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

2012 Wind Technologies Market Report Summary

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WPA All-States Summit

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2012 Wind Technologies Market Report

Purpose, Scope, and Data:

- Publicly available annual report summarizing key trends in the U.S. wind power market, with a focus on 2012
- Scope primarily includes wind turbines over 100 kW in size
- Separate DOE-funded annual reports on distributed and offshore wind
- 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://www1.eere.energy.gov/wind/ **[coming in June-July]**

Funded by: U.S. DOE Wind & Water Power Technologies Office

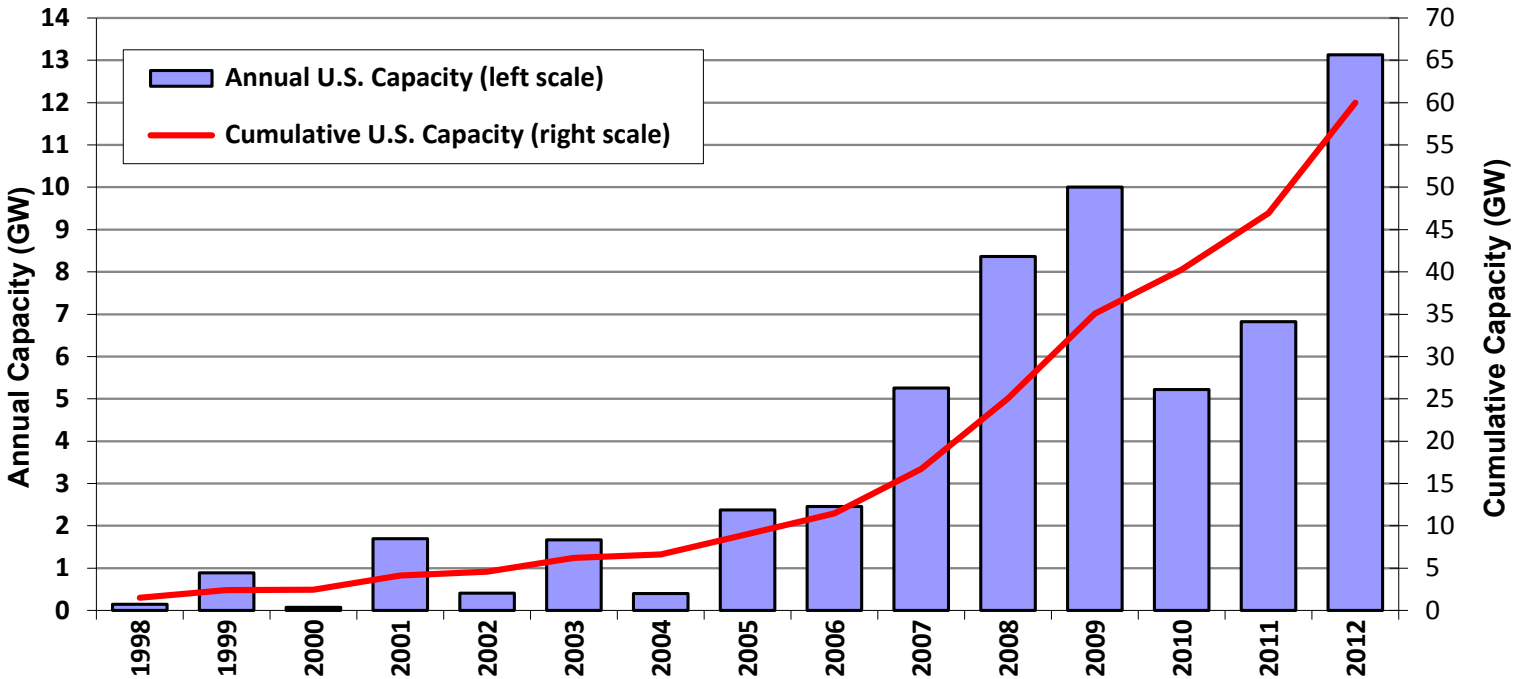
Report Contents

- Installation trends
- Industry trends
- Cost trends
- Performance trends
- Wind power price trends
- Policy and market drivers
- Future outlook

Current presentation will focus to some degree on cost / performance / price trends

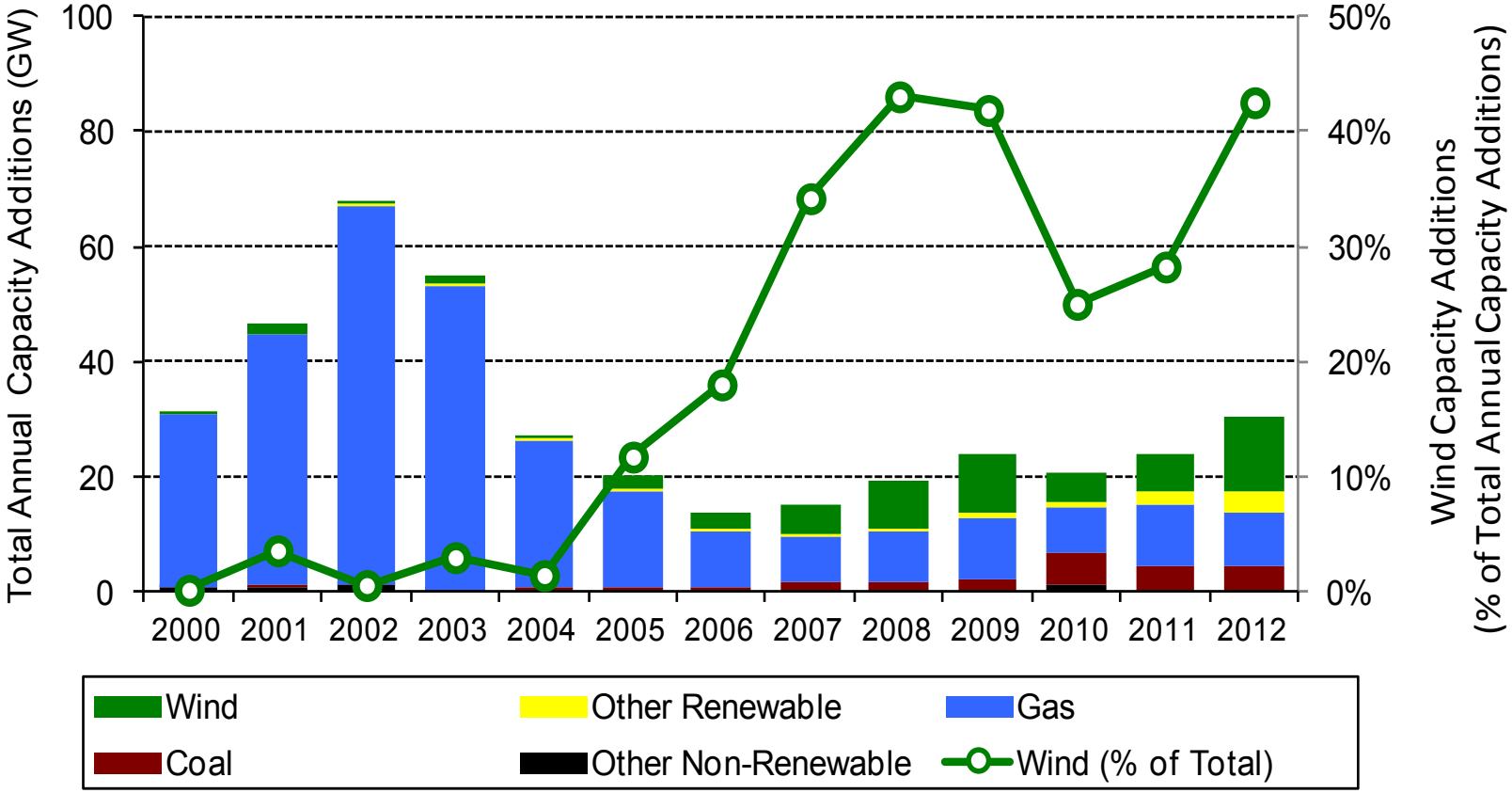
Installation and Industry Trends: A Summary

Wind Power Additions Hit a New Record in 2012, in Part Driven By the Then-Planned Expiration of Federal Tax Incentives



- 13.1 GW of wind added in 2012, more than 90% higher than 2011
- $25 billion invested in wind power project additions
- Cumulative wind power capacity up by 28%, bringing total to 60 GW

Wind Power Was the Largest Source of U.S. Generating Capacity Additions in 2012



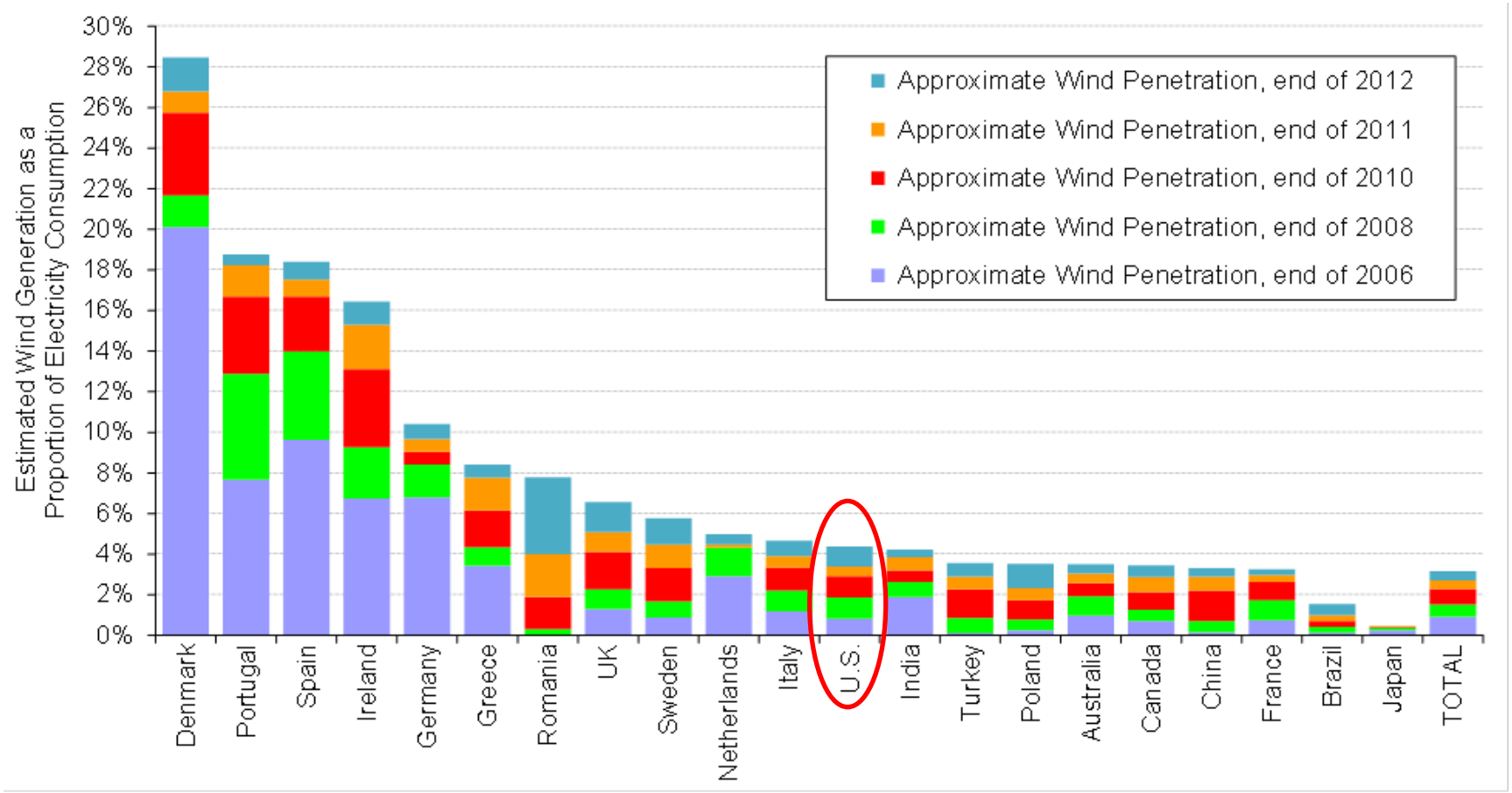
- Wind was, for the first time, the largest resource added in terms of gross capacity, despite persistently low natural gas prices

