U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# 2018 Wind Technologies Market Report: Summary

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# 2018 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 2018
- Scope focuses on land-based wind turbines over 100 kW
- Separate DOE-funded reports on distributed and offshore wind
- Data sources include EIA, FERC, SEC, AWEA, etc. (see full report)

## Report Authors:


- Primary authors:  Ryan Wiser and Mark Bolinger, Berkeley Lab
- Contributions from others at Berkeley Lab, Exeter Associates, National Renewable Energy Laboratory



## Funded by: U.S. DOE Wind Energy Technologies Office


## Available at:  http://energy.gov/windreport

# Report Contents

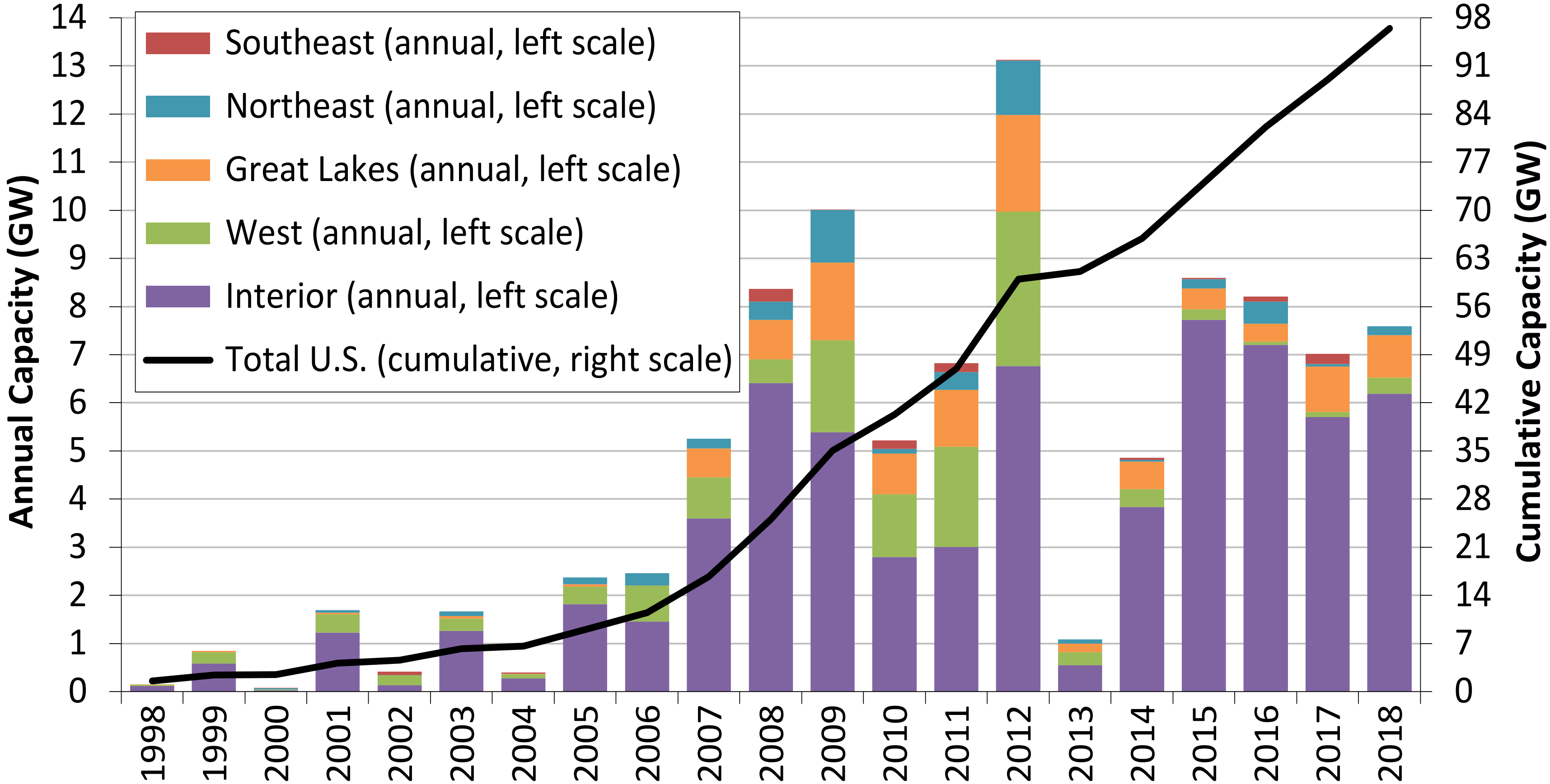
- Installation trends
- Industry trends
- Technology trends
- Performance trends
- Cost trends
- Wind power price trends
- Policy and market drivers
- Future outlook

# Key Findings

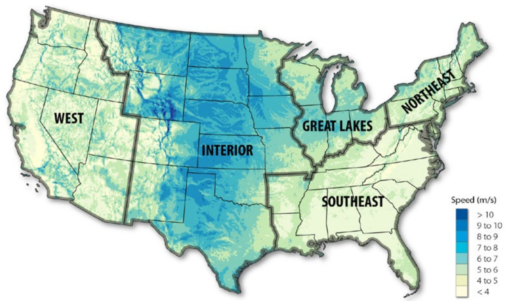
- Wind capacity additions continued at a robust pace in 2018, with significant additional new builds anticipated in near-term in part due to PTC
- Wind has been a significant source of new electric generation capacity additions in the U.S. in recent years
- Supply chain is diverse and multifaceted, with strong domestic content for nacelle assembly, towers, and blades
- Turbine scaling is significantly boosting wind project performance, while the installed cost of wind projects has declined
- Wind power sales prices and levelized cost of energy are at all-time lows, enabling economic competitiveness (with the PTC) despite low gas prices
- Growth beyond current PTC cycle remains uncertain: could be blunted by declining federal tax support, expectations for low natural gas prices and solar costs, and modest electricity demand growth

# Installation Trends

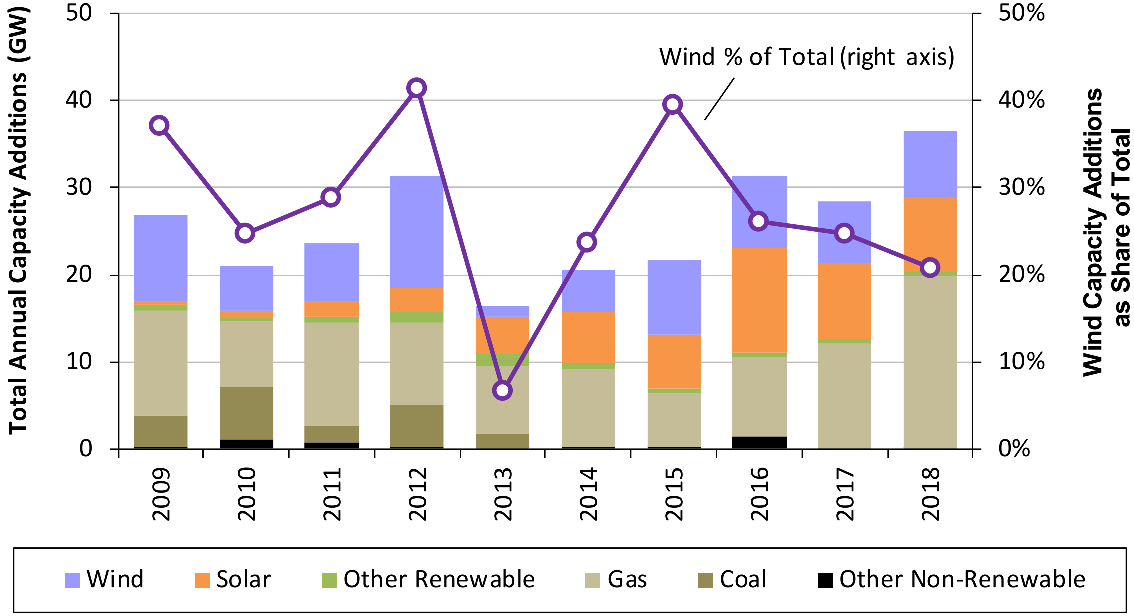
# Wind Power Additions Continued at a Robust Pace in 2018, with 7,588 MW of New Capacity, Bringing the Total to 96,433 MW

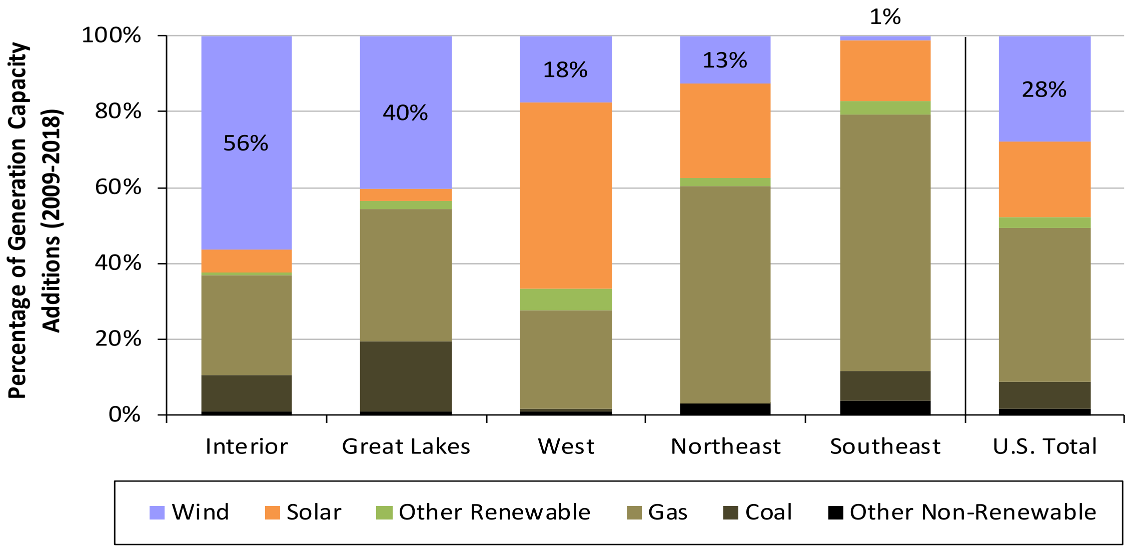



- $11 billion invested in wind power project additions in 2018
- Over 80% of new 2018 capacity located in Interior region
- Partial repowering trend: 1,312 MW of existing wind plants retrofitted in 2018



# Wind Power Represented 21% of Electric-Generating Capacity Additions in 2018, Behind Solar and Natural Gas



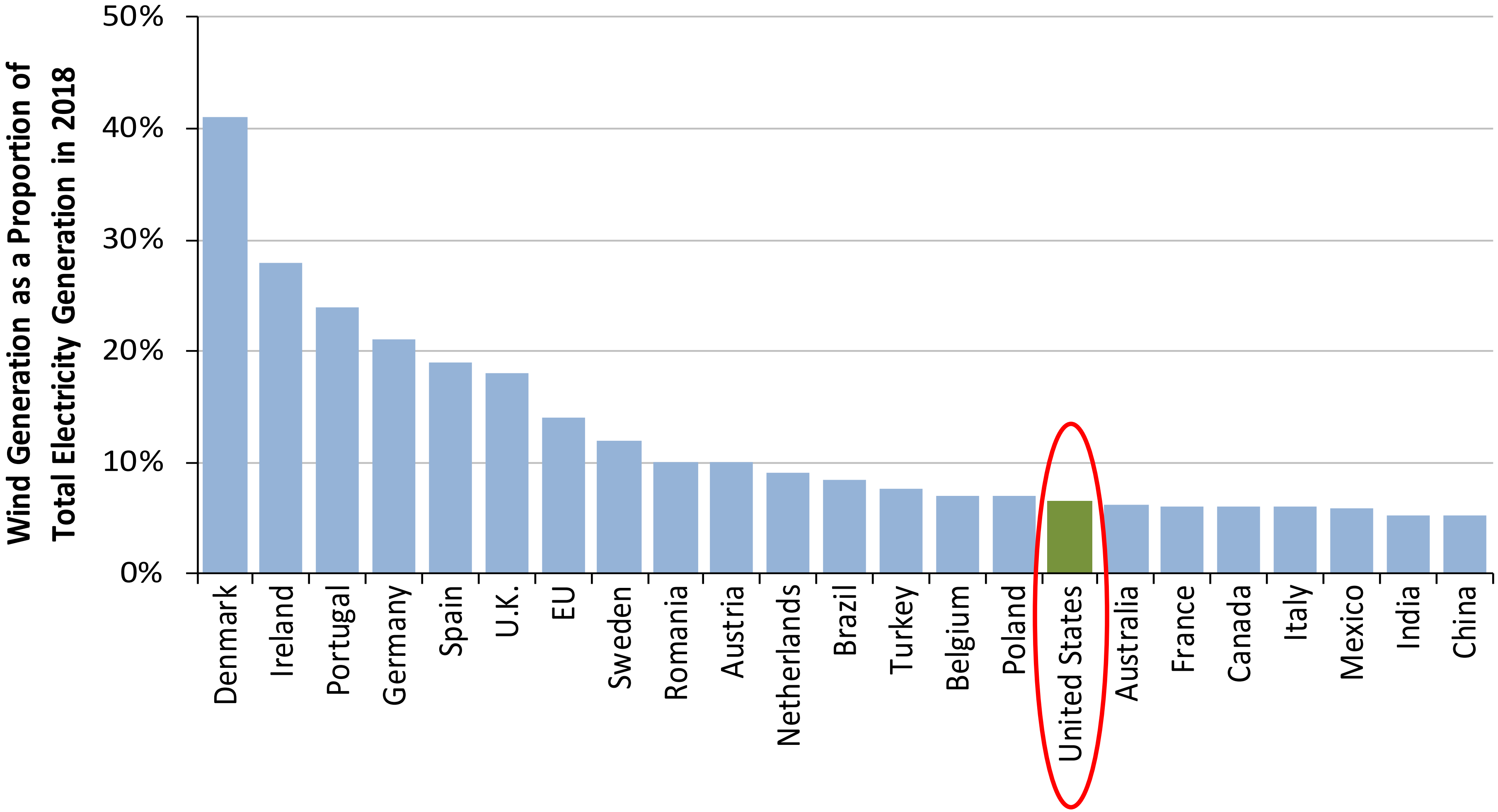

**Over the last decade, wind has comprised 28% of total capacity additions nationwide, and a much higher proportion in some regions of the country**

# Globally, the U.S. Ranked 2nd in Annual Wind Power Capacity Additions in 2018, and in Cumulative Wind Power Capacity

| Annual Capacity (2018, MW) | | Cumulative Capacity (end of 2018, MW) | |
|---|---|---|---|
| China | 21,855 | China | 210,247 |
| United States | 7,588 | United States | 96,433 |
| Germany | 3,371 | Germany | 59,312 |
| India | 2,191 | India | 35,129 |
| Brazil | 1,939 | Spain | 23,531 |
| United Kingdom | 1,901 | United Kingdom | 20,964 |
| France | 1,565 | France | 15,309 |
| Mexico | 929 | Brazil | 14,707 |
| Sweden | 720 | Canada | 12,816 |
| Canada | 566 | Italy | 9,959 |
| *Rest of World* | 7,493 | *Rest of World* | 91,466 |
| **TOTAL** | **50,118** | **TOTAL** | **589,872** |

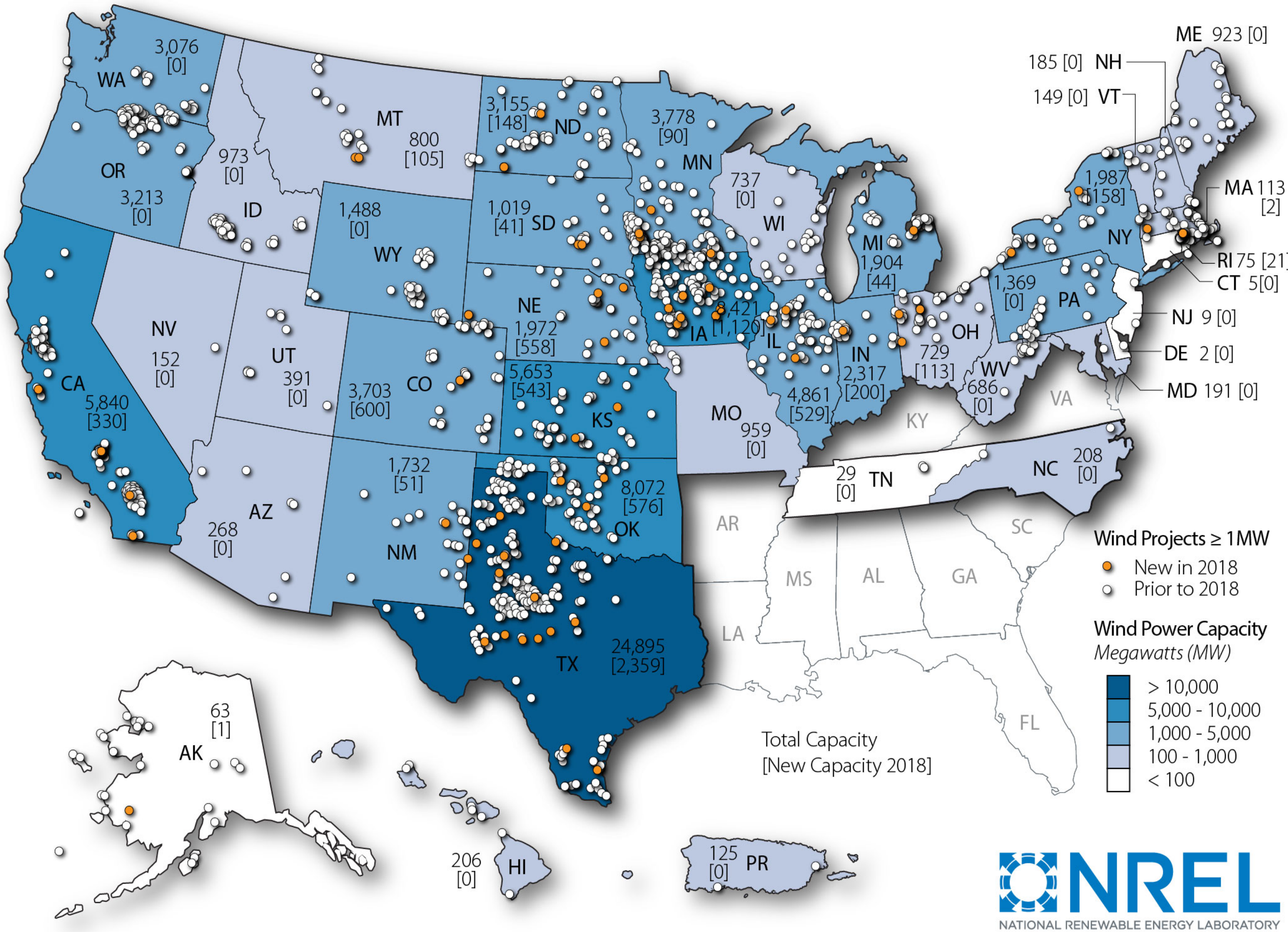
- **U.S. remains a distant second to China in annual and cumulative capacity**
- **Global wind additions in 2018 were below the 53,500 MW added in 2017 and the record level of 63,800 MW added in 2015**

# The United States is Lagging Other Countries in Wind Energy Penetration




*Note: Figure only includes the countries with the most installed wind power capacity at the end of 2018*

# The Geographic Spread of Wind Power Projects Across the United States Is Broad, with the Exception of the Southeast



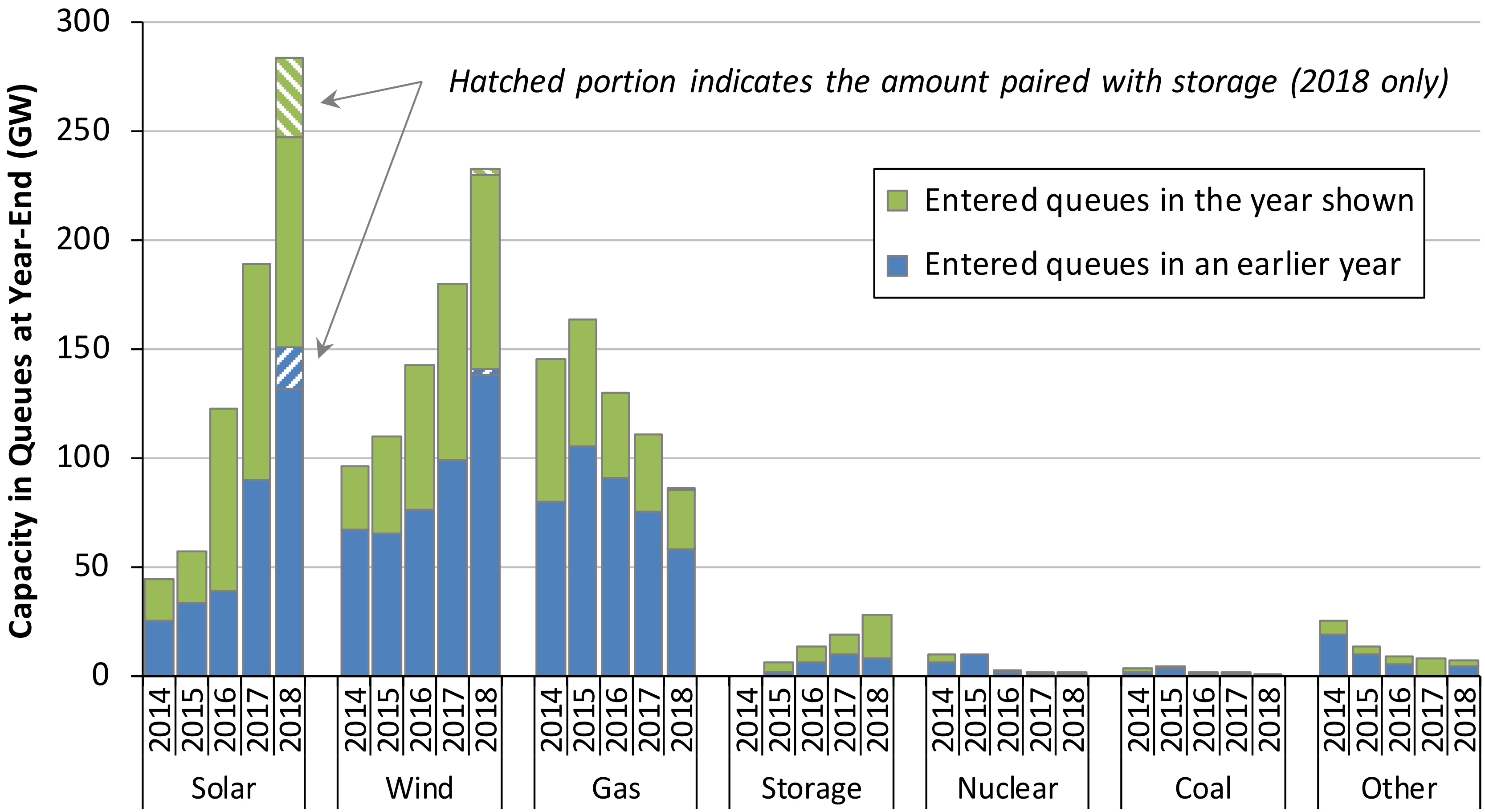

*Note: Numbers within states represent cumulative installed wind capacity and, in brackets, annual additions in 2018*

# Texas Installed the Most Wind Power Capacity in 2018; 14 States Exceed 10% Wind Energy as Percentage of In-State Generation

| Installed Capacity (MW) | | | | 2018 Wind Generation as a Percentage of: | | | |
|---|---|---|---|---|---|---|---|
| Annual (2018) | | Cumulative (end of 2018) | | In-State Generation | | In-State Sales | |
| Texas | 2,359 | Texas | 24,895 | Kansas | 36.4% | North Dakota | 53.5% |
| Iowa | 1,120 | Iowa | 8,421 | Iowa | 33.7% | Kansas | 47.1% |
| Colorado | 600 | Oklahoma | 8,072 | Oklahoma | 31.7% | Oklahoma | 43.4% |
| Oklahoma | 576 | California | 5,840 | North Dakota | 25.8% | Iowa | 43.2% |
| Nebraska | 558 | Kansas | 5,653 | South Dakota | 24.4% | New Mexico | 25.6% |
| Kansas | 543 | Illinois | 4,861 | Maine | 21.0% | Wyoming | 24.9% |
| Illinois | 529 | Minnesota | 3,778 | New Mexico | 18.7% | South Dakota | 21.7% |
| California | 330 | Colorado | 3,703 | Minnesota | 17.9% | Maine | 21.0% |
| Indiana | 200 | Oregon | 3,213 | Colorado | 17.3% | Texas | 18.6% |
| New York | 158 | North Dakota | 3,155 | Texas | 15.9% | Colorado | 17.5% |
| North Dakota | 148 | Washington | 3,076 | Vermont | 15.8% | Minnesota | 17.0% |
| Ohio | 113 | Indiana | 2,317 | Idaho | 14.7% | Nebraska | 16.9% |
| Montana | 105 | New York | 1,987 | Nebraska | 14.1% | Oregon | 15.0% |
| Minnesota | 90 | Nebraska | 1,972 | Oregon | 11.0% | Montana | 14.9% |
| New Mexico | 51 | Michigan | 1,904 | Wyoming | 9.0% | Idaho | 10.8% |
| Michigan | 44 | New Mexico | 1,732 | Montana | 7.9% | Illinois | 9.1% |
| South Dakota | 41 | Wyoming | 1,488 | Illinois | 6.8% | Washington | 8.2% |
| Rhode Island | 21 | Pennsylvania | 1,369 | California | 6.5% | Vermont | 7.1% |
| Massachusetts | 2 | South Dakota | 1,019 | Washington | 6.3% | Hawaii | 5.8% |
| Alaska | 1 | Idaho | 973 | Indiana | 5.0% | Indiana | 5.6% |
| *Rest of U.S.* | 0 | *Rest of U.S.* | 7,005 | *Rest of U.S.* | 1.1% | *Rest of U.S.* | 1.5% |
| TOTAL | 7,588 | TOTAL | 96,433 | TOTAL | 6.5% | TOTAL | 7.3% |

**2018 Wind Penetration by ISO:** SPP: 23.9%; ERCOT: 18.6%; MISO: 7.3%; CAISO: 7.3%; ISO-NE: 2.8%; PJM: 2.7%; NYISO: 2.5%

