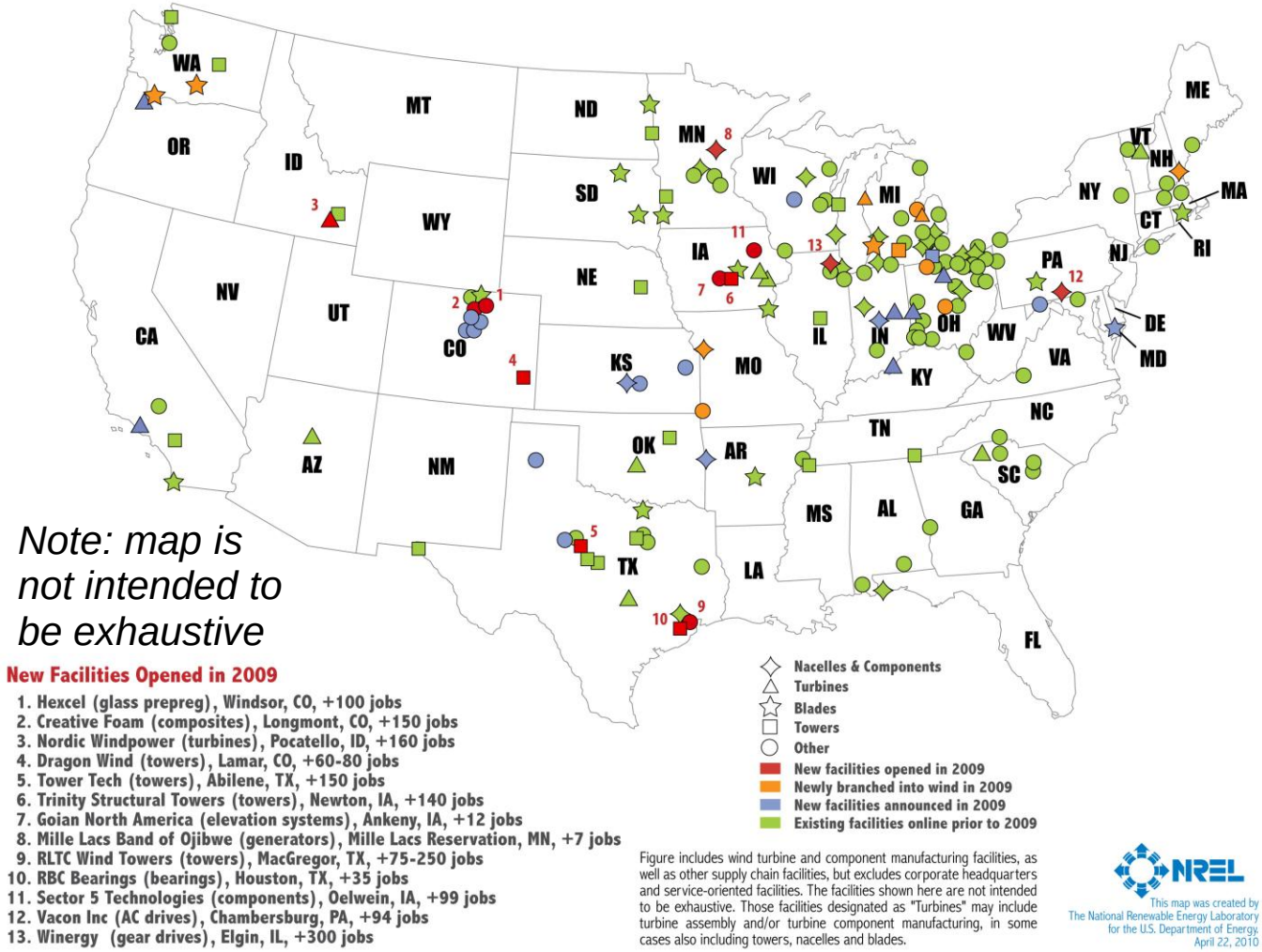


# Most Wind Turbine Vendors Active in the U.S. Market Saw Growth in 2009

| Manufacturer | Turbine Installations (MW) | | | | |
|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 |
| GE Wind | 1,433 | 1,146 | 2,342 | 3,585 | 3,995 |
| Vestas | 700 | 439 | 948 | 1,120 | 1,490 |
| Siemens | 0 | 573 | 863 | 791 | 1,162 |
| Mitsubishi | 190 | 128 | 356 | 516 | 814 |
| Suzlon | 25 | 92 | 197 | 736 | 702 |
| Clipper | 3 | 0 | 48 | 470 | 605 |
| Gamesa | 50 | 74 | 494 | 616 | 600 |
| REPower | 0 | 0 | 0 | 94 | 330 |
| Acciona | 0 | 0 | 0 | 410 | 204 |
| Nordex | 0 | 0 | 3 | 0 | 63 |
| Other | 2 | 2 | 0 | 12 | 31 |
| **TOTAL** | **2,402** | **2,454** | **5,249** | **8,350** | **9,994** |

- Chinese and South Korean manufacturers seeking entry into U.S. market
- For first time in 2009, a turbine vendor from China (Goldwind) saw sales in the U.S.

# U.S. Wind Turbine Manufacturing Strong, But With Slower Growth




*Note: map is not intended to be exhaustive*

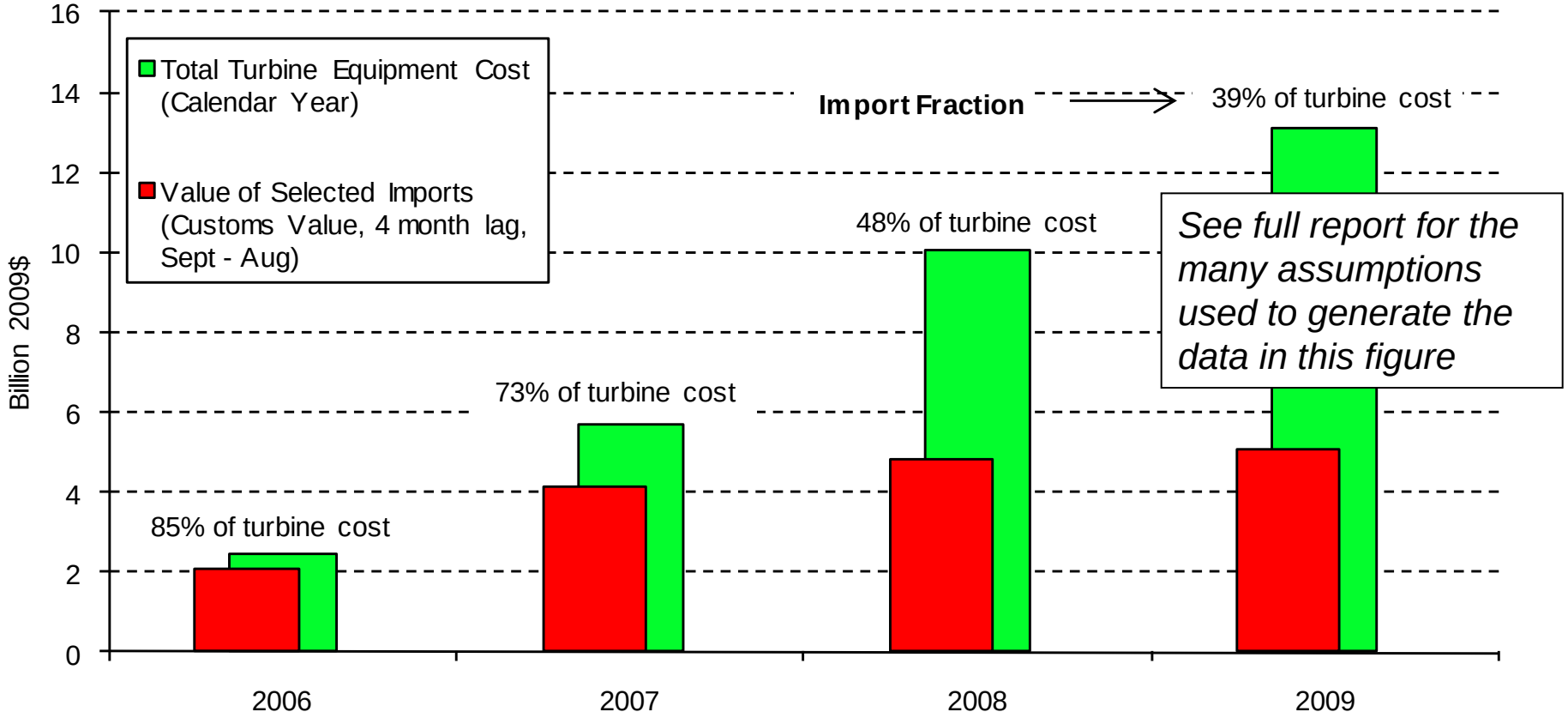
**New Facilities Opened in 2009**

1. Hexcel (glass prepreg), Windsor, CO, +100 jobs
2. Creative Foam (composites), Longmont, CO, +150 jobs
3. Nordic Windpower (turbines), Pocatello, ID, +160 jobs
4. Dragon Wind (towers), Lamar, CO, +60-80 jobs
5. Tower Tech (towers), Abilene, TX, +150 jobs
6. Trinity Structural Towers (towers), Newton, IA, +140 jobs
7. Goian North America (elevation systems), Ankeny, IA, +12 jobs
8. Mille Lacs Band of Ojibwe (generators), Mille Lacs Reservation, MN, +7 jobs
9. RLTC Wind Towers (towers), MacGregor, TX, +75-250 jobs
10. RBC Bearings (bearings), Houston, TX, +35 jobs
11. Sector 5 Technologies (components), Oelwein, IA, +99 jobs
12. Vacon Inc (AC drives), Chambersburg, PA, +94 jobs
13. Winergy (gear drives), Elgin, IL, +300 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, nacelles and blades.

- 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

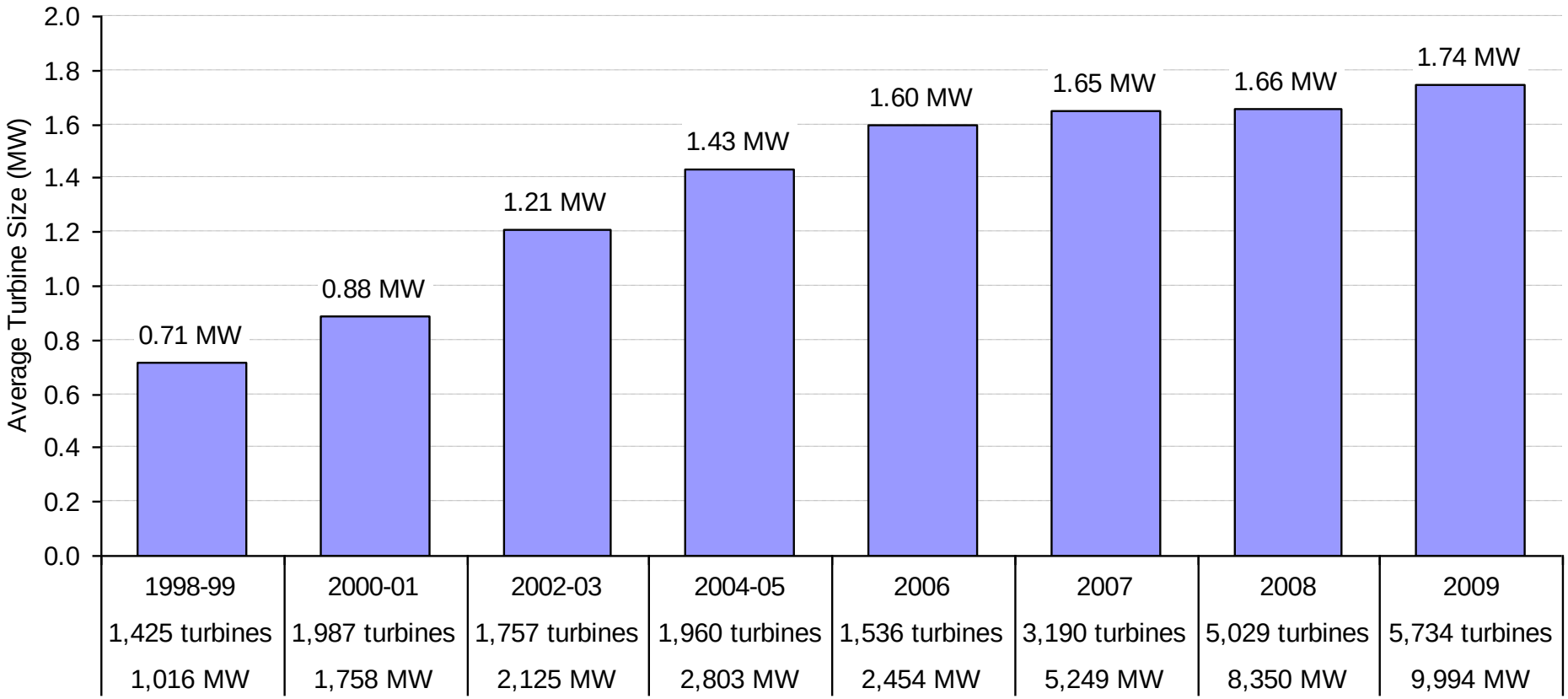
# A Growing % of Equipment Used in U.S. Projects Has Been Sourced Domestically




