Wind Energy Cost, Performance and Pricing Trends: Past & Future

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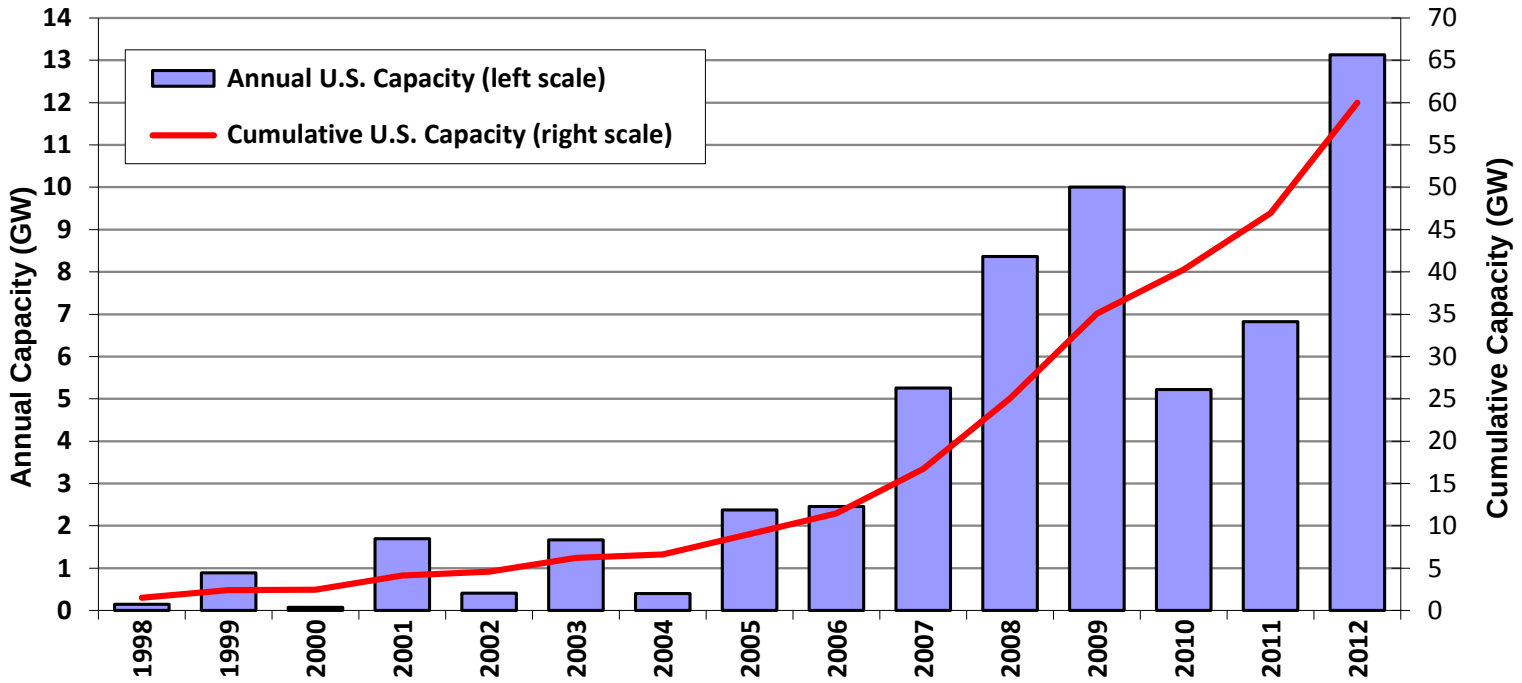
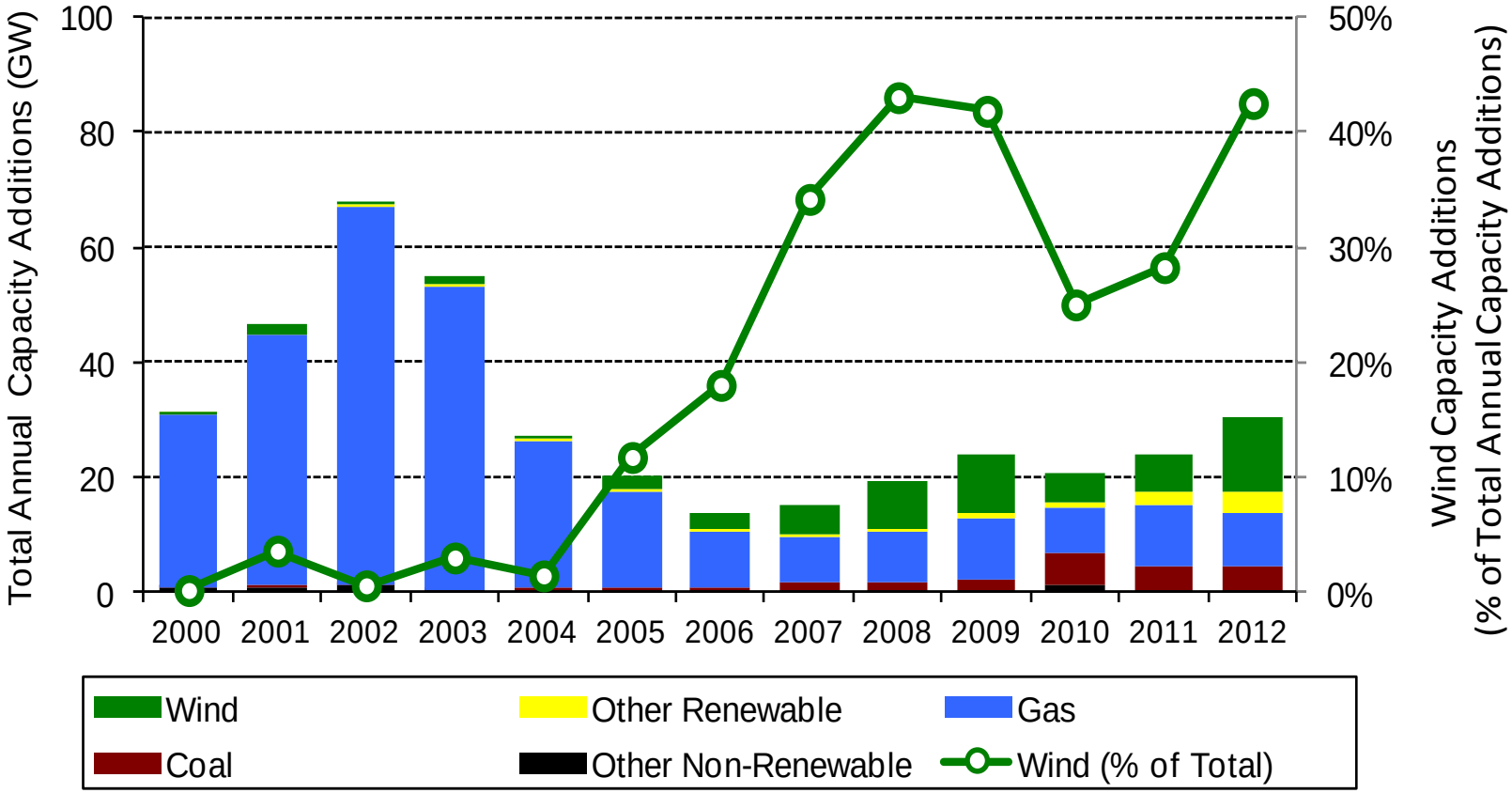
Wind Power Additions Hit a New Record in 2012, in Part Driven By the Then-Planned Expiration of Federal Tax Incentives