The U.S. Narrowly Regained the Lead in Global Annual Wind Power Additions

Annual Capacity (2012, MW)		Cumulative Capacity (end of 2012, MW)	
U.S.	**13,131**	China	75,372
China	12,960	**U.S.**	**60,005**
Germany	2,415	Germany	31,467
India	2,336	Spain	22,462
U.K.	1,958	India	18,602
Italy	1,272	U.K.	9,113
Spain	1,112	Italy	7,998
Brazil	1,077	France	7,593
Canada	936	Canada	6,214
Romania	923	Portugal	4,363
Rest of World	6,838	*Rest of World*	42,368
TOTAL	**44,958**	**TOTAL**	**285,558**

- U.S. led global growth in wind capacity in 2012; expected to lead global contraction in wind capacity additions in 2013
- Remains a distant second to China in cumulative capacity

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



Note: Figure only includes the countries with the most installed wind power capacity at the end of 2012

Texas Added the Most Wind Capacity in 2012; 9 States Exceed 10% Wind Energy

Capacity (MW)				Percentage of In-State Generation			
Annual (2012)		Cumulative (end of 2012)		Actual (2012)*		Estimated (end of 2012)**	
Texas	1,826	Texas	12,214	Iowa	24.5%	Iowa	25.3%
California	1,656	California	5,542	South Dakota	23.9%	South Dakota	23.9%
Kansas	1,441	Iowa	5,133	North Dakota	14.7%	Kansas	20.1%
Oklahoma	1,127	Illinois	3,568	Minnesota	14.3%	Minnesota	16.9%
Illinois	823	Oregon	3,153	Kansas	11.4%	Idaho	16.0%
Iowa	814	Oklahoma	3,134	Colorado	11.3%	North Dakota	15.6%
Oregon	640	Minnesota	2,987	Idaho	11.3%	Oklahoma	14.0%
Michigan	611	Washington	2,808	Oklahoma	10.5%	Colorado	13.1%
Pennsylvania	550	Kansas	2,713	Oregon	10.0%	Oregon	12.8%
Colorado	496	Colorado	2,301	Wyoming	8.8%	Wyoming	8.8%
Idaho	355	North Dakota	1,680	Texas	7.4%	Texas	8.3%
Ohio	315	New York	1,638	New Mexico	6.1%	Hawaii	8.0%
Minnesota	267	Indiana	1,543	Maine	5.9%	California	7.1%
Montana	258	Wyoming	1,410	Washington	5.8%	Montana	7.0%
New York	237	Pennsylvania	1,340	California	4.9%	Maine	6.6%
Washington	235	Michigan	988	Montana	4.5%	New Mexico	6.3%
North Dakota	235	Idaho	973	Illinois	3.9%	Washington	6.1%
Indiana	203	South Dakota	783	Nebraska	3.7%	Illinois	4.8%
Nevada	152	New Mexico	778	Hawaii	3.6%	Nebraska	4.3%
New Hampshire	147	Wisconsin	648	Indiana	2.8%	Vermont	3.7%
Rest of U.S.	743	*Rest of U.S.*	4,673	*Rest of U.S.*	0.6%	*Rest of U.S.*	0.8%
TOTAL	**13,131**	**TOTAL**	**60,005**	**TOTAL**	**3.5%**	**TOTAL**	**4.2%**

* Based on 2012 wind and total generation by state from EIA's *Electric Power Monthly*.

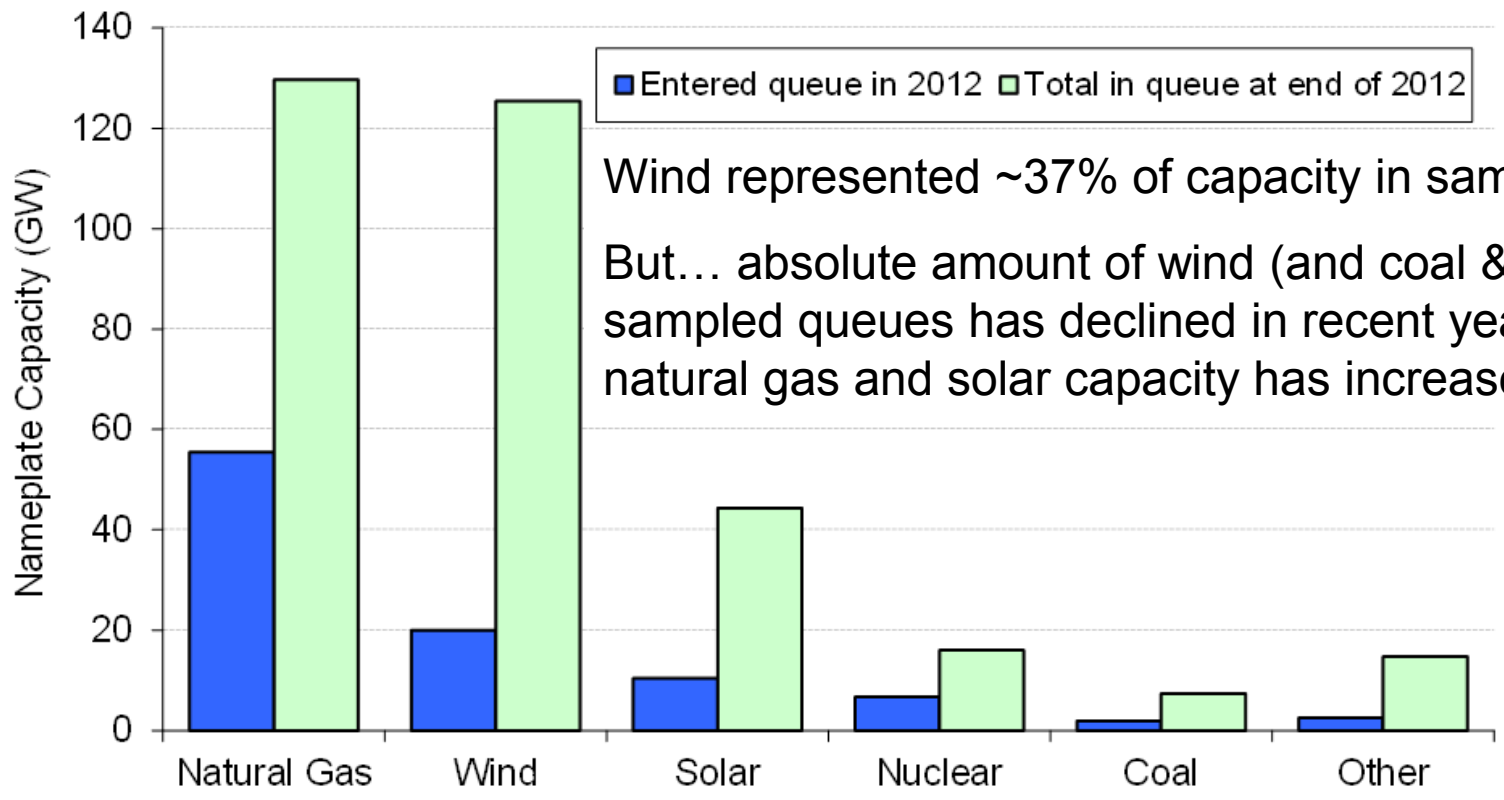
** Based on a projection of wind electricity generation from end-of-2012 wind power capacity, divided by total in-state electricity generation in 2012.

Source: AWEA project database, EIA, Berkeley Lab estimates

At end of 2012:

- Texas had more than twice as much wind capacity as any other state
- 22 states had >500 MW of capacity (15 > 1 GW, 10 > 2 GW)
- 3 states had the ability to provide >20% of total in-state generation from wind (9 > 10%, 17 > 5%)

Interconnection Queues Demonstrate that An Enormous Amount of Wind Is Under Consideration, but that Relative Interest May Be on the Decline

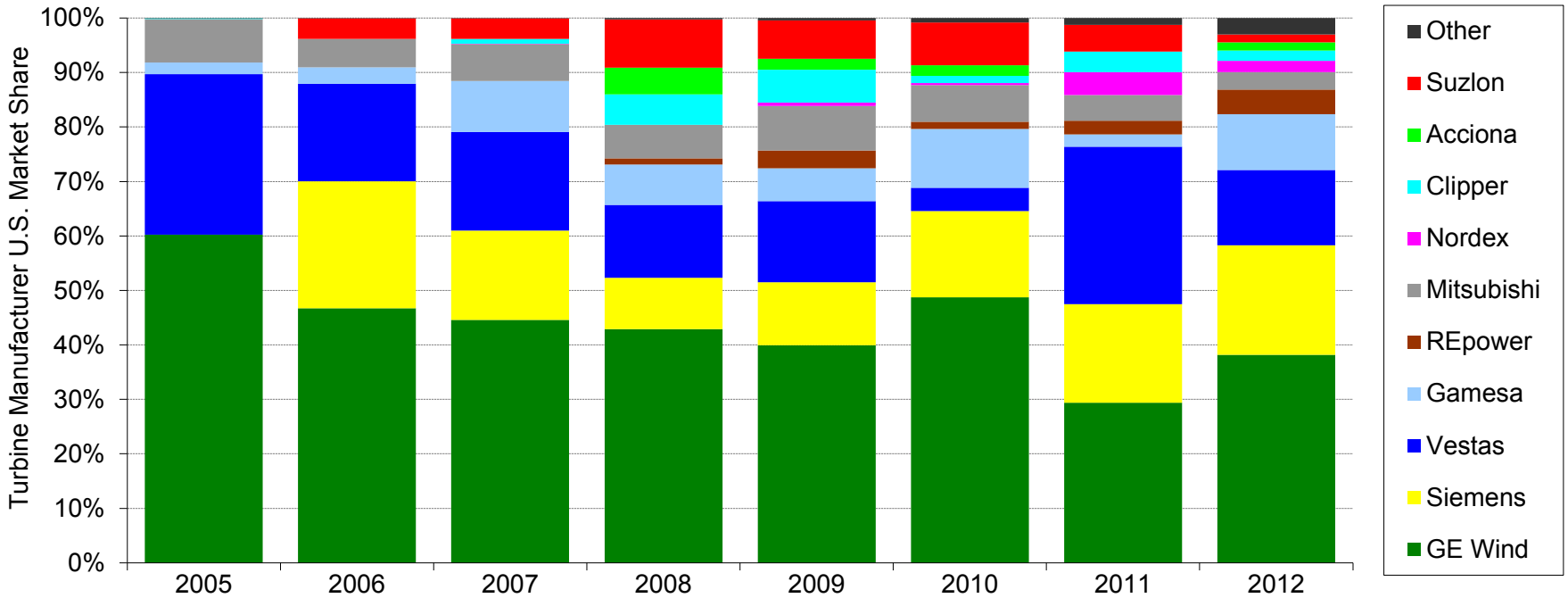


Wind represented ~37% of capacity in sampled 41 queues

But… absolute amount of wind (and coal & nuclear) in sampled queues has declined in recent years whereas natural gas and solar capacity has increased