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

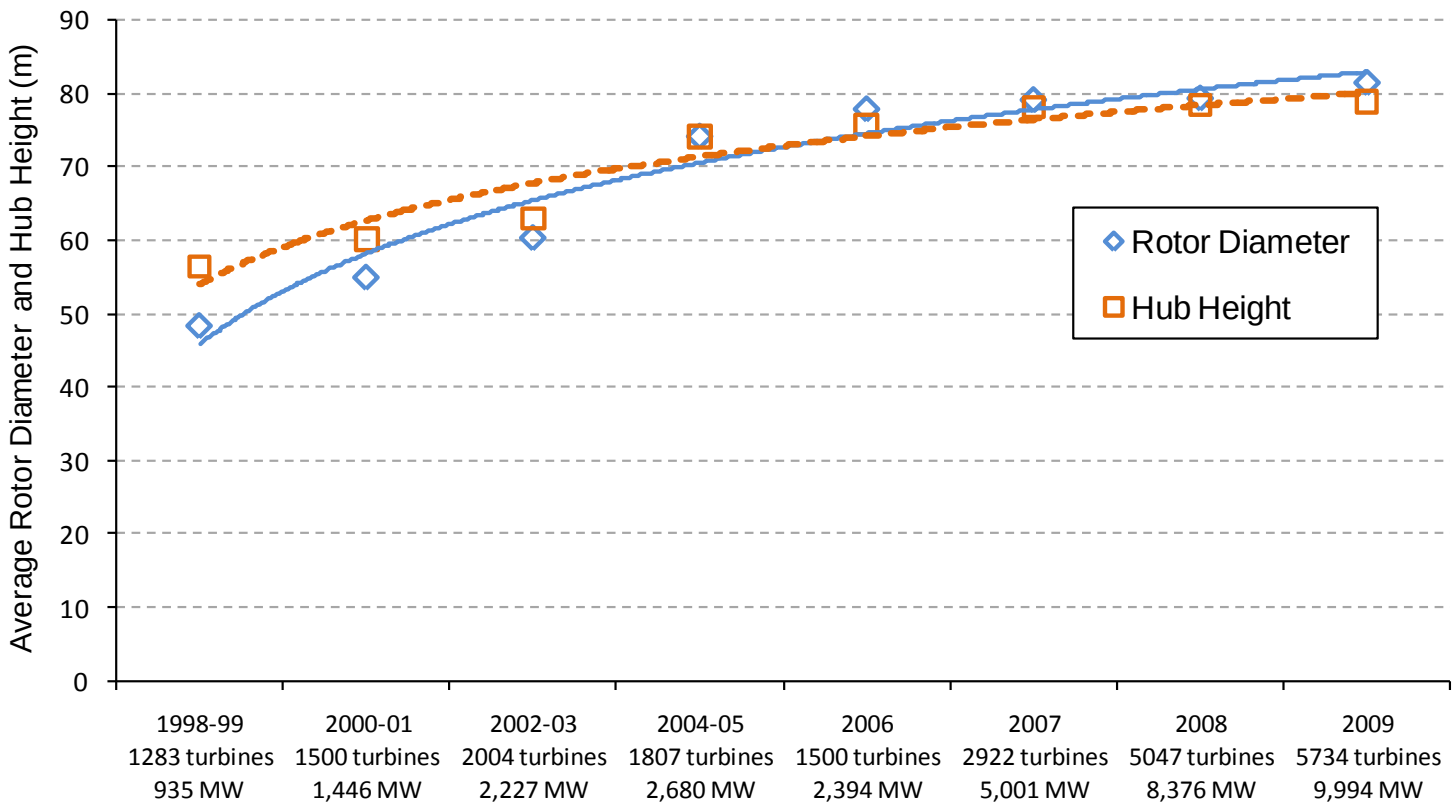
- U.S. is largest importer of wind equipment; 7th largest exporter
- Wind power capacity growth has outpaced import growth

# Average Turbine Size Higher in 2009



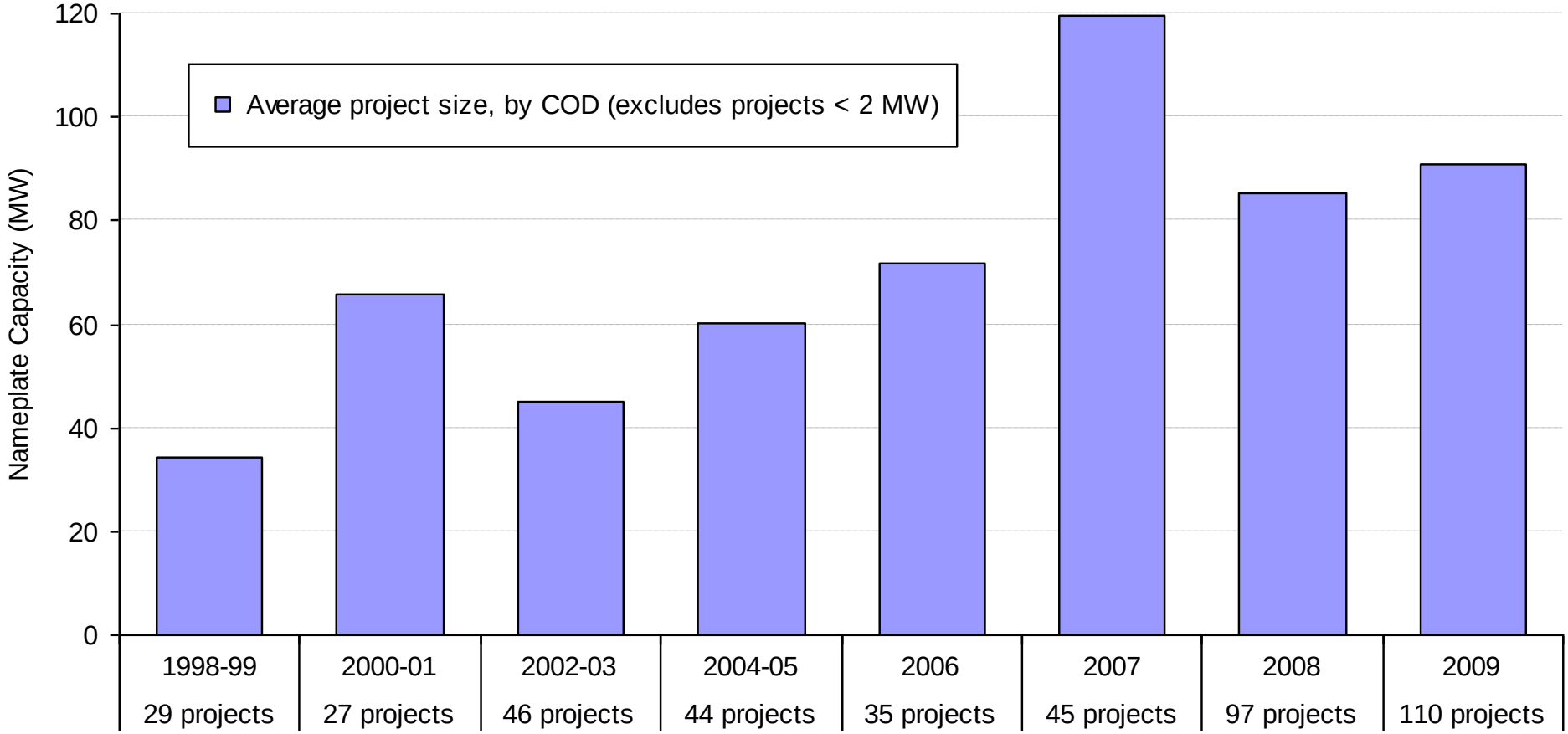

25% of turbines installed in 2009 were larger than 2.0 MW, up from 19% in 2008, 16% in 2006 & 2007, and just 0.1% in 2004-05

# Average Hub Heights and Rotor Diameters Have Increased Over Time




On average, since 1998-99, hub heights are 22 meters (39%) higher and rotor diameters are 33 meters (69%) larger

# Average Project Size Resumed Its Upward Trend in 2009



# Developer Consolidation Continued in 2009

- But acquisitions and investments still below 2006-2007 pace:
  - **2009:** 6 deals = 18 GW of wind development pipeline
  - **2008:** 5 deals = 19 GW
  - **2007:** 11 deals = 37 GW
  - **2006:** 12 deals = 34 GW
  - **2005:** 8 deals = 11 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 | U.S. 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 |
| Riverstone Holdings | Acquisition | Babcock & Brown | Jun-09 |
| Terra Firma | Acquisition | Everpower Wind | Aug-09 |
| APEX Wind Energy | Acquisition | BQ Energy, LLC | Jun-09 |
| Global Infrastructure Partners | Investment | Terra-Gen Power Holdings | Nov-09 |
| NRG Energy | Acquisition | Bluewater Wind | Nov-09 |
| Enel | Investment | Geronimo Wind | Nov-09 |

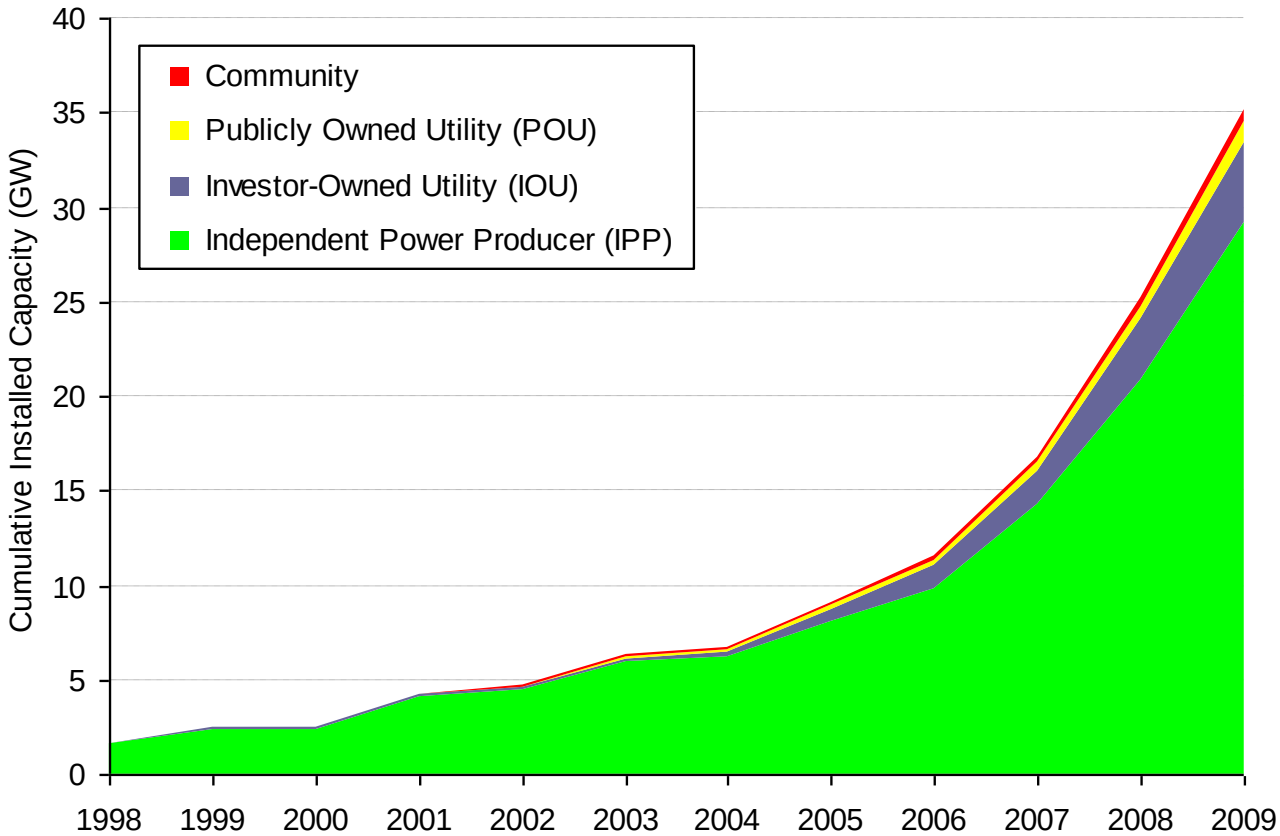
* Select list of announced transactions; excludes joint development activity

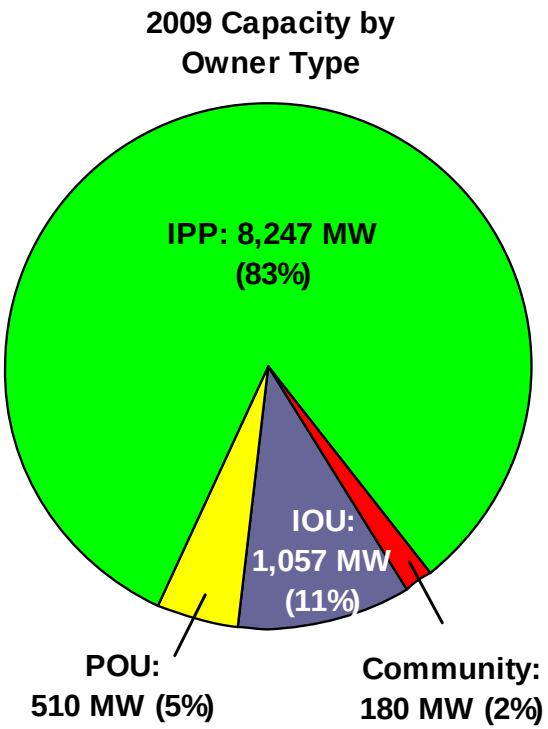
*Source: Berkeley Lab*

# Treasury Cash Grant Expanded Financing Options, Buoyed the Wind Sector

- Section 1603 of Recovery Act allows choice of a cash grant in lieu of the PTC or ITC
  - Reduces dependence on tax equity investors
  - Enables greater use of project-level term debt instead of tax equity
- 6400 MW (>64%) of wind power capacity built in 2009 used grant
  - As much as 2400 MW may not have been built in 2009 absent the grant
  - Only about 7 of >60 projects that chose grant used third-party tax equity
- Efforts to extend the grant program focus on continued shortage of tax equity in the market
- Lenders (both banks and insurance companies) now back in the market, and with improving terms
- Relatively weak demand for federal loan guarantees

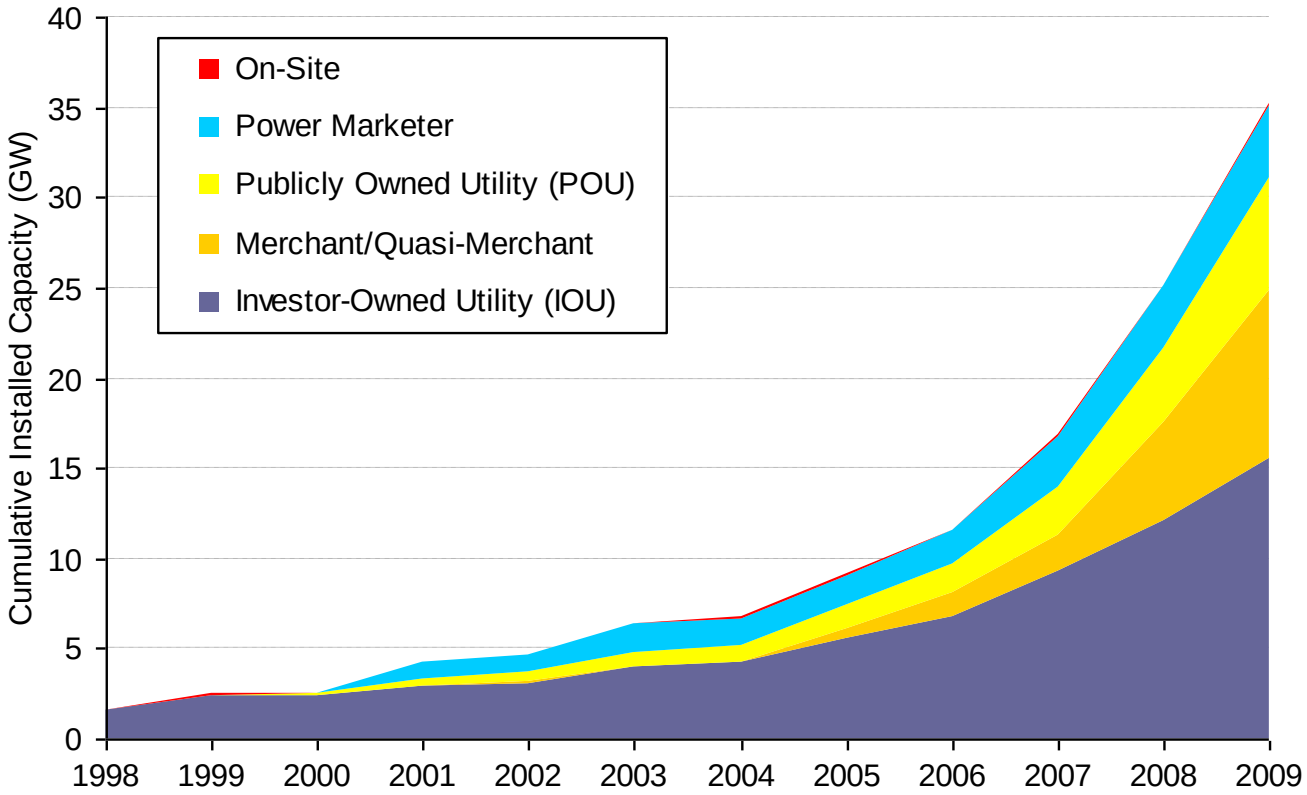
# IPP Project Ownership Remained Dominant