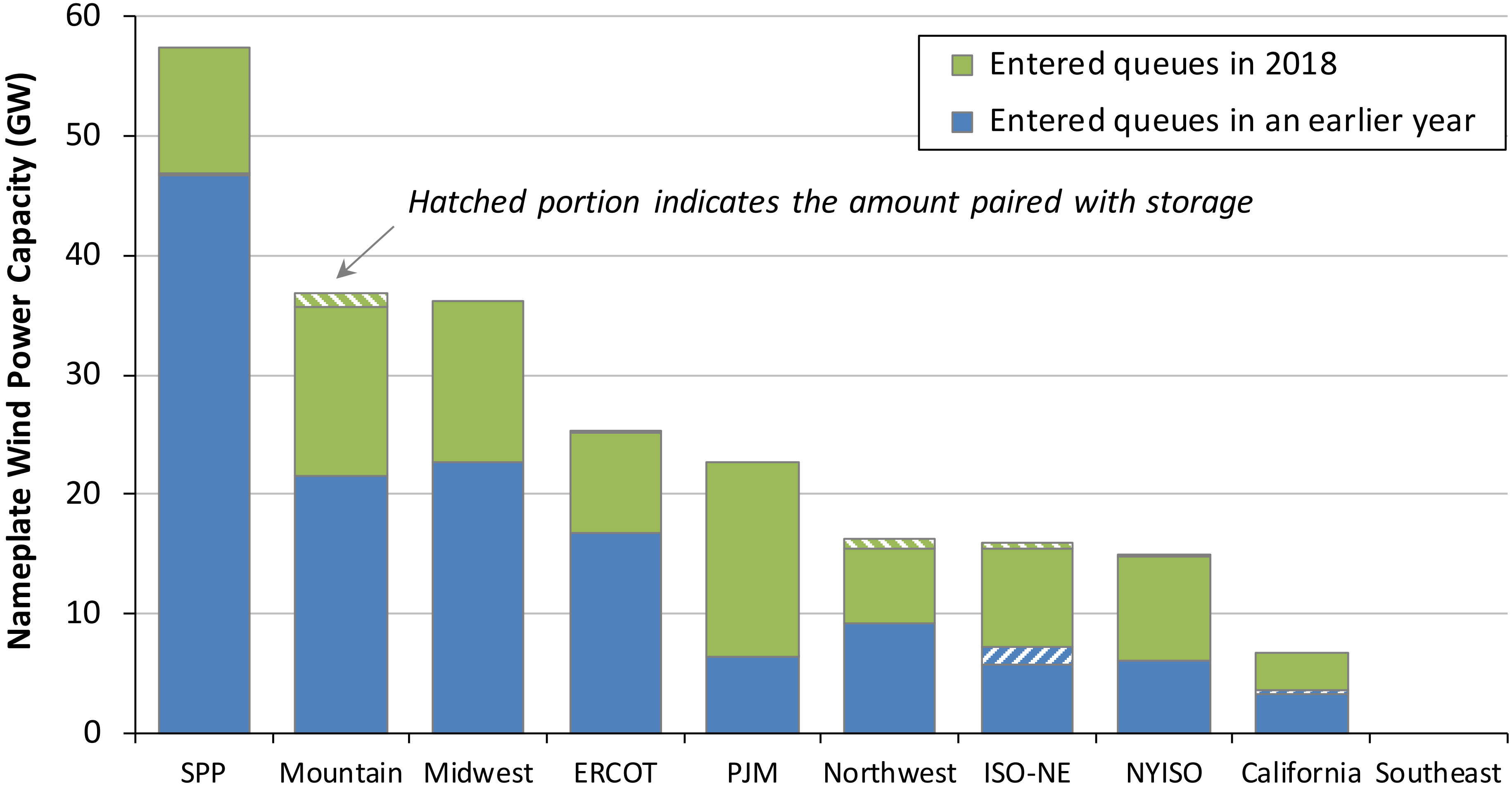
# A Record Level of Wind Power Capacity Entered Transmission Interconnection Queues in 2018; Solar and Storage Also Growing




- **Hybrid plants with storage represent 20% of solar in queue in 2018, but just 2% of wind in queue is proposed to include storage**
- **AWEA reports 39 GW of capacity under construction or in advanced development at end of 1Q2019**

*Note: Not all of this capacity will be built*

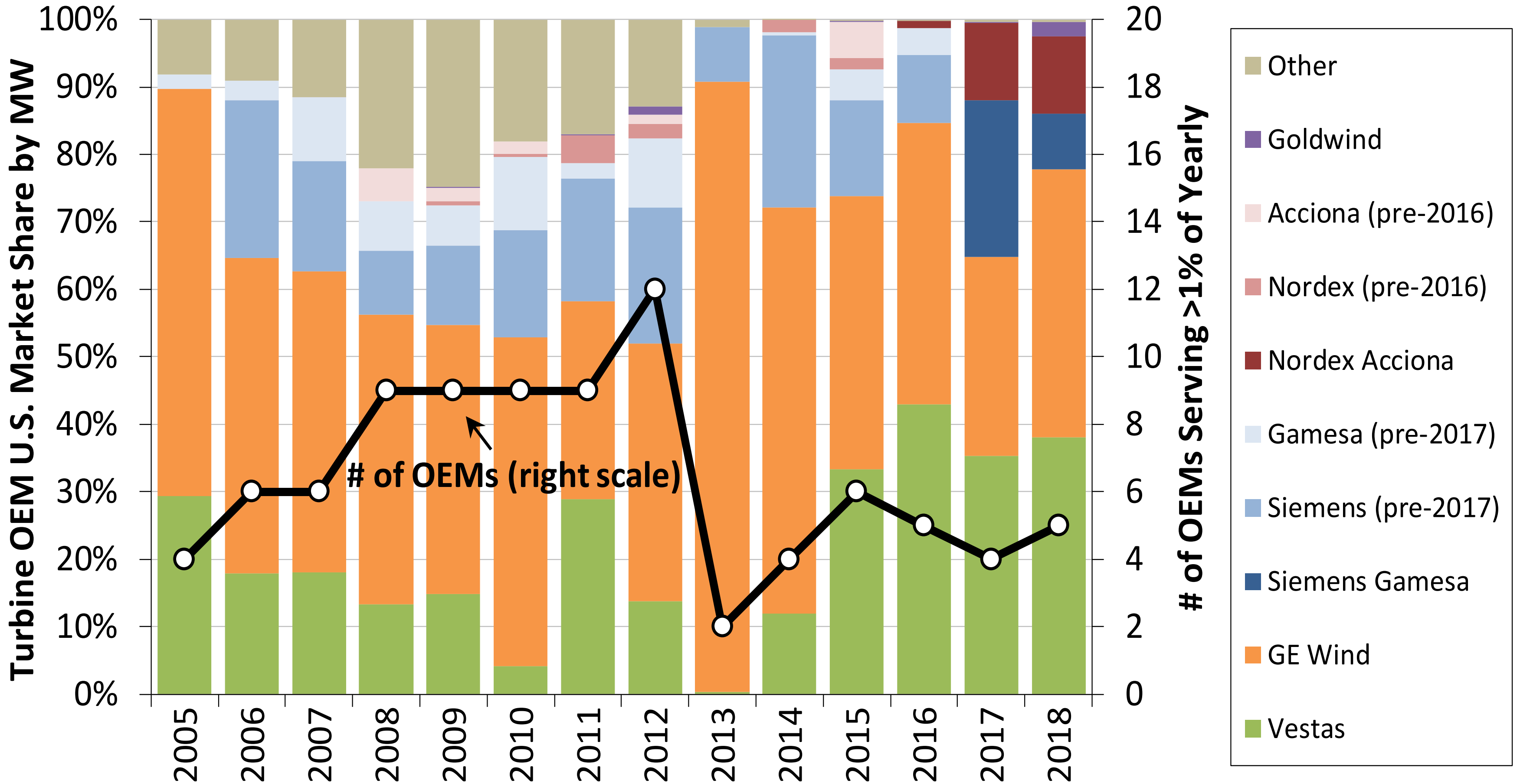
# Larger Amounts of Wind Power Capacity Planned for Southwest Power Pool, Mountain & Midwest Regions; Major Growth in PJM




*Note: Not all of this capacity will be built*

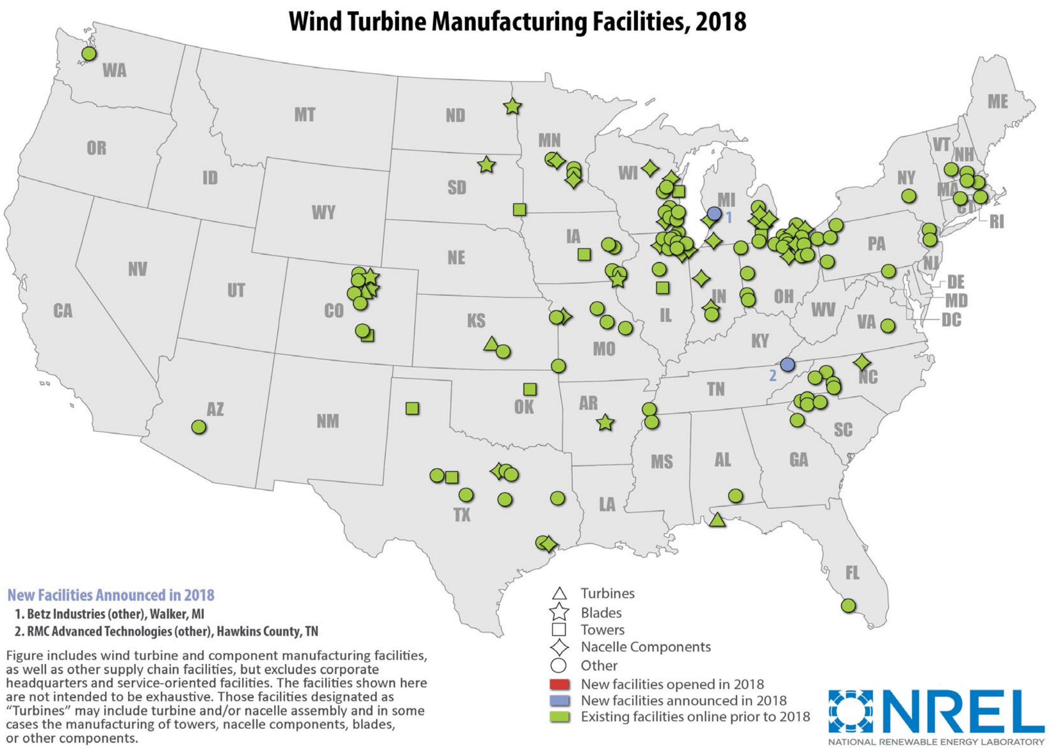
# Industry Trends

# GE and Vestas Accounted for 78% of the U.S. Market in 2018




- Globally, Vestas, Goldwind, Siemens Gamesa, and GE were the top suppliers of wind turbines in 2018
- Chinese suppliers occupied 8 of the top 15 spots in the global ranking, based primarily on sales within their domestic market

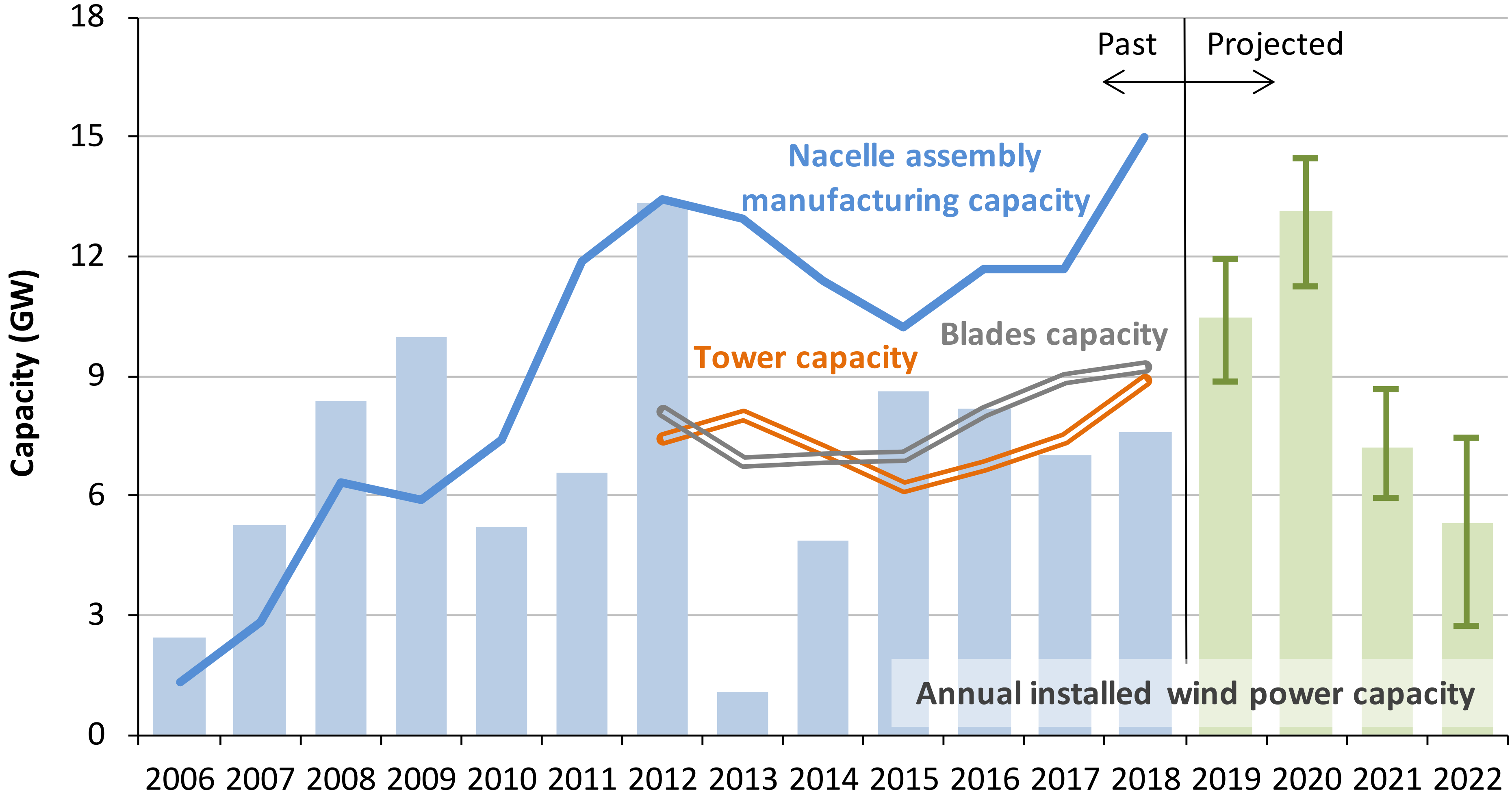
# The Domestic Supply Chain for Wind Equipment is Diverse



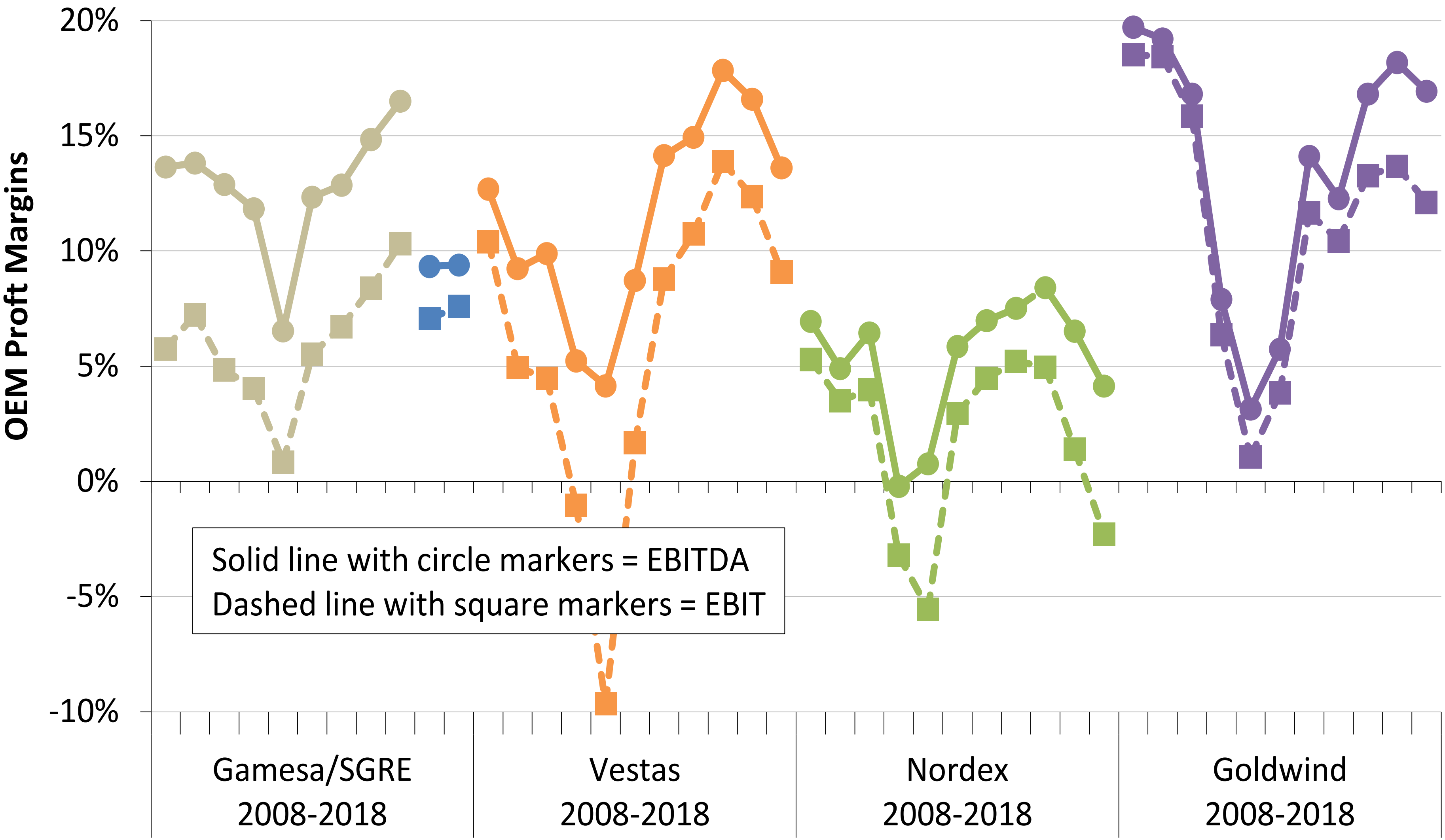

*Note: map not intended to be exhaustive*

- Some manufacturers increased the size of their U.S. workforce in 2018 and/or expanded existing facilities, but expectations for significant additional supply-chain expansion have become less optimistic
- Continued near-term expected growth, but strong competitive pressures and expected reduced demand as PTC is phased out
- Two new manufacturing facilities announced with expected online dates in 2019; four facilities stopped serving industry
- Many manufacturers remain; three of the largest OEMs serving U.S. market all have at least one facility
- Wind-related jobs reached a new all-time high, at 114,000

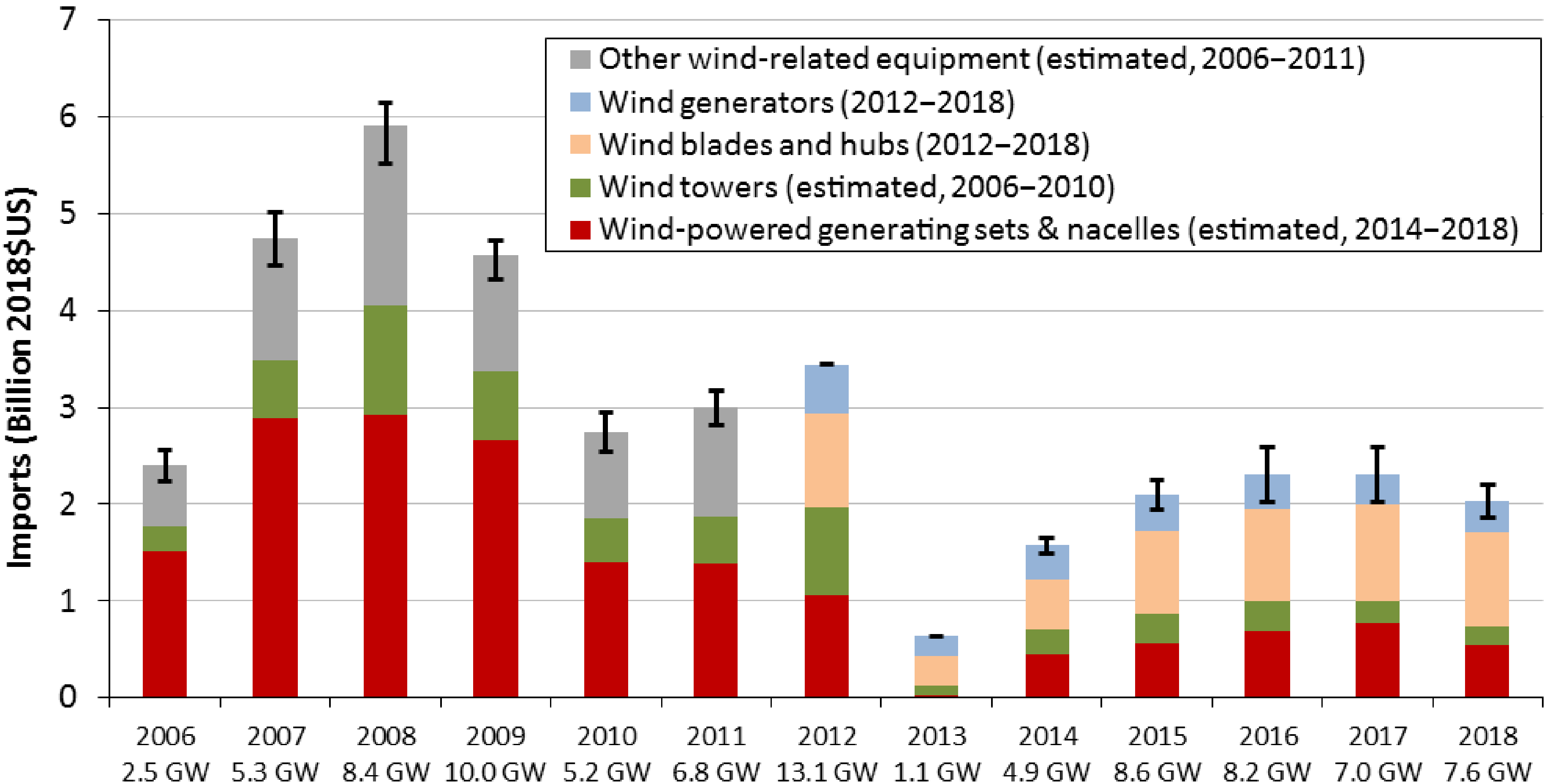
# Domestic Manufacturing Capability for Nacelle Assembly, Towers, & Blades Reasonably Well Balanced Against Historical Demand



# Turbine OEM Profitability Has Generally Declined in Most Recent Years, Following Several Years of Recovery Since Low in 2012