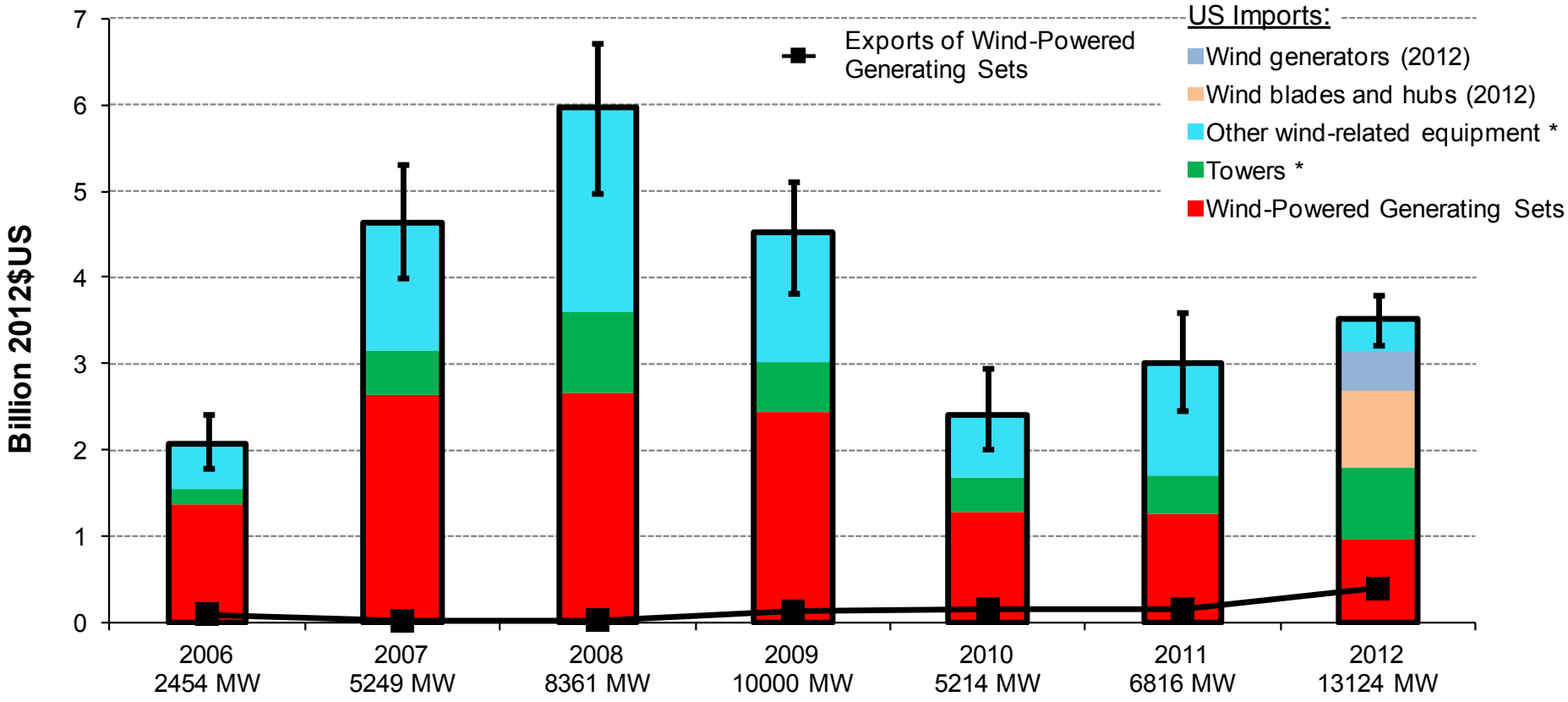
Not all of this capacity will be built….

"Big 3" OEMs Captured >70% U.S. Market in 2012, Yet Diversification Continues



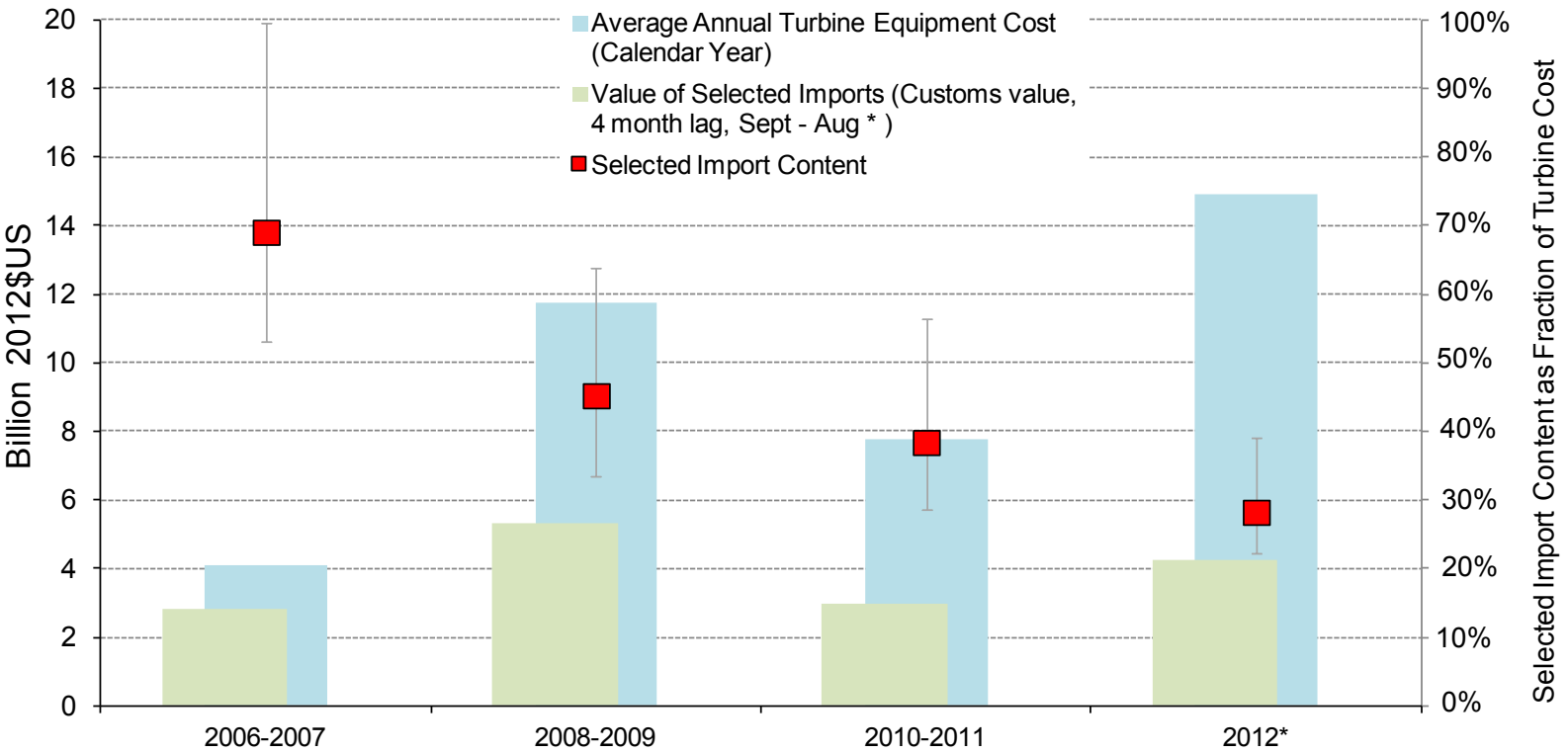
- Turbines (>100 kW) from 27 different OEM's installed in the U.S. in 2012, up from 21 in 2009, 9 in 2007, and 7 in 2005
- 2012 installations by Chinese and South Korean manufacturers included: Goldwind, China Creative, Guodian, Sinovel, Hyundai, HZ, Sany
- Globally, GE ascended to an effective tie with Vestas as the top supplier

Growth in Both Wind-Related Imports and Exports in 2012



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

Despite Challenges Throughout the Supply Chain, Domestic Content Continued to Rise



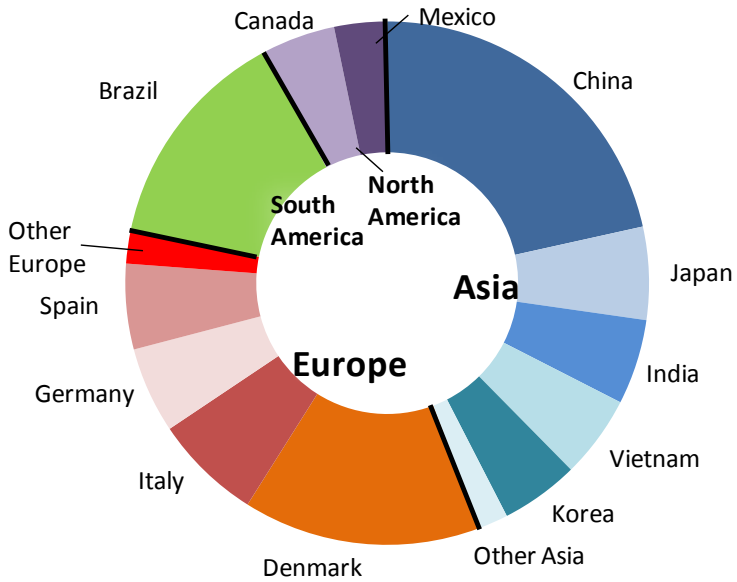
* For 2012, the import period is from September 2011 through November 2012.

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

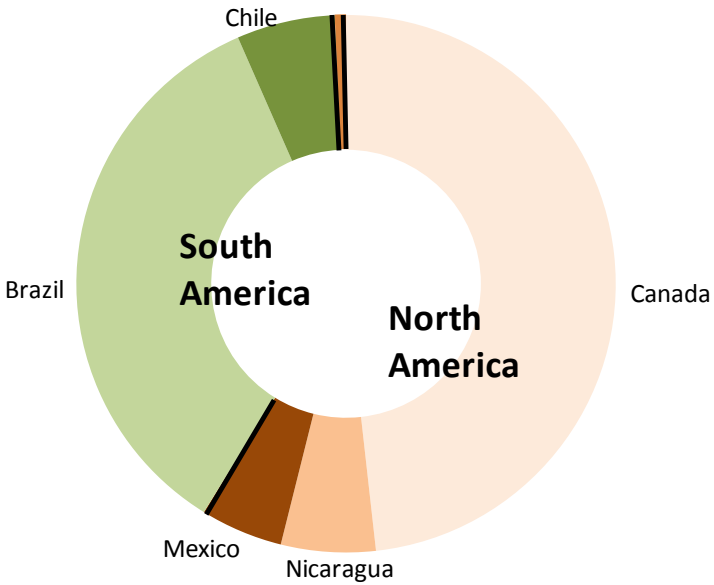
- If imports do not occur through other HTS codes, domestic content increased from: ~30% in 2006-07 to ~70% in 2012