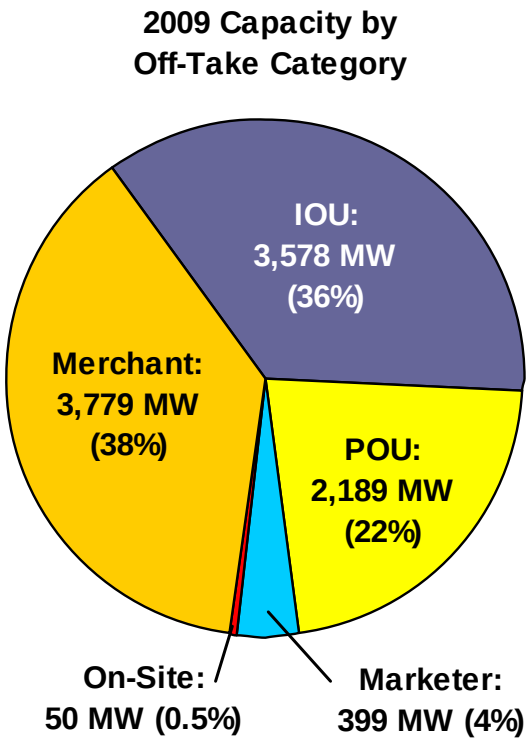



- Utility ownership held steady in 2009
- Community wind market share stagnant since 2004

# Contracted Sales to Utilities Remained the Most Common Sales Arrangement



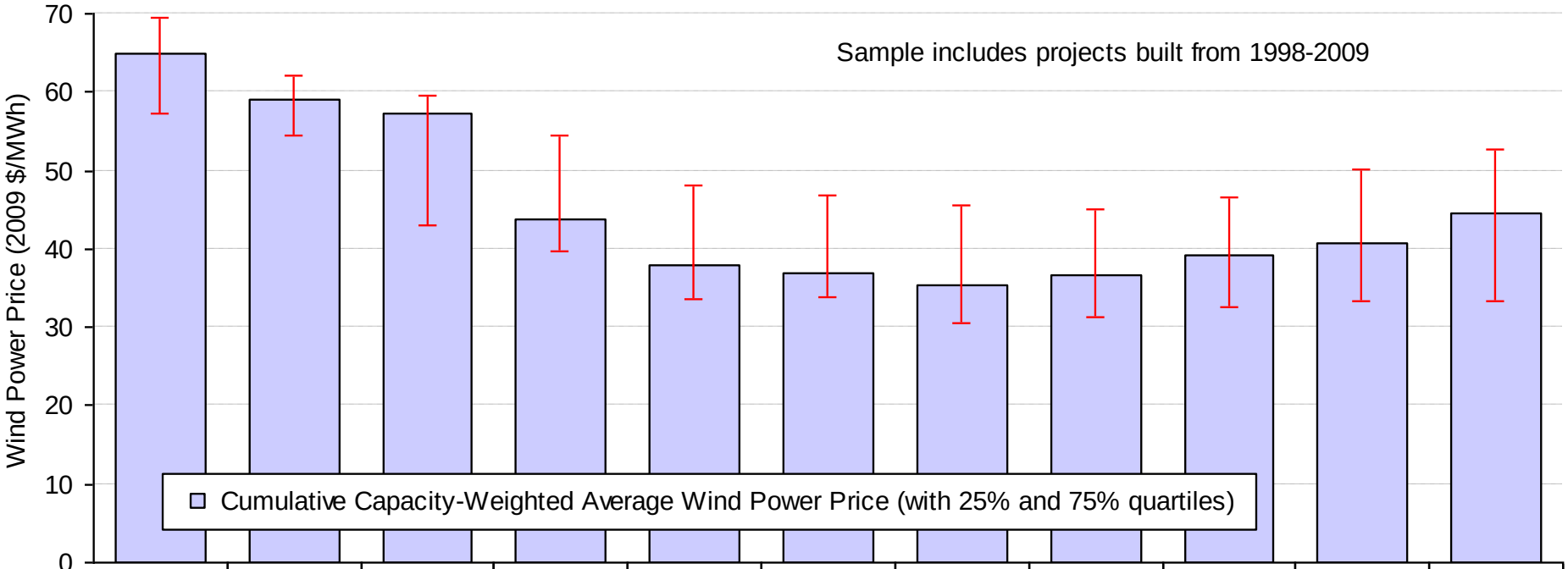

But "merchant" plants were surprisingly (due to tight credit and sharply lower wholesale power prices) popular in 2009

# Price, Cost, and Performance Trends

# Upward Pressure on Wind Power Prices Continued in 2009

- Berkeley Lab maintains a database of wind power sales prices; next few slides present data from that database
- Sample includes 180 projects built from 1998-2009, totaling 12,813 MW (38% 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 or Treasury grant); as a result, prices do not reflect wind energy generation costs -- prices would be higher were state/federal incentives not available

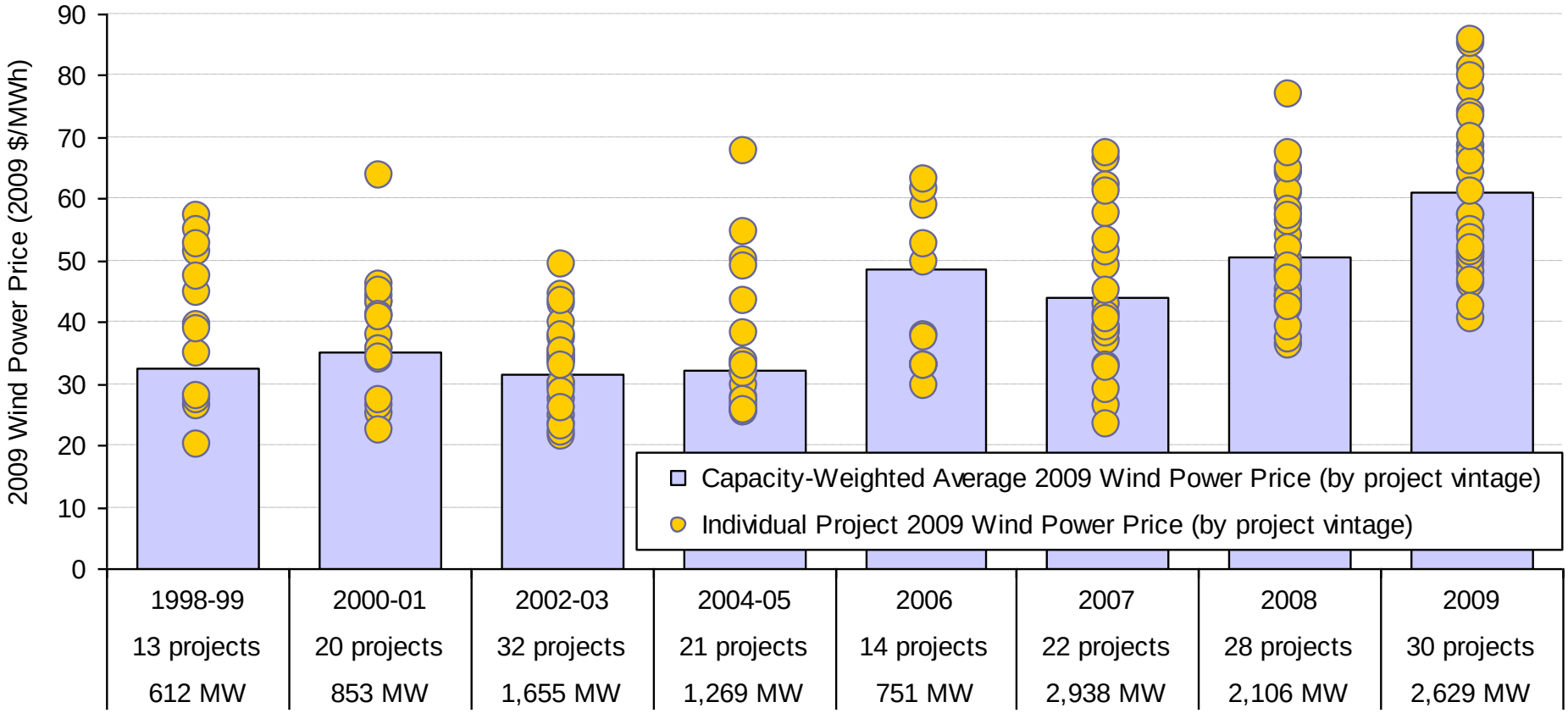
# Cumulative Average Sales Price for Sample of Projects Built After 1997 Low But Rising




| 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 |

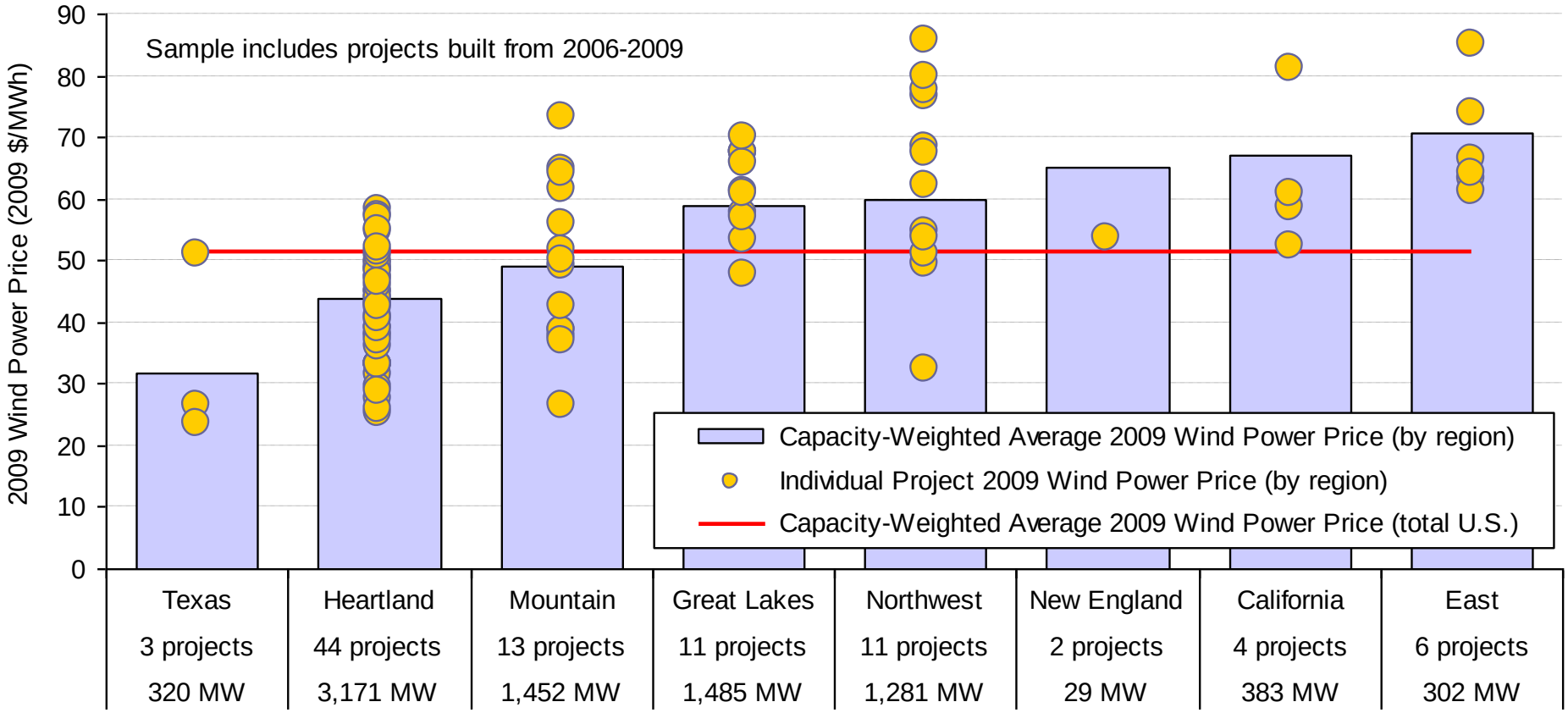
Increase in prices since 2005 due to rising prices from newly built projects, but cumulative nature of graphic mutes degree of apparent price increase