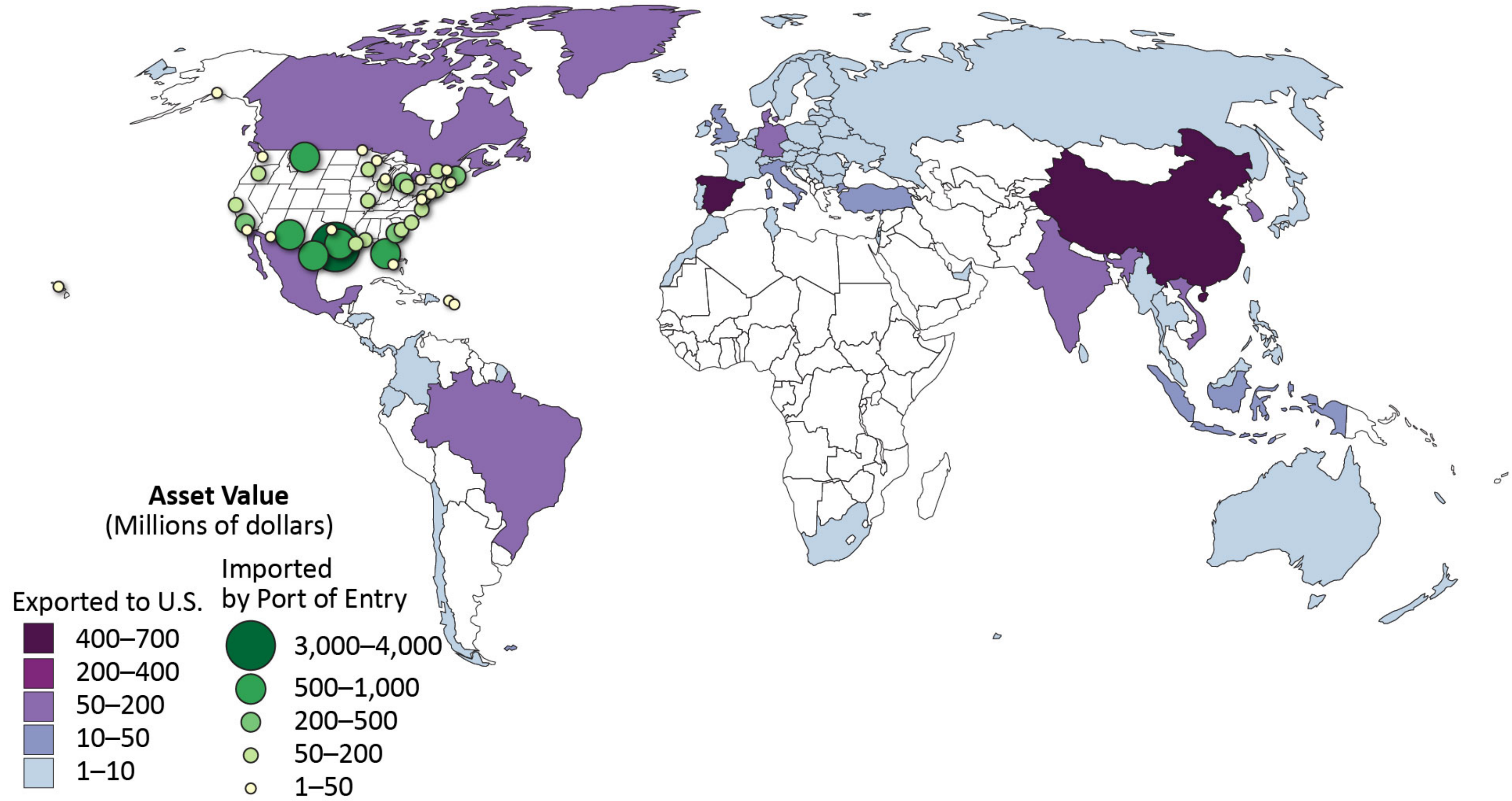


# Imports of Wind Equipment into the United States Are Sizable



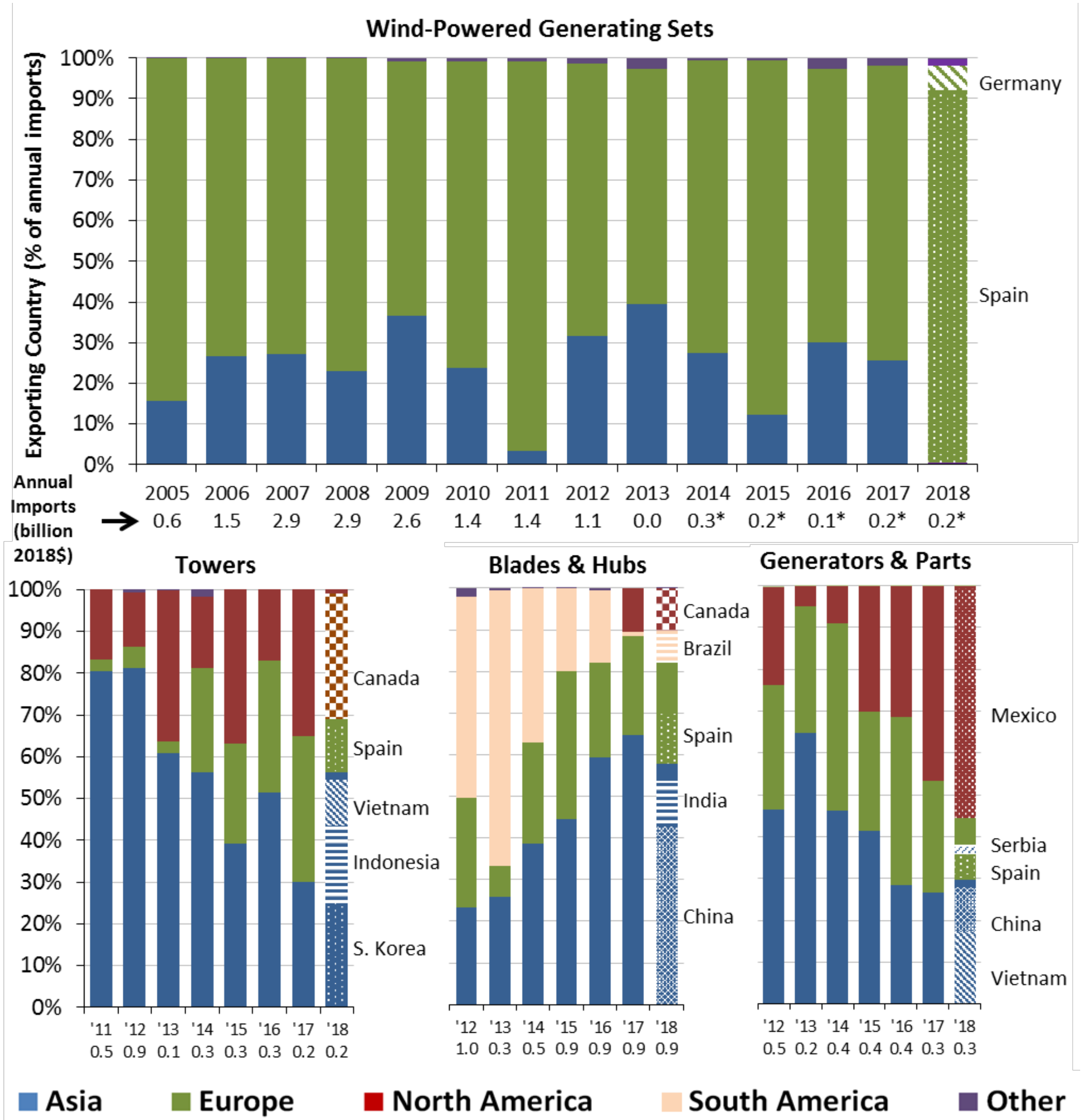

*Notes: Figure only includes tracked trade categories; misses other wind-related imports; see full report for the assumptions used to generate this figure*

# Tracked Wind Equipment Imports in 2018: 44% from Asia, 35% from Europe, 20% from the Americas




*Note: Tracked wind-specific equipment includes: wind-powered generating sets, towers, hubs and blades, wind generators and parts*

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




- Majority of imports of wind-powered generating sets historically from home countries of OEMs, dominated by Europe
- Decline in imports of towers from Asia over time, in part due to tariffs, but rebound in 2018
- Majority of imports of blades & hubs from Asia (especially) China
- Mexico becoming a dominant supplier of generators and parts

** Since 2014, some equipment that would previously have been included in the wind-powered generating sets trade category may be included in a different trade category (not wind specific, so not shown here) due to a change in trade category classification.*

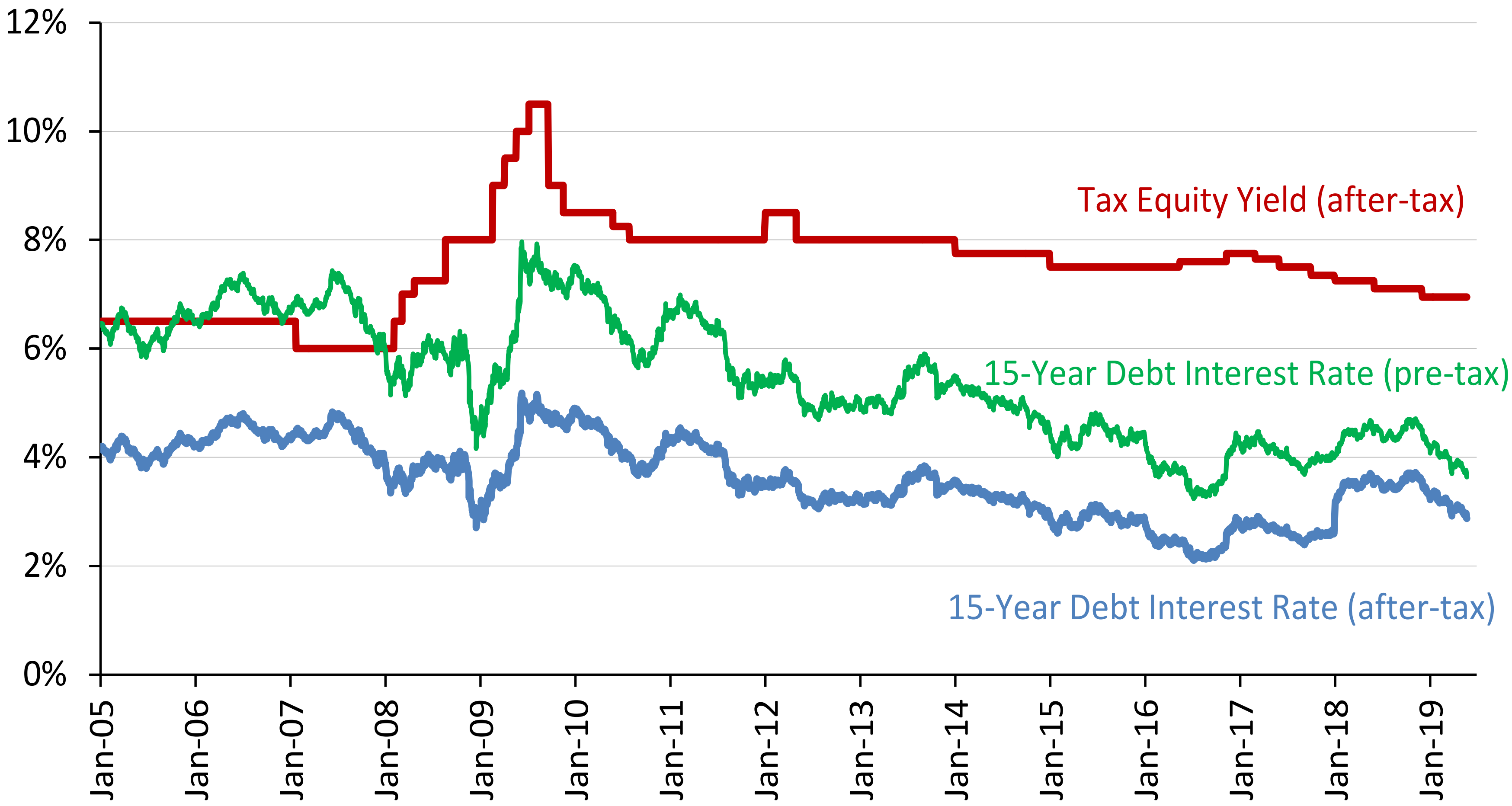
# Domestic Manufacturing Content is Strong for Nacelle Assembly, Towers, and Blades, but not Equipment Internal to the Nacelle

**Domestic Content for 2018 Turbine Installations in the United States:**

| Towers | Blades & Hubs | Nacelle Assembly |
|---|---|---|
| 75–90% | 50–70% | > 85% |

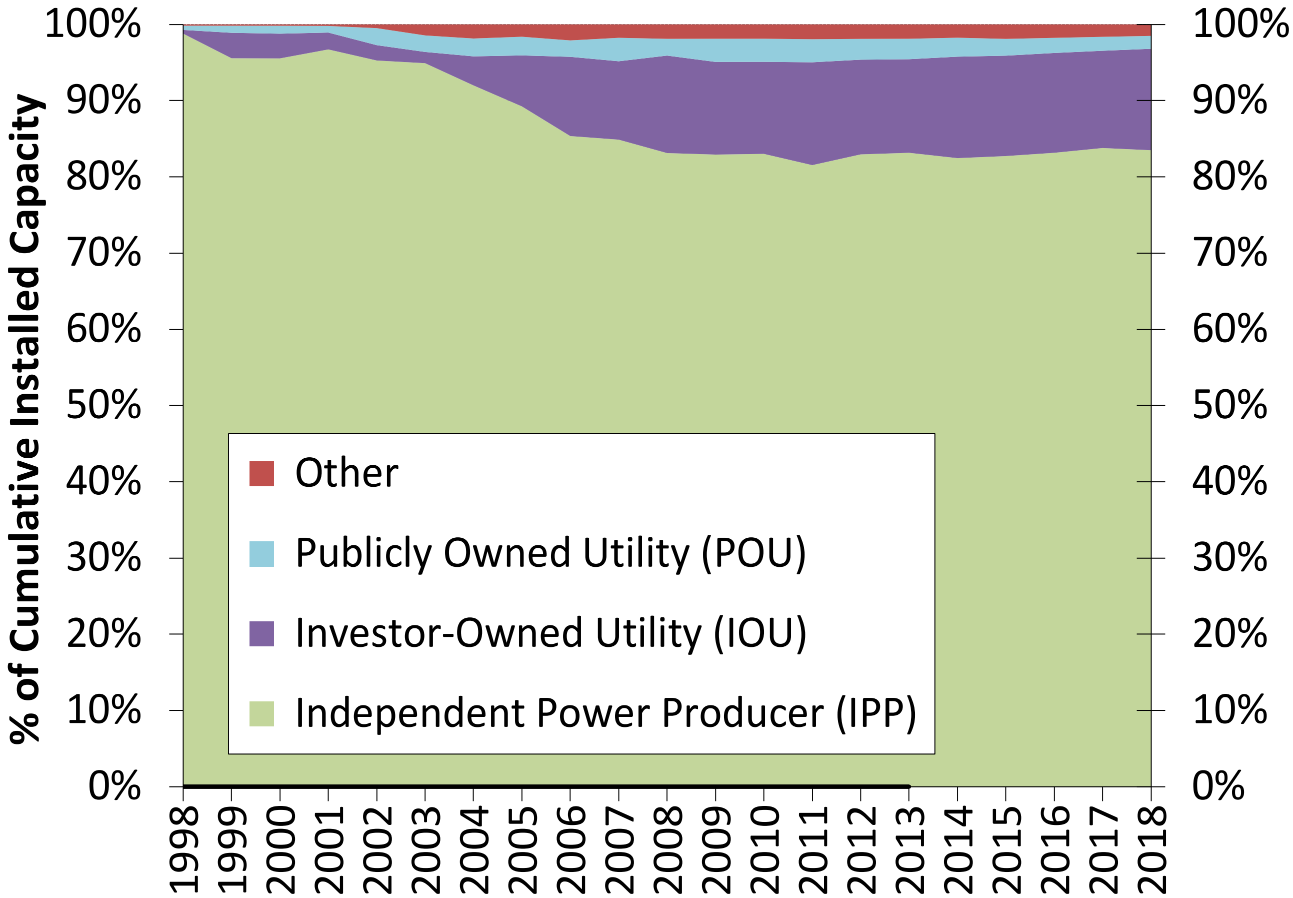
- Imports occur in untracked trade categories, including many nacelle internals; nacelle internals generally have domestic content of < 20%

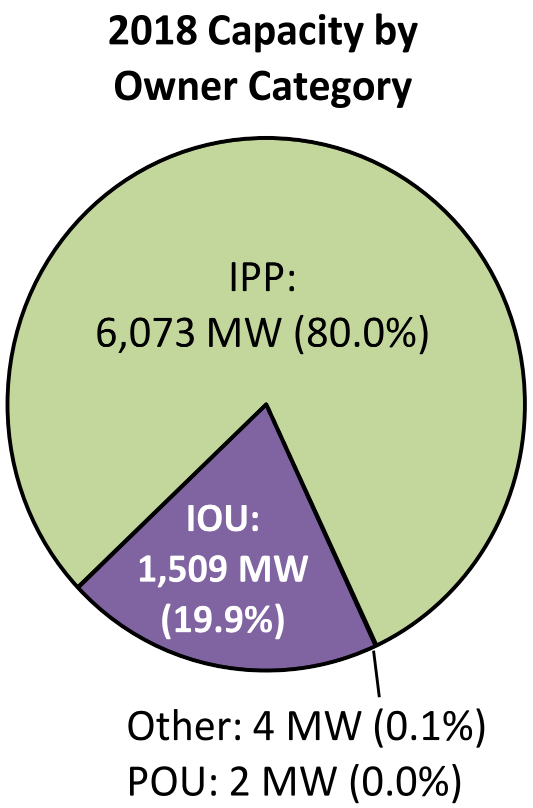
# The Project Finance Environment Remained Strong in 2018




- **Sponsors raised $6-7 billion of tax equity in 2018**
- **Tax reform legislation contained a number of provisions with implications for wind finance, but in general those implications have been modest**

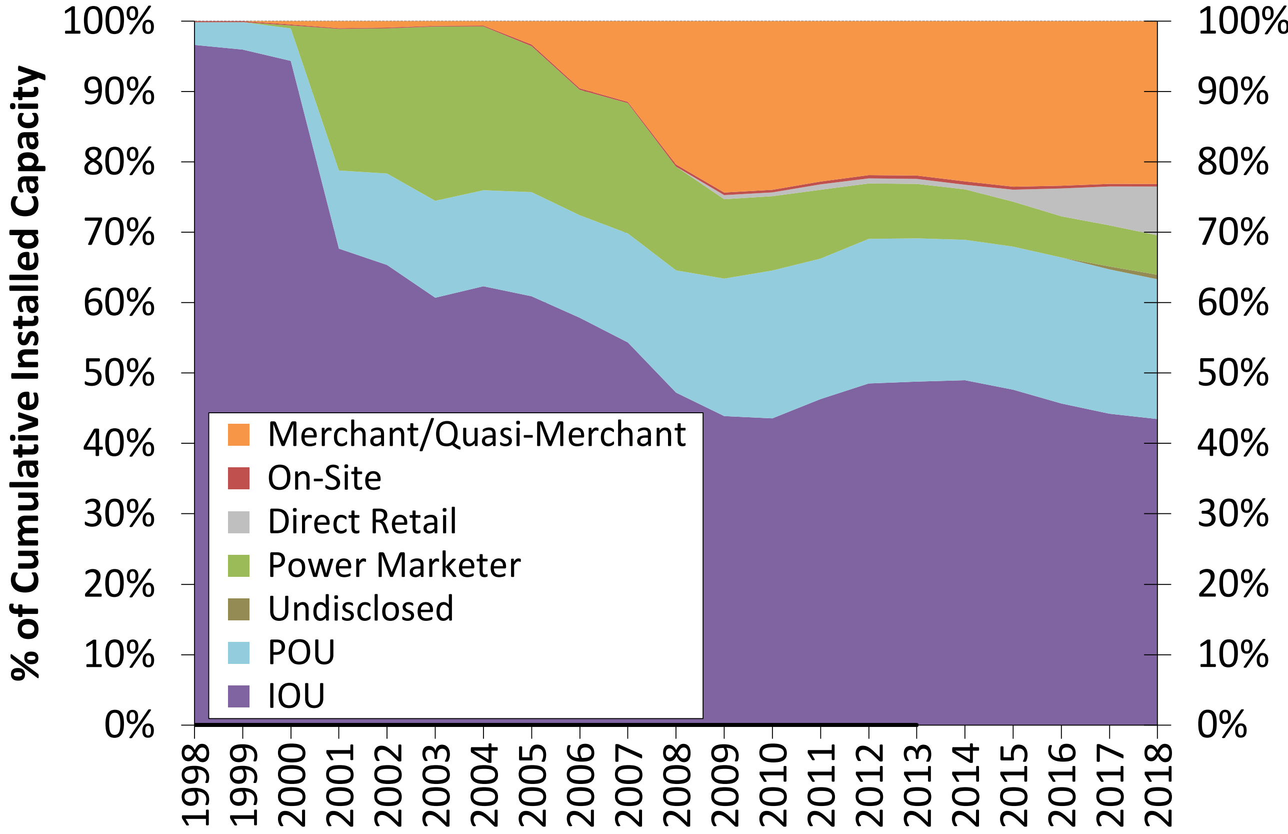
# Independent Power Producers Own the Majority of Wind Assets Built in 2018

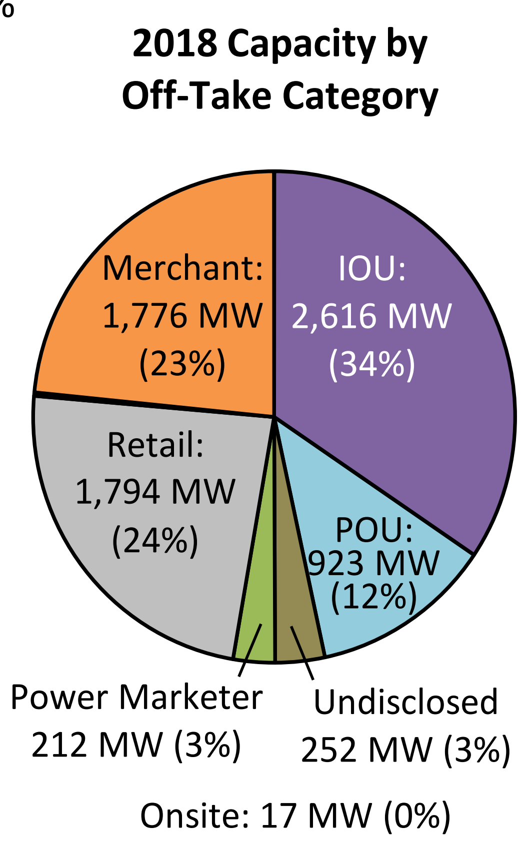



***Note: Graphic on left shows distribution among the growing cumulative fleet of wind projects installed in the U.S. Pie chart shows distribution only among those new projects built in 2018.***

# Long-Term Sales to Utilities Remained Most Common Off-Take, but Direct Retail Sales and Merchant Were Significant



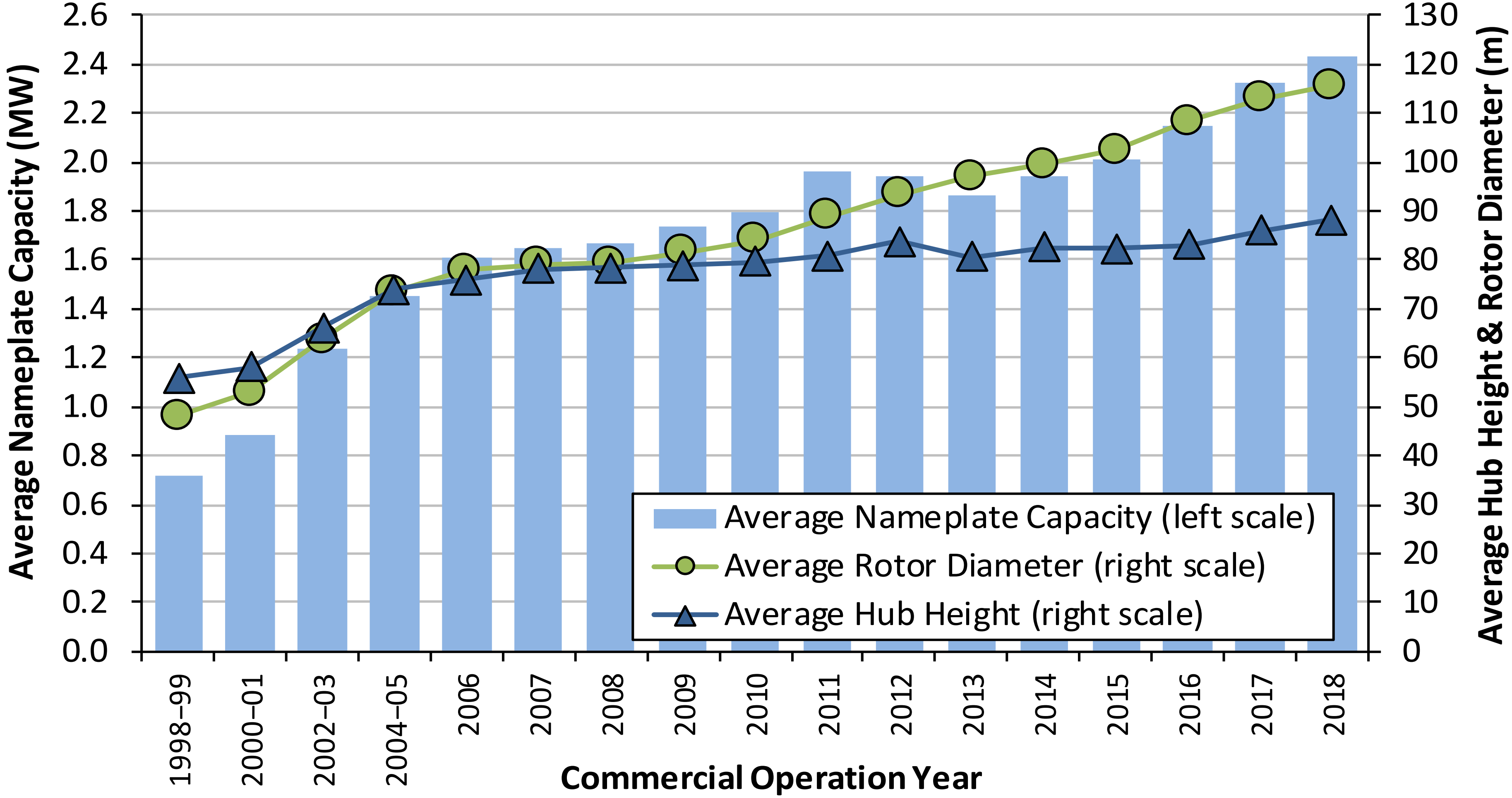




- **24% of added wind capacity in 2018 are from direct retail sales; 49% of total wind capacity contracted through PPAs in 2018 involve non-utility buyers**

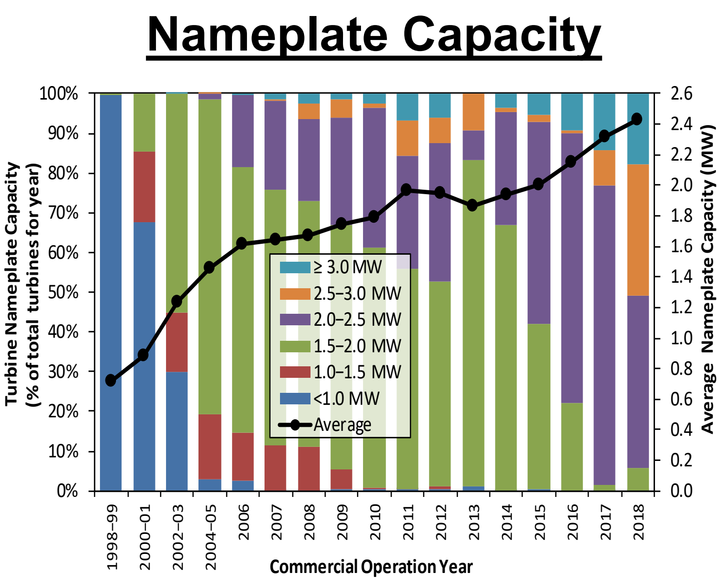
***Note: Graphic on left shows distribution among the growing cumulative fleet of wind projects installed in the U.S. Pie chart shows distribution only among those new projects built in 2018.***