- 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

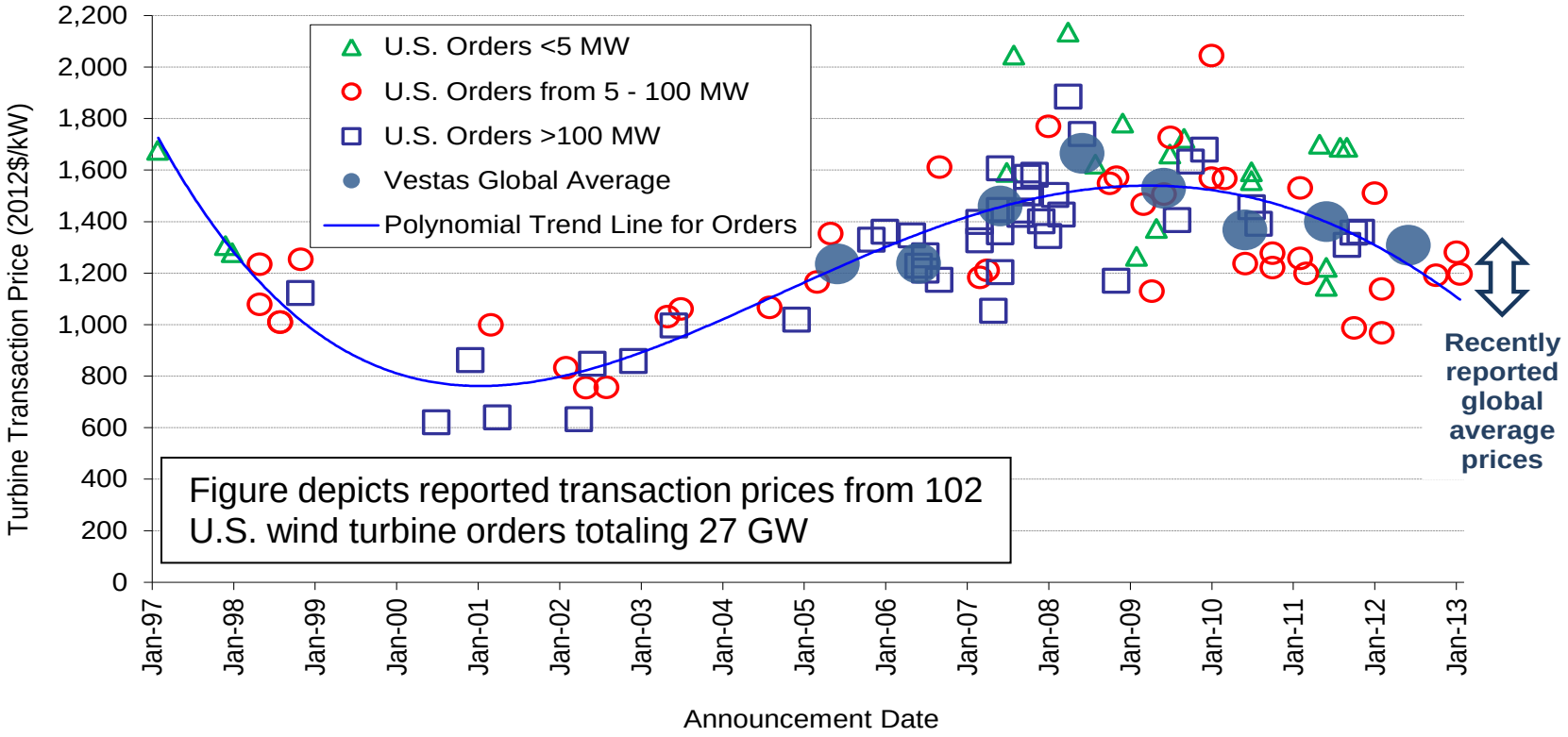


- Wind was, for the first time, the largest resource added in terms of gross capacity, despite persistently low natural gas prices

- Past deployment substantially impacted by wind technology improvement, and impacts on:
  - ✓ Cost trends
  - ✓ Performance trends
  - ✓ Pricing trends
- Future deployment may be impacted to an even greater degree, given policy uncertainty at Federal and State levels
- Presentation focused on past and near-term trends, limited to land-based wind

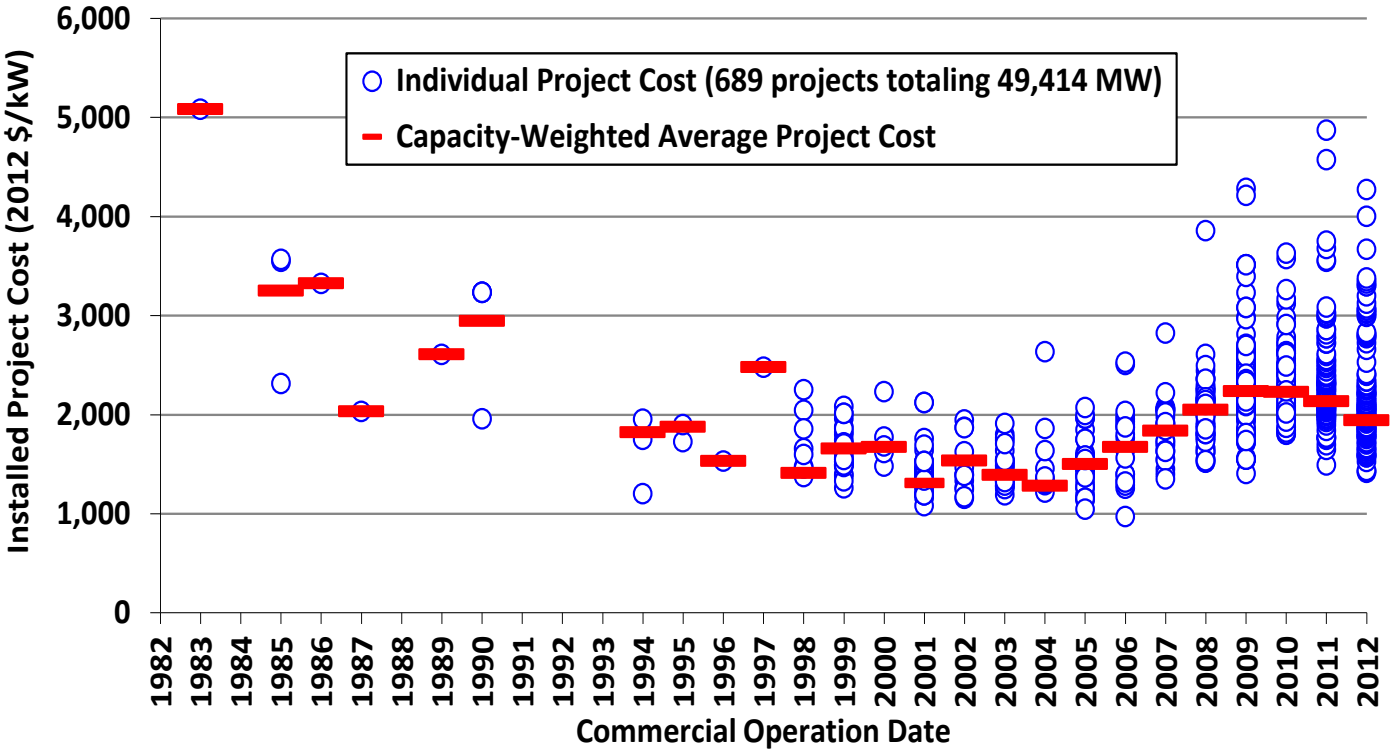
Past Trends: Cost

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



Escalation in turbine prices from 2003 through 2008: rising commodity prices; increased labor costs; improved manufacturer profitability; turbine up-scaling

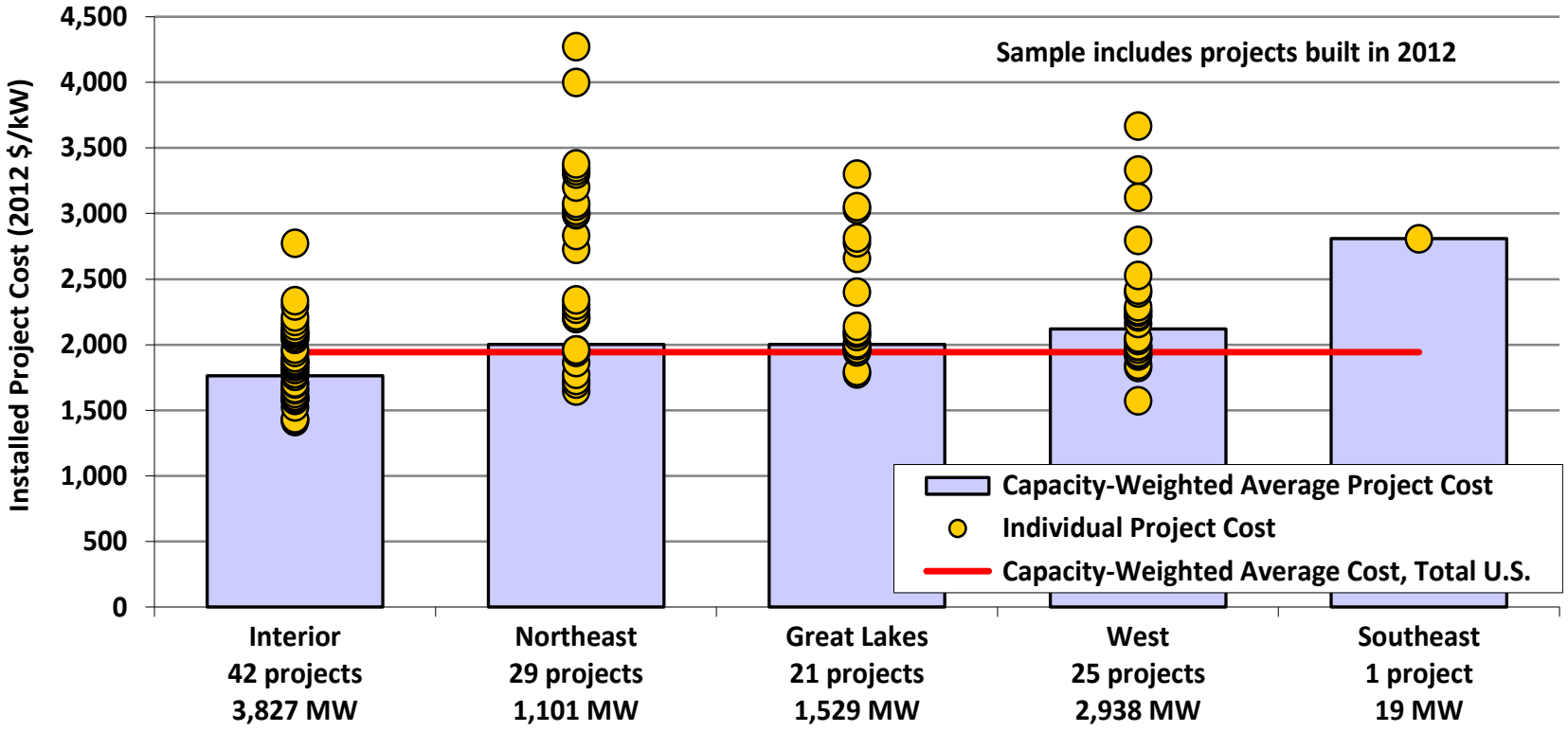
Reported Installed Project Costs Continue to Trend Lower