2012 Wind Imports Mostly from Asia and Europe; Exports to North & South America

2012 Total Wind-Specific Imports = $3.15 B

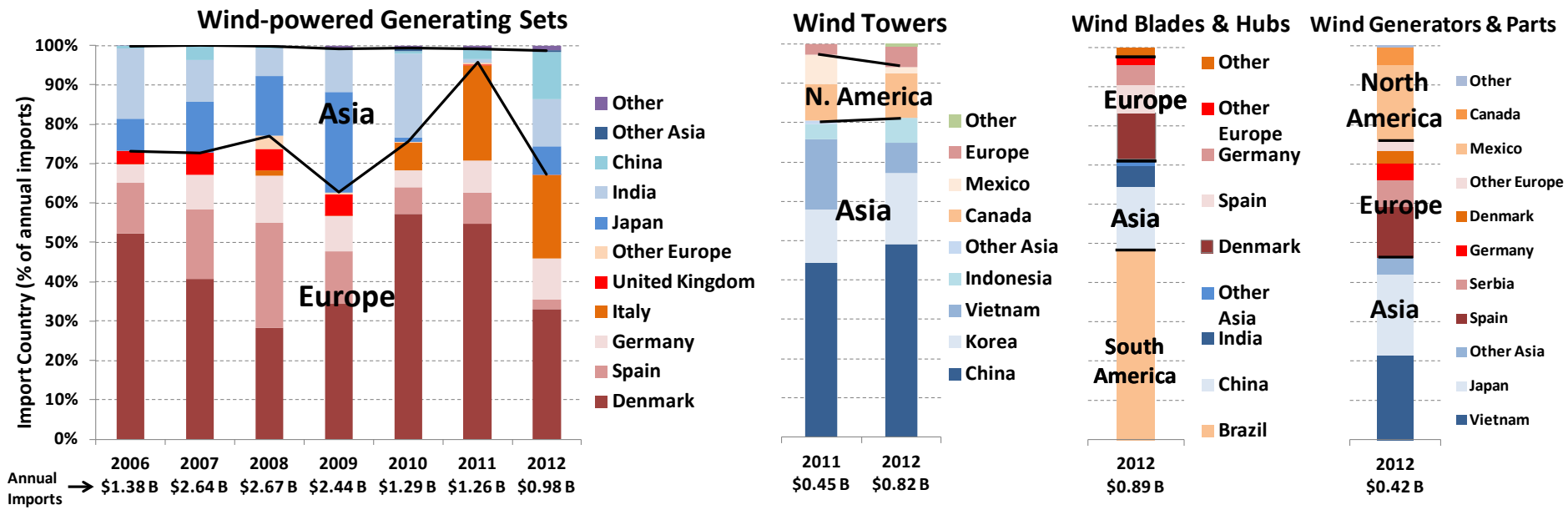


2012 Wind-powered Generating Set Exports = $0.388 B



- Considering all wind-specific imports in 2012, almost half from Asia, one-third from Europe, significant amounts from Americas
- Wind-powered generating set exports in 2012 primarily went to Canada and Brazil
- Non-wind-specific tower exports in 2012 ($154 million in total export value) includes exports that are likely wind to Canada (43%) and Mexico (14%)

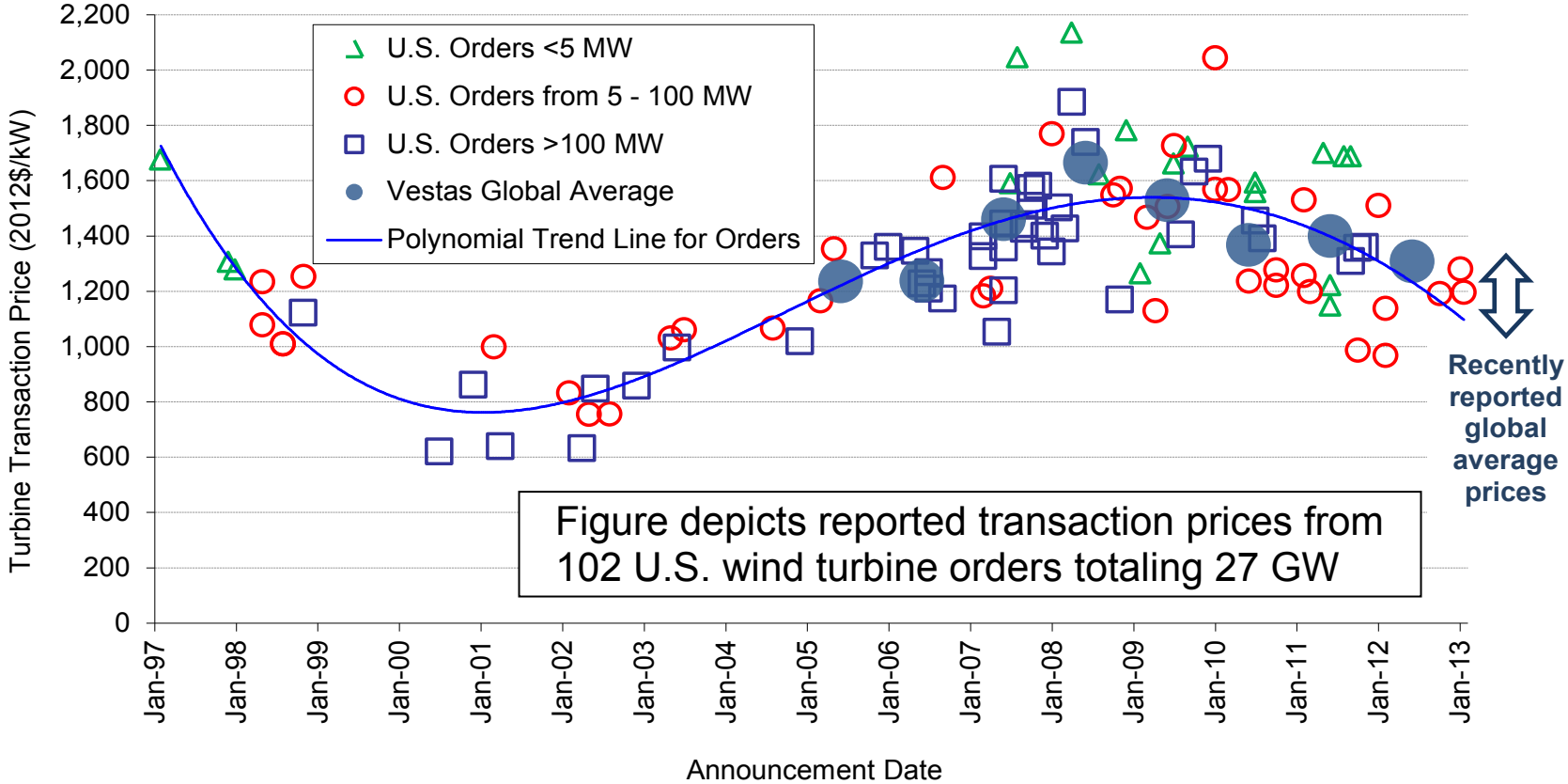
Source Markets for Imports Have Varied Over Time, and By Type of Wind Equipment



- Majority of wind-powered generating sets from Europe (~60%-95%)
- Majority of tower imports from Asia (~80%); less from North America
- Most imports of blades & hubs from Brazil, China, and Denmark; diverse mix
- Majority of wind generators & parts imported from Asia (~45%), remainder mostly from Europe and North America

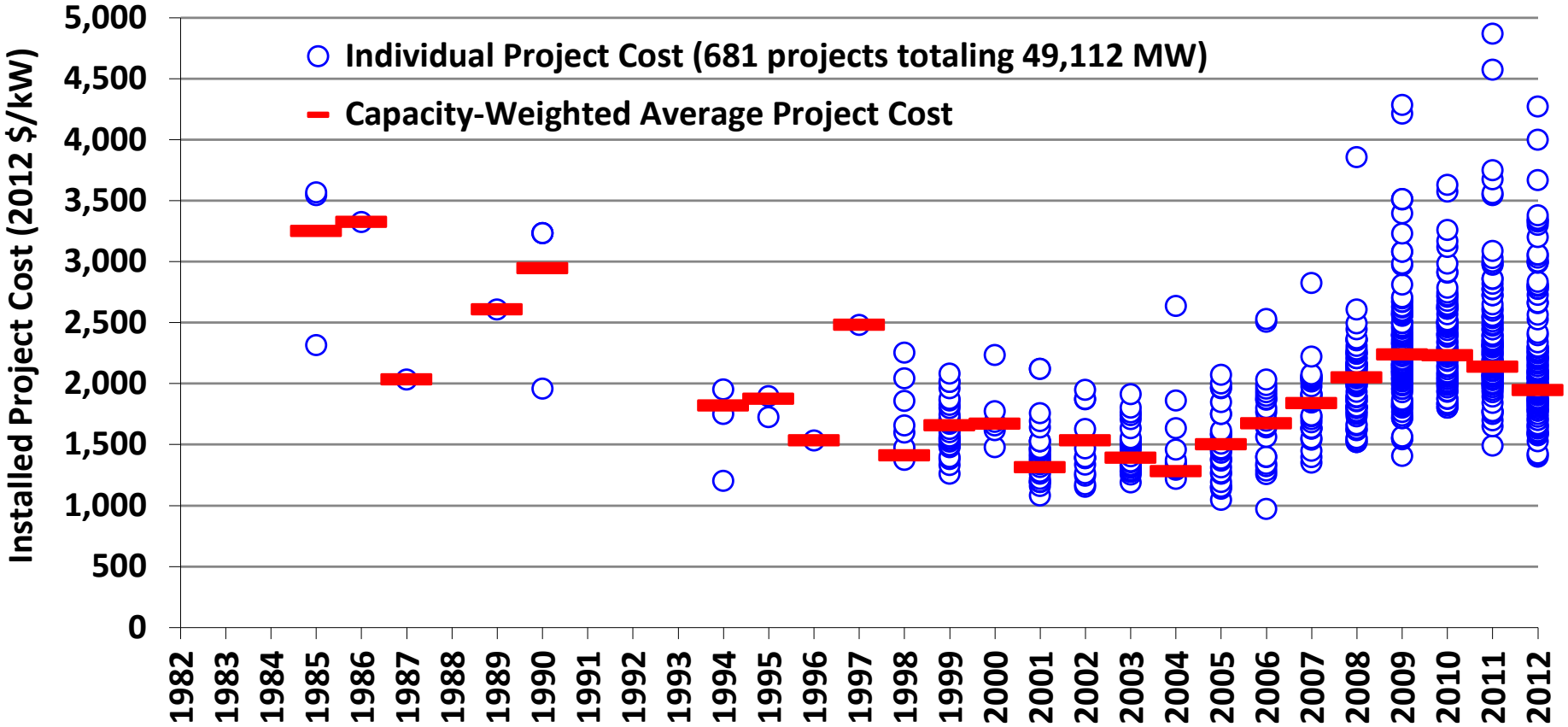
Cost Trends

Wind Turbine Prices Remain Well Below the Levels Seen Several Years Ago



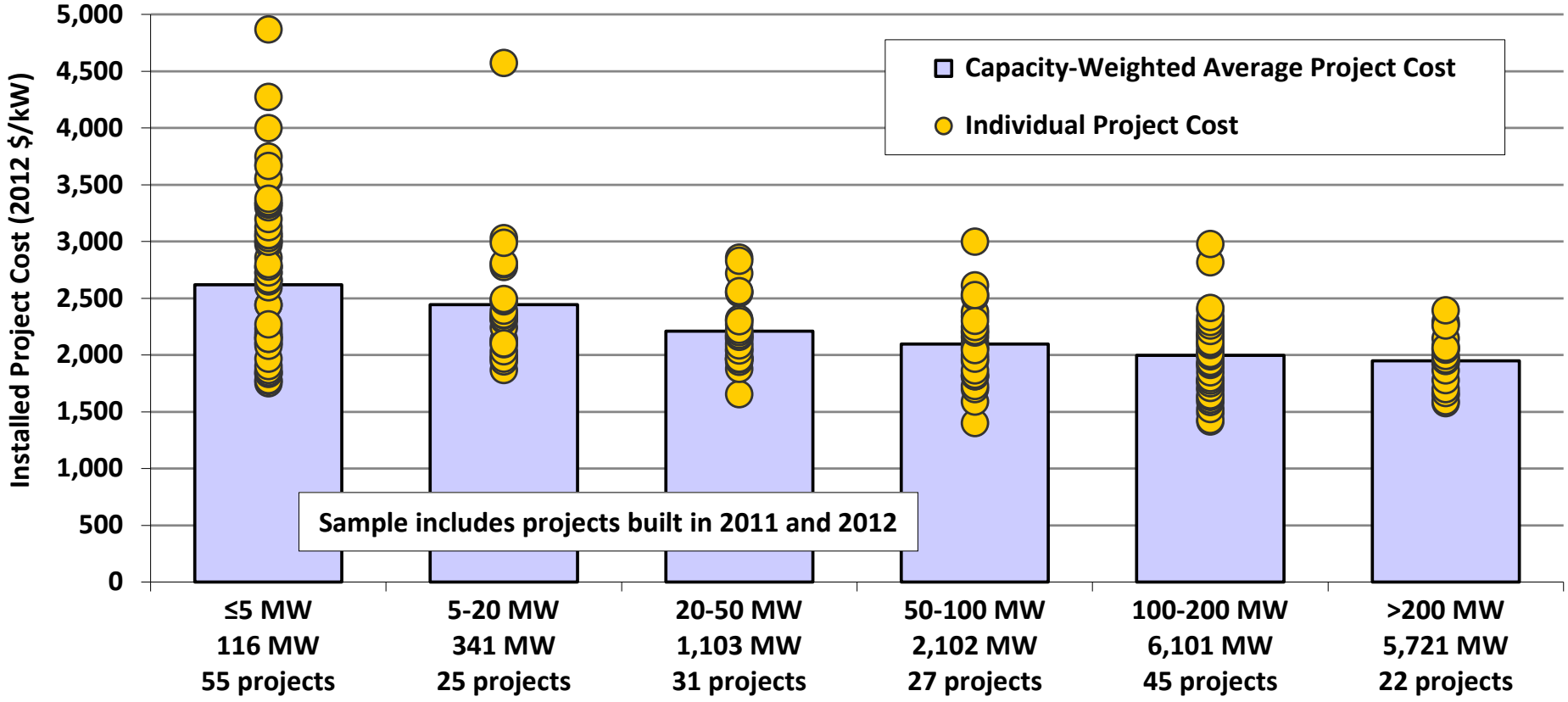
- Recent turbine orders reportedly in the range of $950-1,300/kW, with more-favorable terms for buyers and improved technology