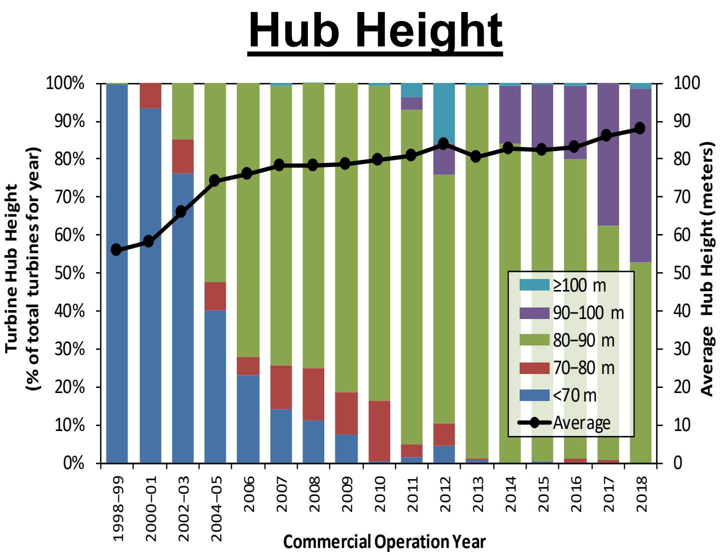
# Technology Trends

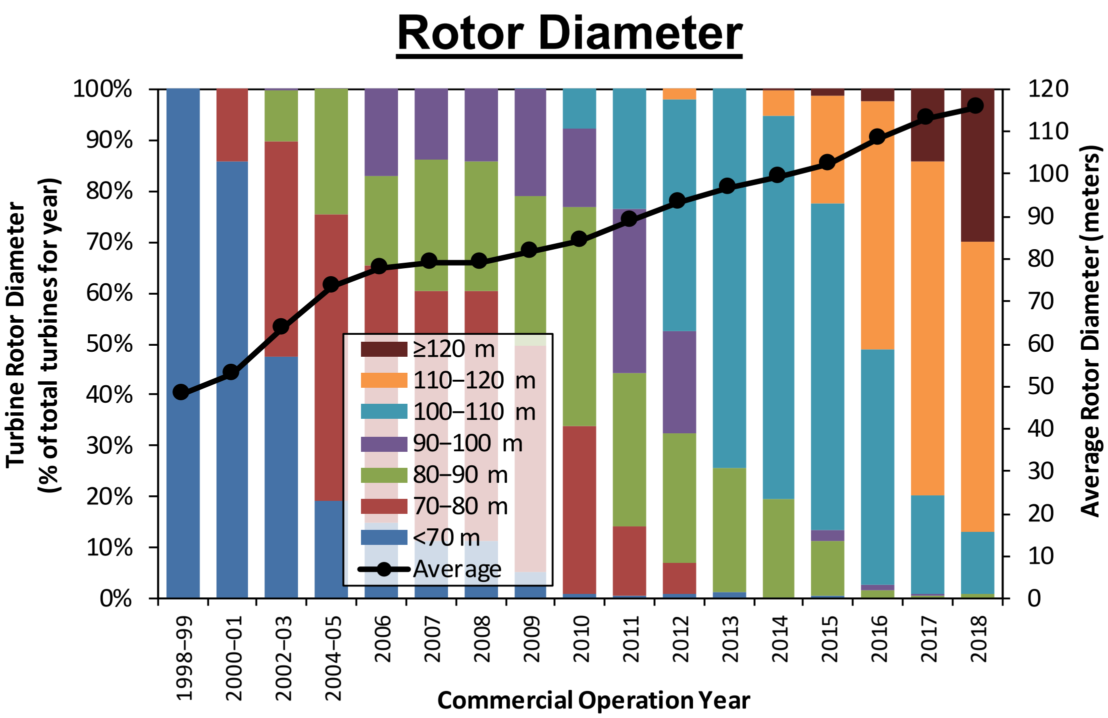
# Turbine Capacity, Rotor Diameter, and Hub Height Have All Increased Significantly Over the Long Term, and in 2018



# Growth in Rotor Diameter and Nameplate Capacity Have Outpaced Growth in Hub Height over the Last Two Decades

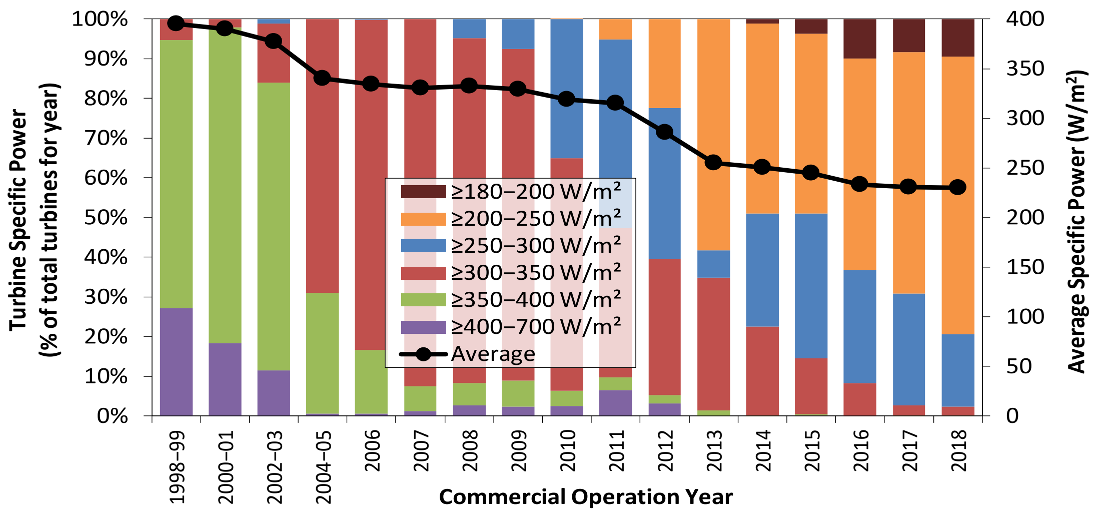


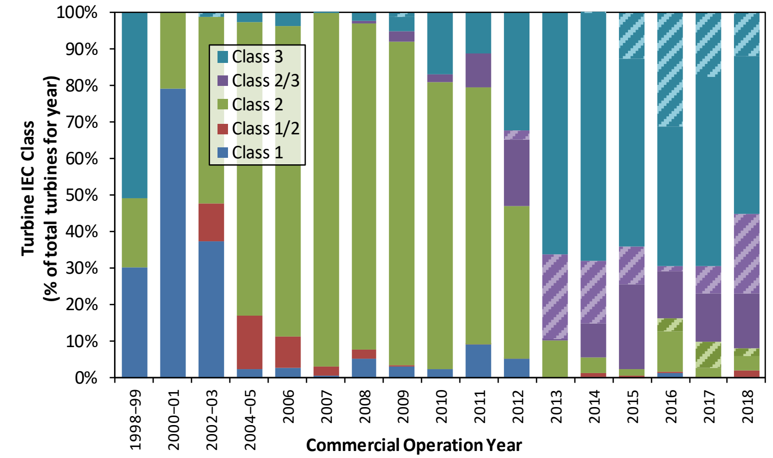



# Turbines Originally Designed for Lower Wind Speed Sites Dominate the Market

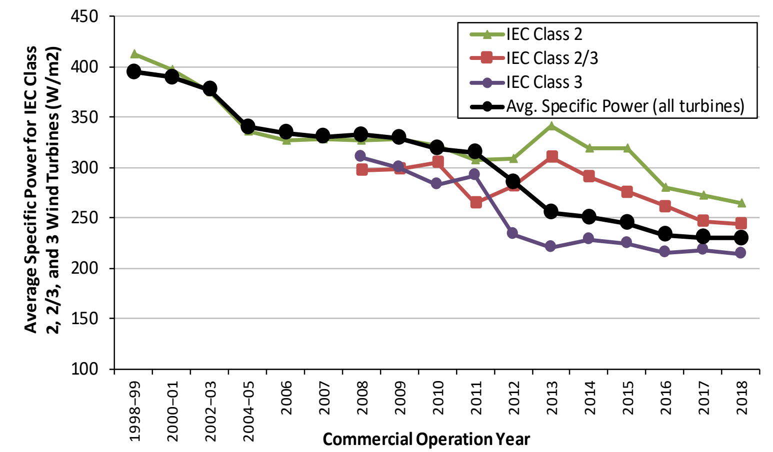
## Specific Power




## IEC Class

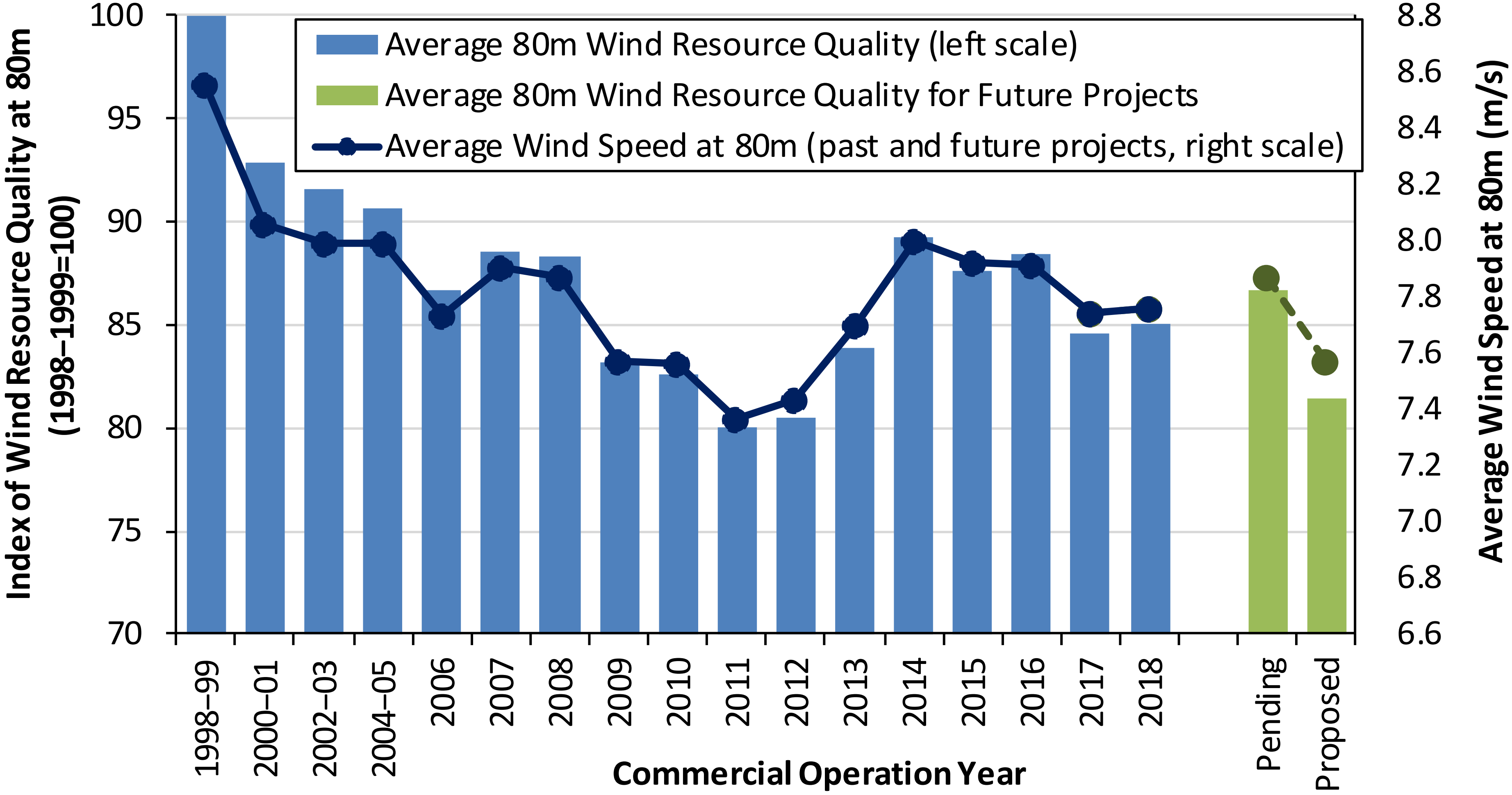



## Specific Power by Selected IEC Class

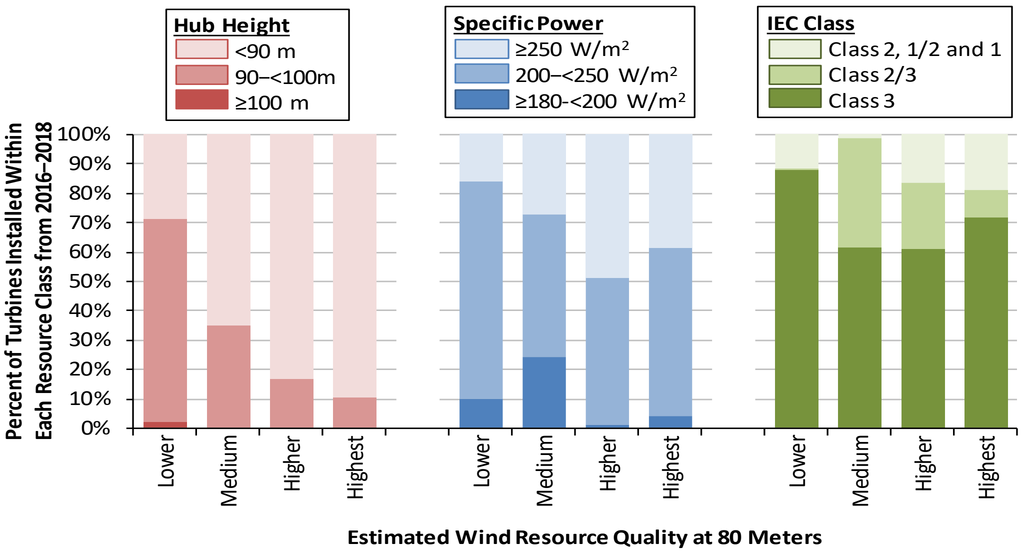


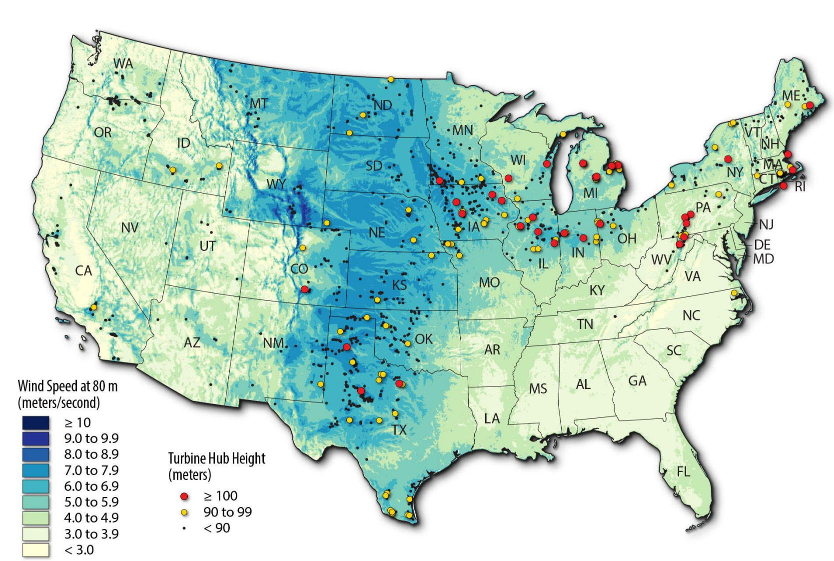

- **Specific power:** turbine nameplate capacity divided by swept rotor area; lower specific power leads to higher capacity factors, as shown later
- **IEC Class 1/2/3** represent turbines designed originally for high, medium, and low wind speed, respectively

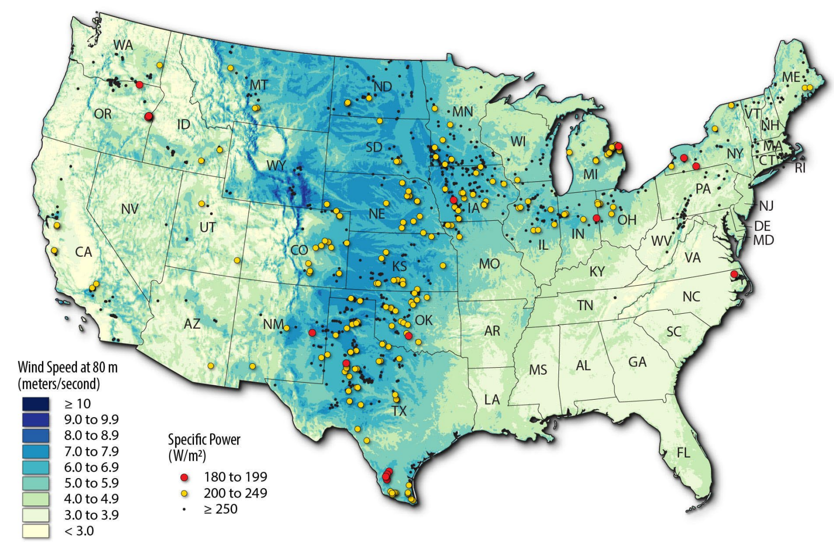
# Wind Turbines Continued to be Deployed in Somewhat Lower Wind-Speed Sites in 2018



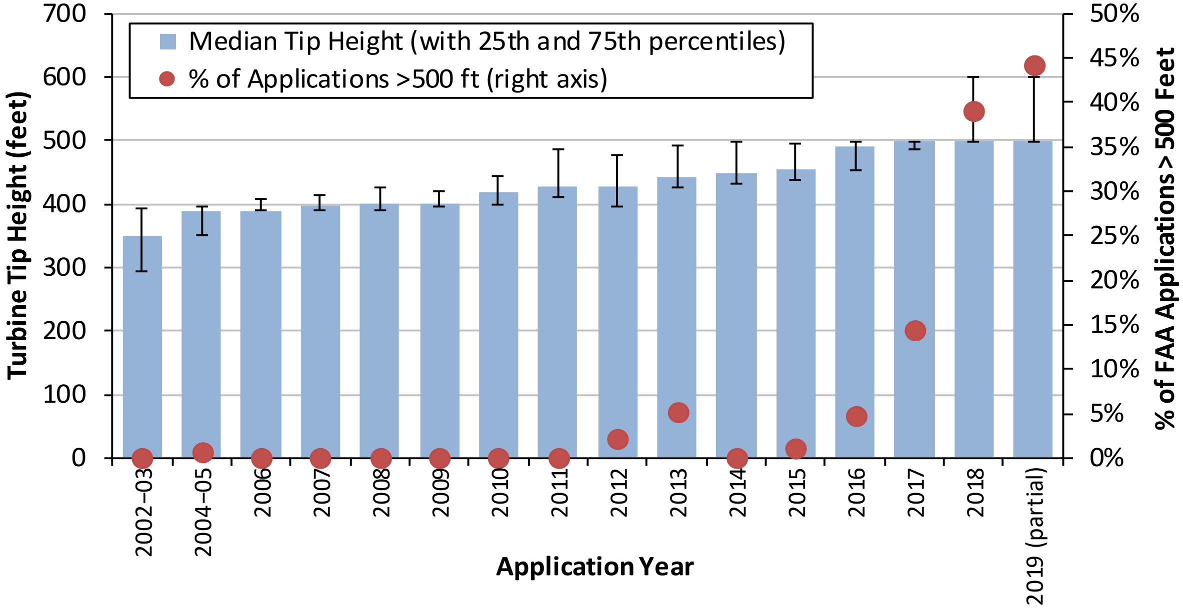
# Low Specific Power Turbines Are Deployed in Low & High Wind Speeds; Taller Towers More Common in Great Lakes & Northeast