# Binning by Commercial Operation Date Shows that Prices Have Increased Recently



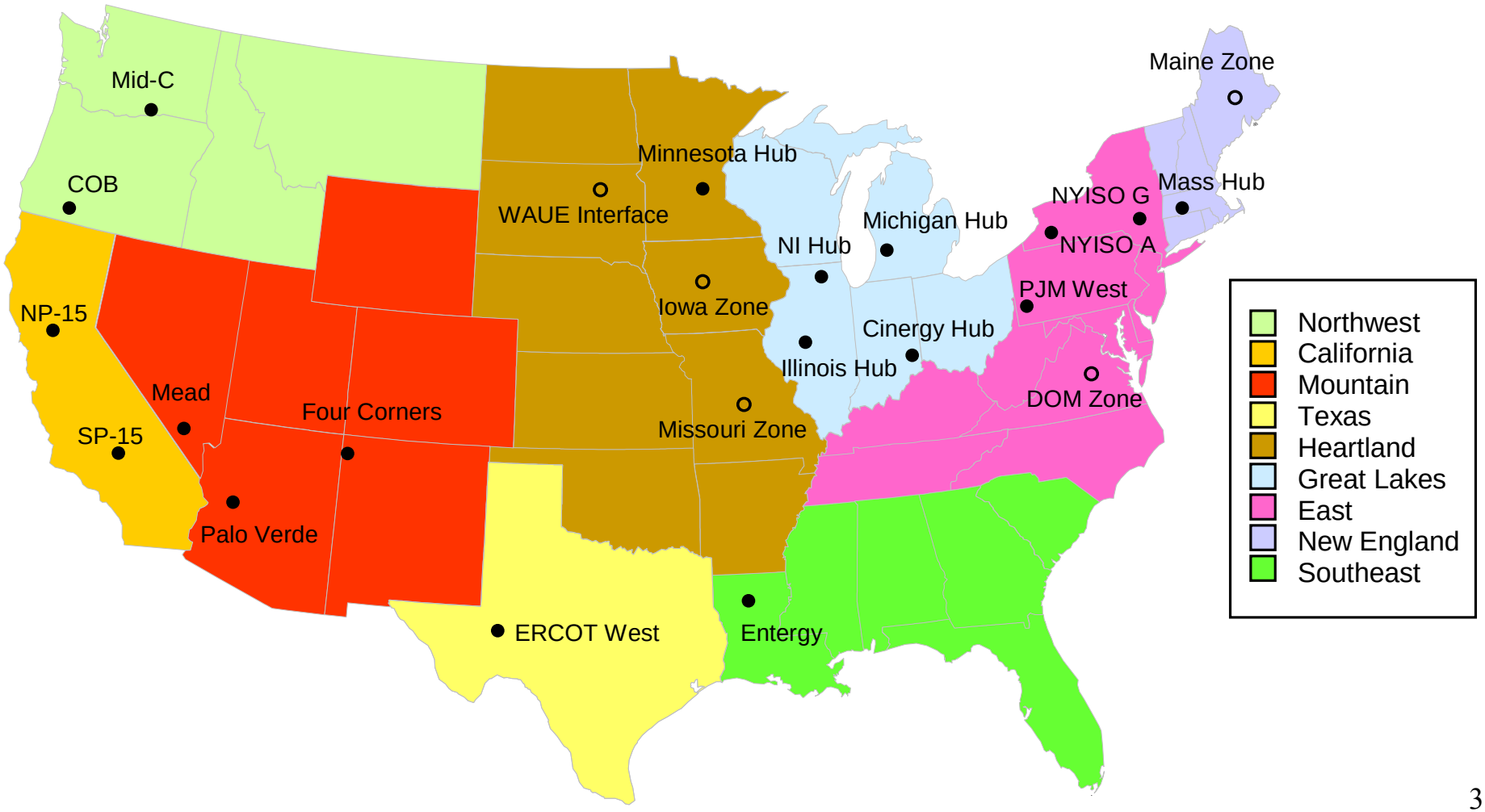

*Graphic shows prices in 2009 from projects built from 1998-2009*

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

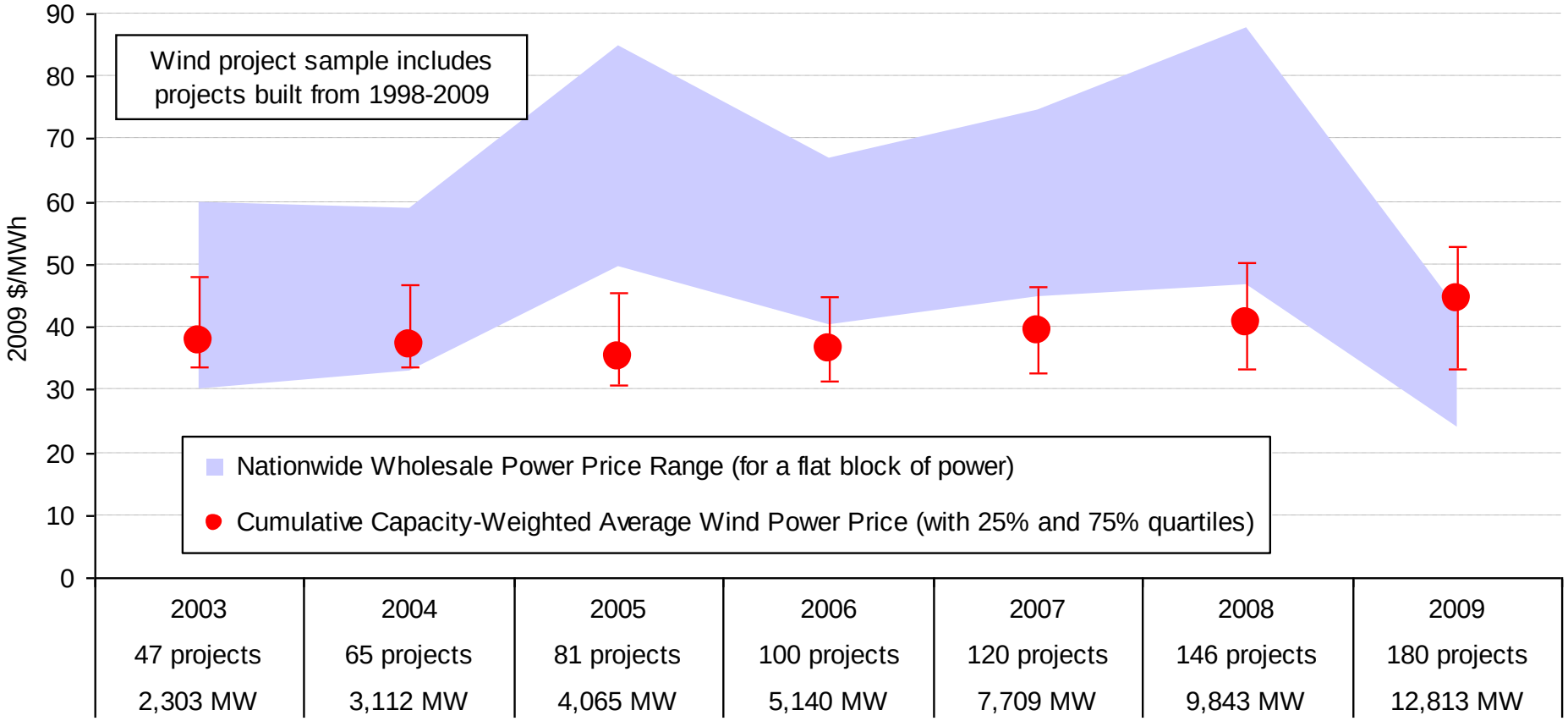



Texas and the Heartland are lower-price regions, while the East and California are higher-price (note: sample size is problematic in many regions)

# Regions and Wholesale Price Hubs Used in Analysis

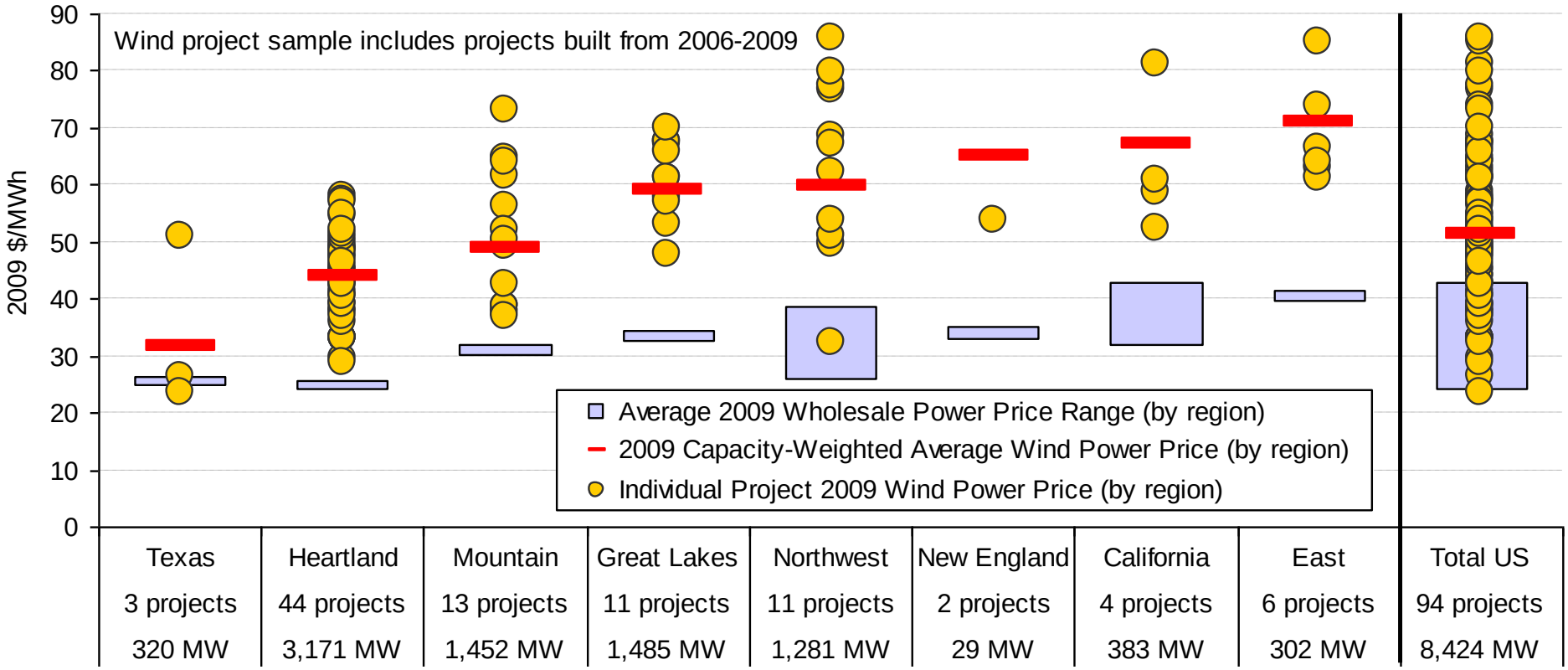


# Sharp Drop in Wholesale Power Prices Challenges the Competitiveness of Wind



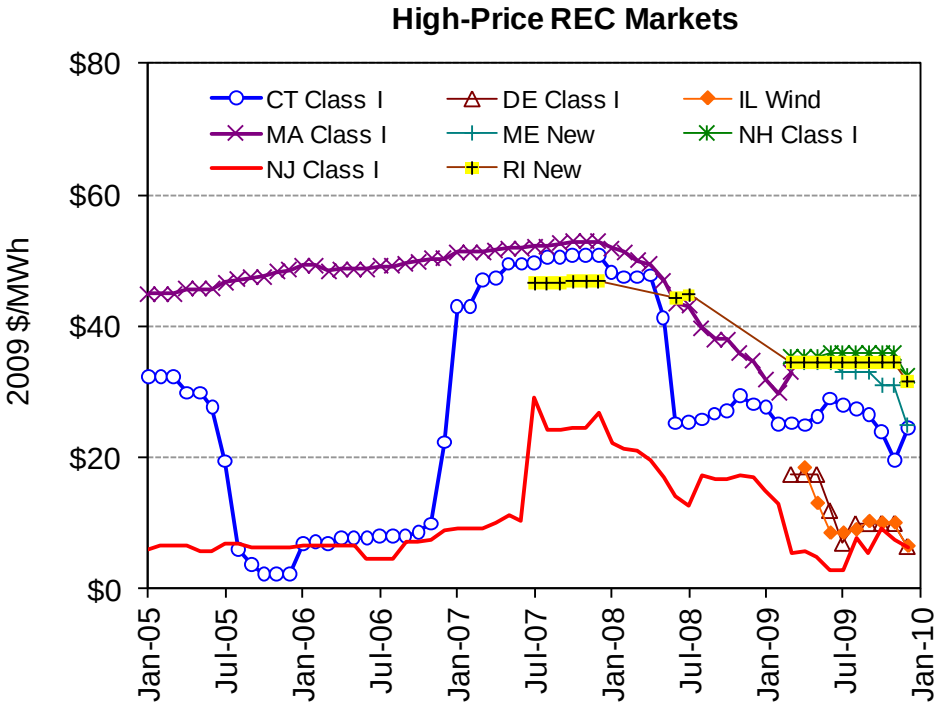

- Wholesale price range reflects flat block of power across 23 pricing nodes (see previous map)
- Wholesale price drop reflects lower natural gas prices, driven by weak economy and shale gas

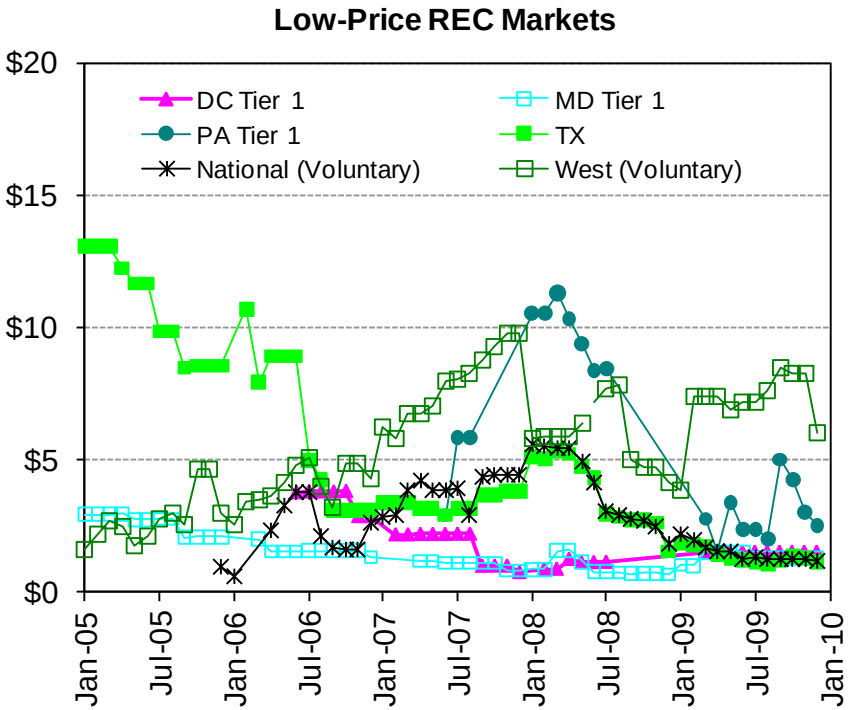
# Wind's Struggle to Compete in 2009 Spans All Regions of the U.S.