Lower Turbine Pricing Starting To Show Up In Reported Total Project Costs

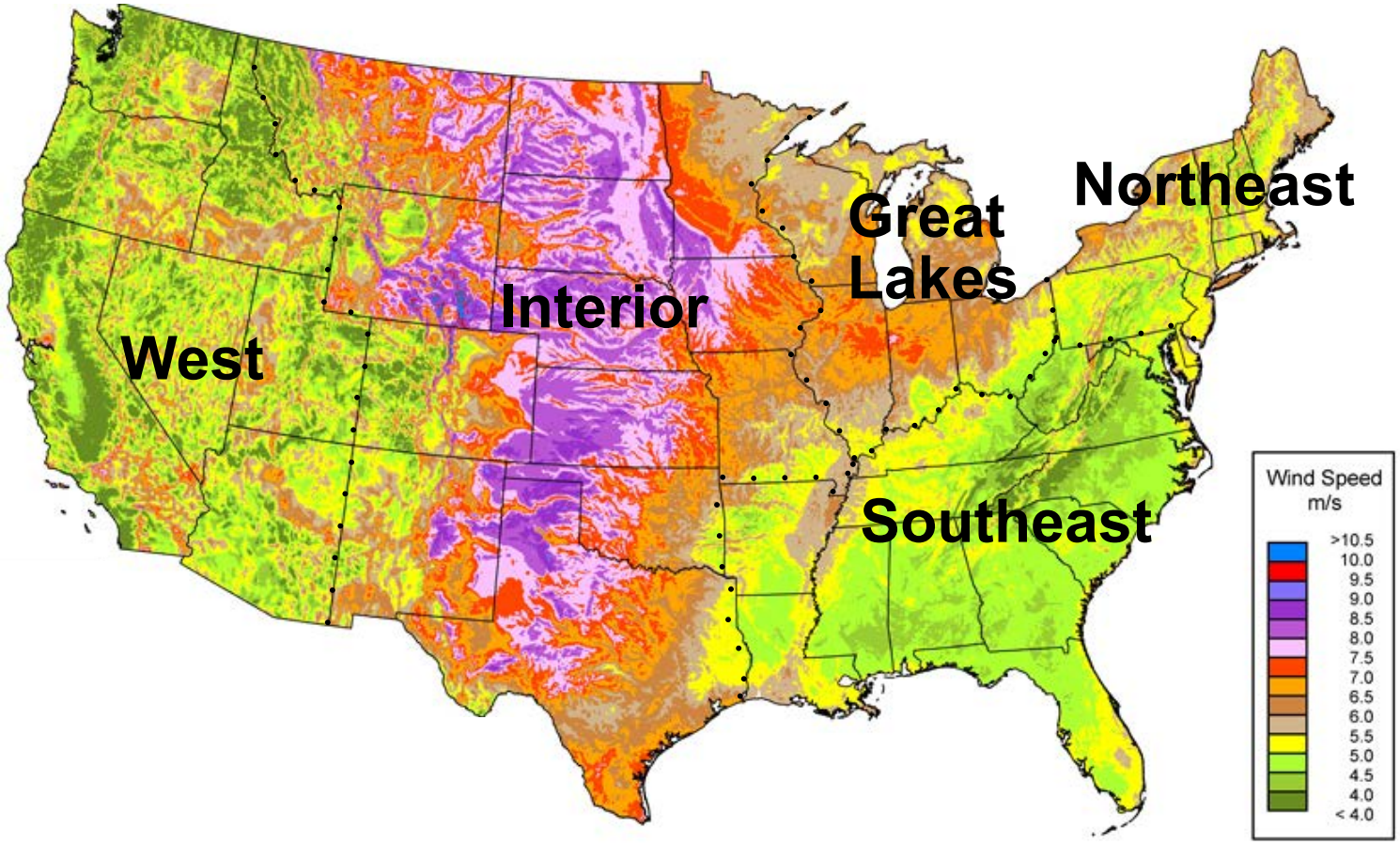


Source: LBNL

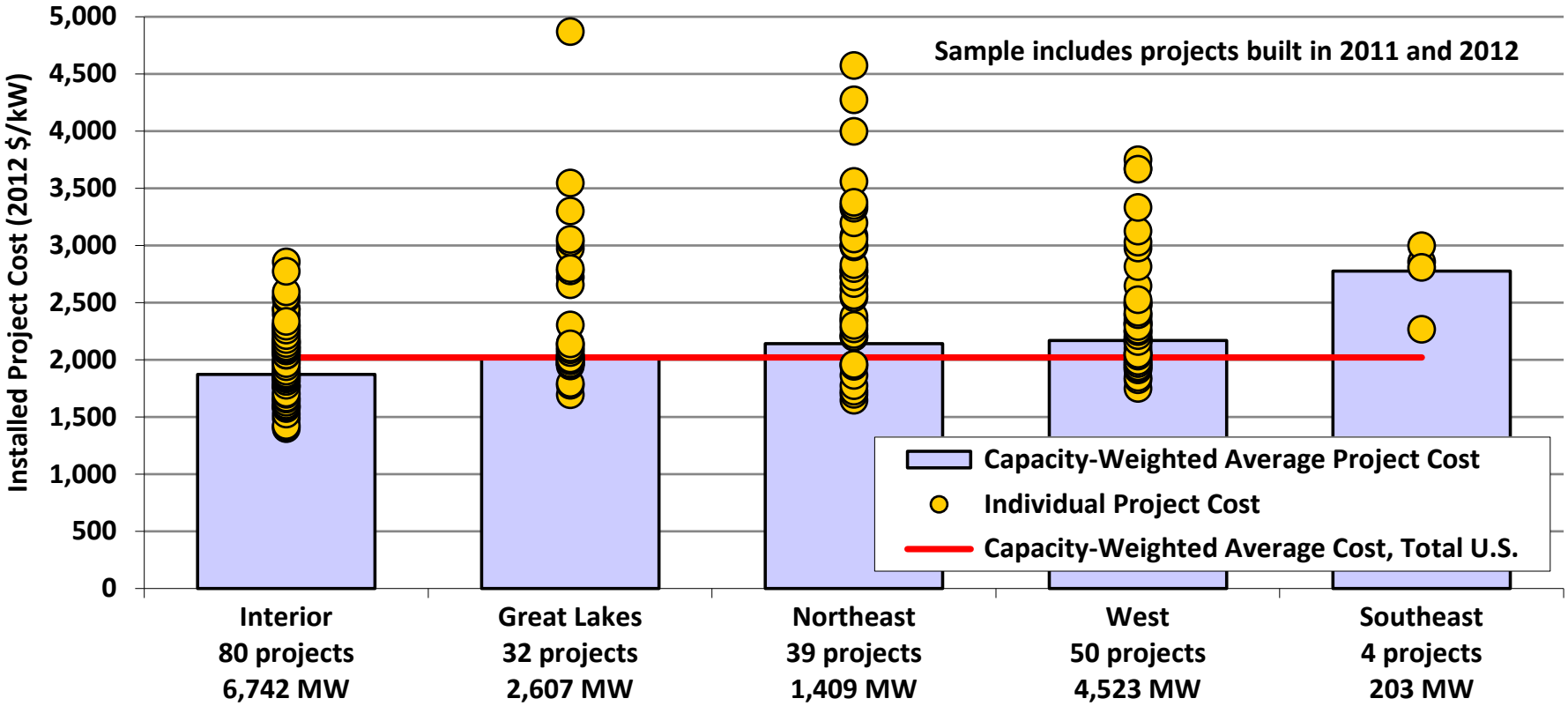
Economies of Scale Evident, Particularly at Low End of Project Size Range



Regional Definitions Based on Combination of Geography and Wind Resource



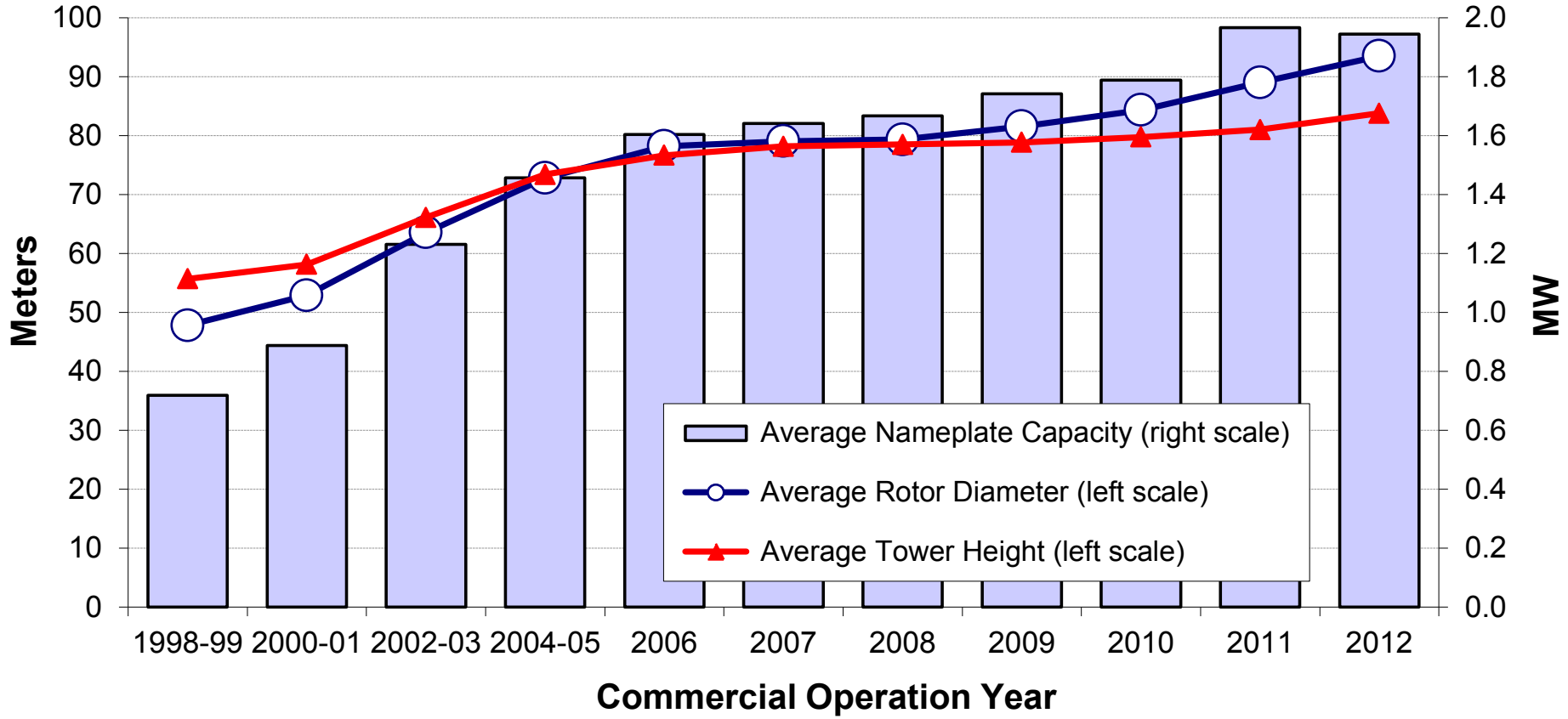
Some Regional Differences in Average Wind Power Project Costs Are Apparent