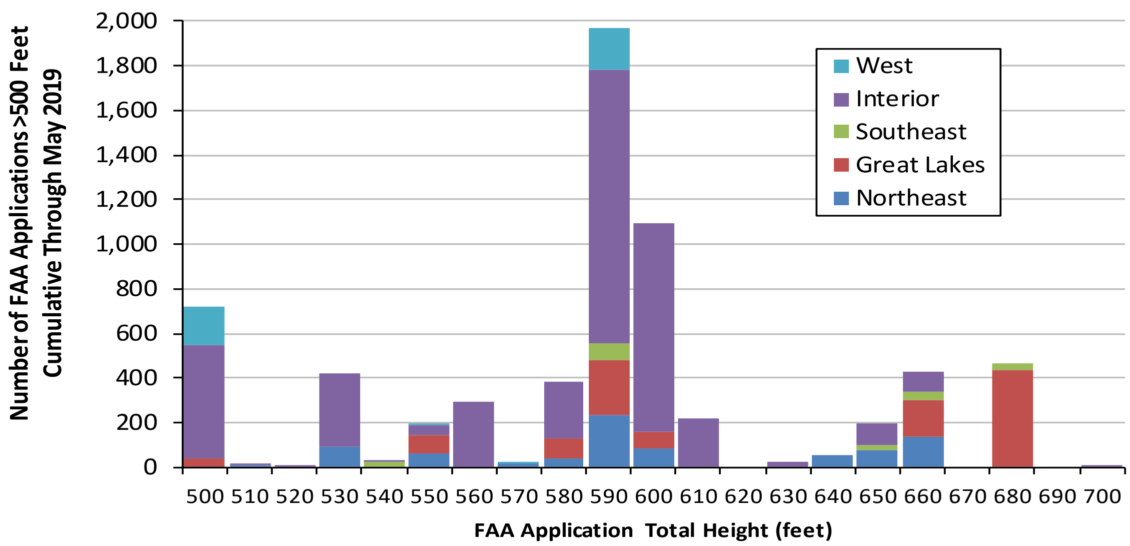



# Wind Power Projects Planned for the Near Future Are Poised to Continue the Trend of Ever-Taller Turbines

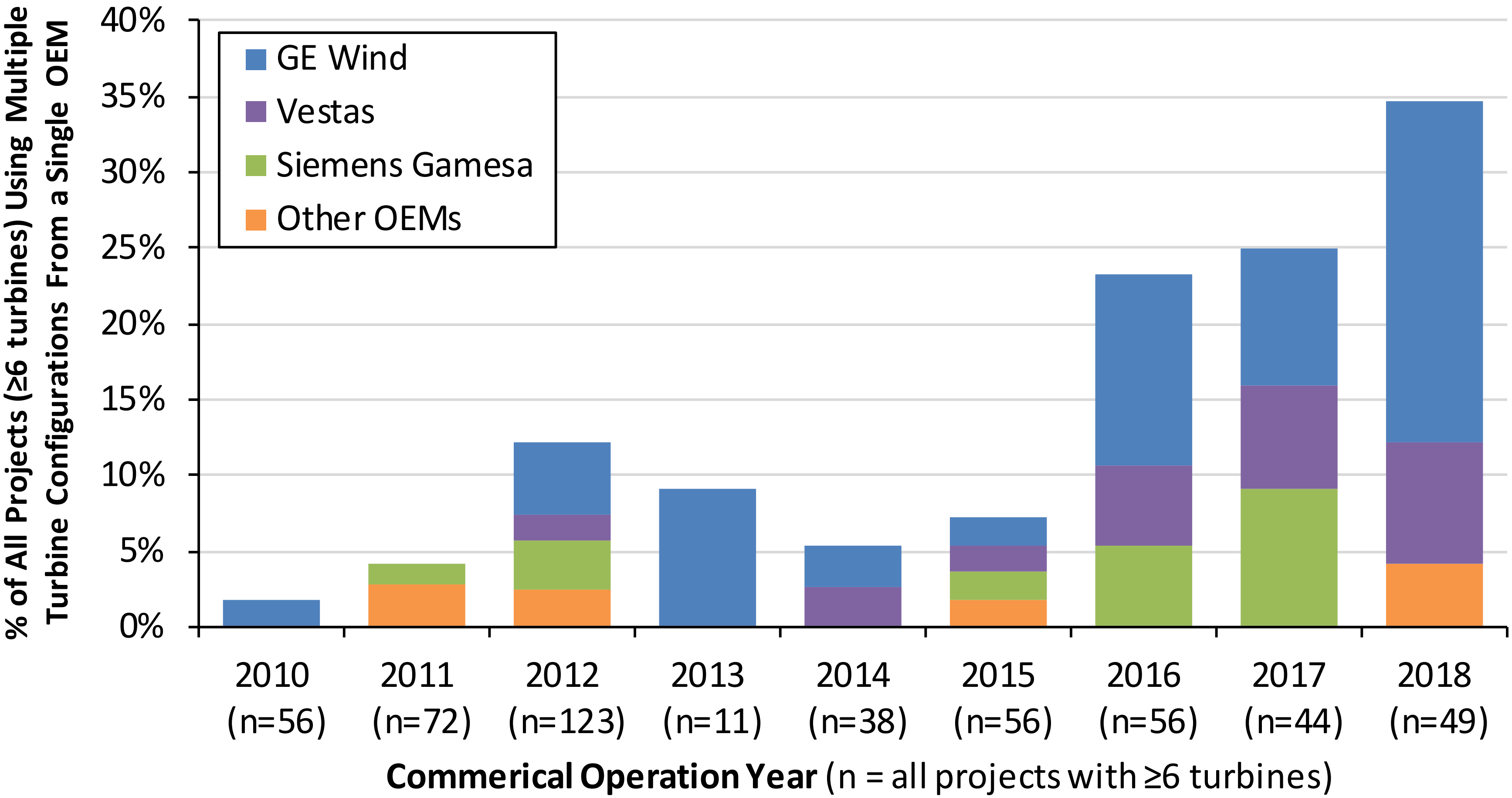



Total turbine heights proposed in FAA applications, over time

Histogram of cumulative FAA applications through May 2019 greater than 500 feet

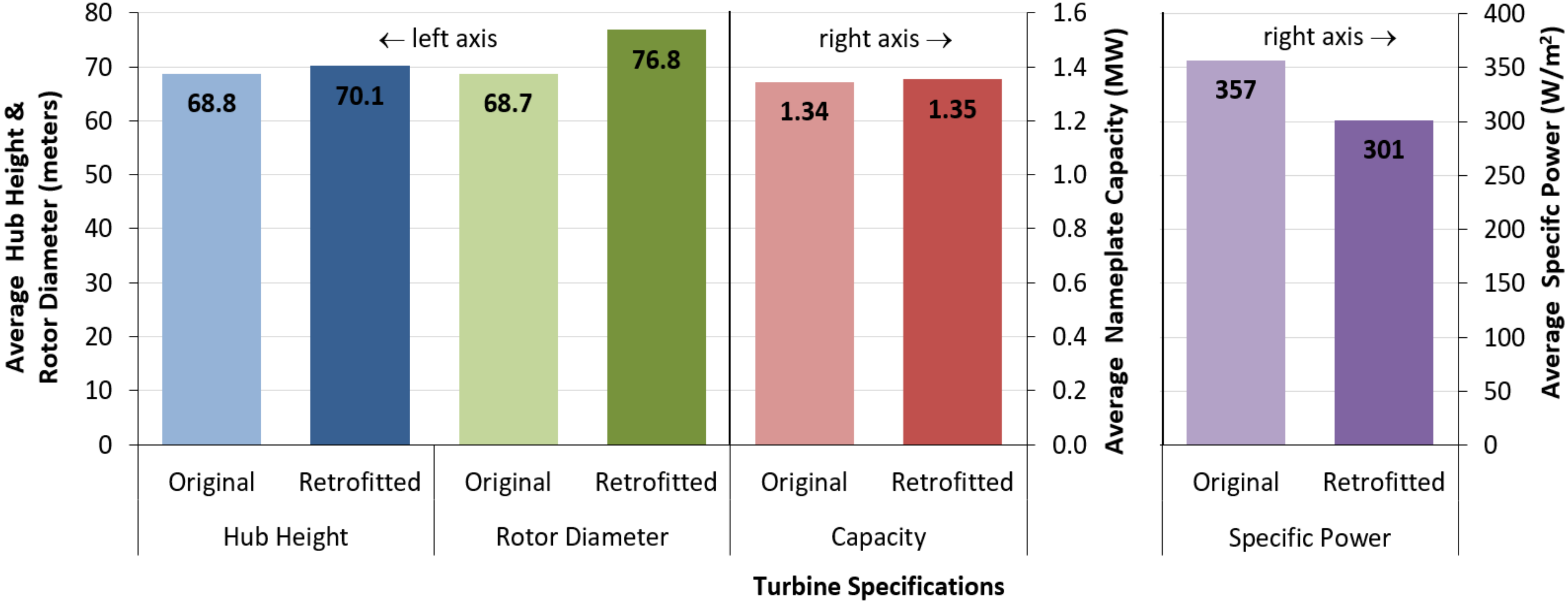


# A Large Number of Projects Continued to Employ Multiple Turbine Configurations from a Single Turbine Supplier



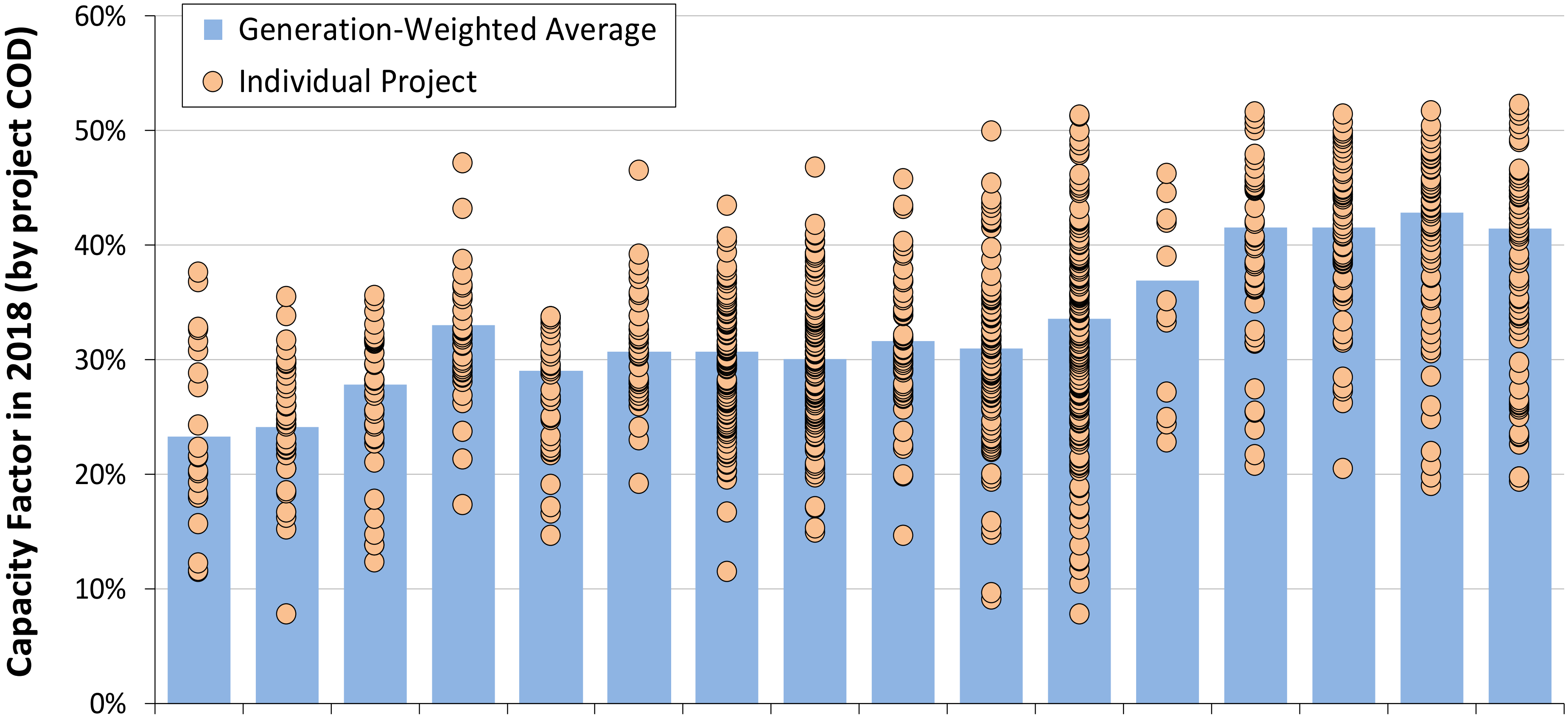

*Note: Turbine configuration = unique combination of hub height, rotor diameter, and/or capacities*

# Through 2018, 23 Projects Have Been Partially Repowered, most of which Feature Larger Rotors and Lower Specific Power



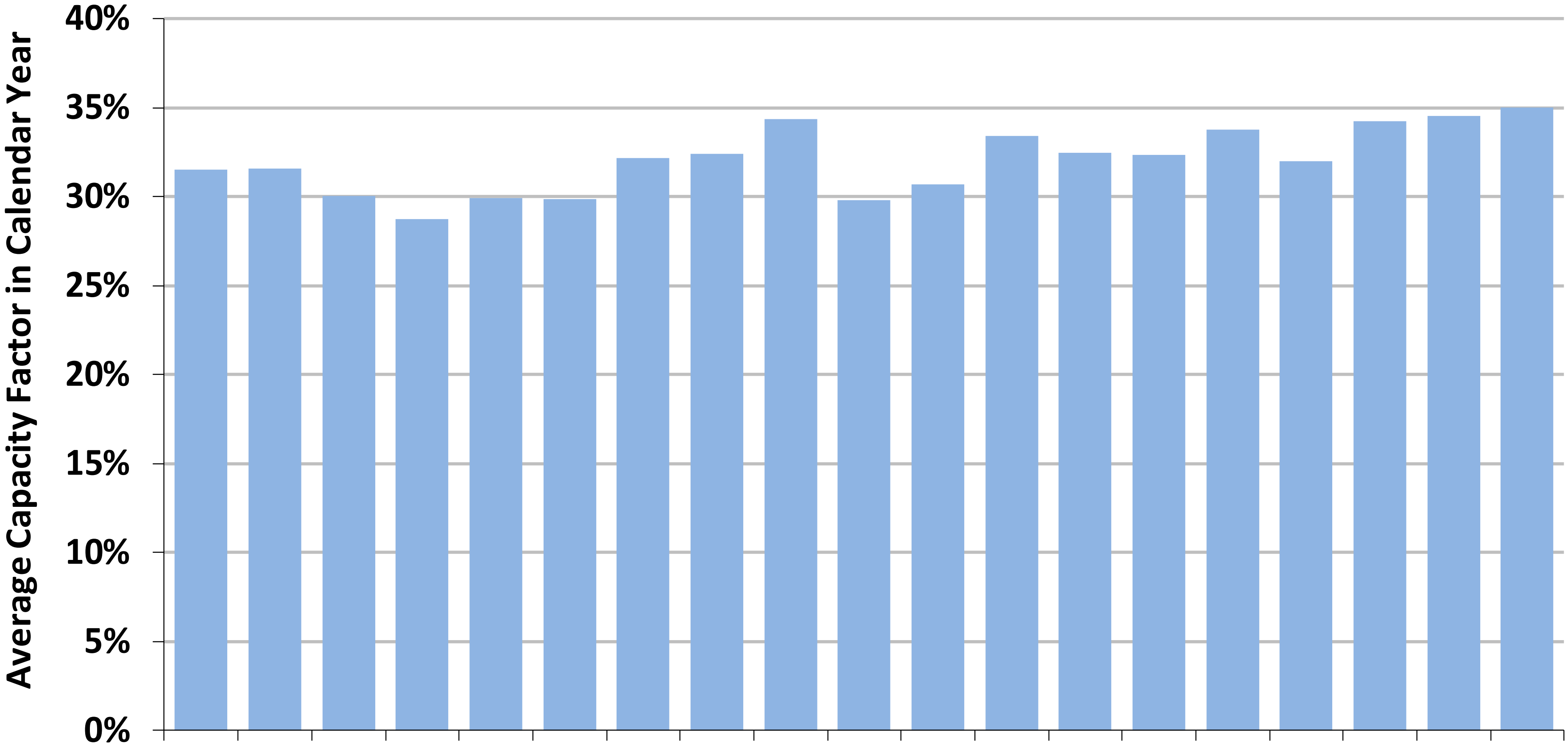
# Performance Trends

# Capacity Factors Have Increased Significantly Over Time, by Online Date (i.e., Commercial Online Date, COD)



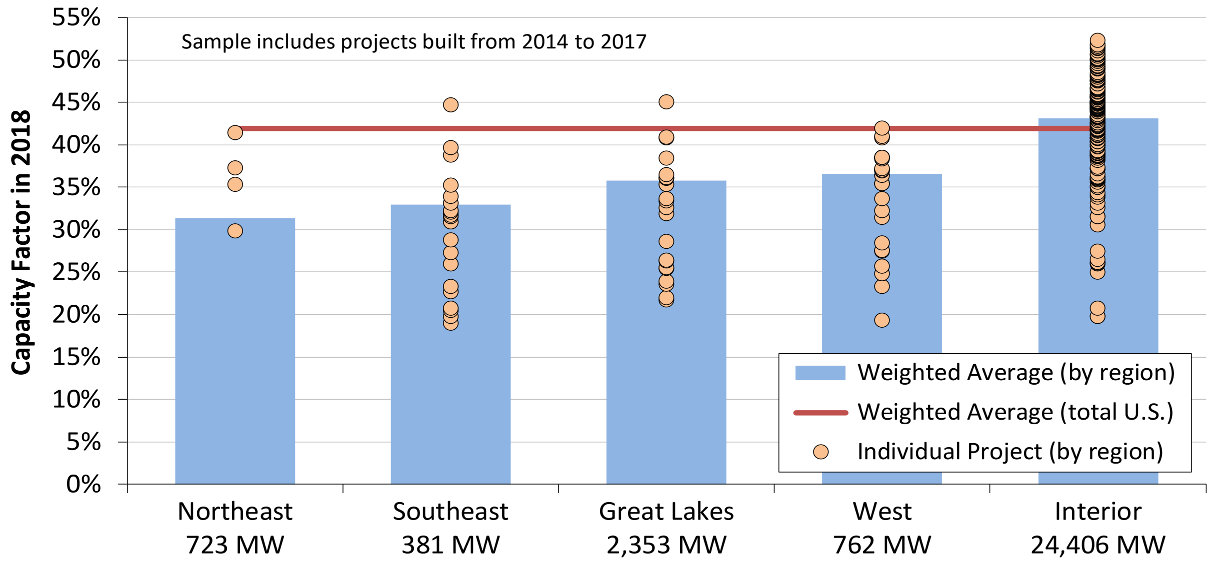

| Year: | '98-99 | '00-01 | '02-03 | '04-05 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of GW: | 0.9 | 0.9 | 1.7 | 2.3 | 1.6 | 5.2 | 7.7 | 9.7 | 4.7 | 5.9 | 13.6 | 1.0 | 5.1 | 8.3 | 8.2 | 7.0 |

# Fleet-Wide Average Capacity Factors Have Gradually Increased, Reaching 35% for the First Time in 2018



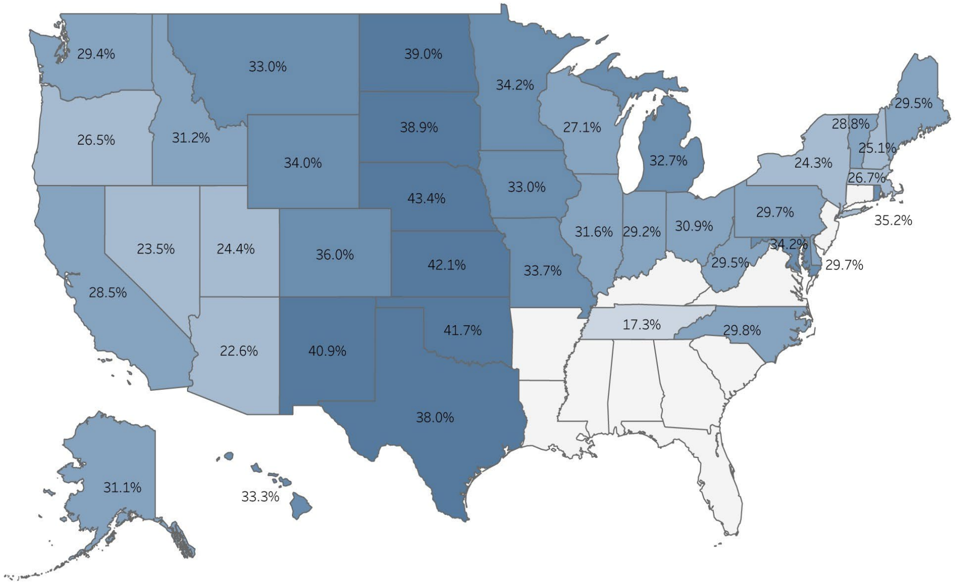

| Year: | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of GW: | 0.6 | 0.9 | 2.7 | 3.1 | 4.5 | 5.1 | 8.0 | 9.9 | 14.9 | 23.6 | 33.3 | 38.5 | 44.7 | 58.2 | 59.4 | 64.3 | 72.7 | 78.6 | 86.2 |

# The Interior Region Features the Highest Capacity Factors, in Part Reflecting the Strength of the Wind Resource

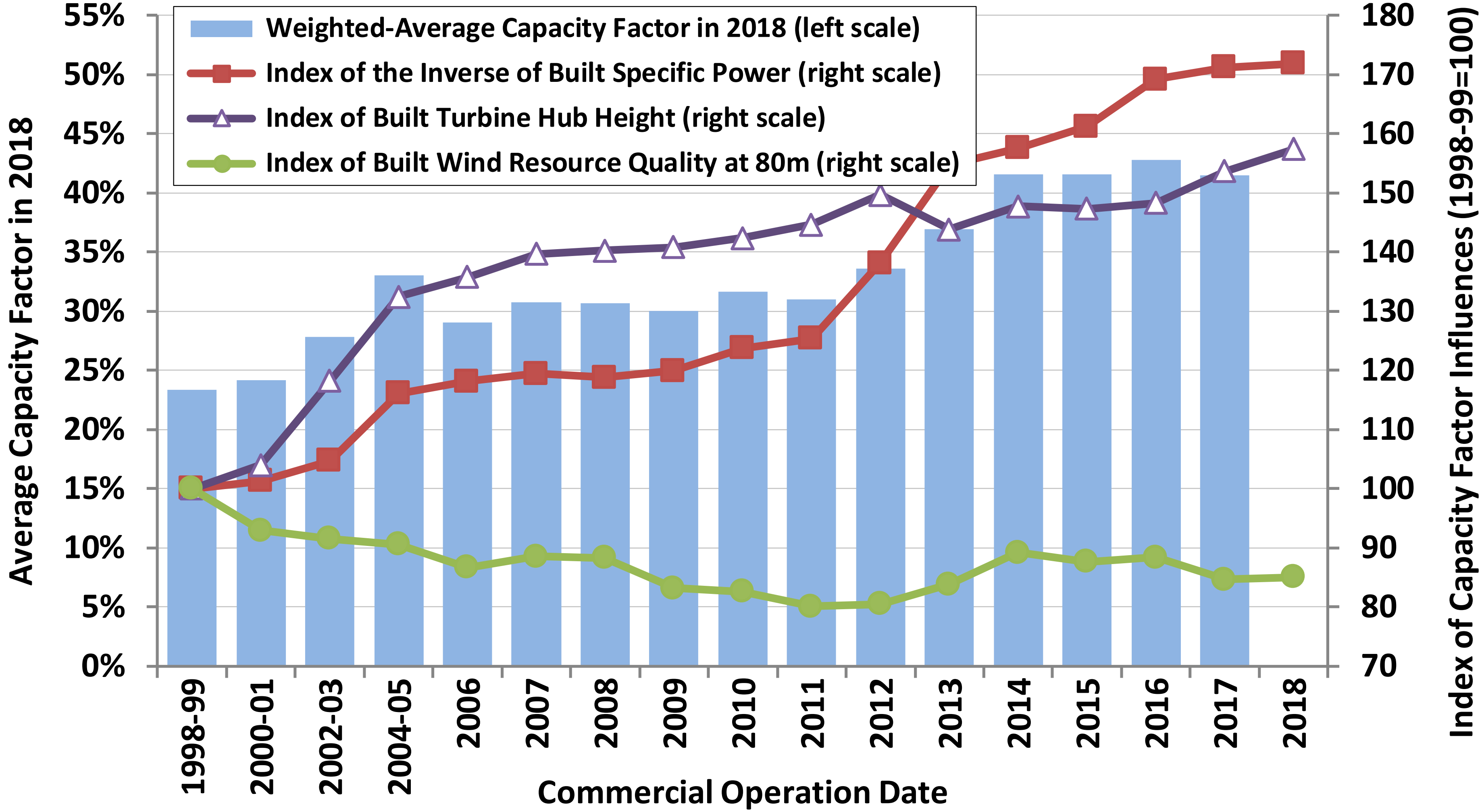



**Only projects built from 2014 to 2017**

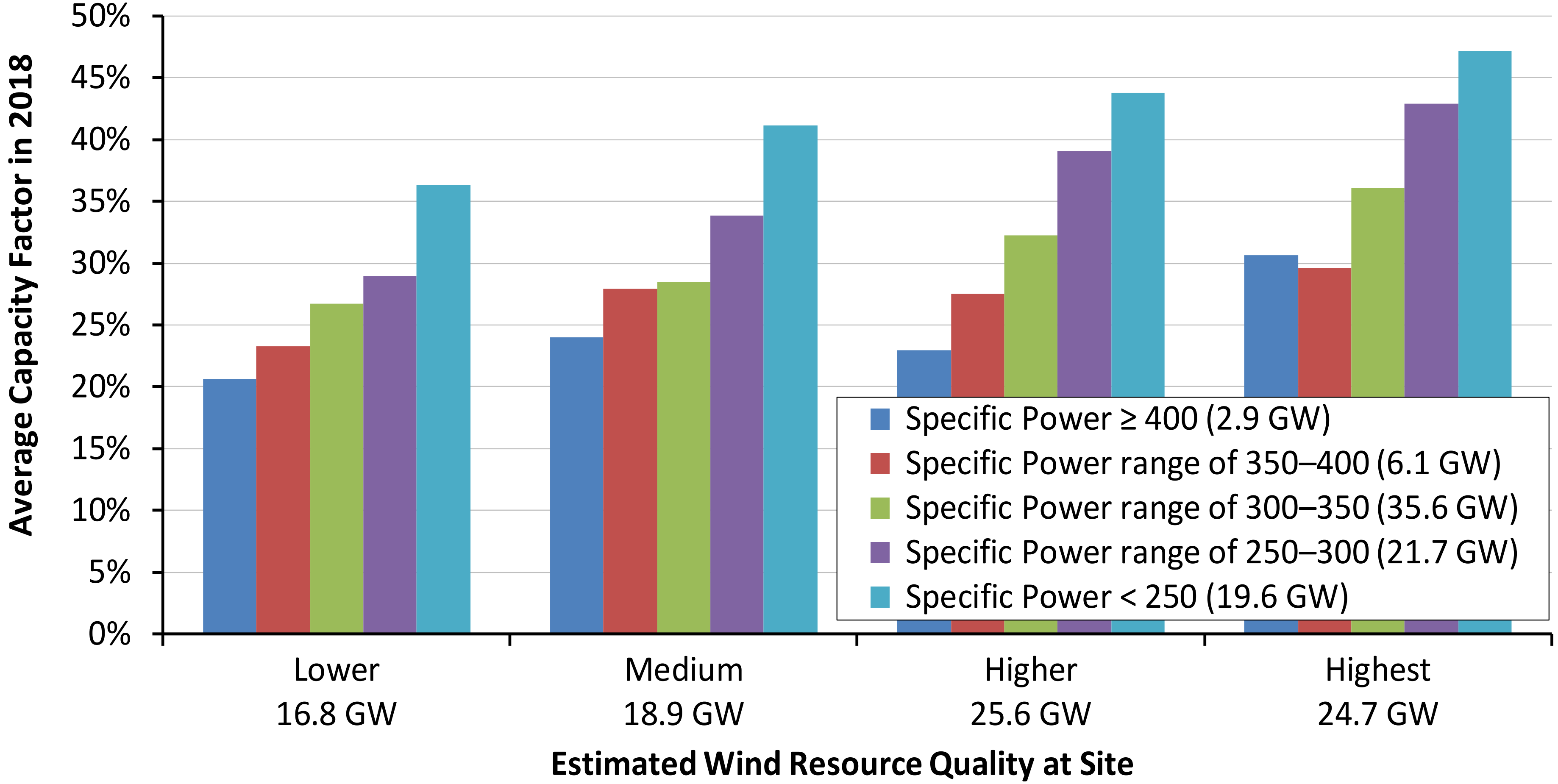
**Projects built from 1998 to 2017**



# Time Trends Explained by Competing Influences of Lower Specific Power, Higher Hub Heights, Varying Quality Wind Resource Sites

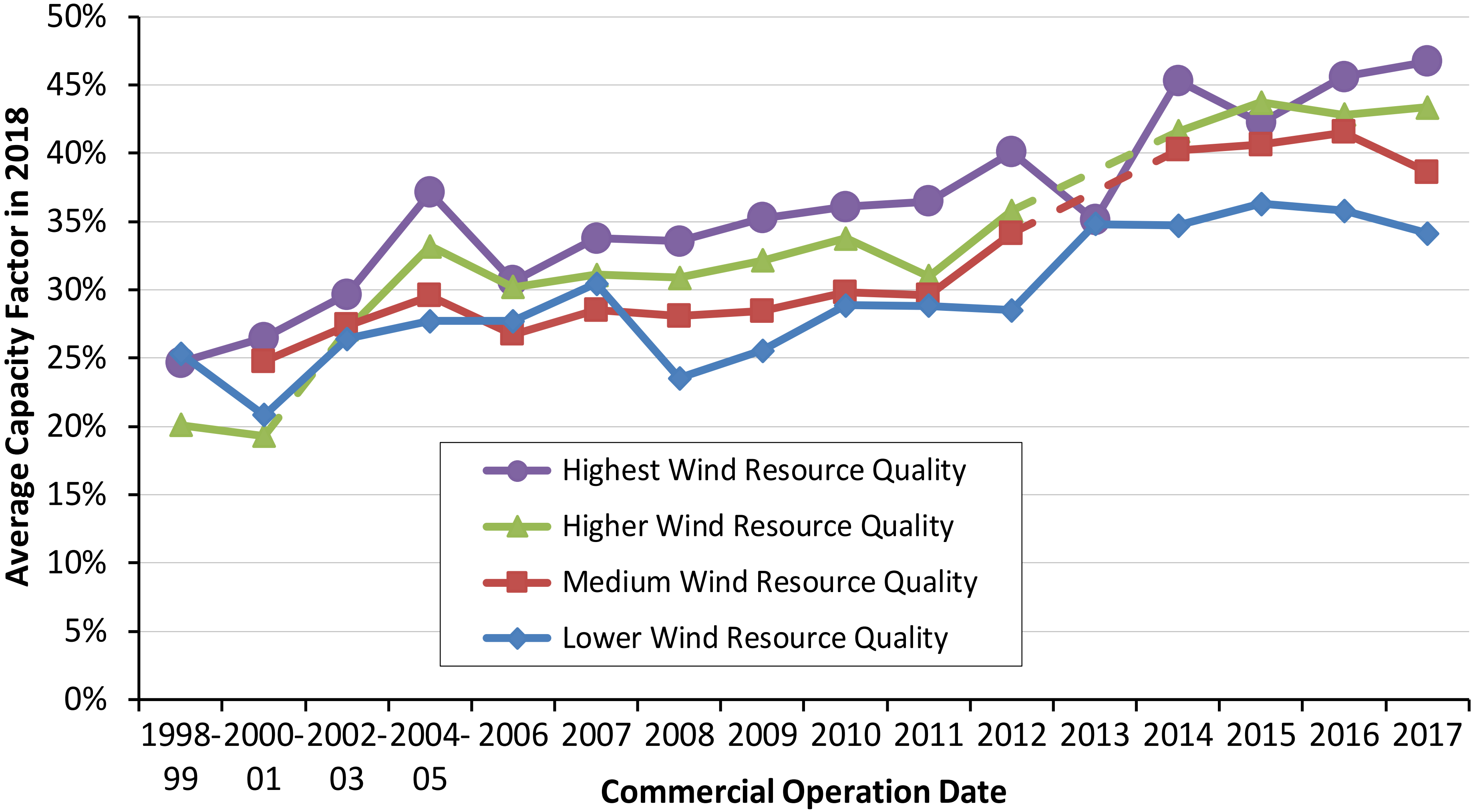


# Controlling for Wind Resource Quality and Specific Power Demonstrates Impact of Turbine Evolution

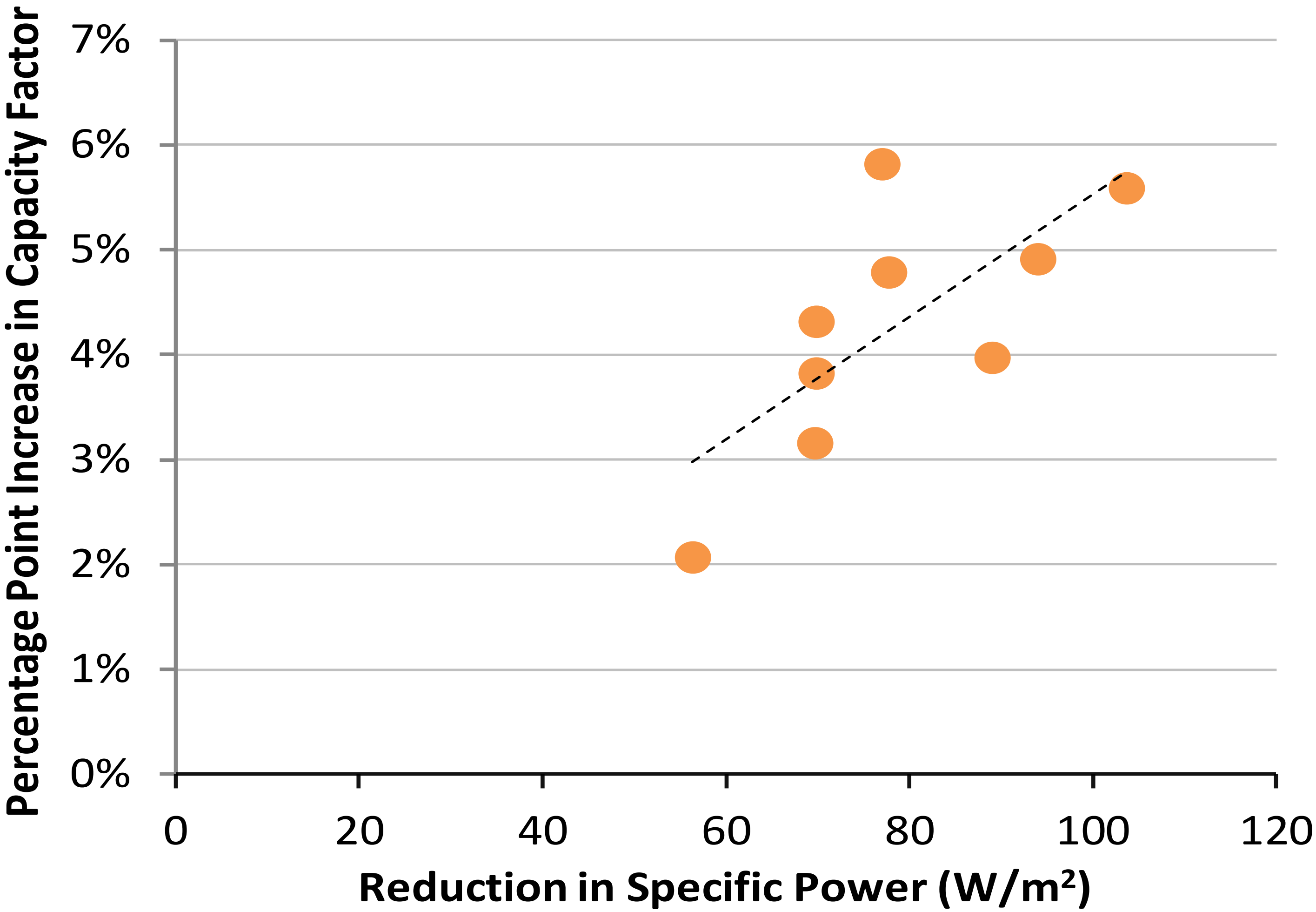



- Turbine design changes are driving capacity factors higher for projects located in given wind resource regimes