2012 average: $1,940/kW, down $200/kW from 2011; down $300/kW from peak

Whereas turbine prices peaked in 2008/2009, project-level installed costs peaked in 2009/2010, reflecting the normal passage of time between when a turbine supply agreement is signed and when those turbines are actually installed

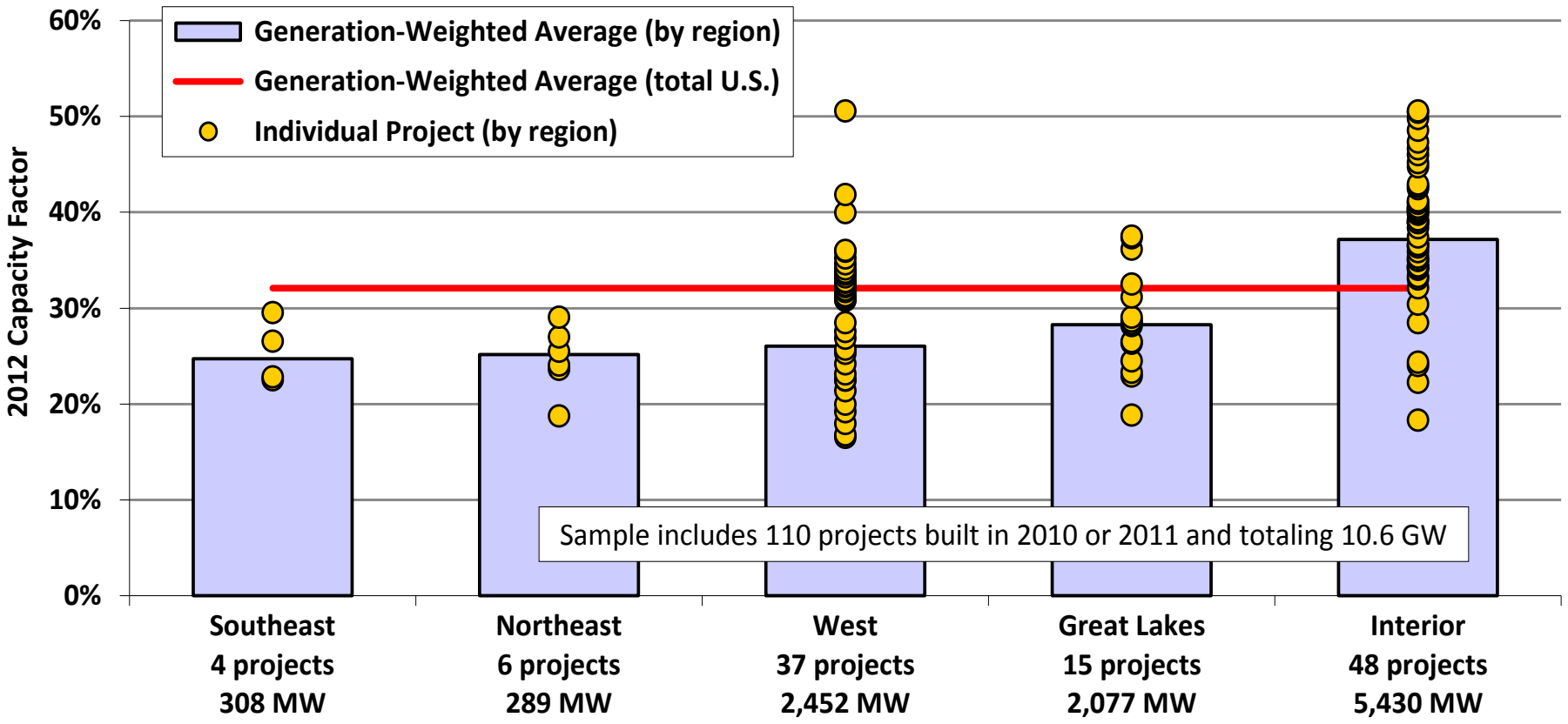
Some Regional Differences in Average Wind Power Project Costs Are Apparent



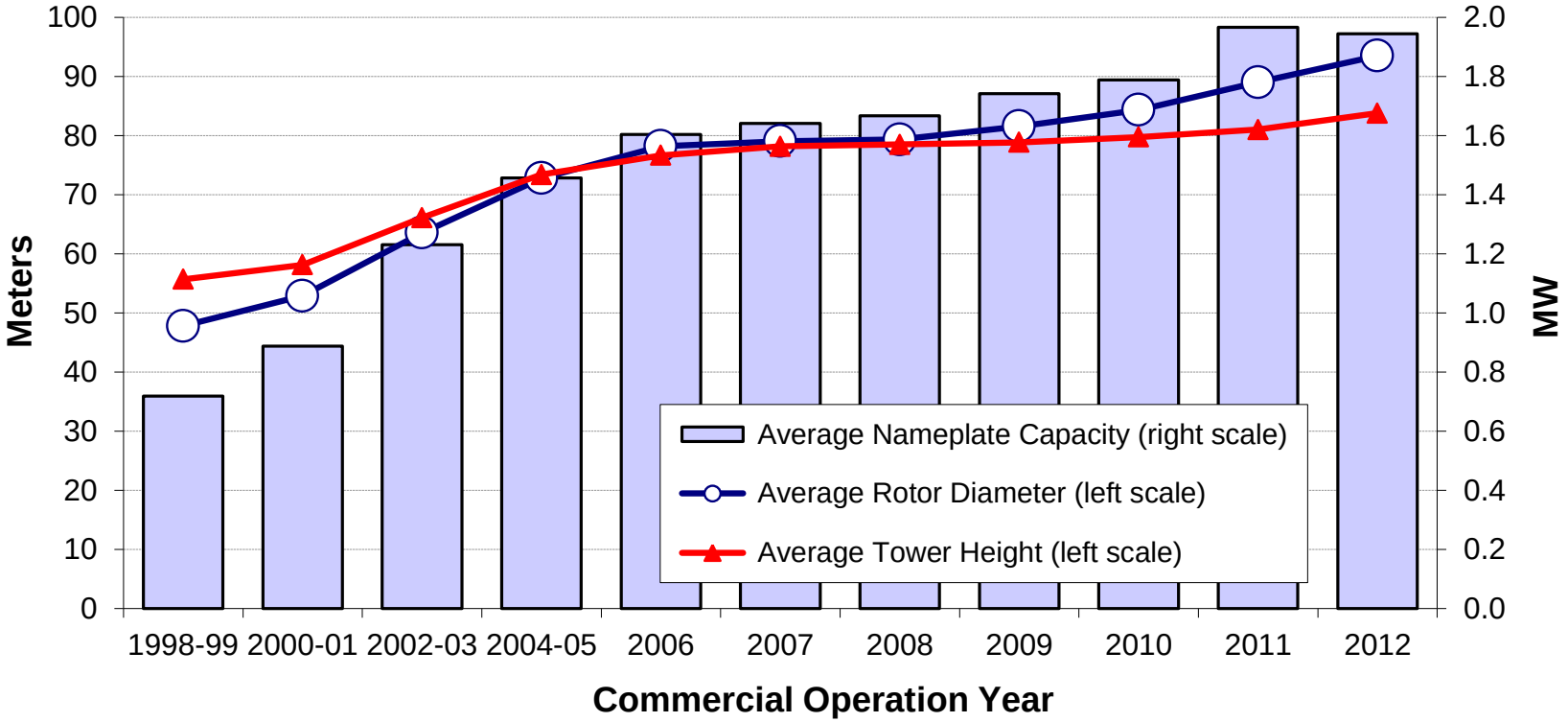
Different permitting/development costs may play a role at both ends of spectrum: it's easier/cheaper to build in the US interior and harder/more expensive along the coasts