Different permitting/development costs may play a role at both ends of spectrum: it's easier/cheaper to build in the US interior and harder/more expensive along the coasts

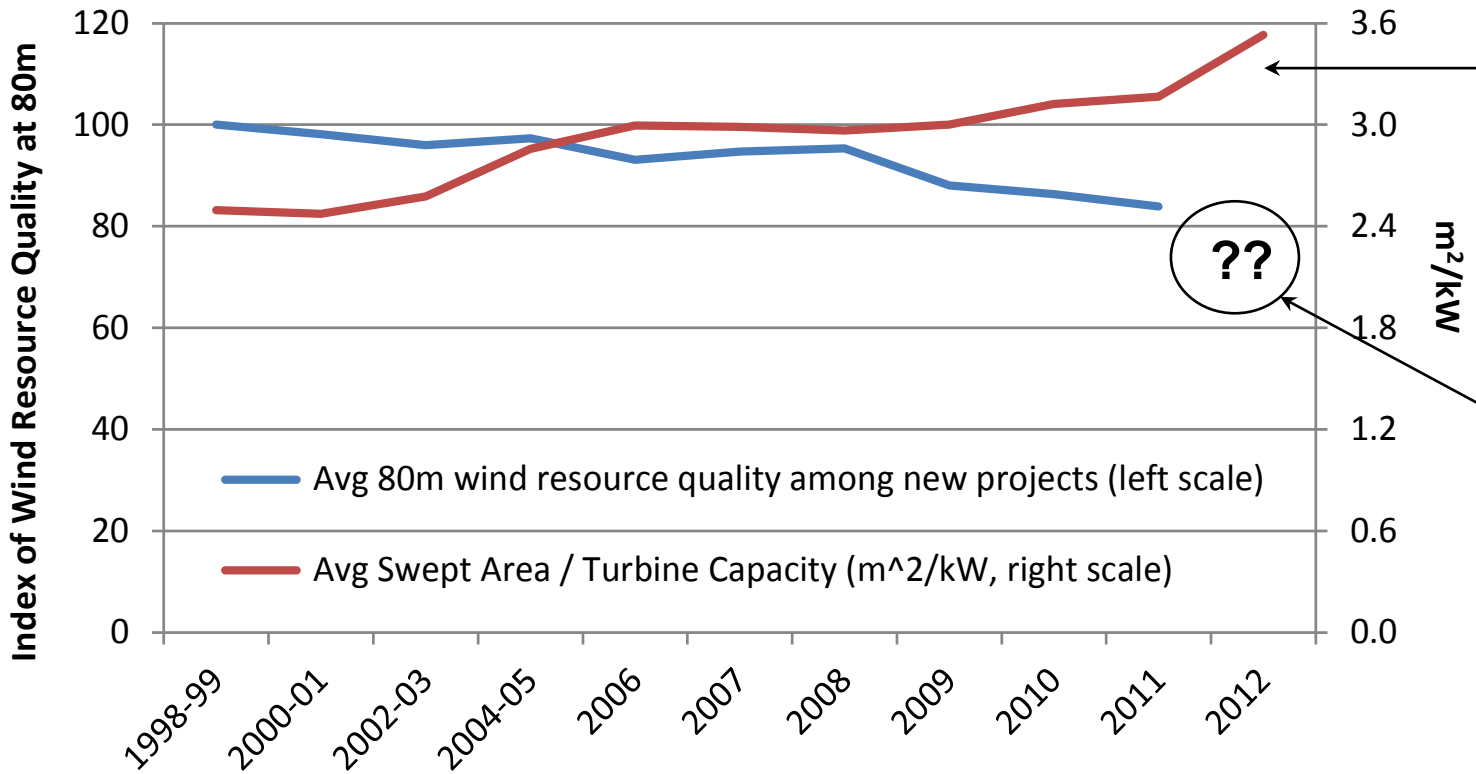
Performance Trends

Performance Is Impacted by the Physical Characteristics of the Turbine Fleet…



- Two periods of rapid scaling: 1998-2006 and 2009-present
- 2007-2008 mostly stagnant, as OEMs focused on meeting demand

… and the Quality of the Local Wind Resource…



On average over time, rotor swept area has grown faster than rated turbine capacity

On average over time, new projects have been built in lower quality wind resource sites (data for 2012 projects are not yet available)

All else equal:

- Growth of rotor swept area relative to capacity will boost capacity factor
- Building projects in lower wind resource sites will hurt capacity factor

… and the Level of Wind Curtailment

Estimated Wind Curtailment (GWh and % of potential wind generation)

	2007	2008	2009	2010	2011	2012
Electric Reliability Council of Texas (ERCOT)	109.1 (1.2%)	1,416.6 (8.4%)	3,872.2 (17.1%)	2,066.5 (7.7%)	2,621.5 (8.5%)	1,038.0 (3.7%)
Southwestern Public Service Company (SPS)	N/A	0 (0.0%)	0 (0.0%)	0.9 (0.0%)	0.5 (0.0%)	N/A
Public Service Company of Colorado (PSCo)	N/A	2.5 (0.1%)	19.0 (0.6%)	81.5 (2.2%)	63.9 (1.4%)	N/A
Northern States Power Company (NSP)	N/A	25.4 (0.9%)	42.4 (1.7%)	44.3 (1.7%)	58.7 (1.6%)	120.5 (3.1%)
Midwest Independent System Operator (MISO), less NSP	N/A	N/A	249.6 (2.0%)	779.7 (4.2%)	782.6 (3.4%)	726.2 (2.5%)
Bonneville Power Administration (BPA)	N/A	N/A	N/A	4.6* (0.1%)	128.7* (1.4%)	70.8* (0.7%)
PJM	N/A	N/A	N/A	N/A	N/A	111.6# (1.8%)#
Total Across These Seven Areas:	**109 (1.2%)**	**1,444 (5.7%)**	**4,183 (9.7%)**	**2,978 (4.9%)**	**3,656 (4.9%)**	**2,067 (2.7%)**

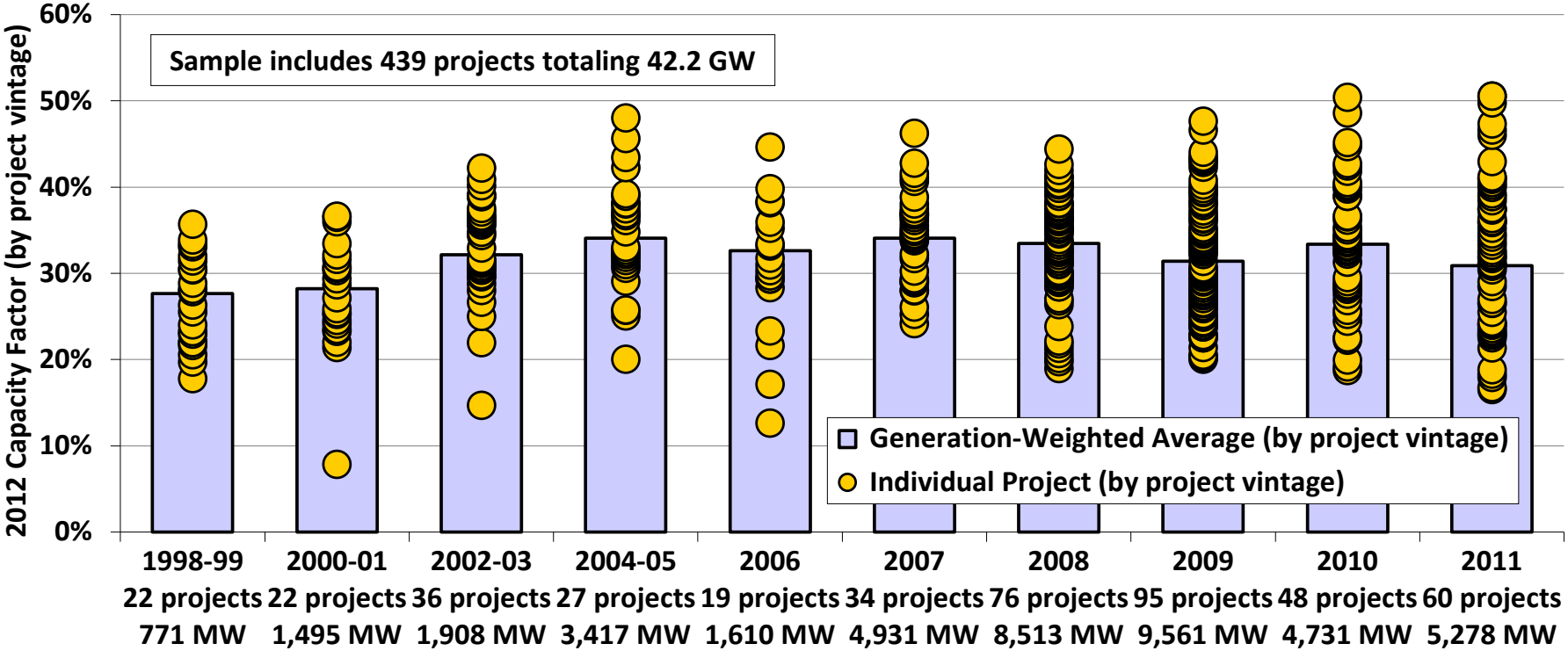
*A portion of BPA's curtailment is estimated assuming that each curtailment event lasts for half of the maximum possible hour for each event.

#2012 curtailment numbers for PJM are for June through December only (data for January through May are not available).