# Controlling for Wind Resource Quality and Commercial Operation Date Also Illustrates Impact of Turbine Evolution

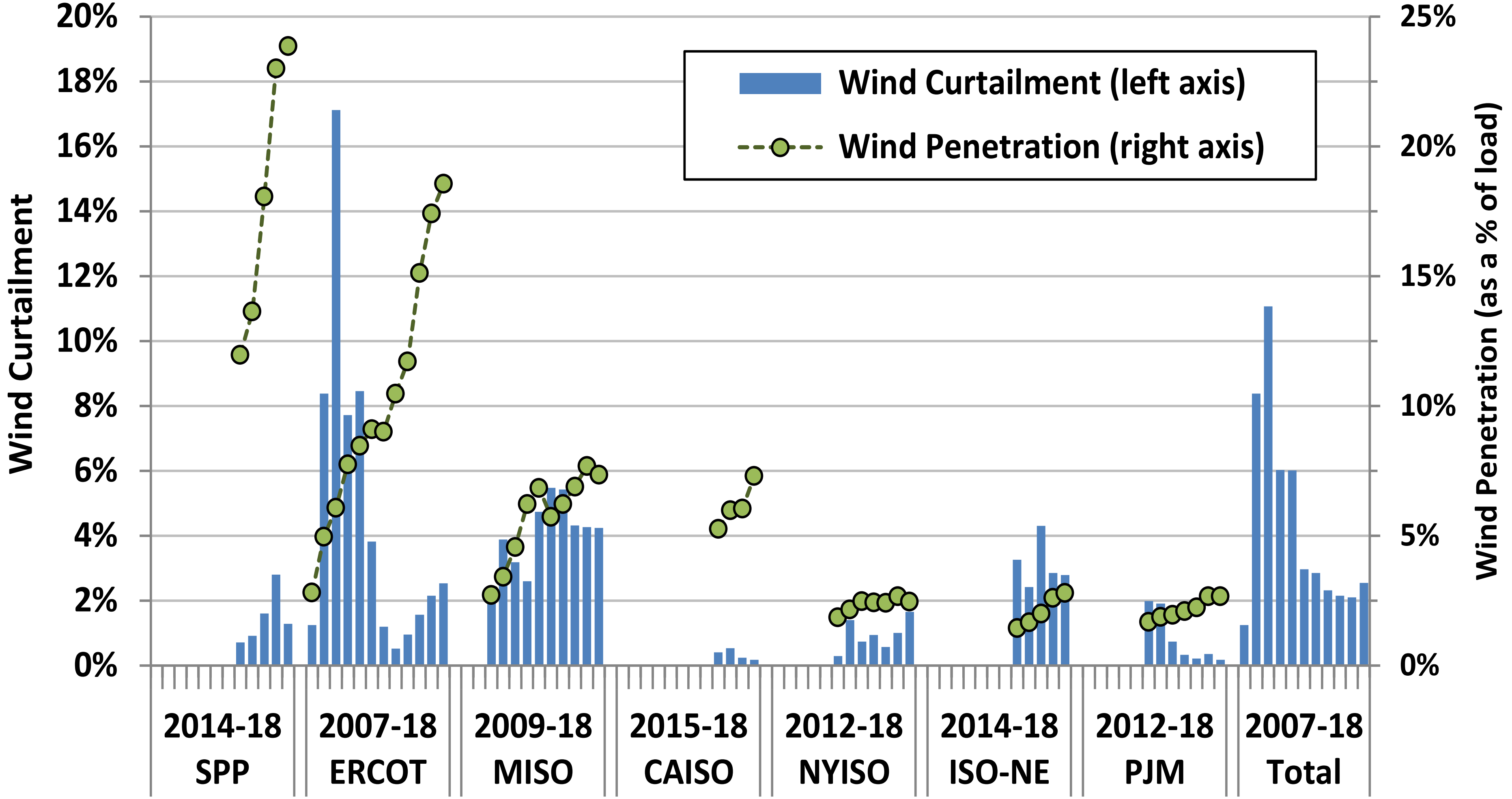


# First Wave of Partial Repowering Demonstrates Higher Capacity Factors from Lower Specific Power



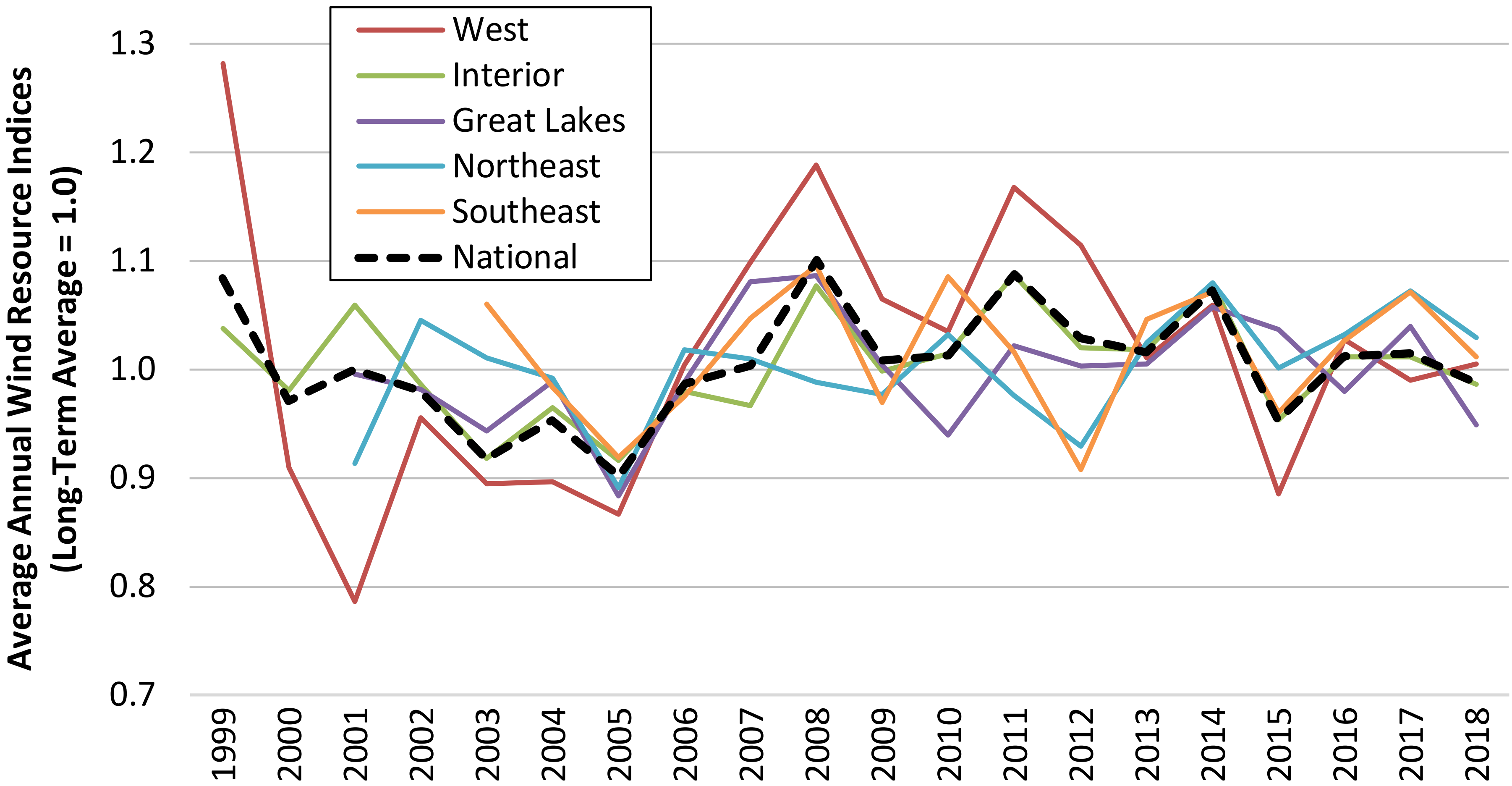

- Graphic includes 9 projects totaling 2.2 GW that partially repowered their turbines in 2017, and shows the increase in capacity factor in 2018 (relative to the 4-year average from 2013-2016) as a function of the reduction in average specific power

# Wind Curtailment Varies by Region; Was Highest in MISO in 2018, but Highest-Ever in ERCOT in 2009

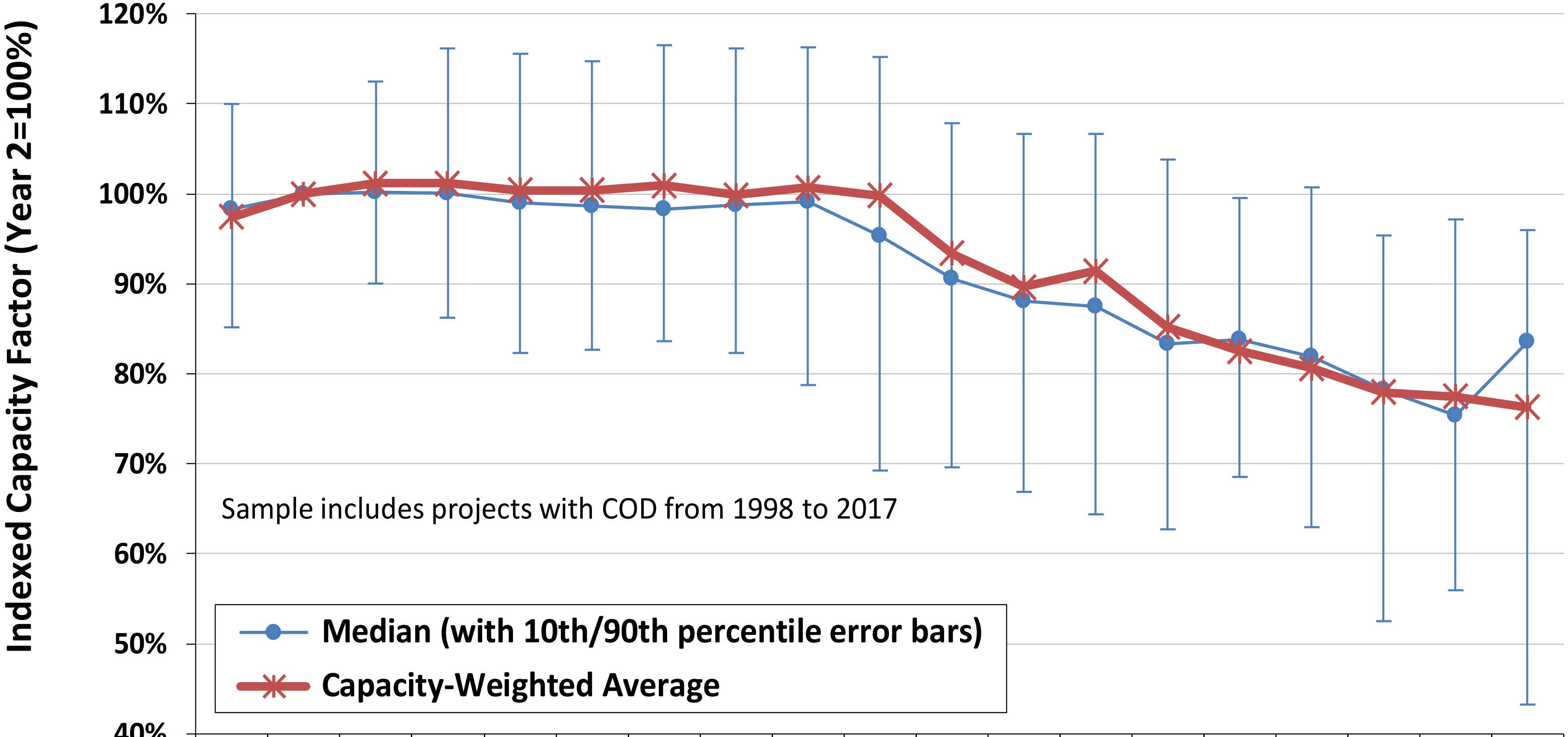



- In areas where curtailment has been particularly problematic in the past—principally in Texas—steps taken to address the issue have born fruit

# Yearly Variations in Average Wind Speed Also Impact Project Performance, but 2018 Was a Reasonably Normal Wind Year



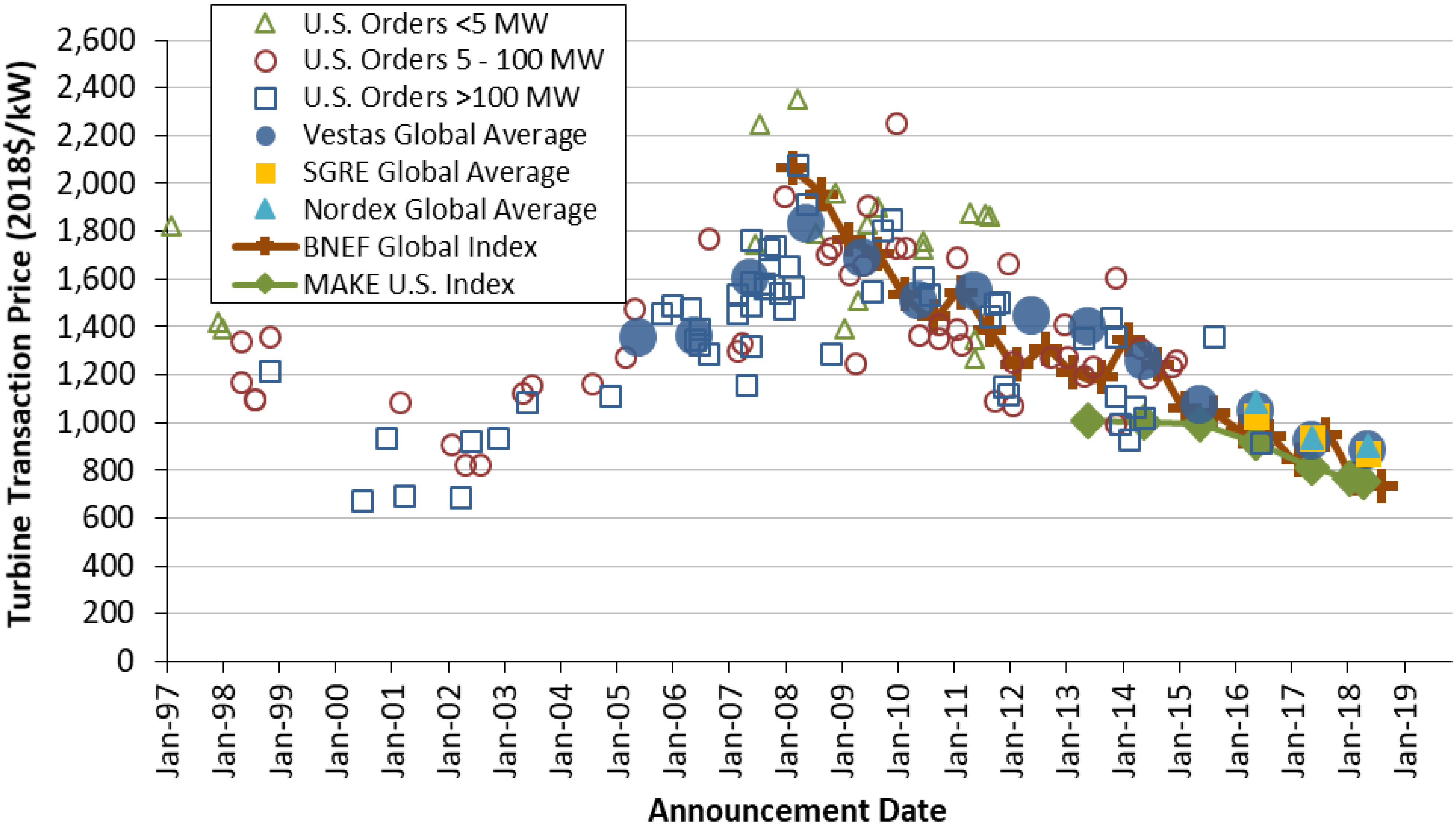
# Change in Performance as Projects Age Also Impacts Overall Trends; Performance Degradation Shown After Year 10




| Years post-COD: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample GW: | 79.5 | 79.8 | 71.5 | 63.3 | 58.1 | 57.1 | 43.5 | 37.7 | 32.4 | 23.2 | 14.6 | 8.8 | 8.0 | 5.1 | 4.2 | 2.9 | 1.7 | 0.8 | 0.8 |

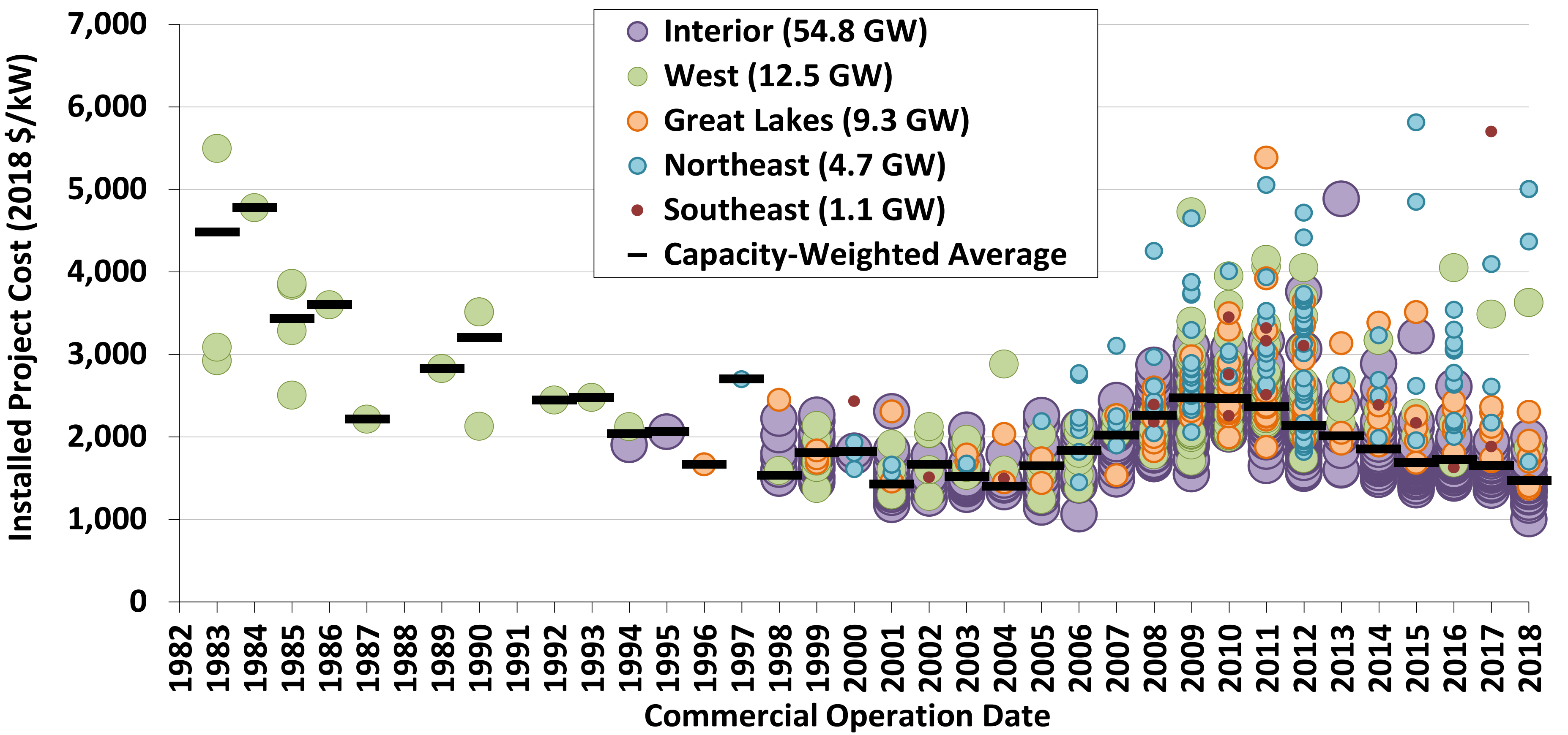
# Cost Trends

# Wind Turbine Prices Remained Well Below the Levels Seen a Decade Ago



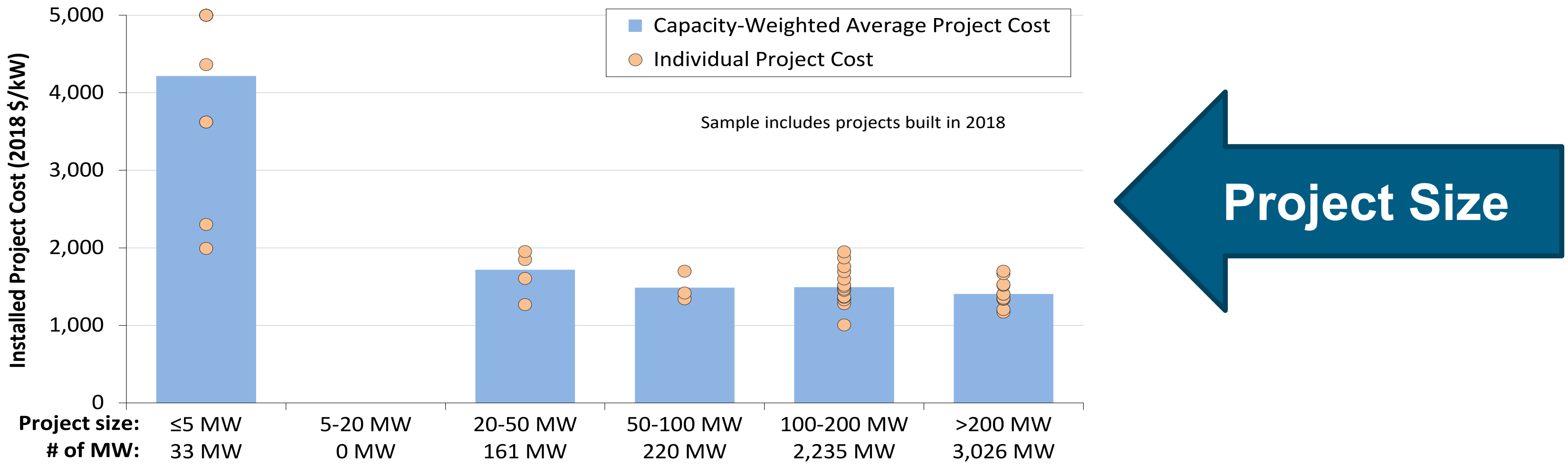

- Recent turbine orders in the range of $700-900/kW

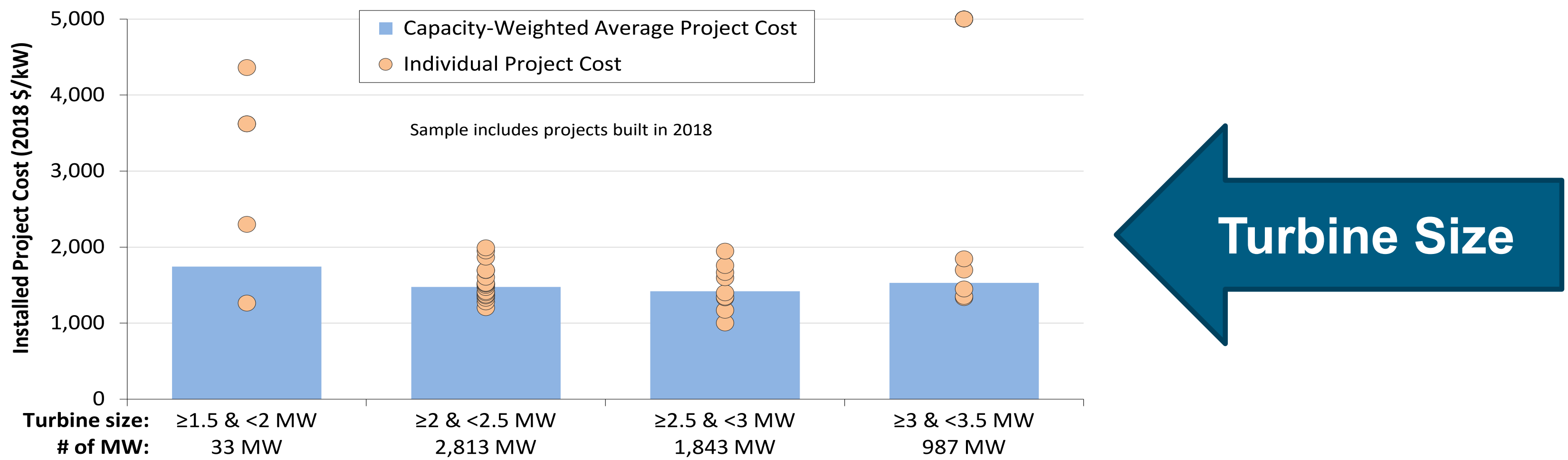
# Lower Turbine Prices Have Driven Reductions in Total Installed Project Costs