Past Trends: Performance

Regional Variations in Capacity Factor Reflect the Strength of the Wind Resource

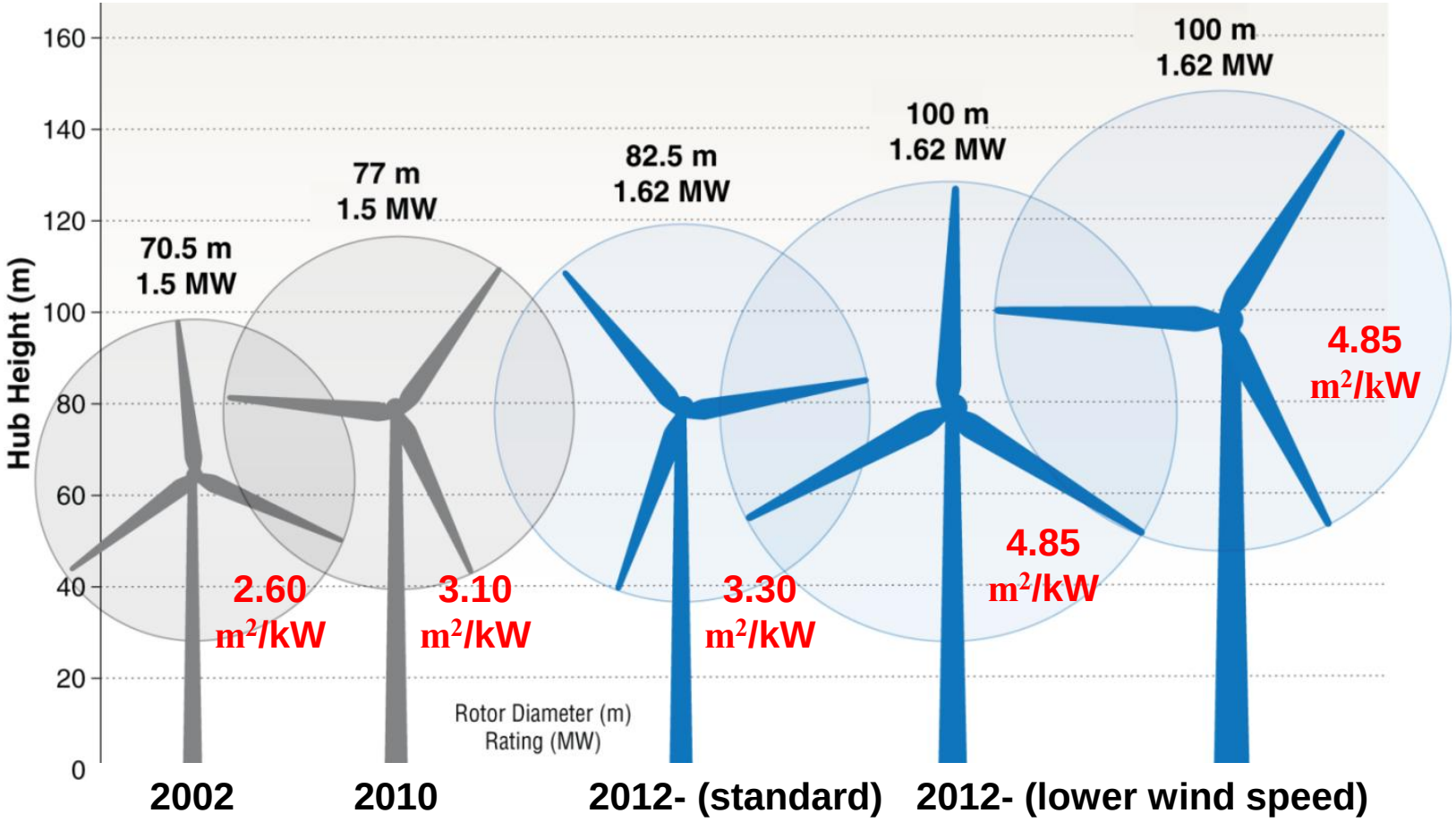


Average Hub Height and Rotor Diameter Have Increased Dramatically: Would Expect Capacity Factor Increases to Follow

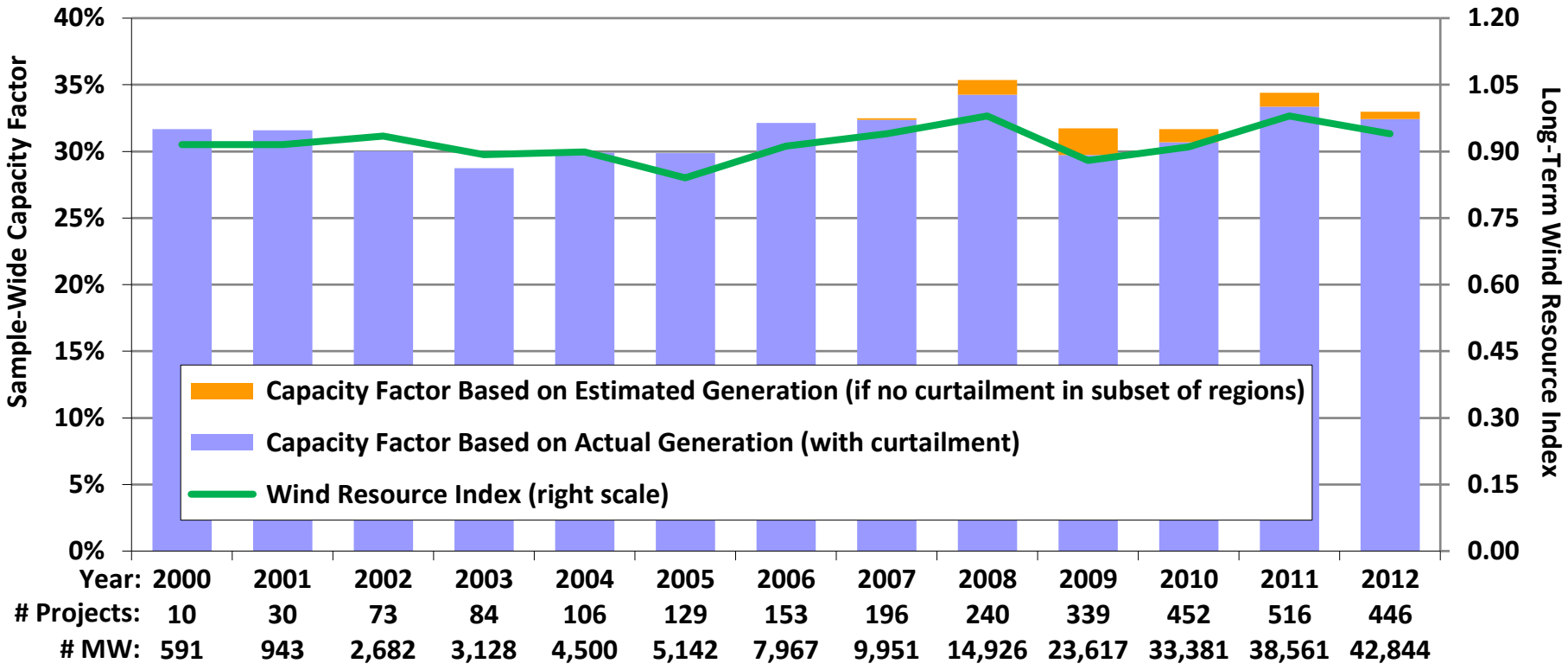


- Two periods of rapid scaling: 1998-2006 and 2009-present
- 2007-2008 mostly stagnant, as OEMs focused on meeting demand

As Dominant Turbine OEM in the US, GE Provides a Useful *Example* of the Evolution of Turbine Design

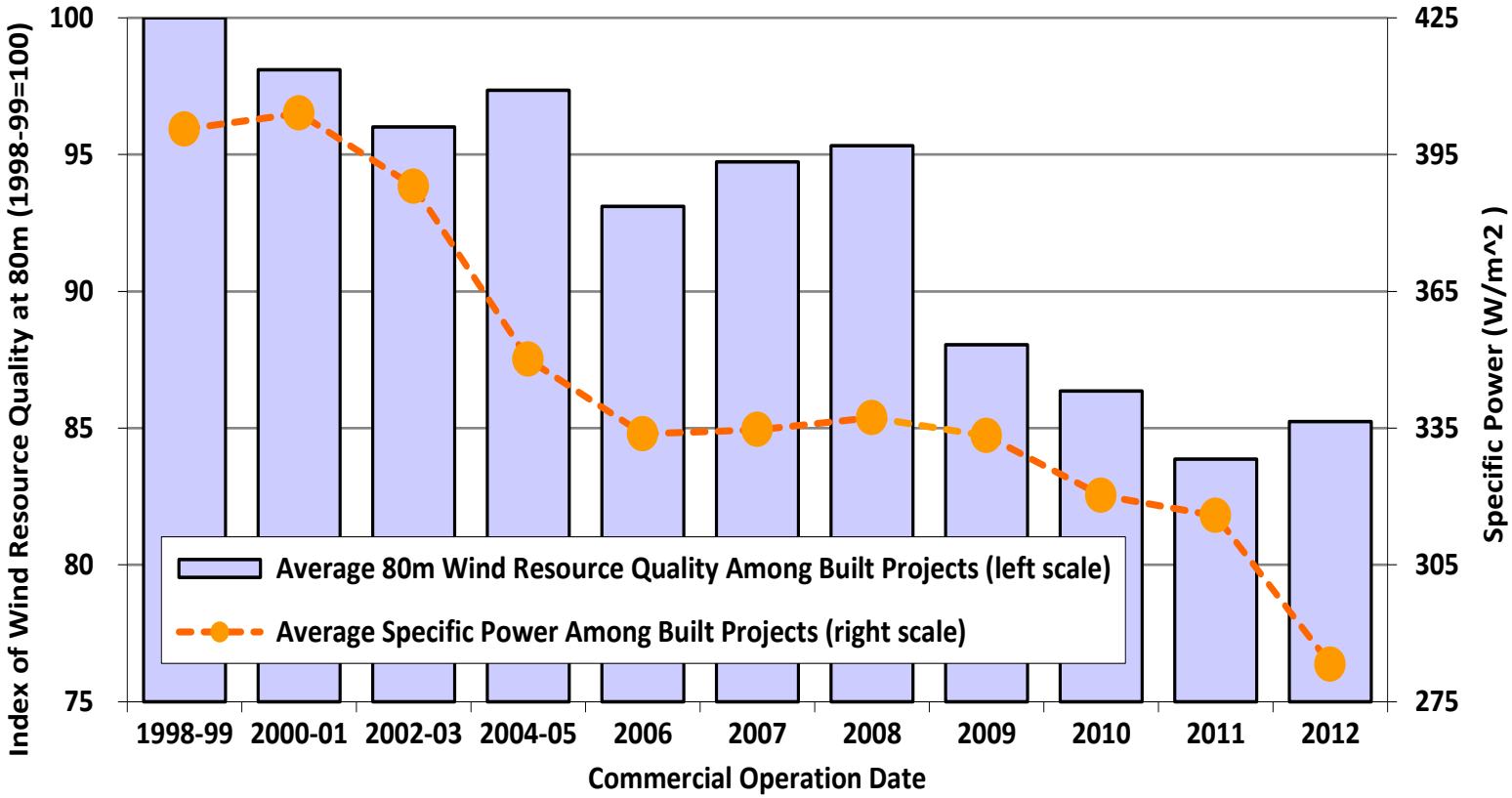


However, Trends in Sample-Wide Capacity Factors Were Impacted by Curtailment and Inter-Year Wind Resource Variability…



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).