- ERCOT numbers represent both forced (non-market) and voluntary (market) curtailment
- All other regions show only forced curtailment

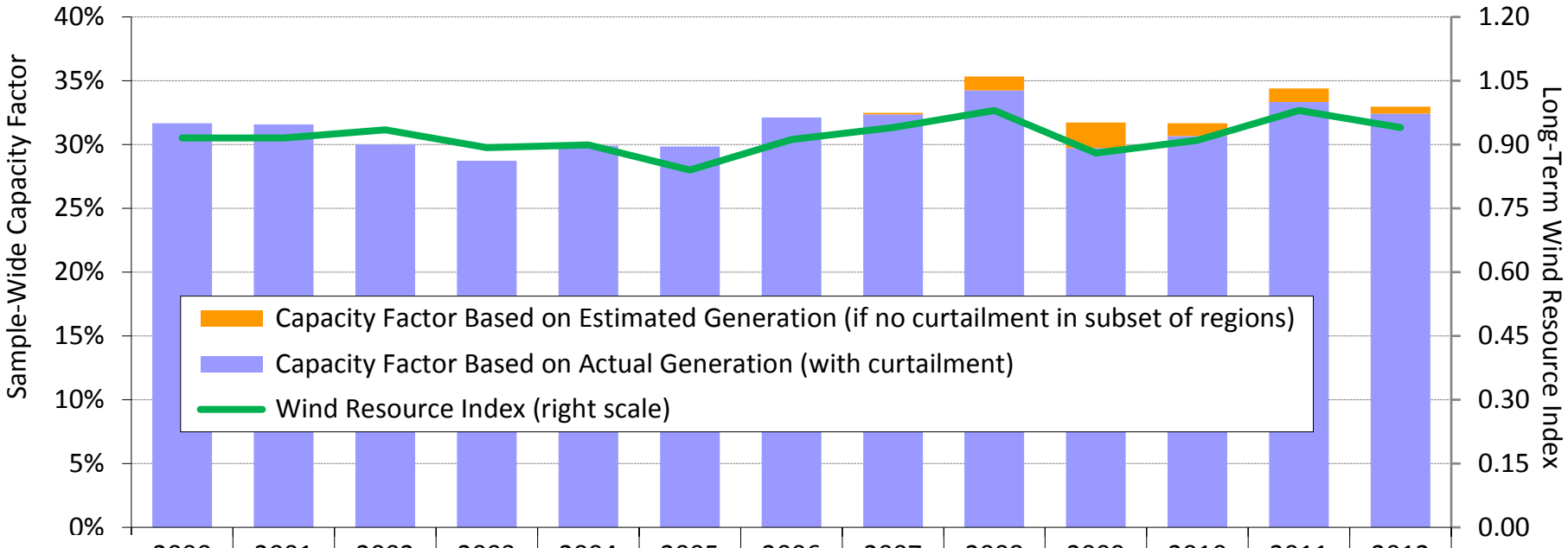
Assuming a 33% capacity factor, the total amount of wind generation curtailed in 2012 within just the territories shown above equates to the annual output of roughly 715 MW of wind power capacity

Competing Influences Result in Lackluster Trend in Capacity Factor by Project Vintage



Sample-wide average *not* strongly trending higher with more-recent vintages as might be expected based on rotor and hub height scaling trends: does not incorporate 2012 scaling and does not control for wind resource quality

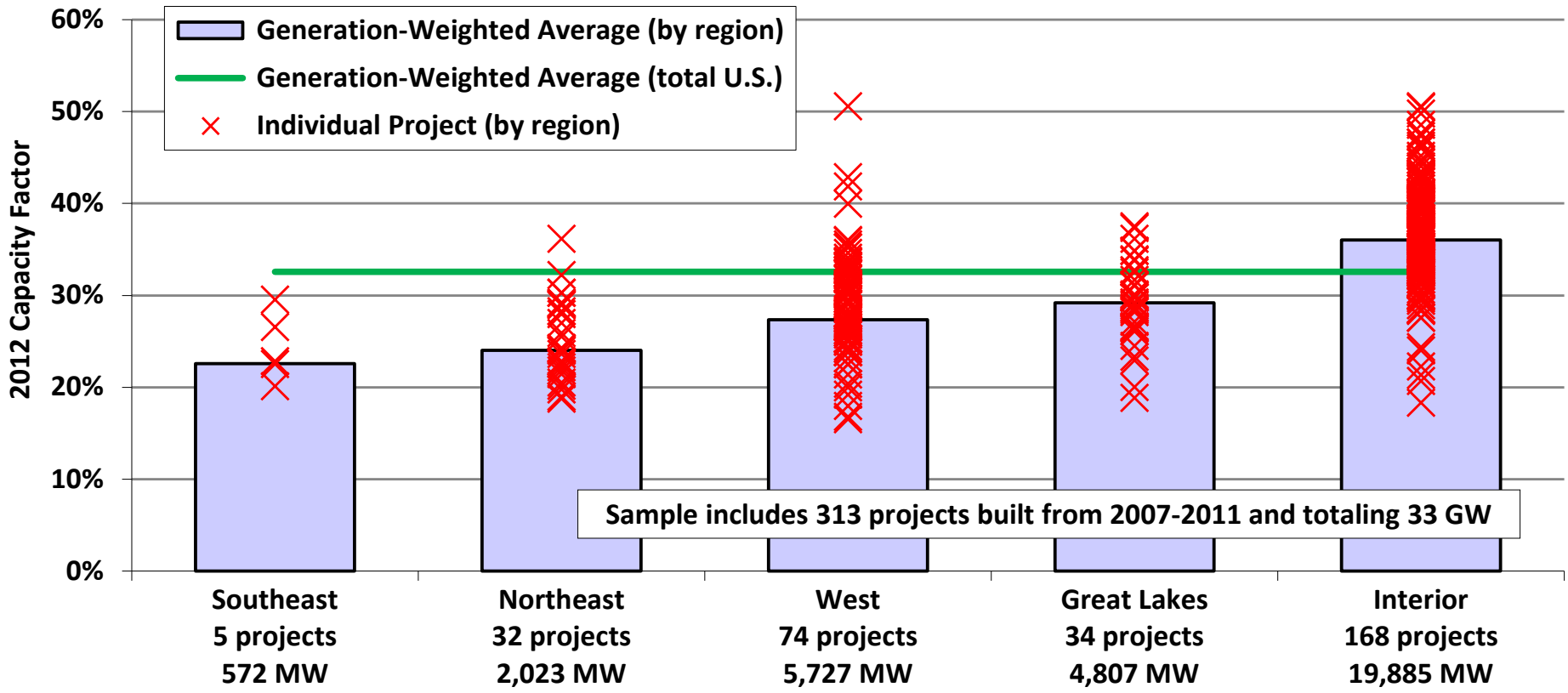
… and Allow Fleet-Wide Capacity Factor Trends To Be Dominated By Year-to-Year Resource Variations



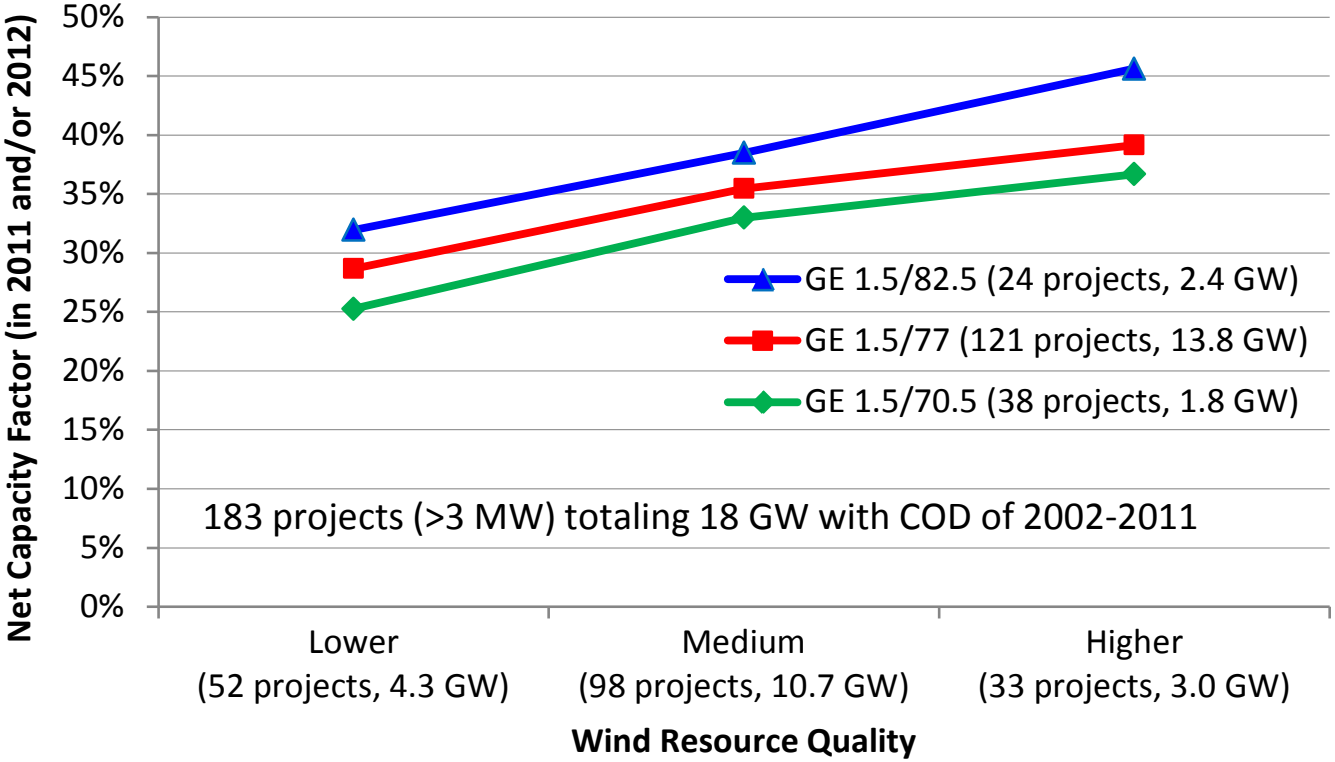
Year:	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
# Projects:	10	31	74	85	107	130	154	197	241	340	453	517	443
# MW:	591	944	2,683	3,129	4,501	5,144	7,968	9,952	14,927	23,618	33,382	38,563	42,281

The wind resource index is compiled from NextEra Energy Resources reports. The pre-2007 portion of the index is adjusted to approximate the conversion from wind speed to generation (this adjustment is unnecessary starting in 2007).

But… Regional Trends in Average Capacity Factors Are Clearly Apparent



Controlling for Wind Resource Quality Demonstrates Impact of Turbine Evolution (of at least the 1.5 MW turbines)



Wind Resource Quality is based on AWS Truepower site estimate of gross capacity factor at 80 m:

- Lower = 30%-40%
- Medium = 40%-50%
- Higher = 50%-60%

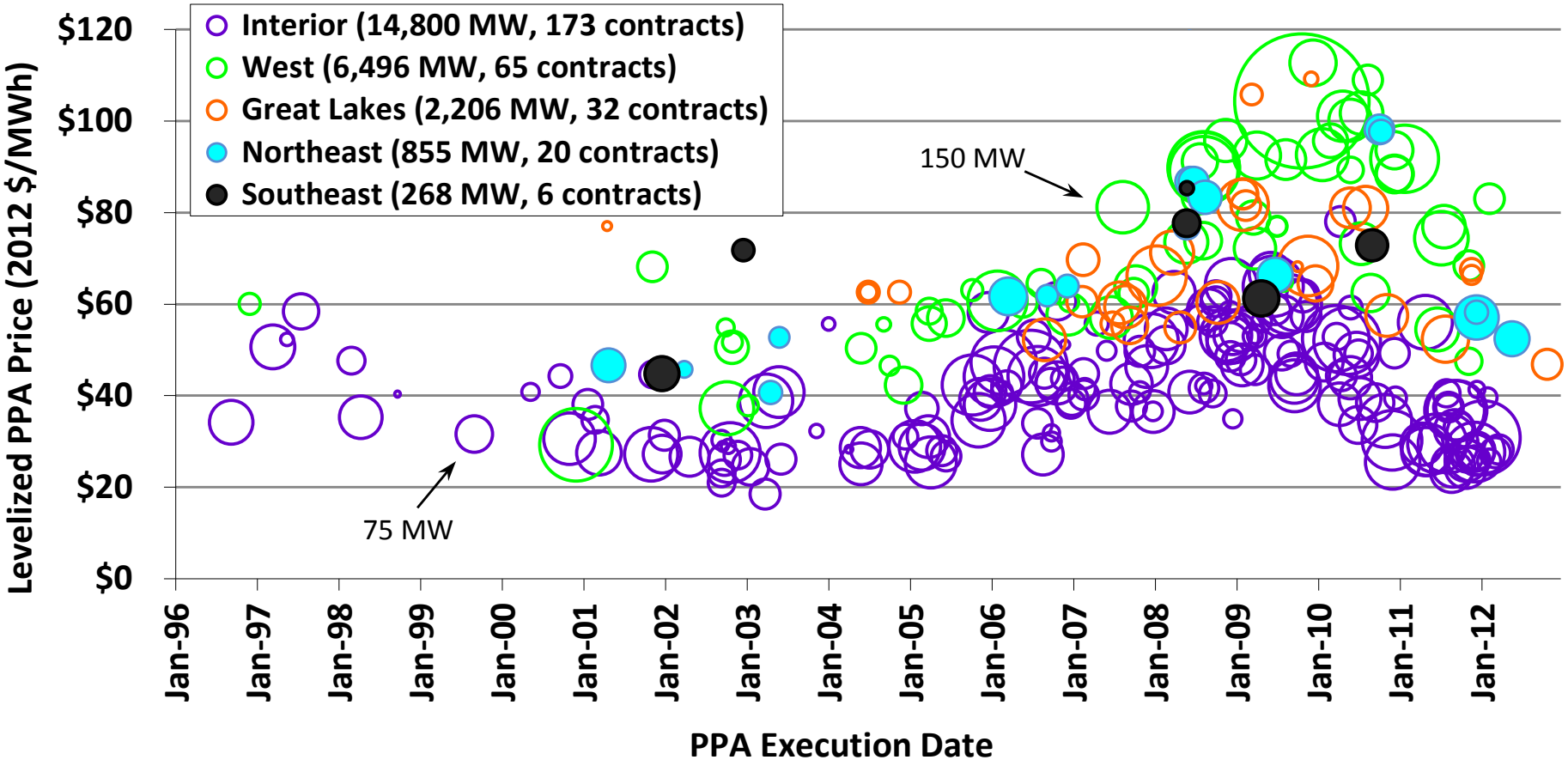
- Still too early for GE 1.6/100 turbines to be reflected in empirical capacity factor data: expect a much larger increase in years ahead