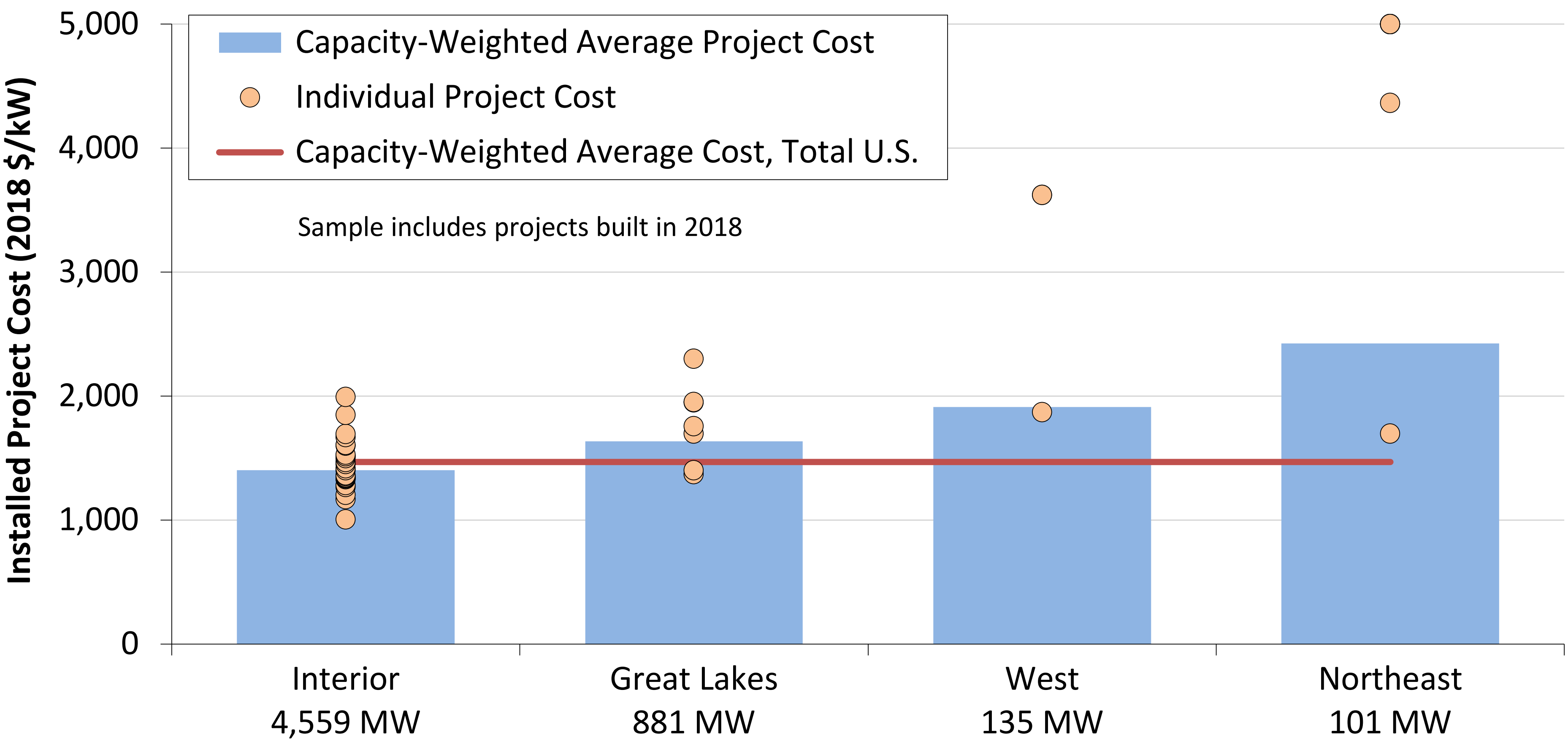

- 2018 projects had average cost of $1,470/kW, down ~$1000/kW since 2009-2010
- Limited sample of under-construction projects suggest somewhat lower costs in 2019

# Economies of Scale Are Apparent, Especially when Moving from Small- to Medium-Sized Projects

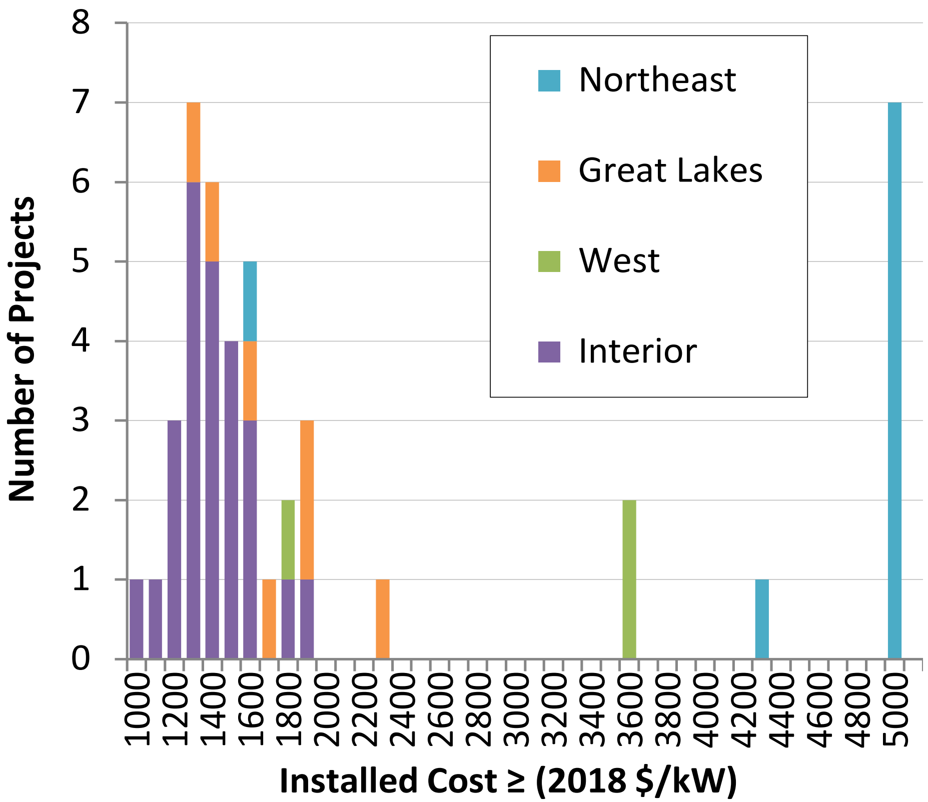


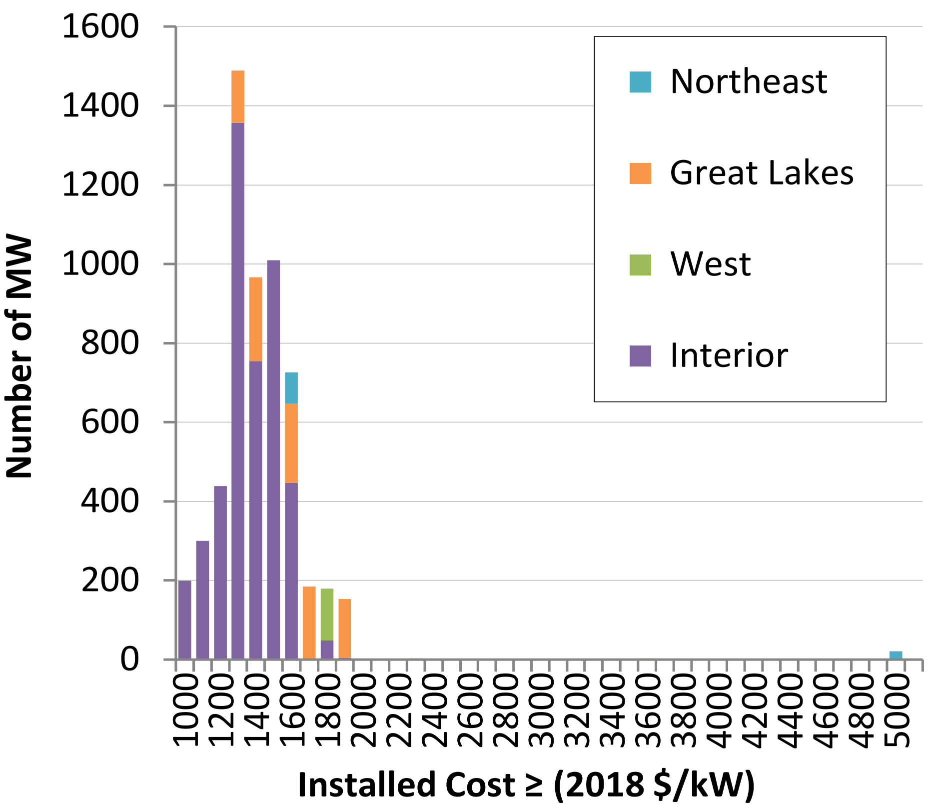



# Regional Differences in Average Wind Power Project Costs Are Apparent, but Sample Size Is Limited



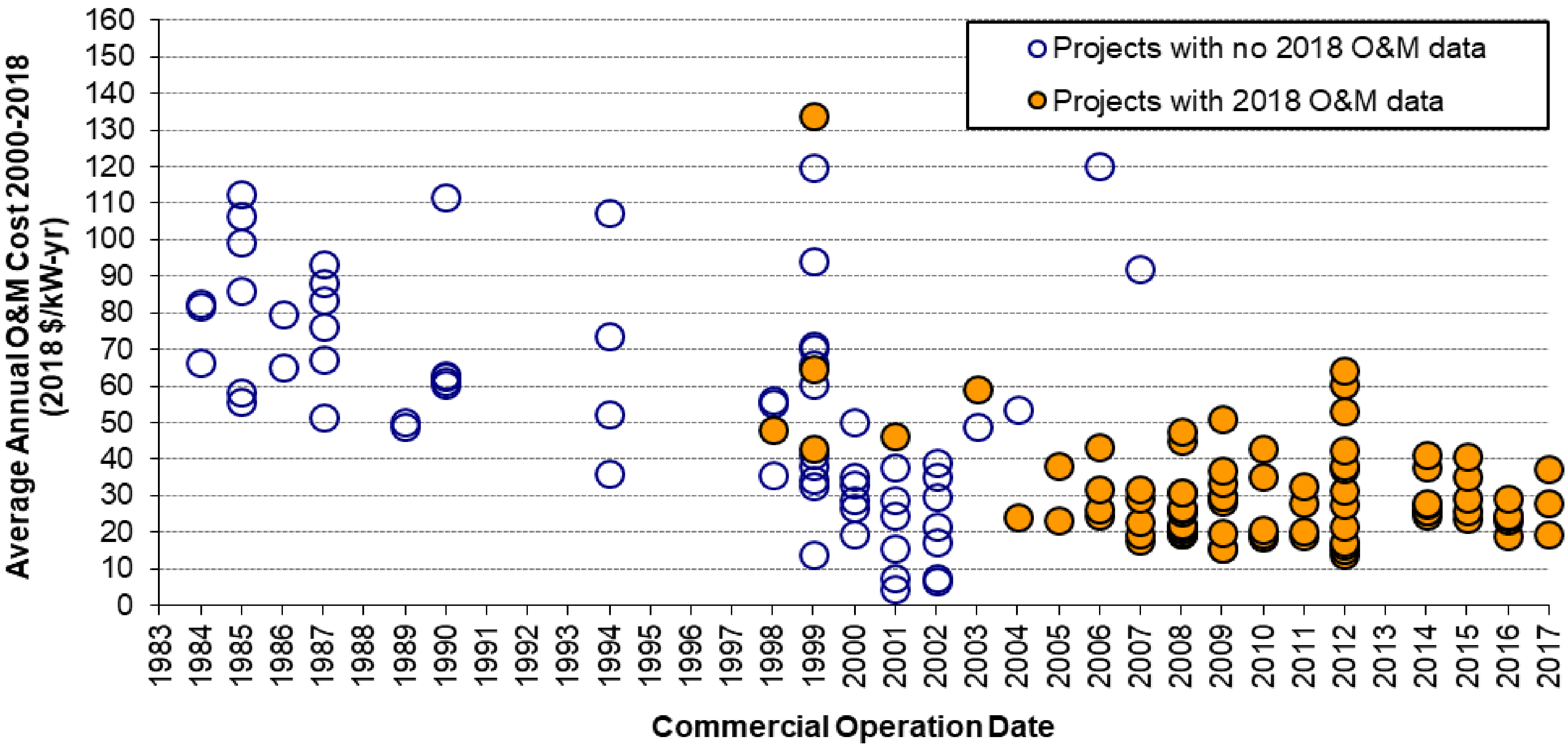
# Most Projects—and All of the Lowest-Cost Projects—Are Located in the Interior; Other Regions Have Higher Costs




*Note: Only includes 2018 projects*

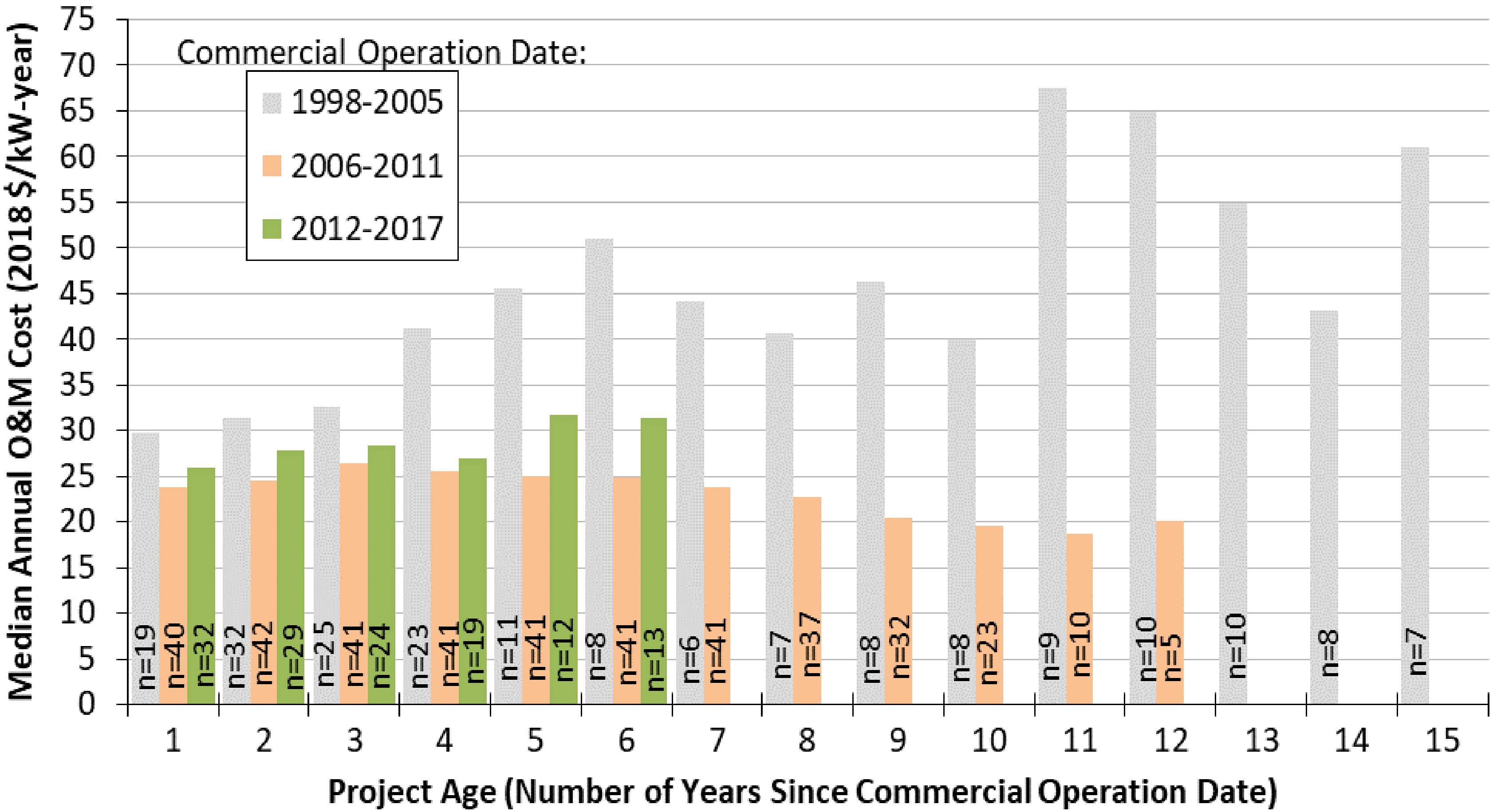
# O&M Costs Vary By Project Age and Commercial Operations Date




*Note: Sample is limited; few projects in sample have complete records of O&M costs from 2000-18; O&M costs reported here DO NOT include all operating costs*

- **Capacity-weighted average 2000-2018 O&M costs for projects built in the 1980s equal $72/kW-year, dropping to $60/kW-year for projects built in the 1990s, to $29/kW-year for projects built in the 2000s and since 2010**

# O&M Costs Are Lower for More-Recent Projects, and Increase with Age for the Older Projects




*Note: Sample size is limited*

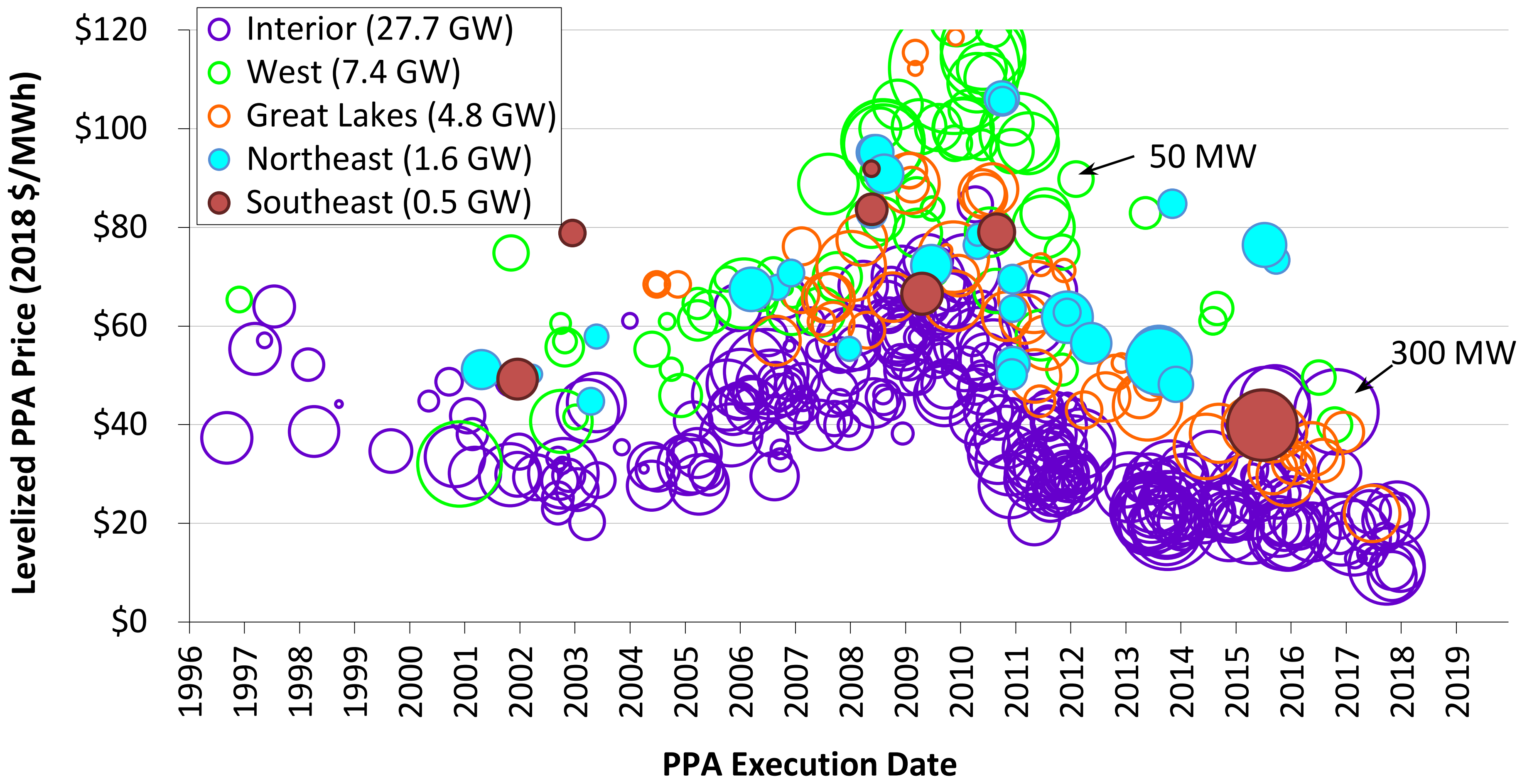
- O&M reported in figure does not include all operating costs: recent work by Berkeley Lab suggests all-in operating costs for the most recent wind projects in the United States of ~$40/kW-yr

# Wind Power Price Trends

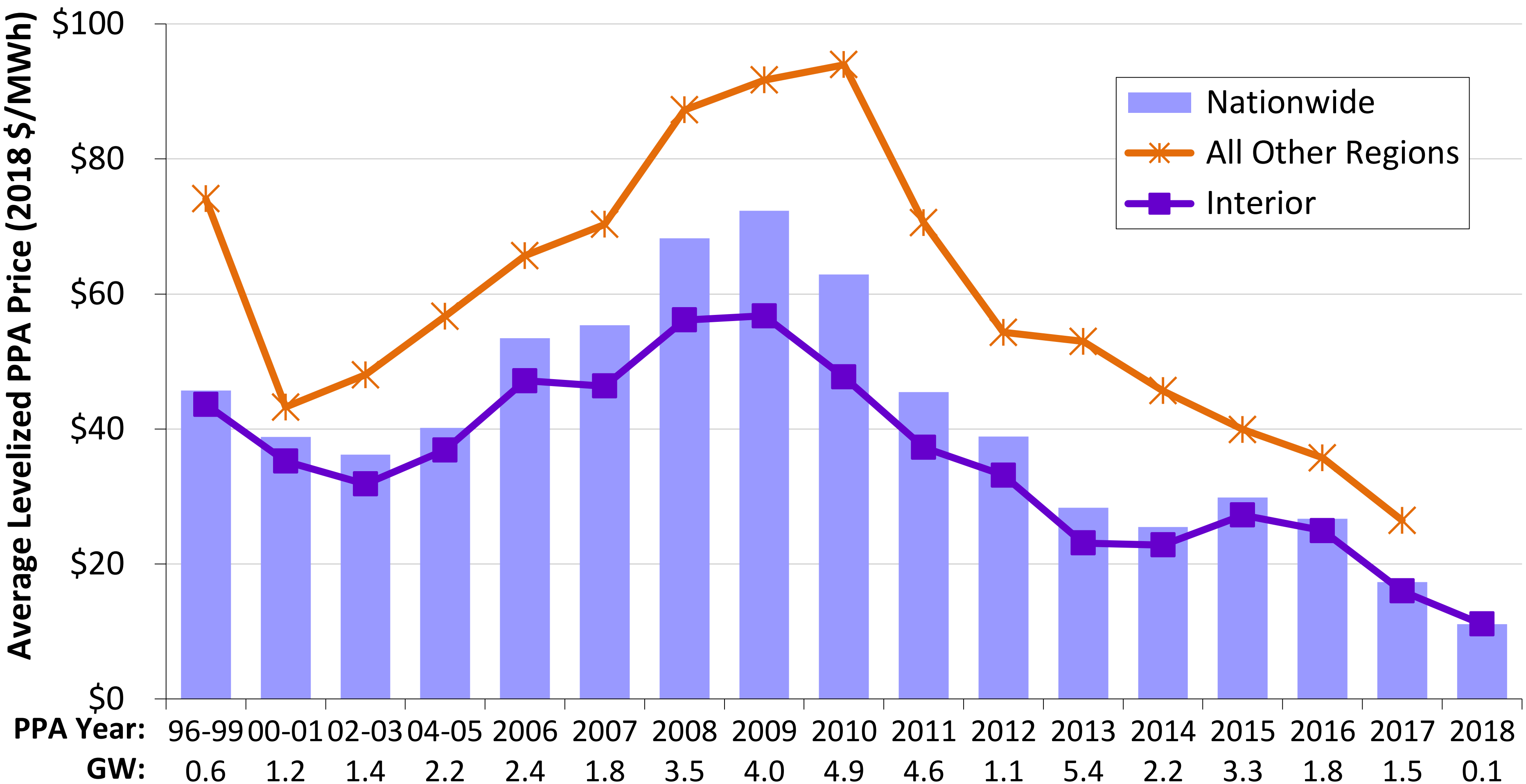
# Sample of Wind Power Sales Prices

- **Berkeley Lab collects data on historical wind power sales prices, and long-term power purchase agreement (PPA) prices**
- **PPA sample includes 448 contracts totaling 42,018 MW from projects built from 1998 to the present, or planned for installation in 2019 or beyond**
- **Prices reflect the bundled price of electricity and RECs as sold by the project owner under a PPA**
  - Dataset excludes merchant plants, projects that sell renewable energy certificates (RECs) separately, and direct retail sales
  - 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