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

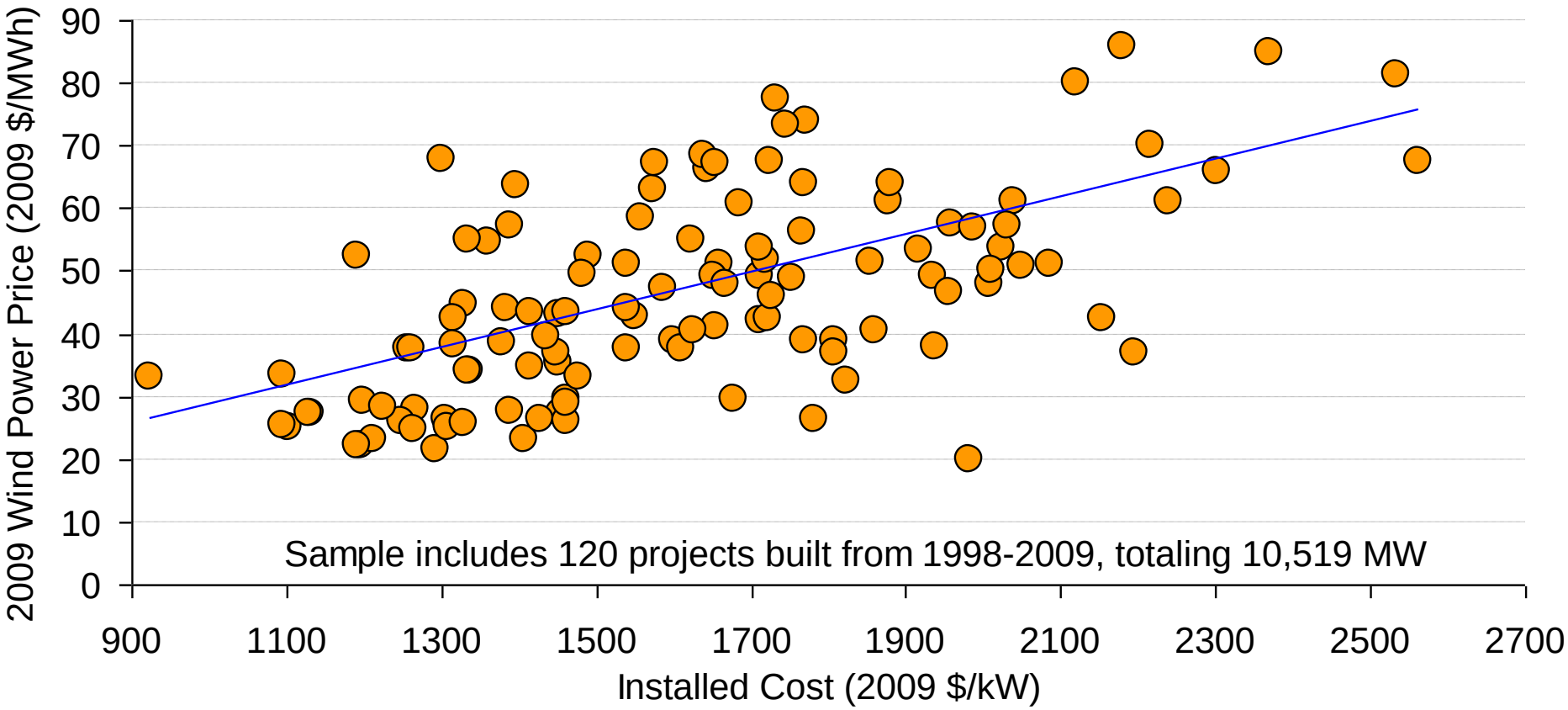


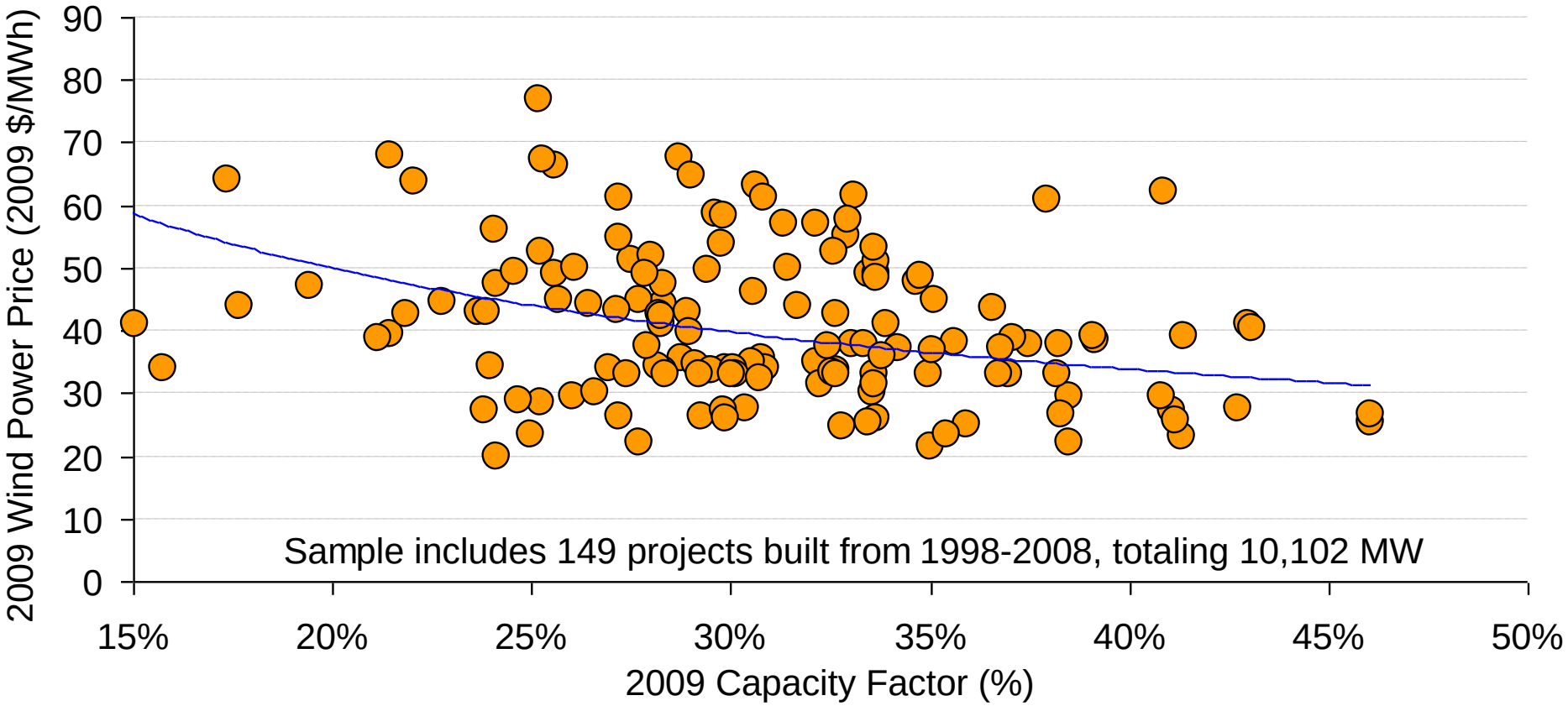

<u>REC prices vary by:</u>

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

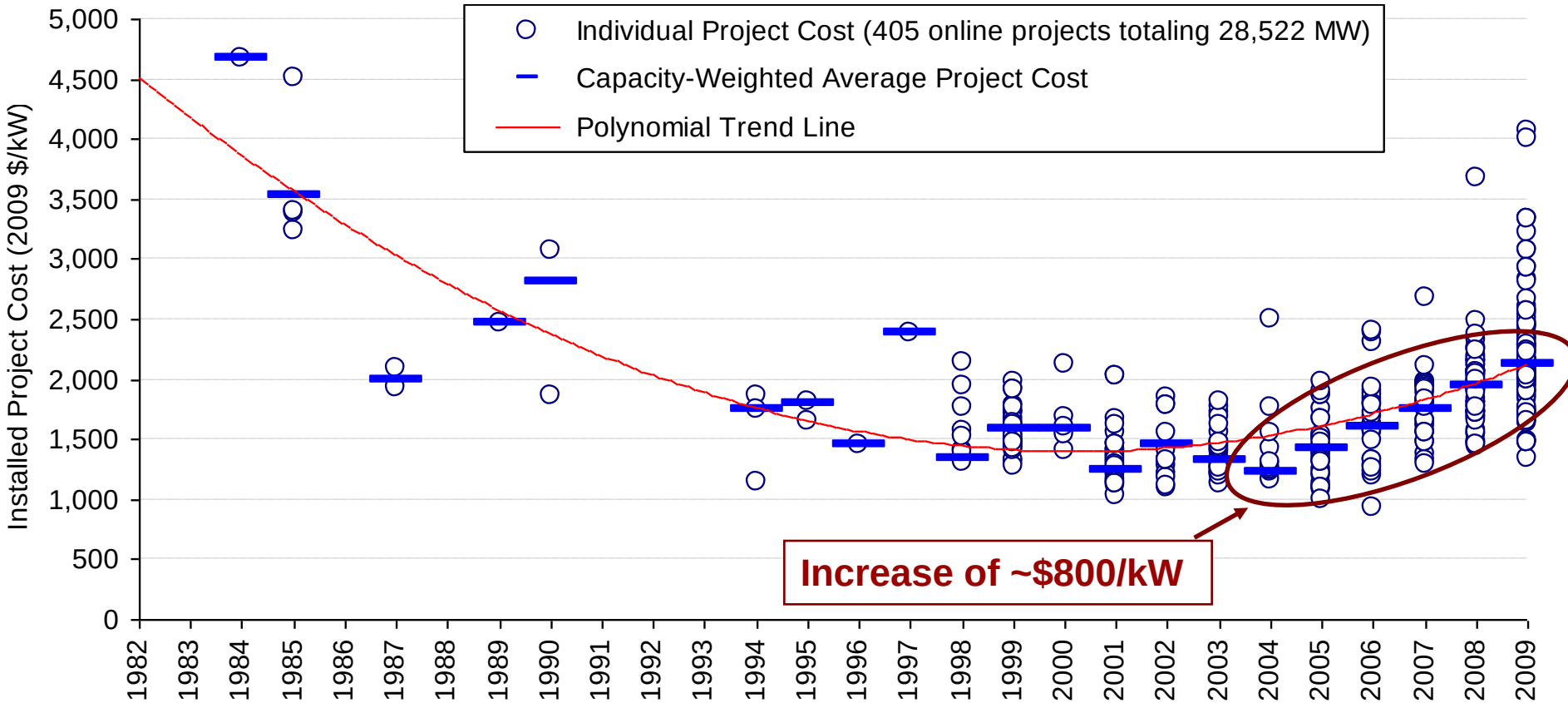
# Wind Power Sales Prices Are Affected by Installed Project Costs...