And… Despite Turbine Scaling that Should Boost Capacity Factors, Project Build-Out in Lower-Quality Wind Resource Areas Has Pushed the Other Way



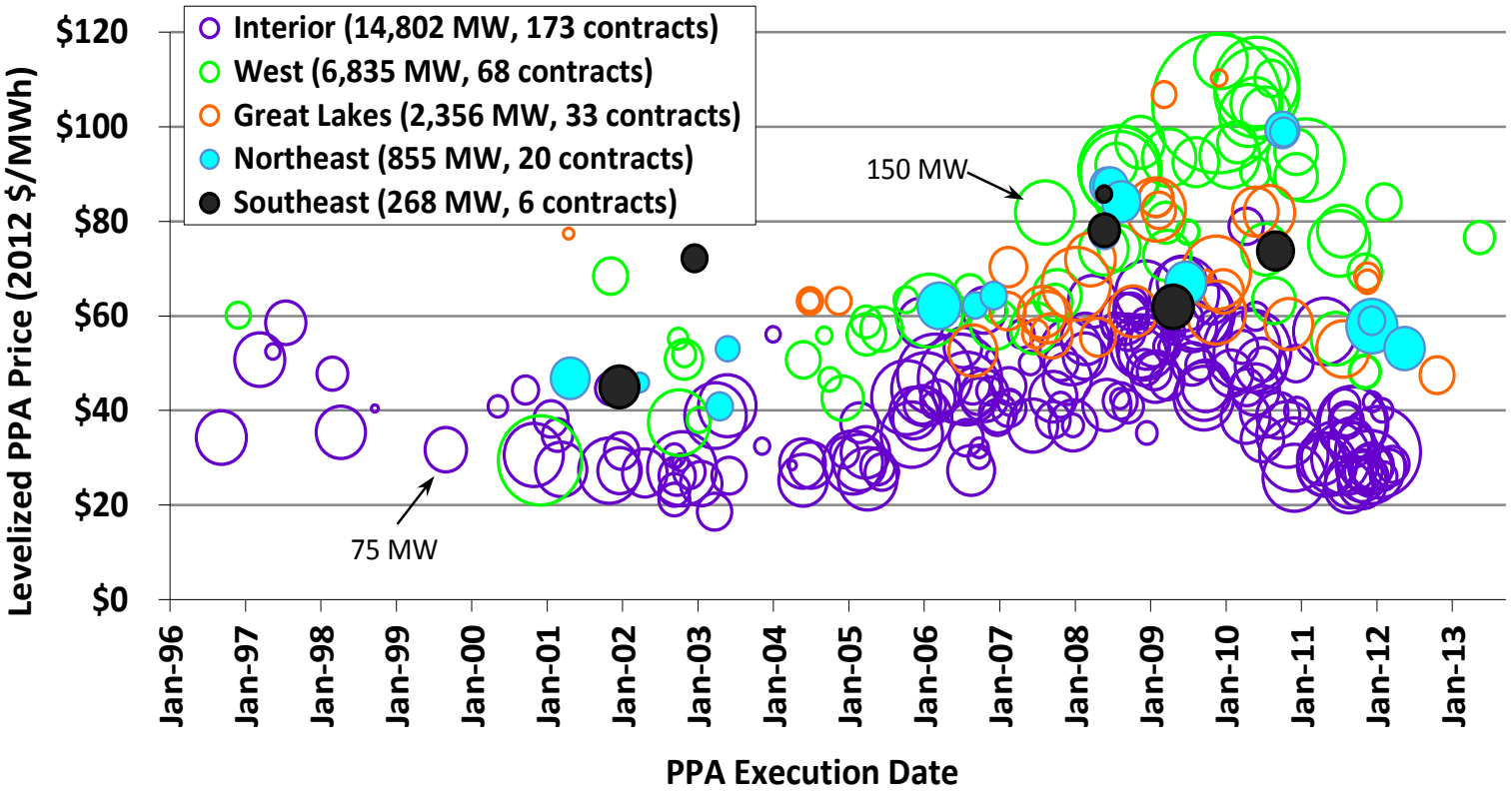
Past Trends: Wind Power Price

Sample of Wind Power Prices

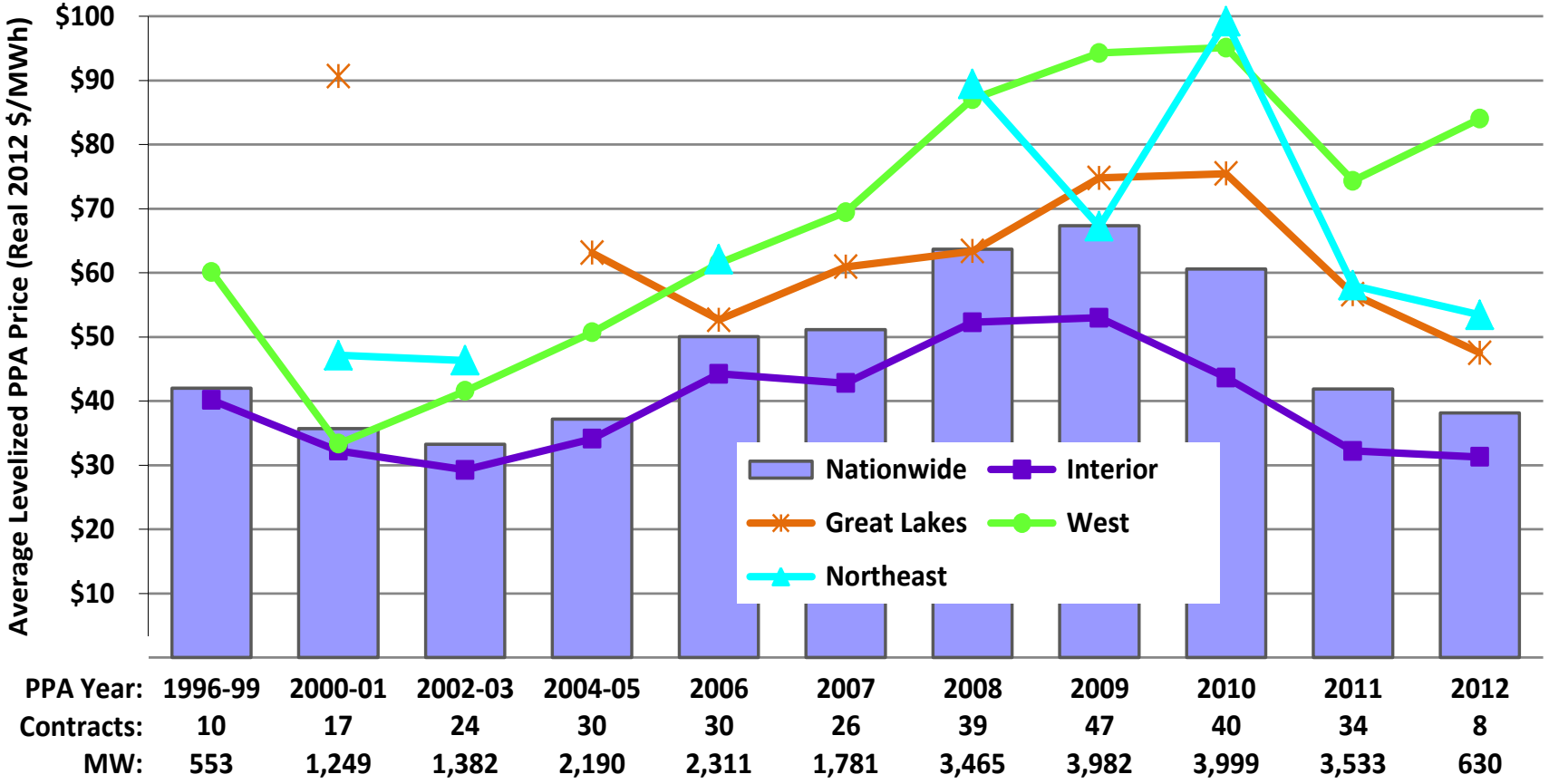
- Berkeley Lab collects data on historical wind power sales prices, and long-term PPA prices
- PPA sample includes 302 contracts from projects built from 1998-2012, totaling 24,626 MW (42% of all wind capacity added in that period, and 70% of all capacity added that is sold under bundled PPAs)
- Prices 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 do not reflect wind energy generation costs

Wind PPA Prices Generally Have Been Falling Since 2009 and Now Rival Previous Lows Set a Decade Ago

(this despite the trend to lower-quality wind resource sites)