Wind Power Price Trends

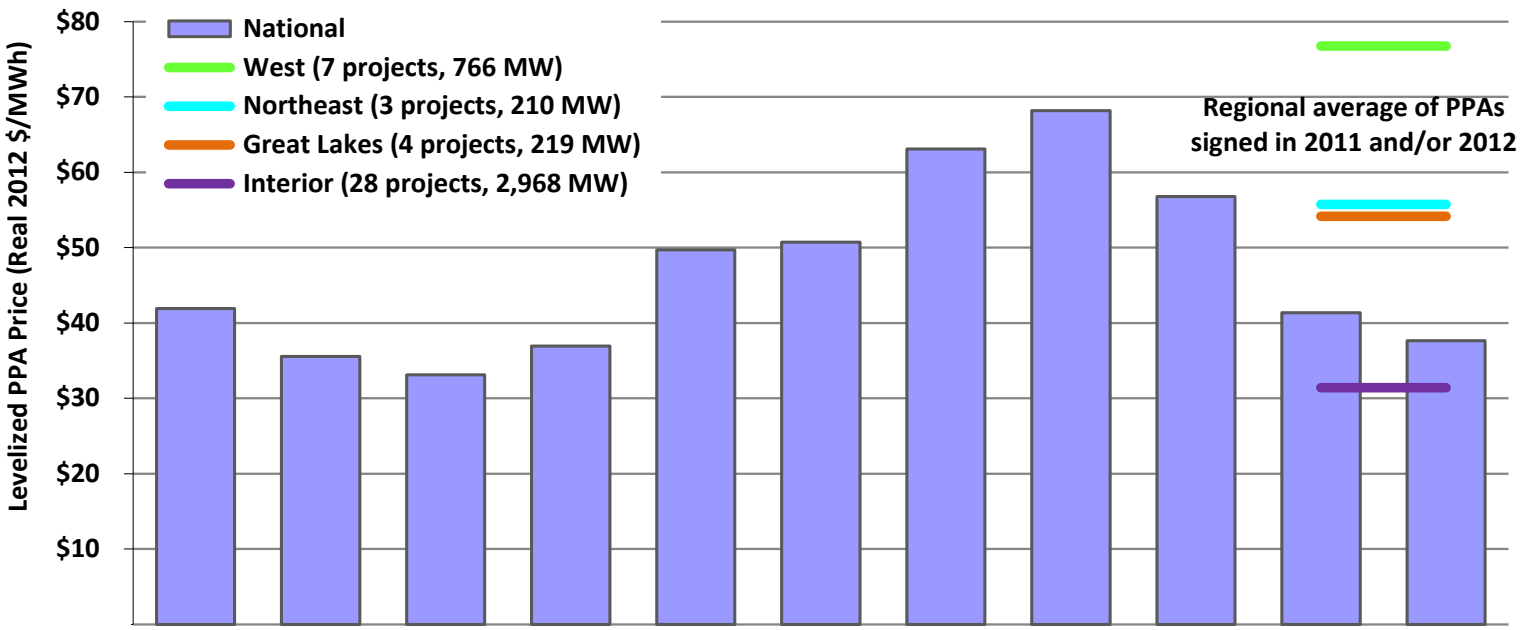
Sample of Wind Power Prices

- Berkeley Lab collects data on historical wind power sales prices, and long-term PPA prices
- PPA sample includes 302 contracts from projects built from 1998-2012, totaling 24,625 MW (42% of all wind capacity added in that period, and 70% of all capacity added that is sold under bundled PPAs)
- 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 well as various local policy and market influences; as a result, prices <u>do not</u> reflect wind energy generation costs

Lower Costs and Better Capacity Factors Enable Aggressive Recent PPA Pricing



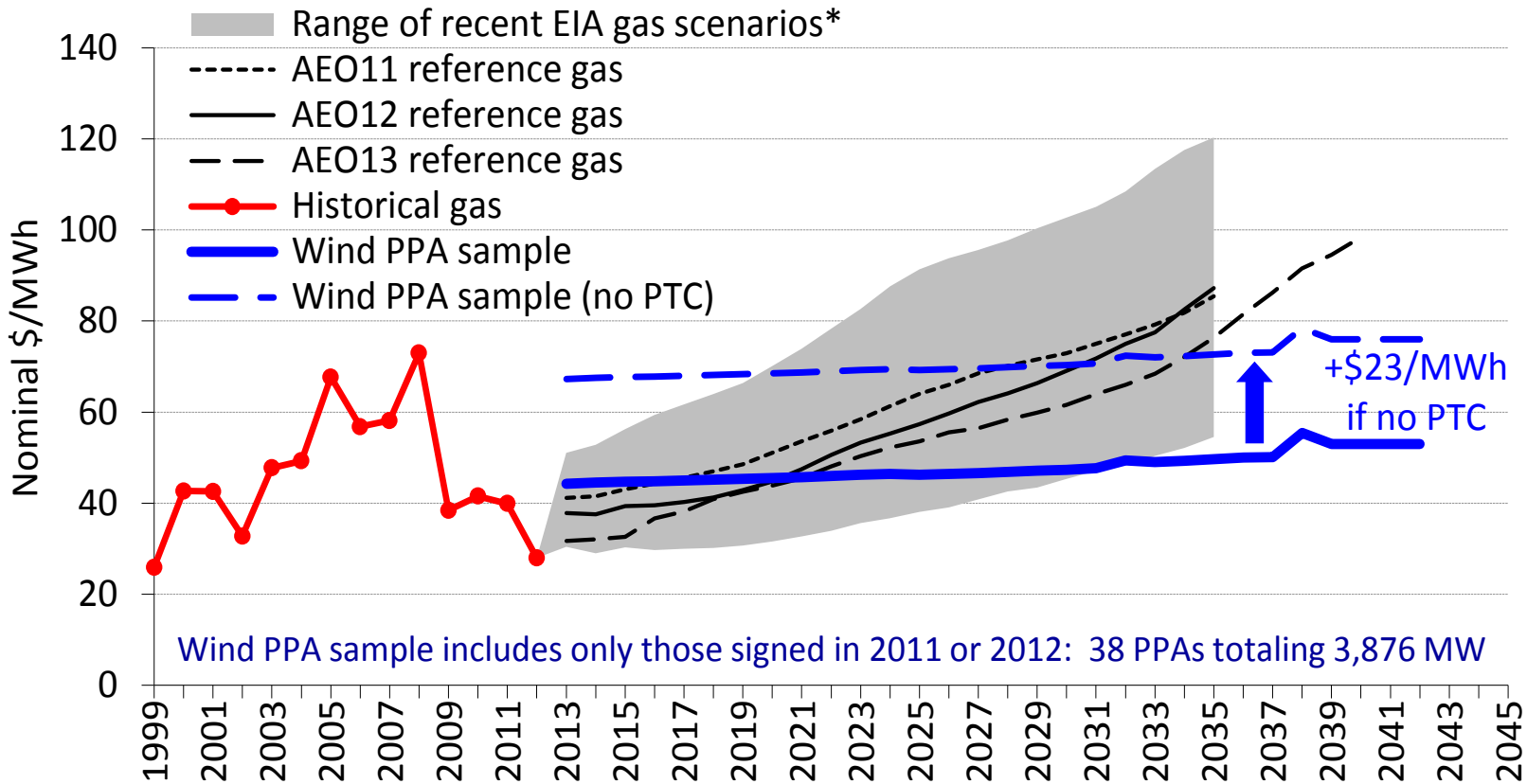
A Smoother Look at the Time Trend Shows Steep Recent Decline in Pricing; Especially Low Pricing in Interior Region



PPA Year:	1996-99	2000-01	2002-03	2004-05	2006	2007	2008	2009	2010	2011	2012
Contracts:	10	17	24	30	30	26	39	48	36	34	8
MW:	553	1,249	1,382	2,190	2,311	1,781	3,465	4,132	3,399	3,532	630

- Current PPA prices rival lows reached a decade ago – despite the trend towards sites with lower quality wind resources

Despite Lower Gas Prices, Recent Wind Contracts (w/ the PTC) Can Still Compete



Fuel cost projections are translated from $/MMBtu into $/MWh terms using average heat rates implied in the NEMS modeling output

- Wind is modeled merely as a "fuel saver" – i.e., wind is assumed to offset only the fuel costs of gas-fired generation (no credit given for capacity value, etc.)

Future Outlook

2013 Expected to Be a Slow Year for Wind Additions as Pipeline Recharges; Growth in 2014, then Uncertainty in 2015 and Beyond

Forecasts for Annual U.S. Wind Additions (MW)

Source	2013	2014	2015
Bloomberg NEF (2013a, 2013c)	2,800	8,000	3,200
IHS EER (2013)	2,000	6,000	7,300
Navigant (2013)	5,000	9,000	3,500
Make Consulting (2013)	2,700	6,600	na
EIA (2013b)	3,500	8,600	na

Current Low Prices for Wind Energy May Support Higher Growth in the Future, but Headwinds Include…

- Lack of clarity about fate of federal tax incentives
- Continued low natural gas and wholesale electricity prices
- Modest electricity demand growth
- Limited near-term demand from state RPS policies
- Inadequate transmission infrastructure in some areas
- Growing competition from solar in some regions

Growth expectations in near term do not match what would be required to achieve 20% wind by 2030

Conclusions

- Wind has been a significant source of new generation in the U.S.
- The supply chain is under duress, but domestic manufacturing content remains strong
- Turbine scaling is boosting wind project capacity factors, while the installed cost of wind is on the decline
- Trends are enabling very aggressive wind power pricing and solid economics in many regions despite low natural gas prices
- It will take time to re-build the project pipeline, ensuring a slow year for new additions in 2013, and then solid growth in 2014
- Medium to longer term growth remains uncertain, dictated in part by future natural gas prices as well as state and federal policy decisions, though recent declines in the price of wind energy help boost the prospects for future growth

For More Information...

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

- http://www1.eere.energy.gov/wind/

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