# ...and by Wind Power Project Performance

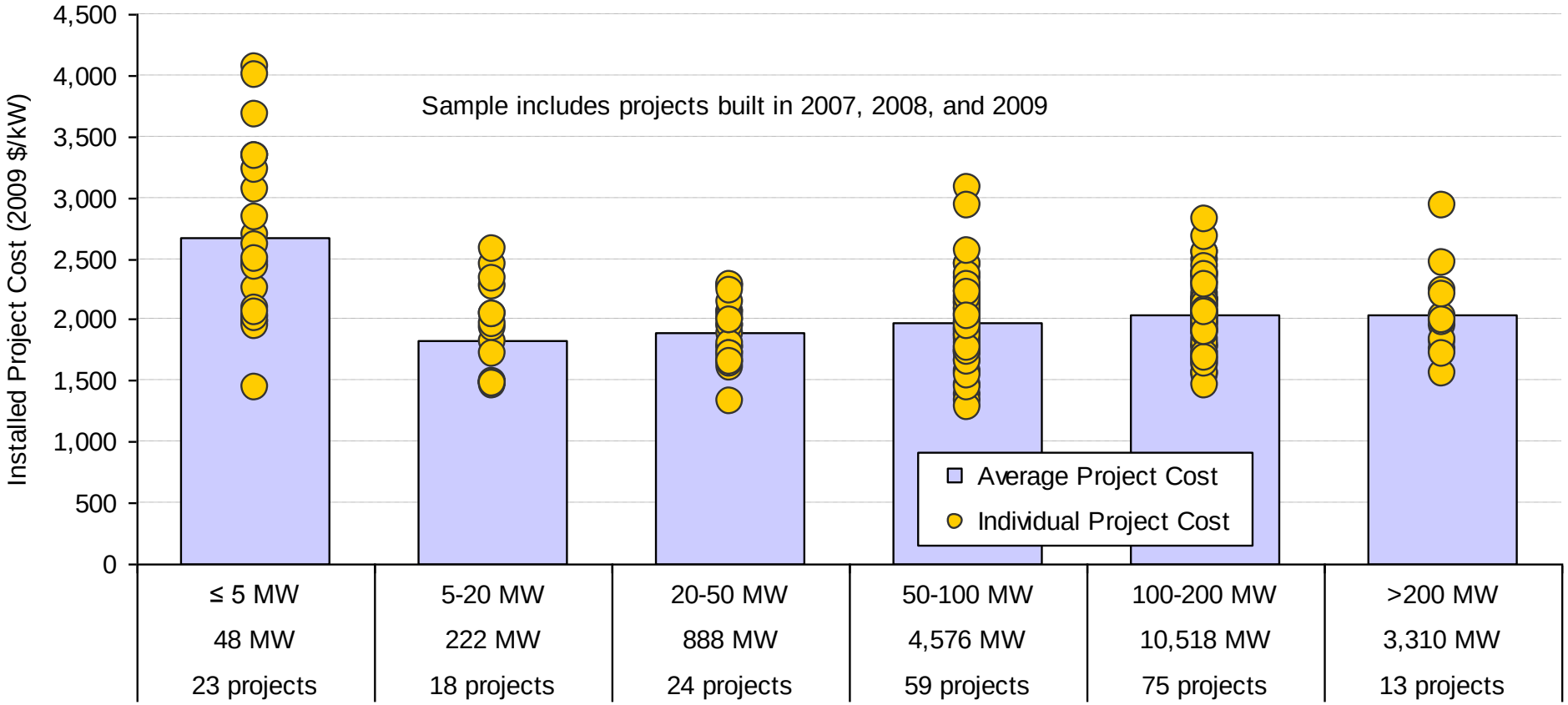


# Installed Project Costs Continued to Rise in 2009, After a Long Period of Decline



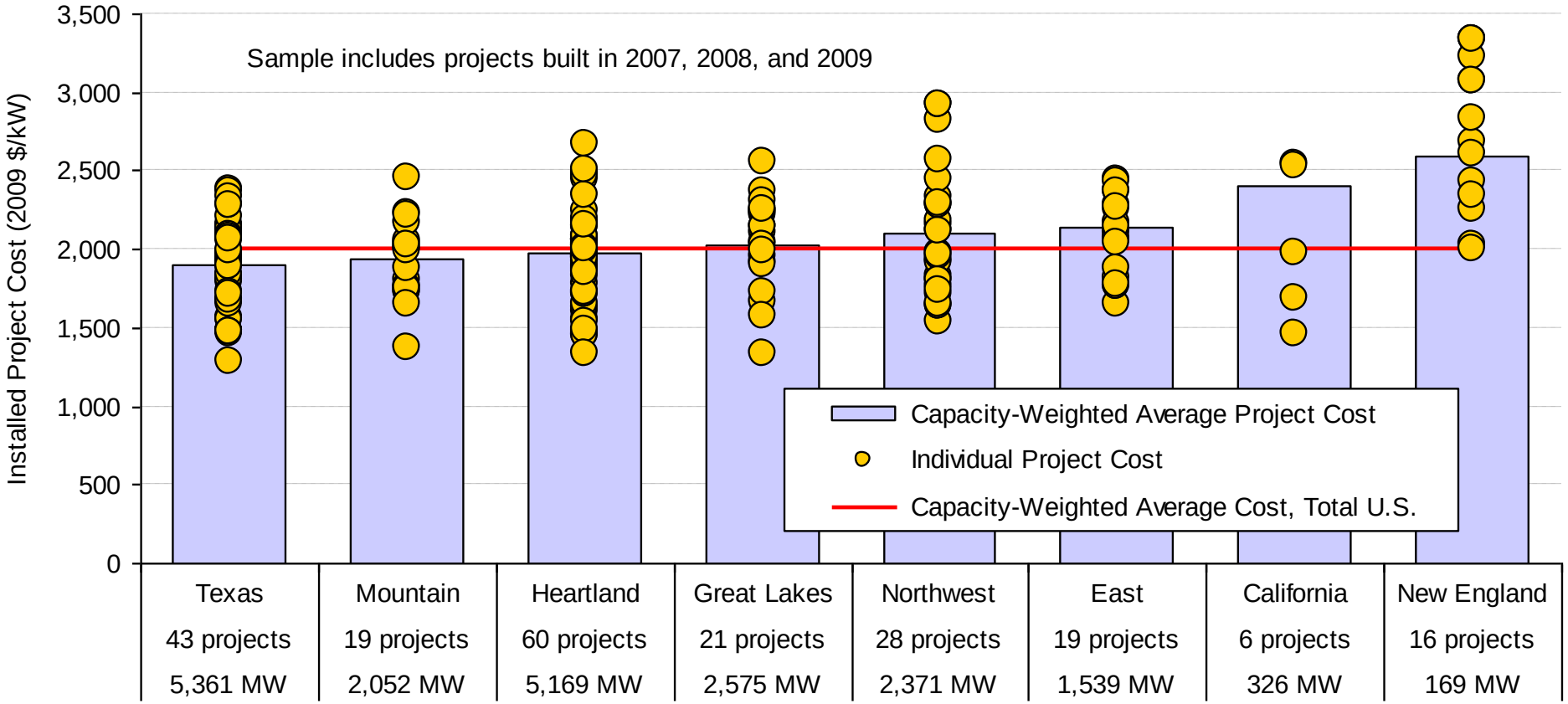

Rumors of cost declines abound, but have not yet been substantiated by the data

# Economies of Scale Evident At Low End of Project Size Range



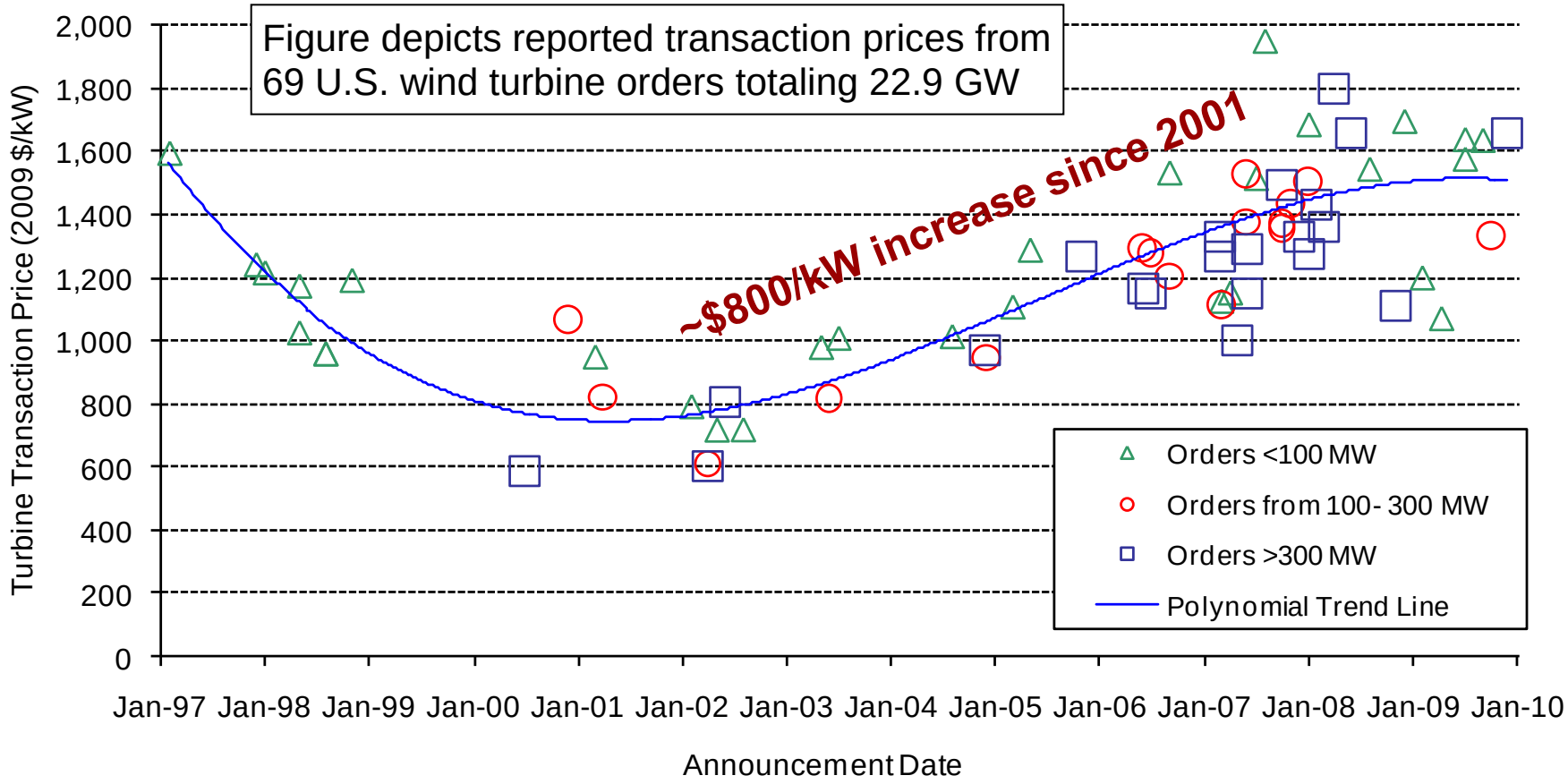

Cost trend essentially flat above 5-20 MW project size range

# Some Regional Differences in Wind Power Project Costs Are Apparent



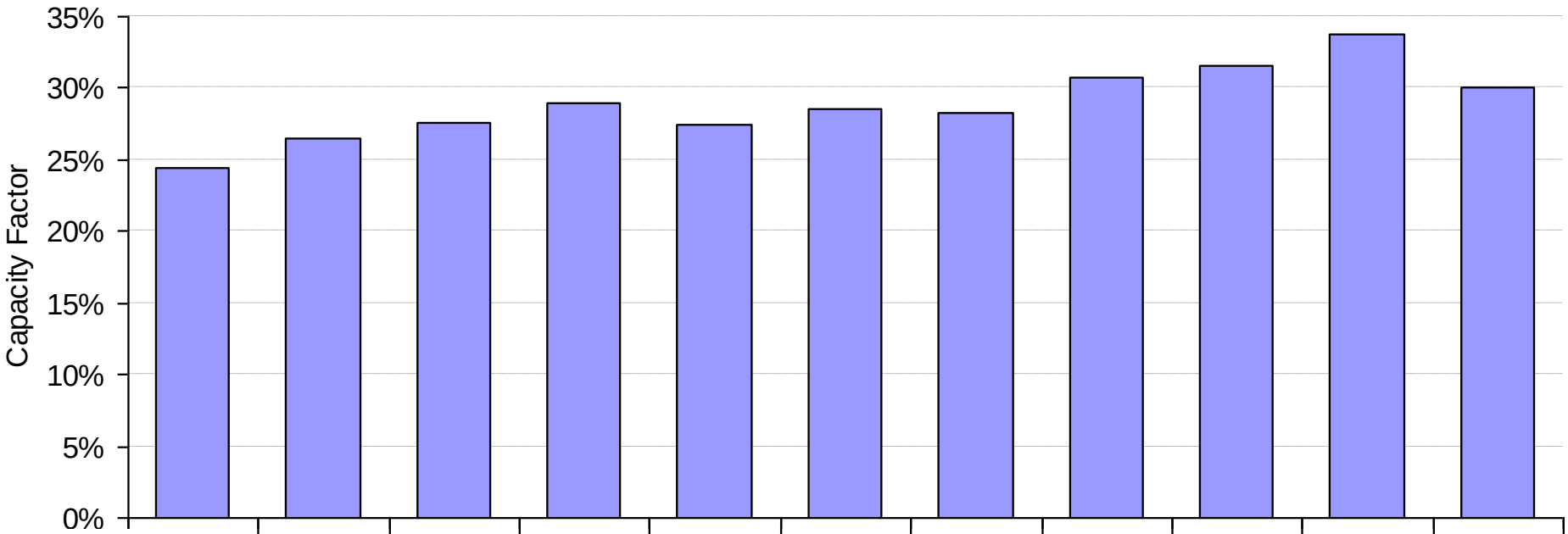

No clear low-cost leaders, but California & New England highest-cost

# Project Cost Increases Are a Function of Wind Turbine Prices




Relative dearth of data since 2008 makes it hard to discern any recent trend, though turbine prices are rumored to be lower

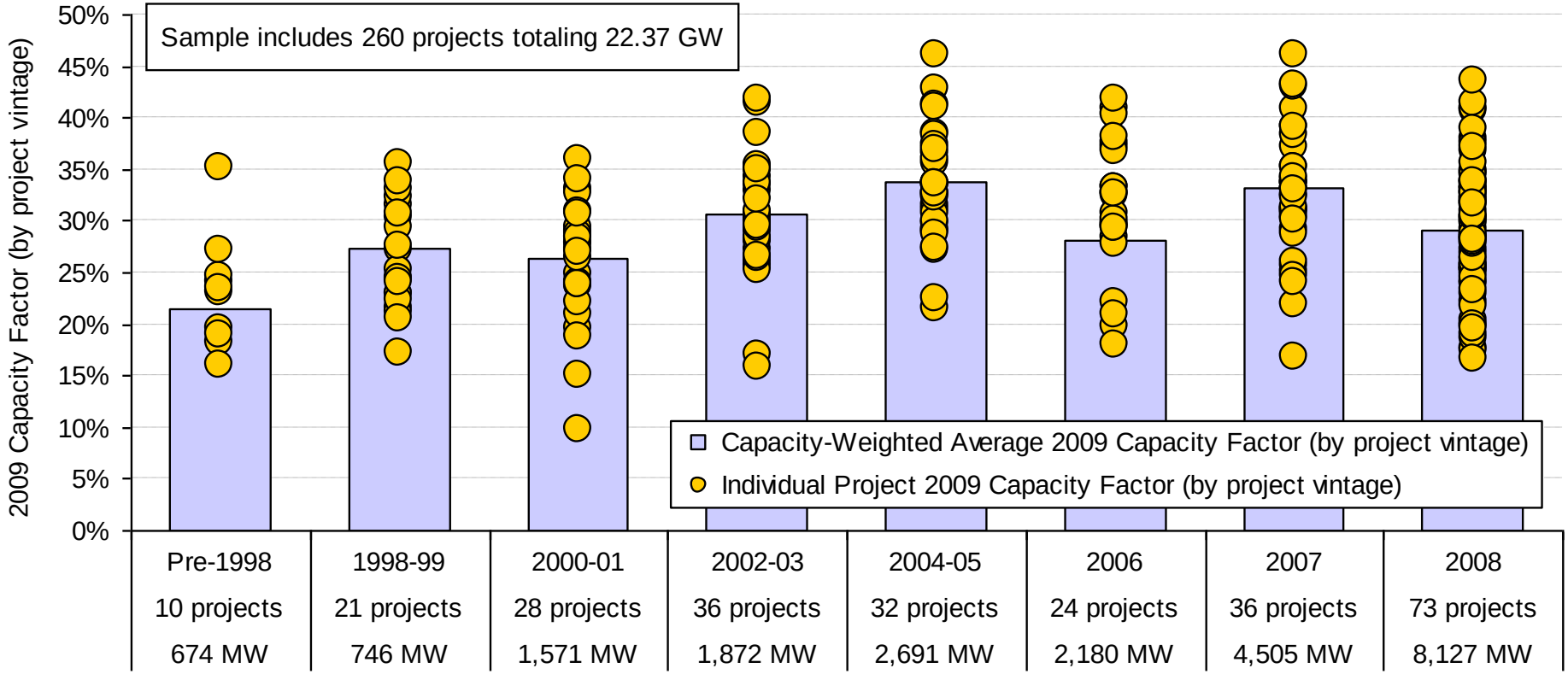
# Average Capacity Factors Have Improved Over Time, But Leveled Off in Recent Years




| 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 |

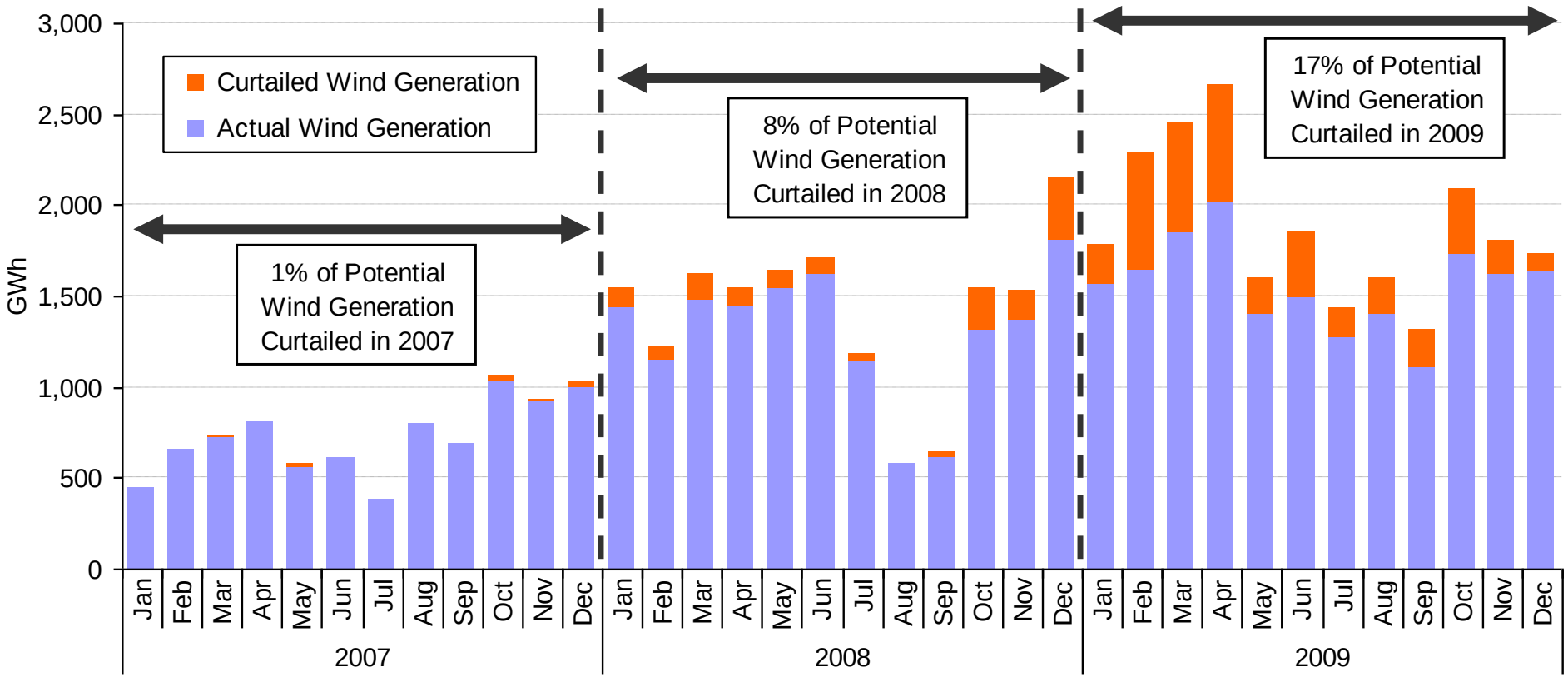
- General improvement reflects increase in hub height and rotor diameter (see slide 24)
- Inter-annual wind resource variation also plays a role: 2009 was a bad wind year
- Curtailment was another major factor in lower 2009 capacity factor (see slide 47)