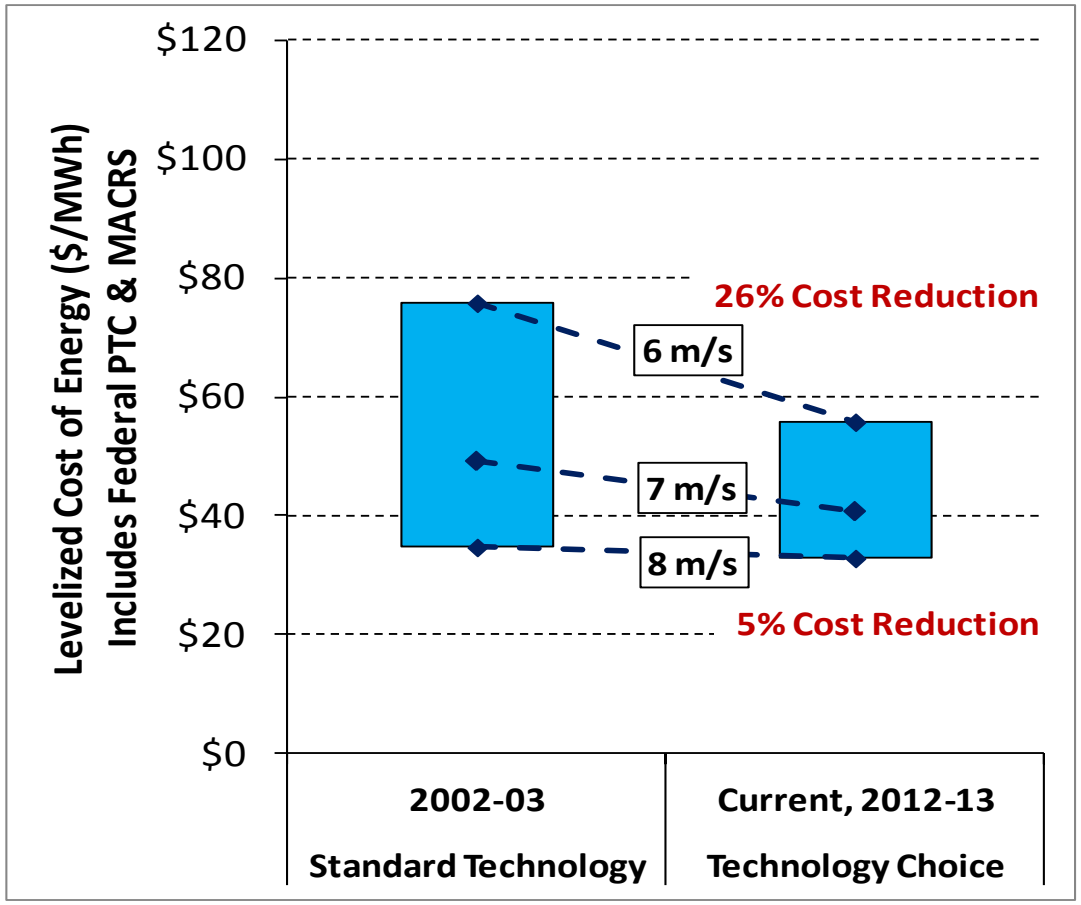


A Smoother Look at the Time Trend Shows Steep Recent Decline in Pricing; Especially Low Pricing in Interior Region



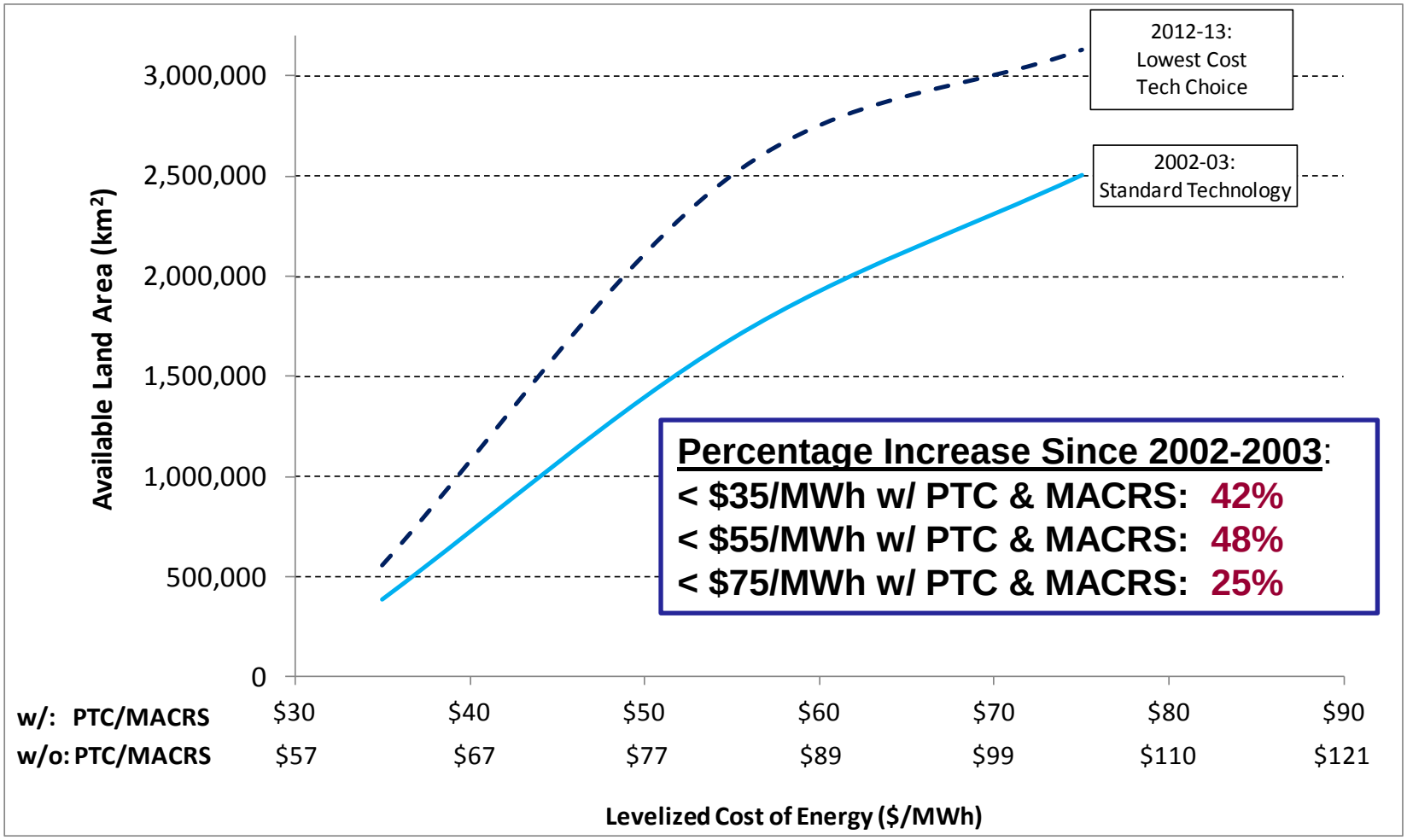
PPA Year:	1996-99	2000-01	2002-03	2004-05	2006	2007	2008	2009	2010	2011	2012
Contracts:	10	17	24	30	30	26	39	47	40	34	8
MW:	553	1,249	1,382	2,190	2,311	1,781	3,465	3,982	3,999	3,533	630

New Lower Wind-Speed Technology Reduces the Variability in LCOE Across a Range of Wind Resource Sites: *Modeled Results*



Note: Graphic only includes changes in capital cost and turbine design (i.e., capacity factors); graphic does not include changes in O&M, availability, financing, etc.