# Binning by Project Vintage and Focusing on 2009 Performance Tells A Similar Story



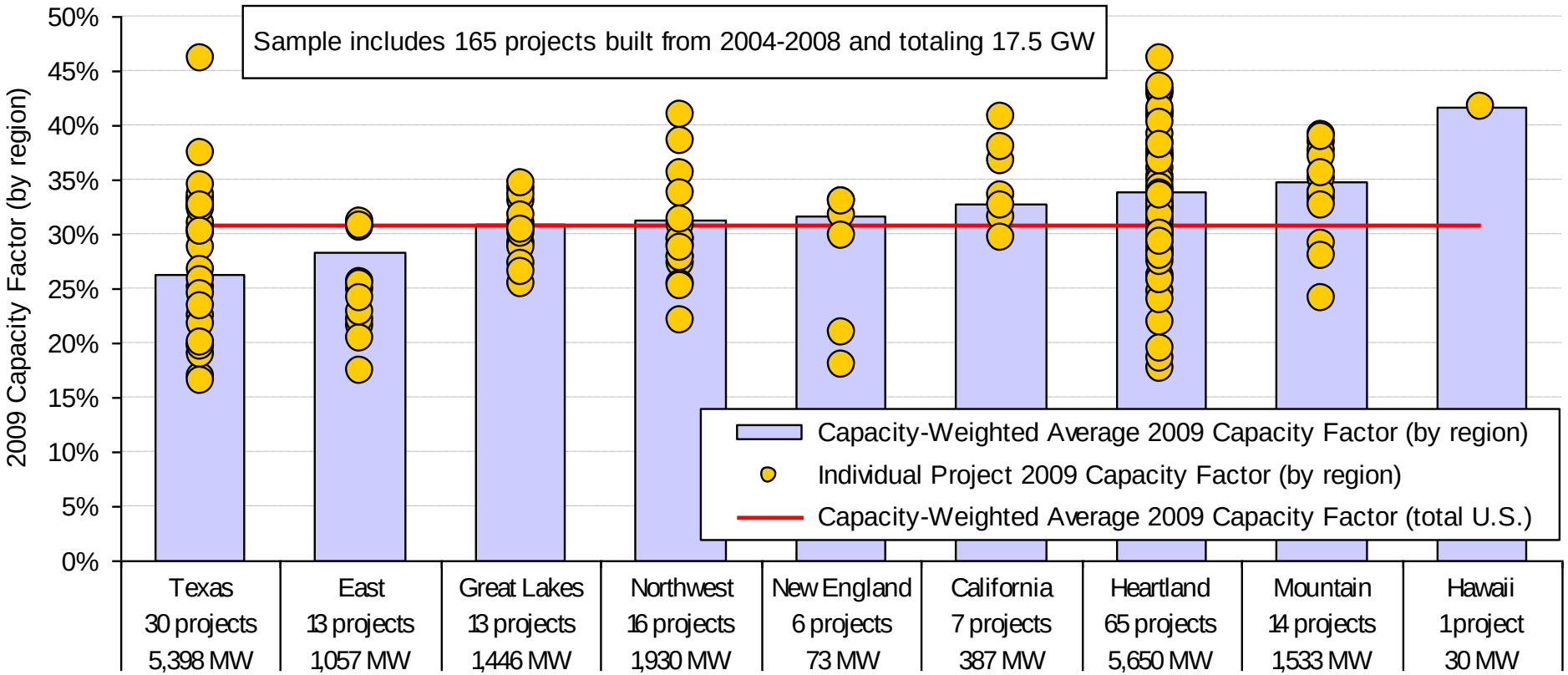

Projects installed since 2005 have bucked the trend of generally increasing capacity factors among more-recently built projects

# Curtailment a Major Issue in Texas (ERCOT)



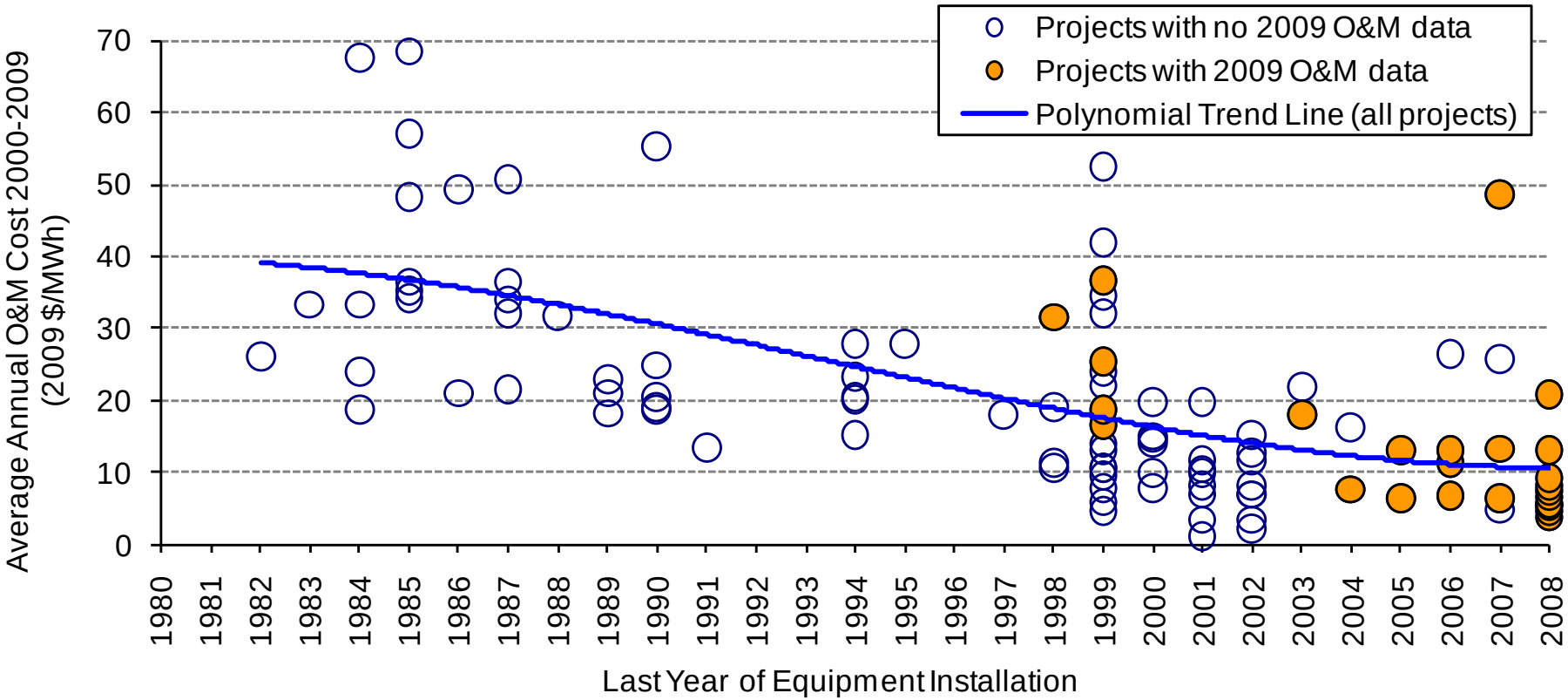

If there had been no curtailment in 2009, ERCOT's fleet-wide wind power project capacity factor would have been 31.1% (rather than 25.8%), raising the national average from 30% to 32%

# Regional Performance Differences Are Apparent




Average capacity factors highest in Hawaii and the Mountain region, lowest in Texas (again, due largely to curtailment) and the East

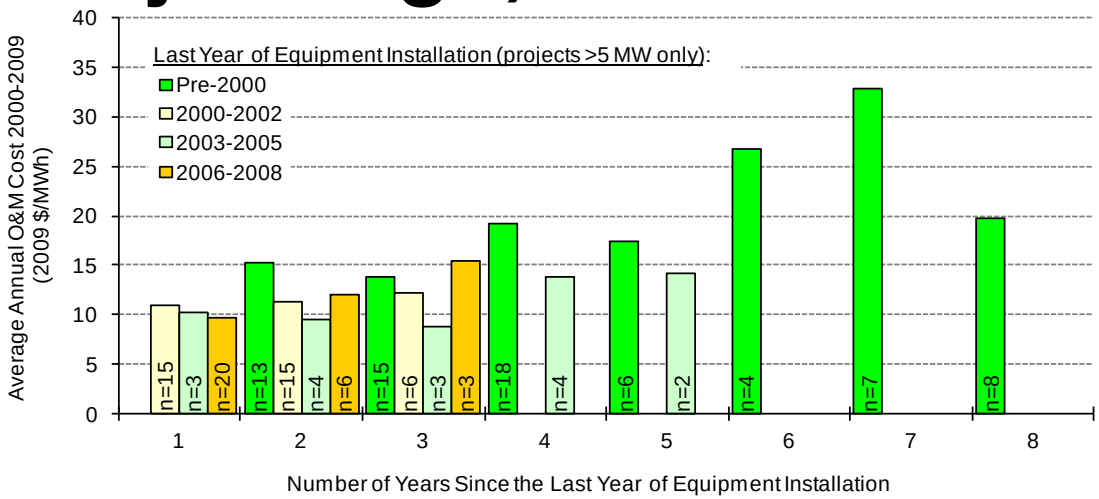
# Average O&M Costs from 2000-2009 Are Affected By Year of Installation

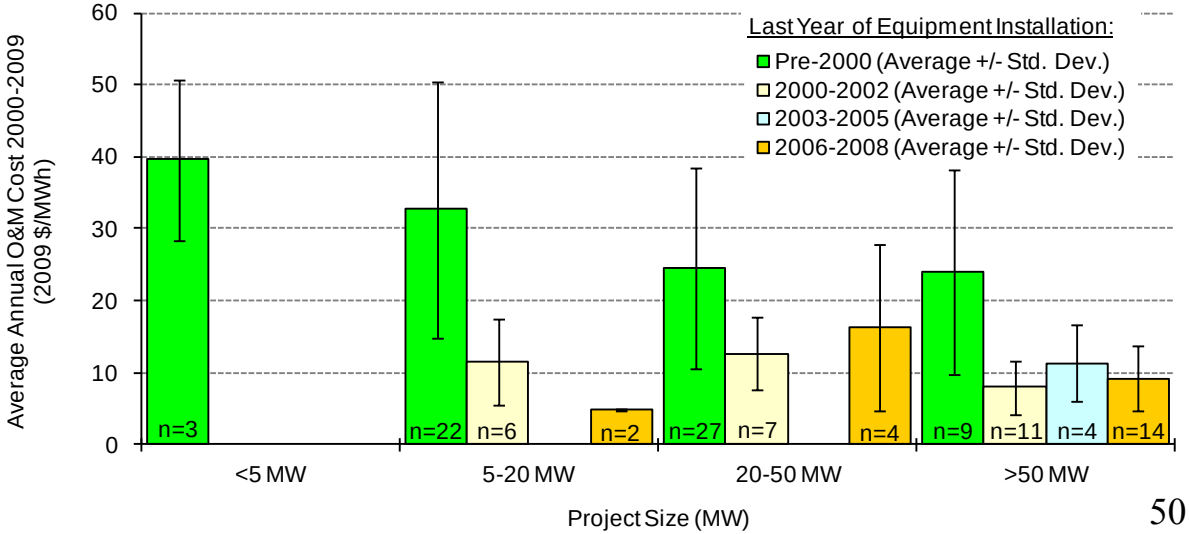



Capacity-weighted average 2000-09 O&M costs for projects built in 1980s equal **$32/MWh**, dropping to **$22/MWh** for projects built in 1990s, and to **$9/MWh** for projects built in 2000s

*Note: Sample is limited, and consists of 115 wind power projects totaling 6,097 MW; few projects in sample have complete records of O&M costs from 2000-09*