Available Land Area Exceeding LCOE Thresholds Has Increased: *Modeled Results*



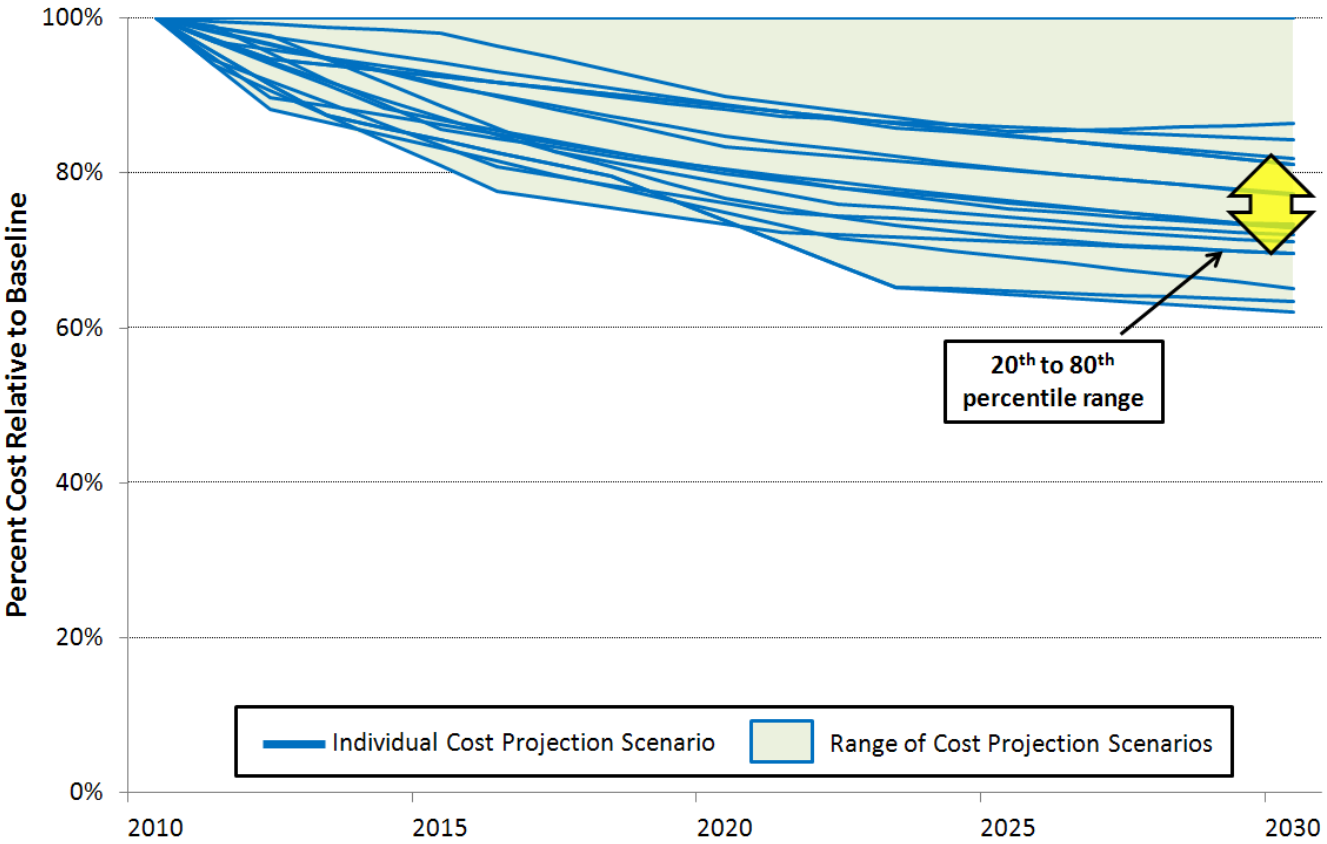
Current and Future Trends

Areas of Continued Wind Power Technology Advancement

Land-based wind technology is relatively mature, but continued advancement opportunities include:

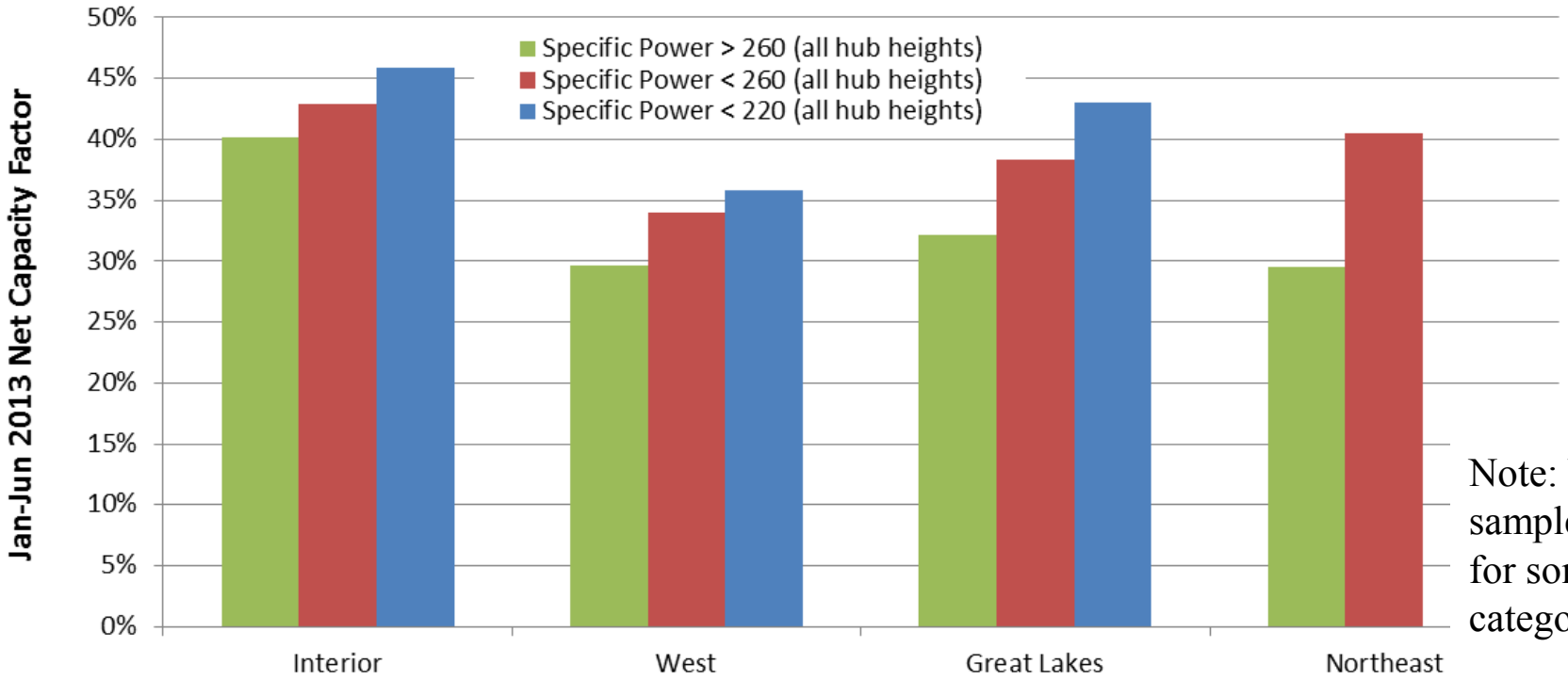
- Plant-level design and management to maximize production
- Advanced control systems for turbines *and* plants to increase energy production, reduce loads
- Improved numerical methods for understanding wind resource
- Blade innovations to increase performance, reduce loads & noise
- Multiple drivetrain technologies, with increase reliability
- Enhanced reliability & robustness among all components & systems
- Continued turbine scaling, especially low to mid wind speed sites

Most Projections for Land-Based Wind Plant LCOE Anticipate Further Reductions



Note: Projections included here were derived from a variety of methods including learning curves, expert elicitation, and engineering-based models

Focusing on Projects Installed from 2009-2012 (to control for resource quality) and on Capacity Factor in First Six Months of 2013 (to include 2012 installations) Shows Technology Evolution



Note: Very small sample size exists for some of these categories

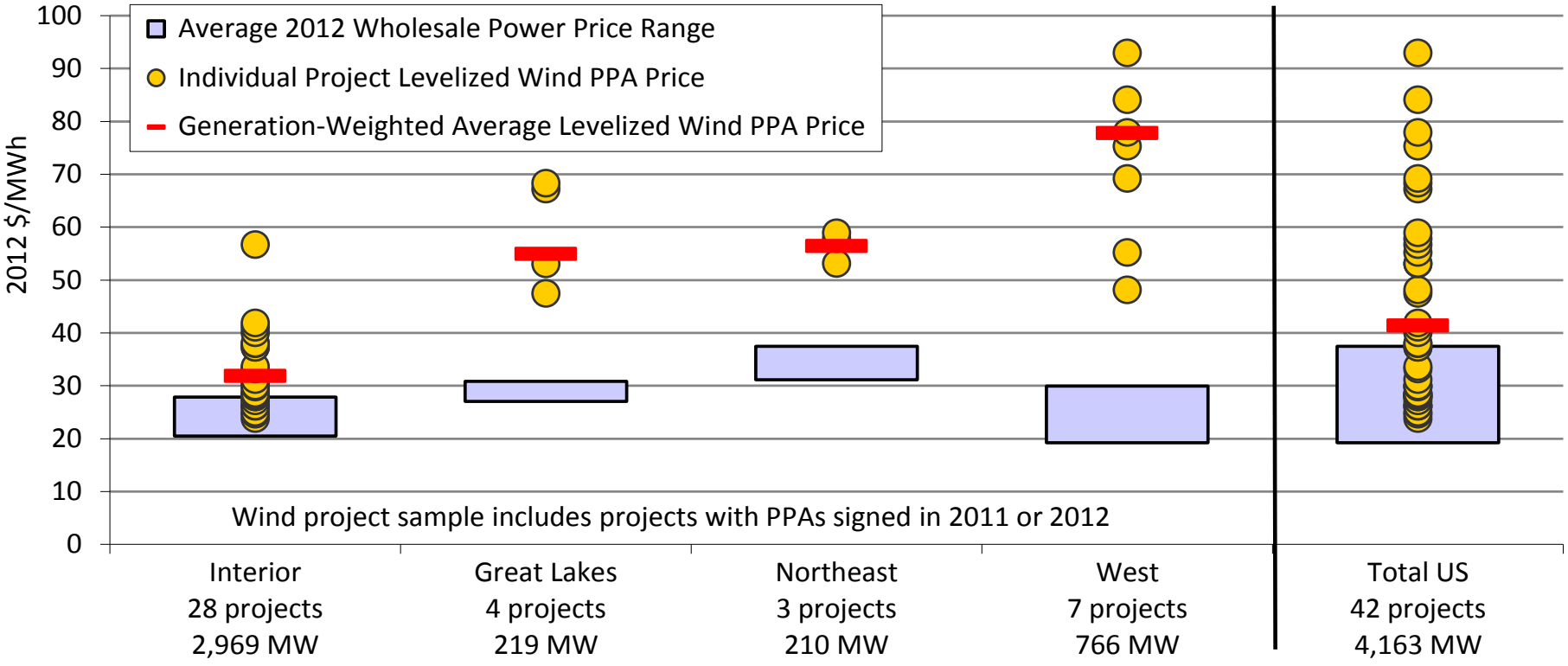
Specific Power < 260 = recent, lower wind-speed models such as GE 1.6 MW / 100m rotor; Siemens 2.3/108; Vestas 1.8/100; Nordex 2.4/117; Specific Power < 220 = GE 1.6/100