# O&M Costs Appear to Increase with Project Age, Decrease with Project Size



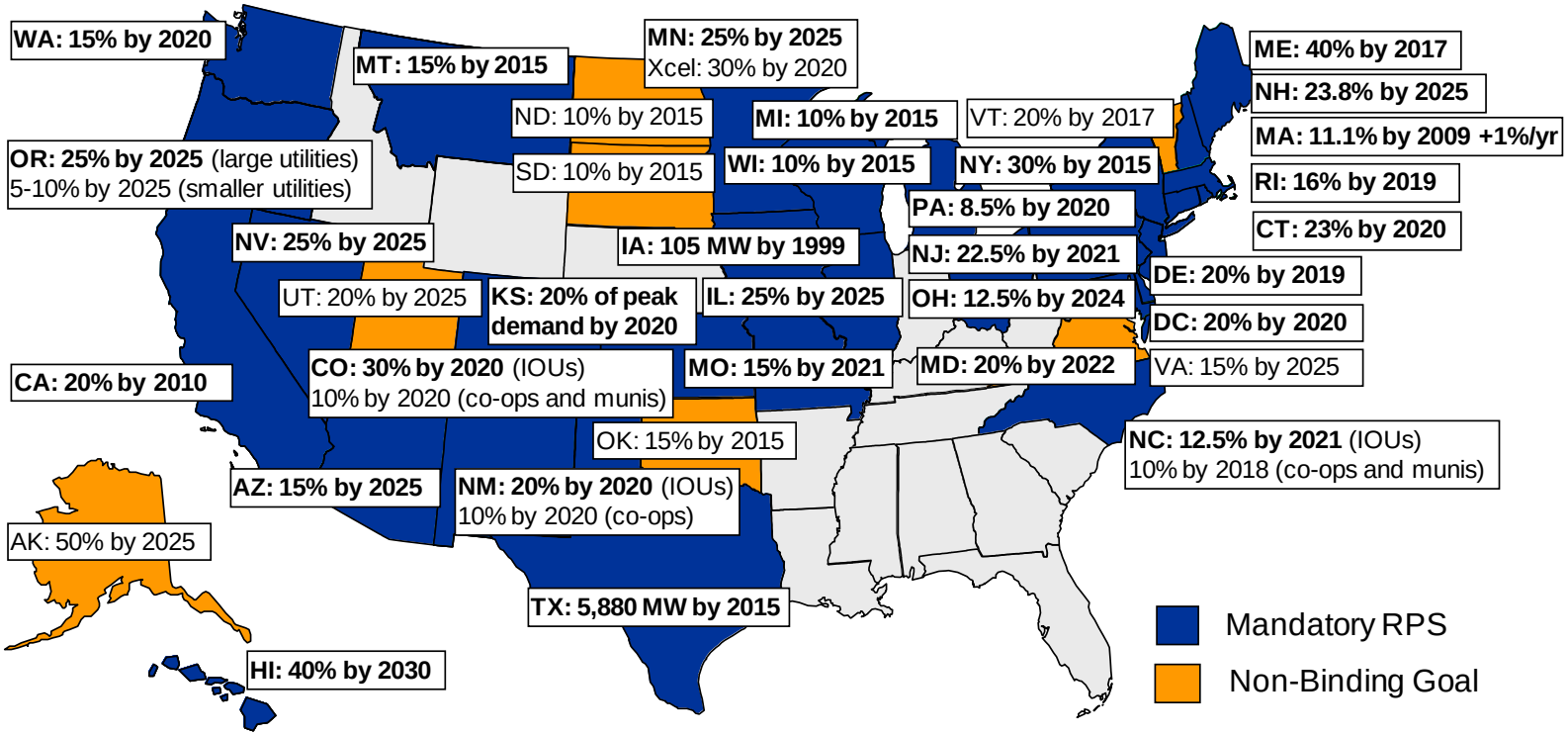

*Note: Sample size is extremely limited*

# Policy and Market Drivers

# Federal Policy Is Now More Favorable Than At Any Other Time in the Past Decade

- The Recovery Act established a number of federal policies to support wind
- Federal PTC currently in place through 2012 (longest extension in history)
- 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
- $2.2 billion of new Clean Renewable Energy Bonds allocated
- Expansion and enhancement of Federal loan guarantee program
- $2.3 billion in advanced energy manufacturing tax credits awarded
- Increased R&D funding
- Increased funding for USDA's Rural Energy for America Program (REAP)
- Efforts to pass an RPS and carbon regulation at the Federal level continue
- But… major policies expire after 2012, leaving uncertainty for future years

# State Policies Help Direct the Location and Amount of Wind Power Development




- One new state (KS) established a mandatory RPS in 2009 (total is now 29 states and Washington, D.C.)
- State renewable funds, tax incentives, utility resource planning, voluntary green power, and growing interest in carbon regulation all also played a role in 2009

# Despite Progress on Overcoming Transmission Barriers, Constraints Remain

- Cost allocation continues to be a major issue at FERC and among the ISOs/RTOs
- The DOE, states, grid operators, and regional organizations continue to take proactive steps to encourage transmission investment to improve access to renewable resources
- A variety of efforts to proactively plan for transmission, often through analyses of state and regional renewable energy zones, also continued in 2009
- Progress was made in 2009 on some transmission projects that are designed, in part, to support wind power – e.g., Tehachapi in California, and NextEra's 200-mile line in Texas

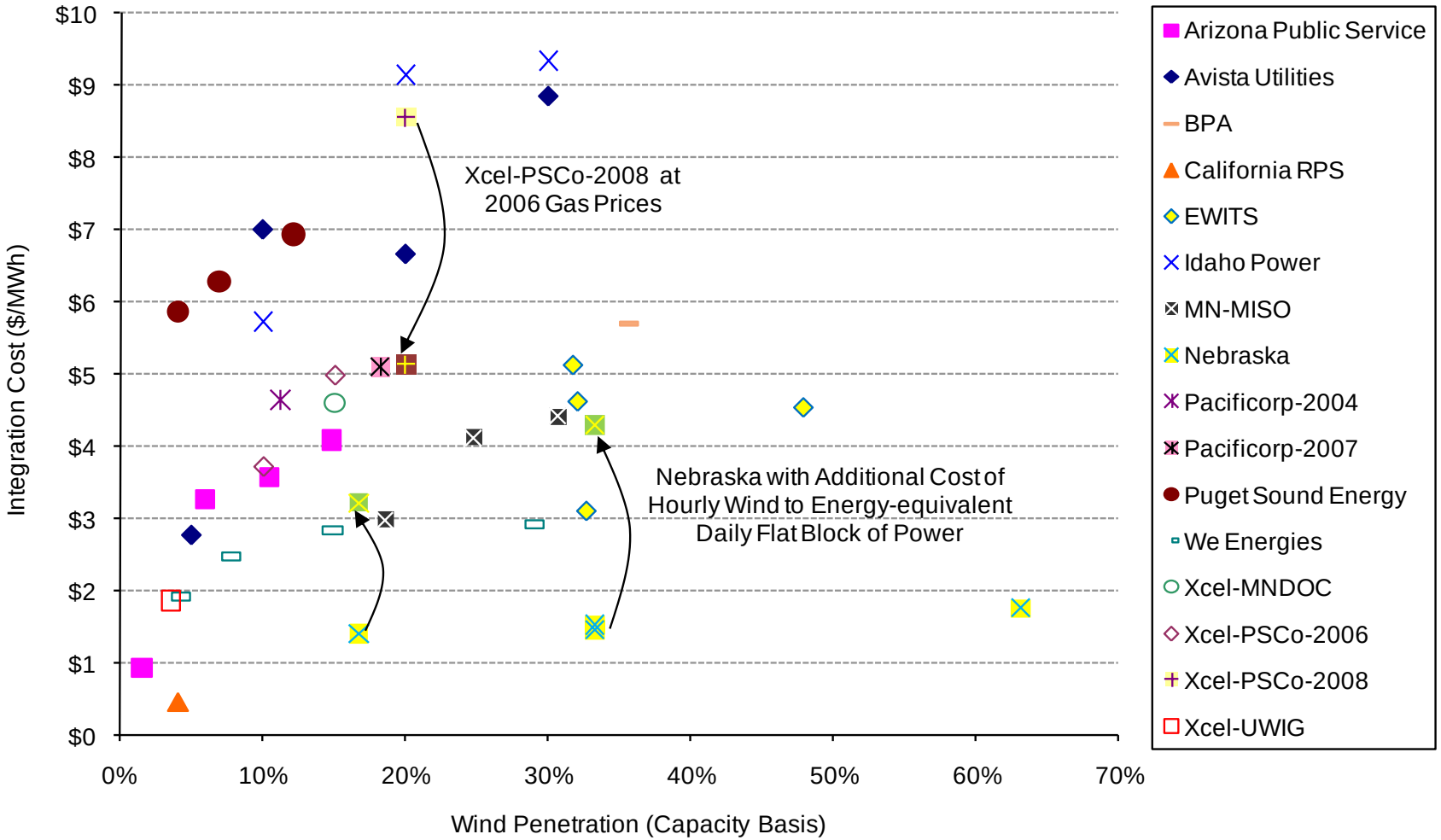
# Studies Find that the Cost of Integrating Wind into Power Systems Is Manageable

| Year | 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 | - | 1.85 |
| 2003 | We Energies | 29% | 1.02 | 0.15 | 1.75 | - | 2.92 |
| 2004 | Xcel-MNDOC | 15% | 0.23 | - | 4.37 | - | 4.60 |
| 2005 | PacifiCorp-2004 | 11% | 0 | 1.48 | 3.16 | - | 4.64 |
| 2006 | Calif. (multi-year)* | 4% | 0.45 | trace | trace | - | 0.45 |
| 2006 | Xcel-PSCo | 15% | 0.20 | - | 3.32 | 1.45 | 4.97 |
| 2006 | MN-MISO** | 31% | - | - | - | - | 4.41 |
| 2007 | Puget Sound Energy | 12% | - | - | - | - | 6.94 |
| 2007 | Arizona Pub. Service | 15% | 0.37 | 2.65 | 1.06 | - | 4.08 |
| 2007 | Avista Utilities | 30% | 1.43 | 4.40 | 3.00 | - | 8.84 |
| 2007 | Idaho Power | 20% | - | - | - | - | 7.92 |
| 2007 | PacifiCorp-2007 | 18% | - | 1.10 | 4.00 | - | 5.10 |
| 2008 | Xcel-PSCo*** | 20% | - | - | - | - | 8.56 |
| 2009 | Bonneville (BPA)+ | 36% | 0.22 | 1.14 | - | - | 5.70 |
| 2010 | EWITS++ | 48% | - | - | 1.61 | - | 4.54 |
| 2010 | Nebraska+++ | 63% | - | - | - | - | 1.75 |

* 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.
+ Costs in $/MWh assume 31% capacity factor. Aside from regulation and following reserves, the costs of BPA's imbalance reserves are $4.33/MWh.
++ The unit commitment costs listed in EWITS are the cost of day-ahead wind forecast error; the remaining integration costs included in the total are for shorter term variable reserves that account for regulation and short-term forecast errors (energy imbalance).
+++ These integration costs only capture regulating reserves and day-ahead forecast error. A sensitivity case in this study shows that integration costs increase if the differences between the actual hourly deliveries of wind energy are compared to daily flat block of power. The increased costs are shown in Figure 39.

- Wind integration costs are < $10/MWh for capacity penetrations of up to or exceeding 40%
- Regulation impacts are small, load-following and unit commitment larger
- Larger balancing areas, intra-hour scheduling and use of wind energy forecasts can ease integration challenges, and grid operators are increasingly relying on these strategies

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



# Future Outlook

# 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 | -- | -- | -- |

# Uncertainties in Near-Term Market Growth Reflect Conflicting Trends

## Stronger Growth

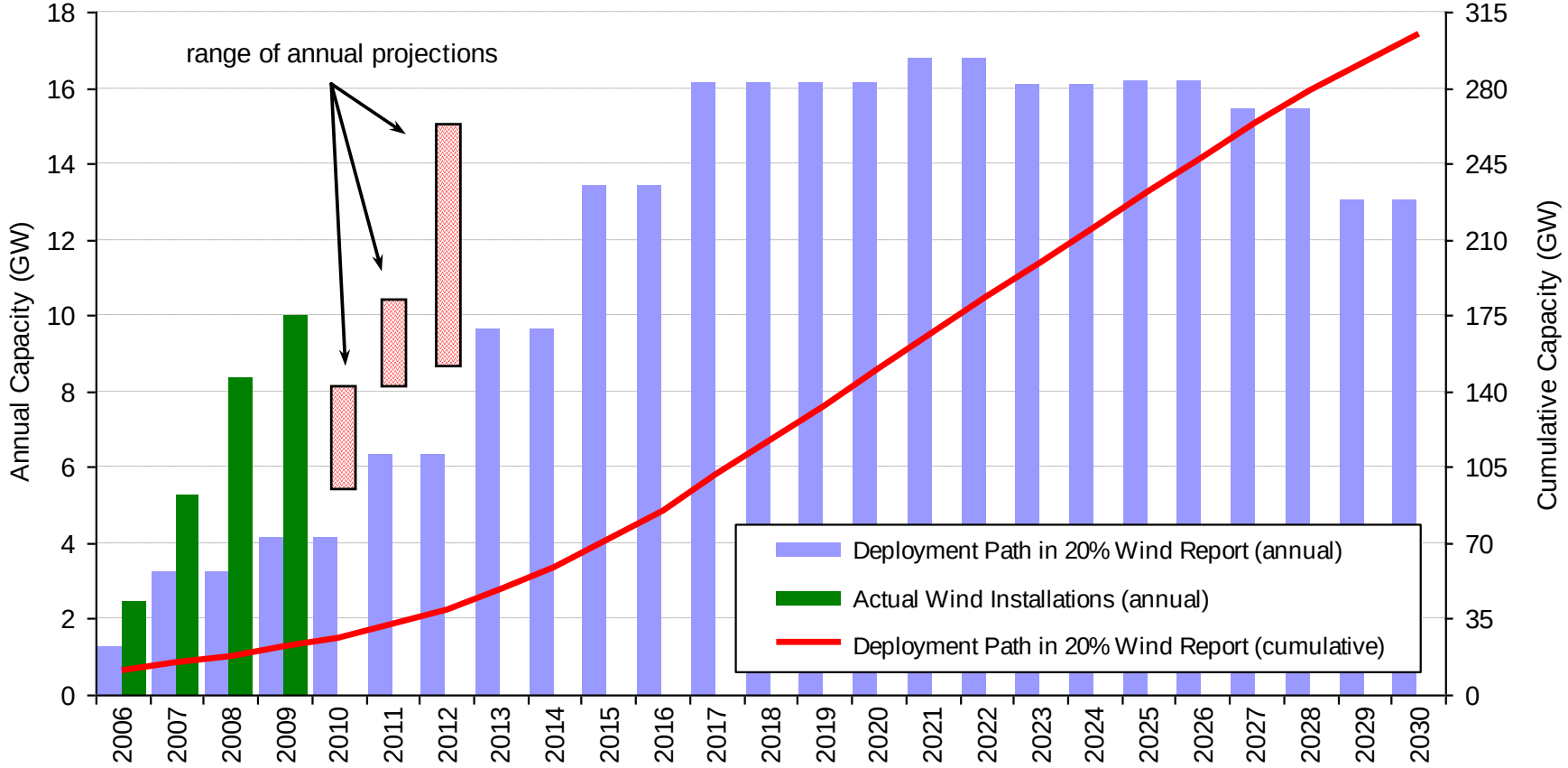
- Stronger federal and state policy support than at any point in last decade
- Possible further federal policy support through extension of Recovery Act programs, RPS, climate, and/or transmission policy
- Falling wind turbine prices may improve comparative economics of wind energy

## Weaker Growth

- Treasury grant eligibility expires at end of 2010, but tax equity market not fully recovered
- Natural gas and wholesale power prices / expectations have plummeted
- Softer demand from state RPS markets in near term
- Inadequate transmission infrastructure beginning to constrain new builds
- Increased competition from other renewable energy sources

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

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 used, etc.

- http://windandwater.energy.gov/

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