Recent PPA Trends Suggest Further Price Reductions (and capacity factor increases)

- Xcel (SPS; 700 MW proposed to regulator):
  - **5700 MW of bids < $30/MWh w/ RECs [RECs value <$2.5/MWh]**
  - Mammoth -- 199 MW, OK, 57.1% CF: **$22/MWh** energy only
  - Palo Duro -- 249 MW, TX, 54.1% CF: **$23/MWh** energy only
  - Roosevelt -- 250 MW, NM, 48.4% CF: **$23/MWh** energy only
- Xcel (CO, MN; 1200 MW total): **$25-35/MWh**

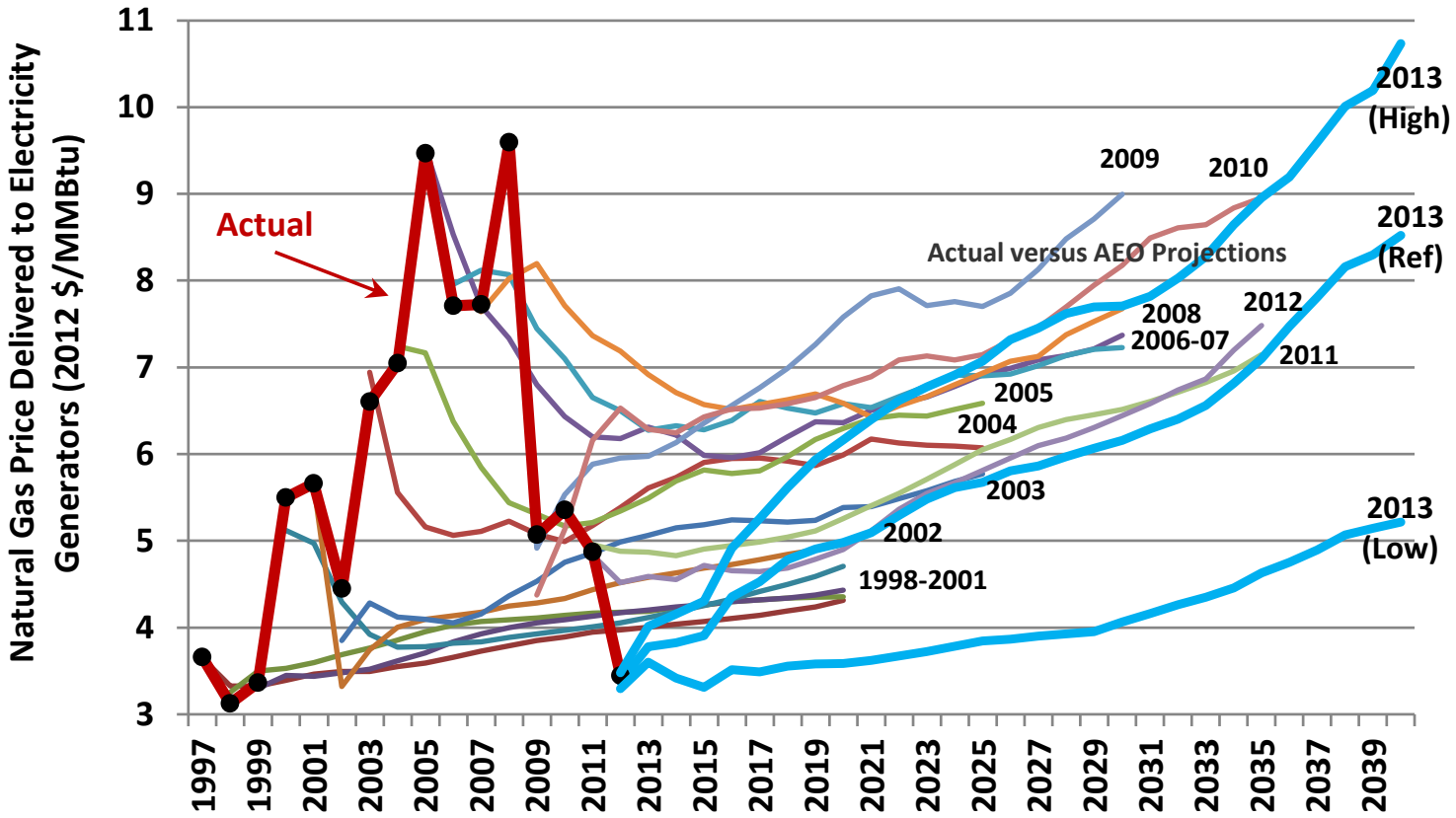
  "It works out to a very good levelized cost for our customers," Xcel CEO Fowke said. "These prices are so compelling, the energy [cost] associated with it is less than you can do locking in a 20-year gas strip." Xcel expects the wind projects to save its customers about $800 million in fuel costs over 20 years.
- AEP-PSO (OK; 600 MW): 50.6% expected capacity factor
- OPPD (NE; 400 MW): 50% expected capacity factor

Though Low Wholesale Electricity Prices Have Challenged the Relative Economics of Wind Power in Recent Years…



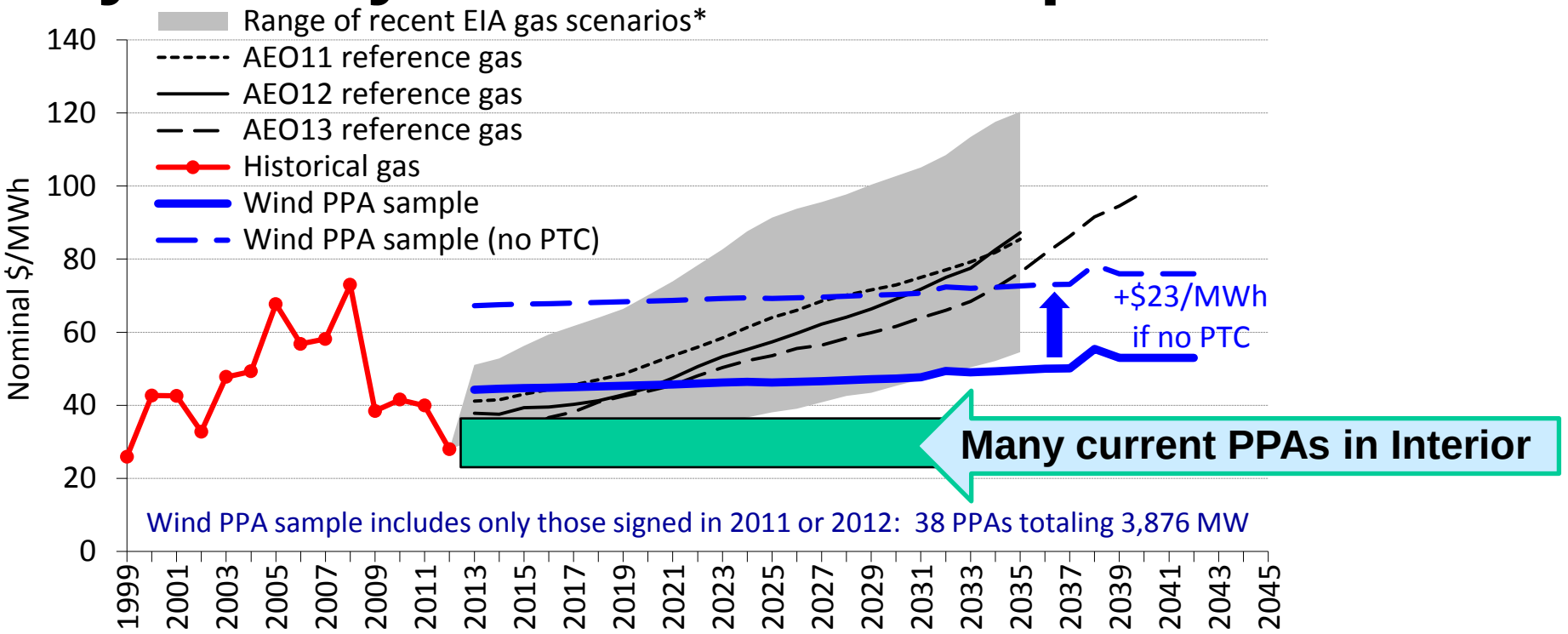
Wind PPA prices are most competitive with wholesale prices in the Interior region (where PPAs signed in 2011/2012 generally ranged from $20-40/MWh)

Uncertainties in Future Natural Gas Prices Are Substantial, and Upwards Trajectory in Prices Is Anticipated



Source: LBNL compilation of forecasts and data from the Energy Information Administration

Recent Wind PPAs Can Compete on a Long-Term Basis, and Many Very Recent PPAs Can Compete in Short Term; PTC Plays a Key Role in this Competitiveness



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

Note: Wind is modeled as "fuel saver" – i.e., assumed to offset only fuel costs of gas generation (no credit for capacity value, etc.)

Conclusions

Current Low Prices for Wind Energy Can Compete with Only the *Operating* Cost of Natural Gas Plants in *Some* Areas, and May Support Higher Growth in the Future, but Other Pricing Headwinds Include…

- Lack of clarity about fate of federal tax incentives
- Continued low natural gas and wholesale electricity prices
- Growing competition from solar in some regions

Regional Definitions Based on Combination of Geography and Wind Resource