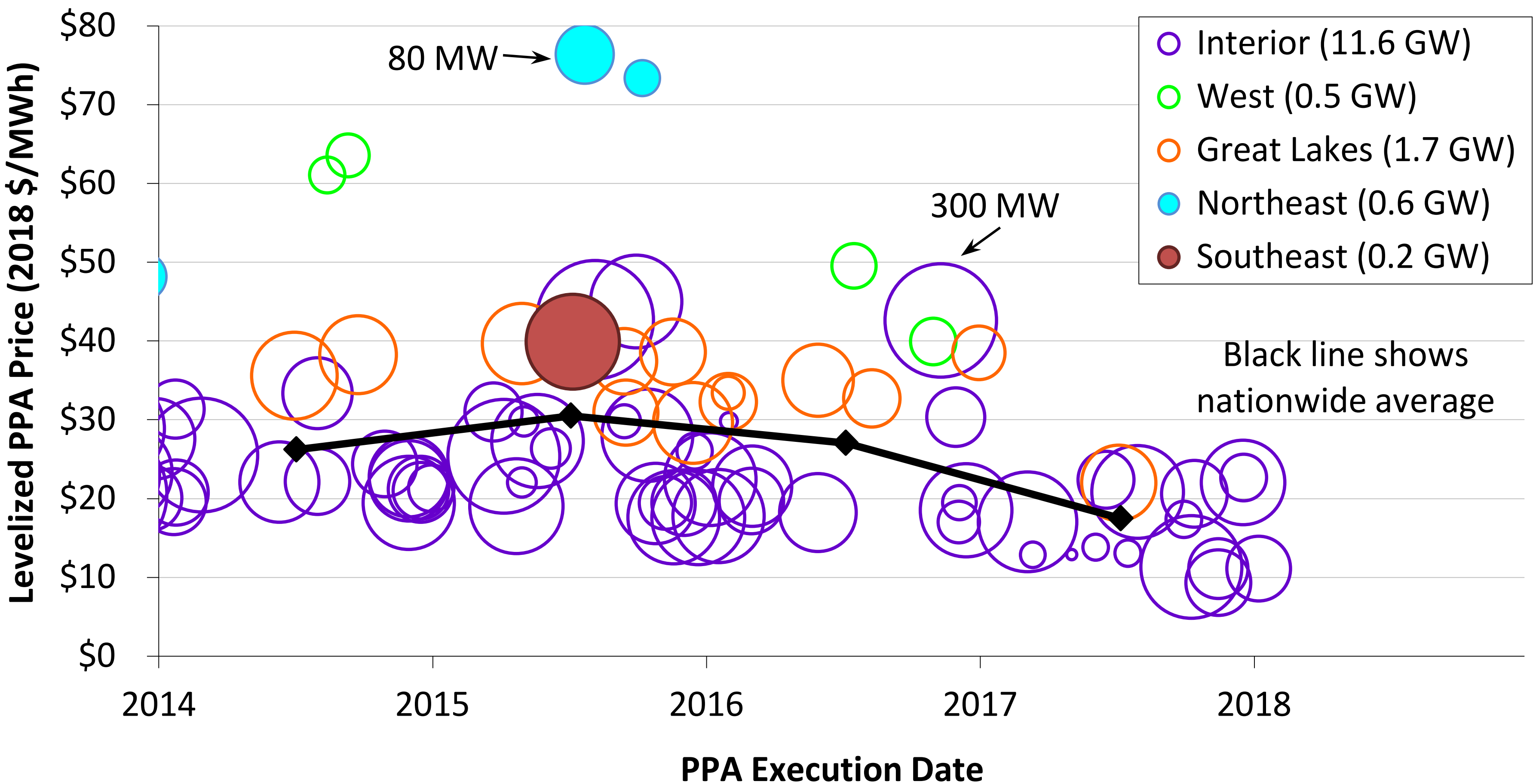
# Wind PPA Prices Are at Historical Lows



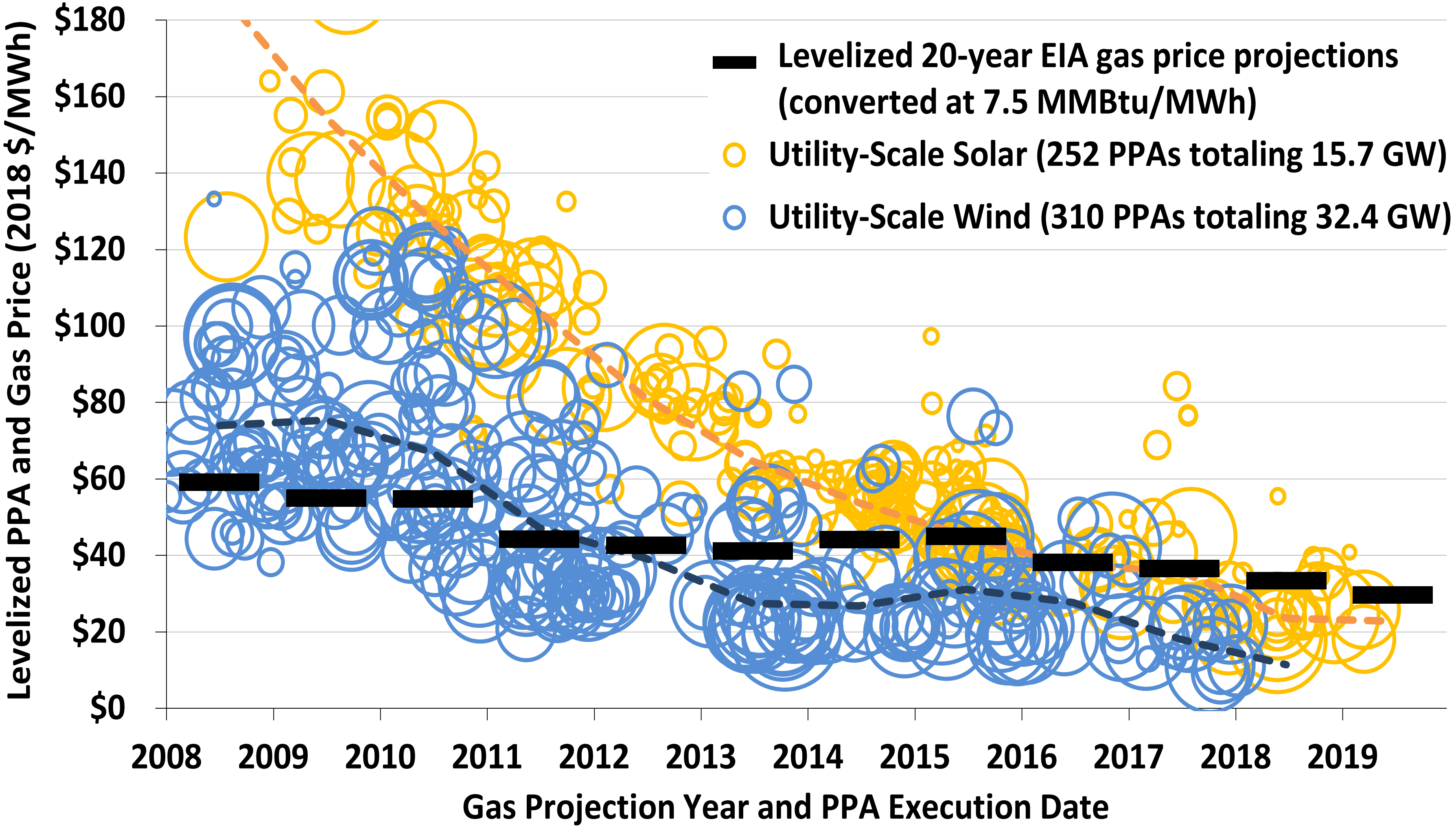
# A Smoother Look at the Time Trend Shows a Steep Decline in Pricing Since 2009; Prices Below $20/MWh in Interior Region



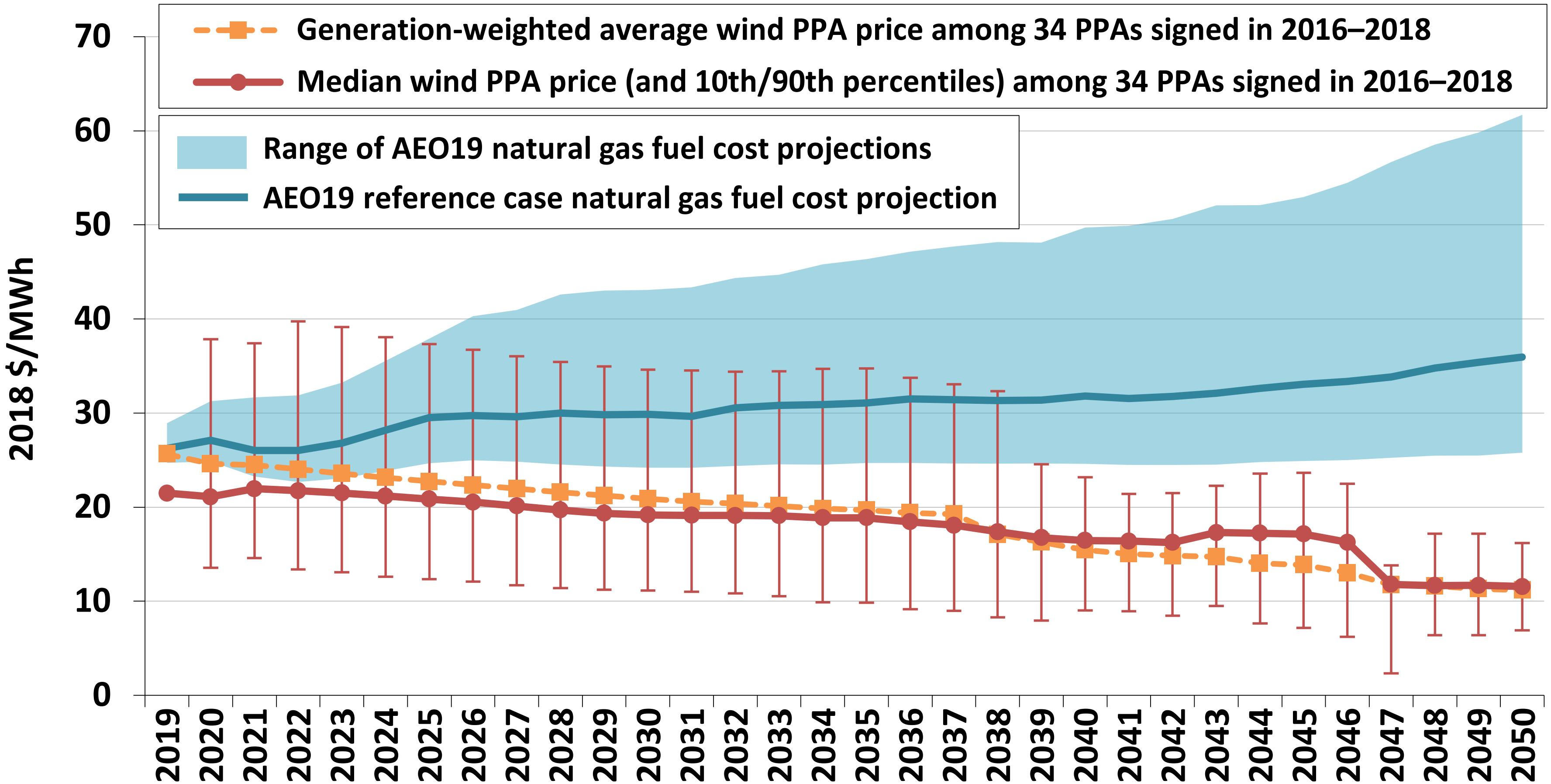
# Recent Wind PPAs Are Priced in the Mid-Teens in Some Cases



# Despite Recent Low PPA Prices, Wind Faces Competition from Solar and Natural Gas

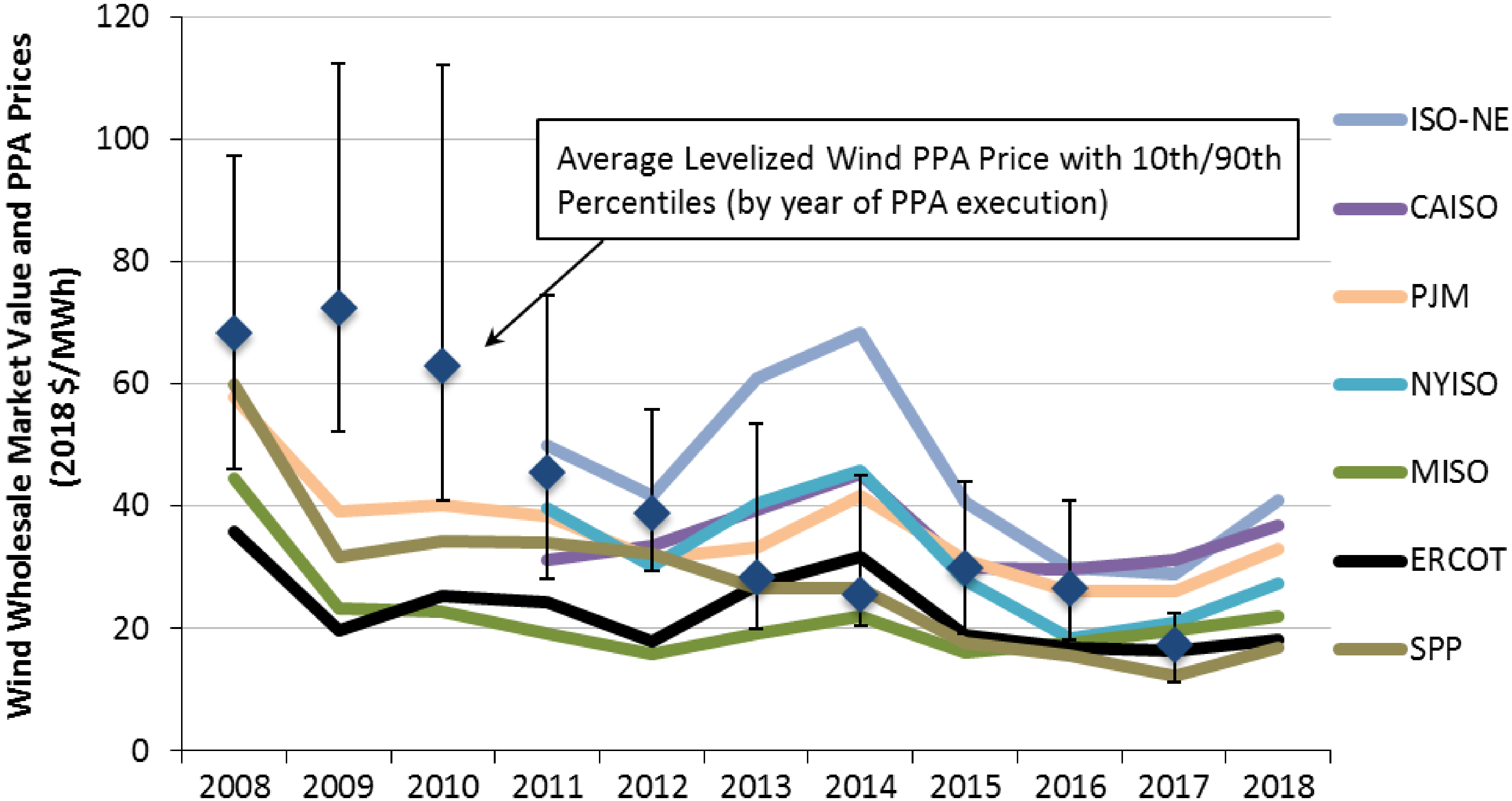


# Recent Wind Prices Are Competitive with the Expected Future Cost of Burning Fuel in Natural Gas Plants



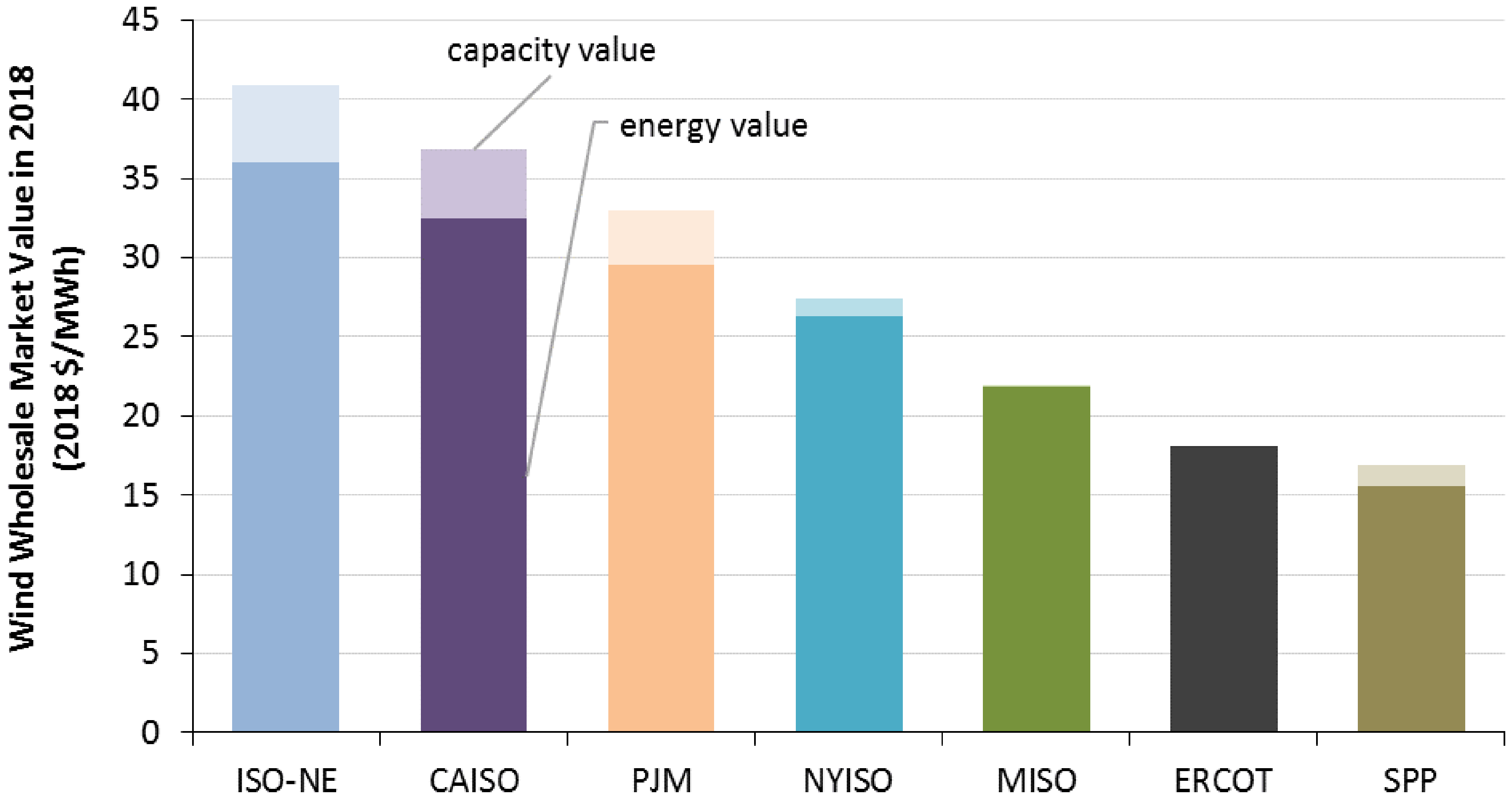

- Price comparisons shown are far from perfect—see full report for caveats

# The Economic Competitiveness of Wind Power Is Affected by Its Grid-System Value (Energy & Capacity) in Wholesale Markets

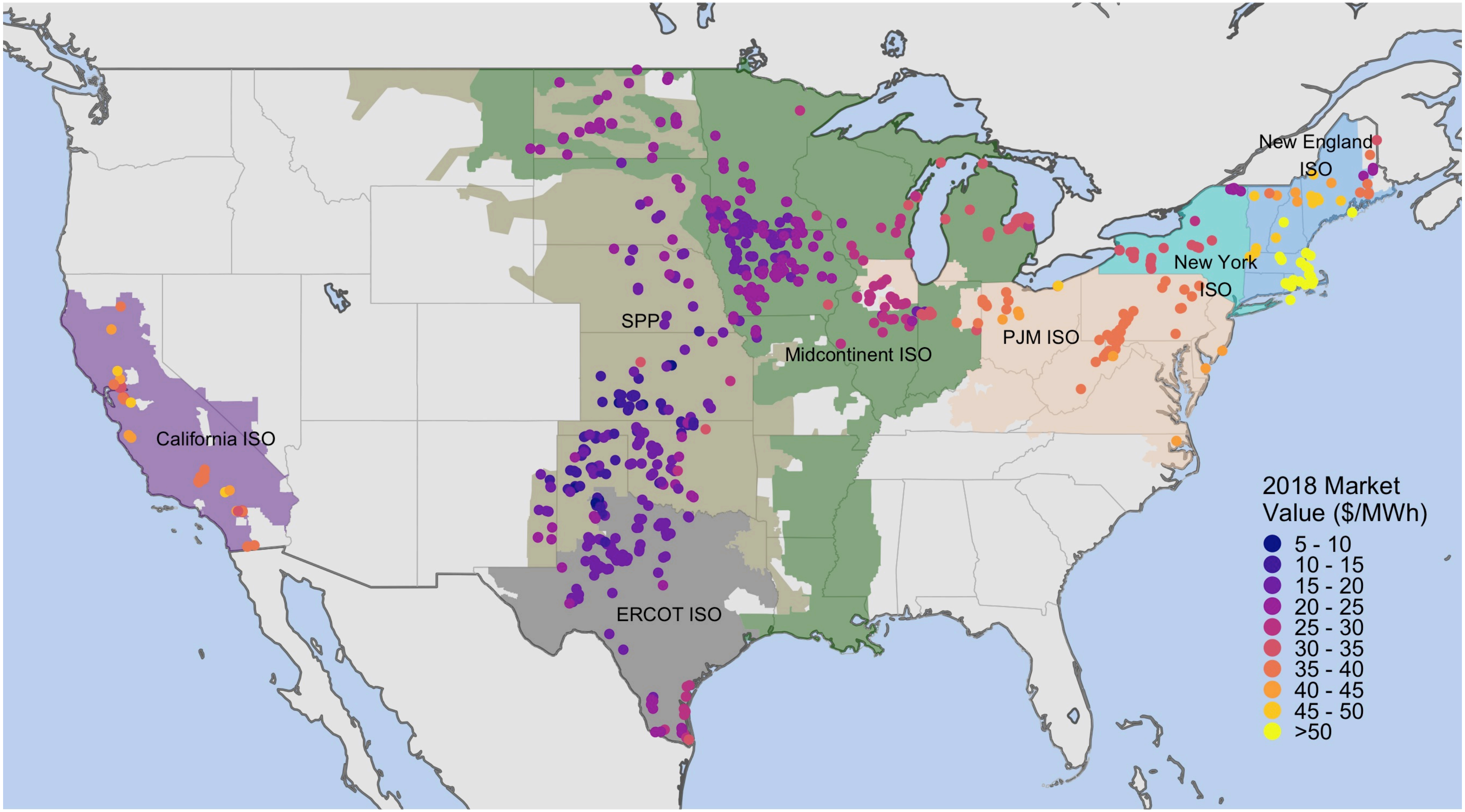



- Wholesale market value considers hourly local wholesale energy price and hourly wind output, along with capacity value where available
- Wholesale market value has declined over last decade, but increased in last couple years
- Recent wind PPAs are comparable to grid-system market value, with a number of recent PPAs coming in at a discount relative to wholesale market value estimates

# The Wholesale Market Value of Wind Energy in 2018 Varied by Region: Lowest in SPP, Highest in ISO-NE

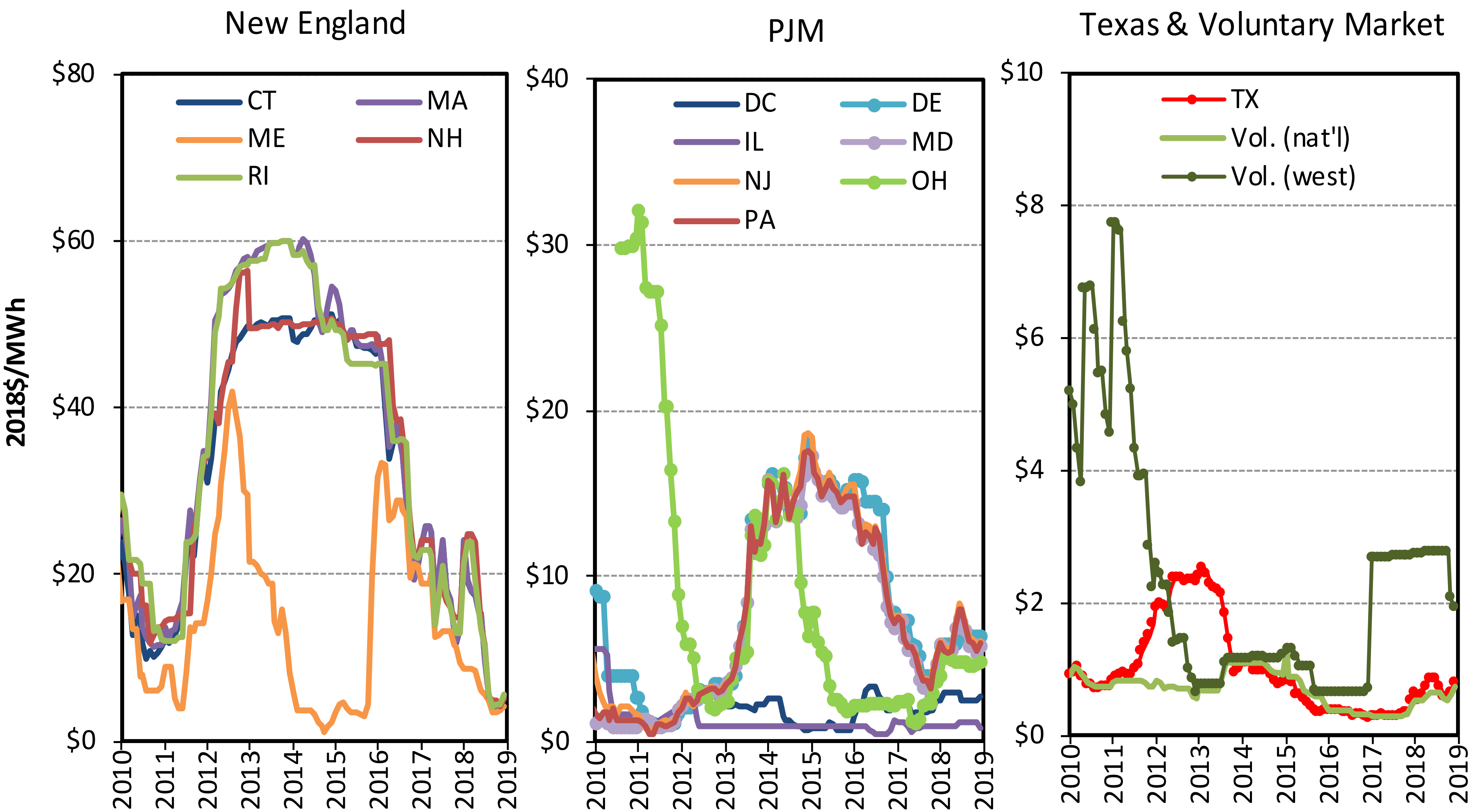


# The Wholesale Market Value of Wind Energy in 2018 Varied by Project



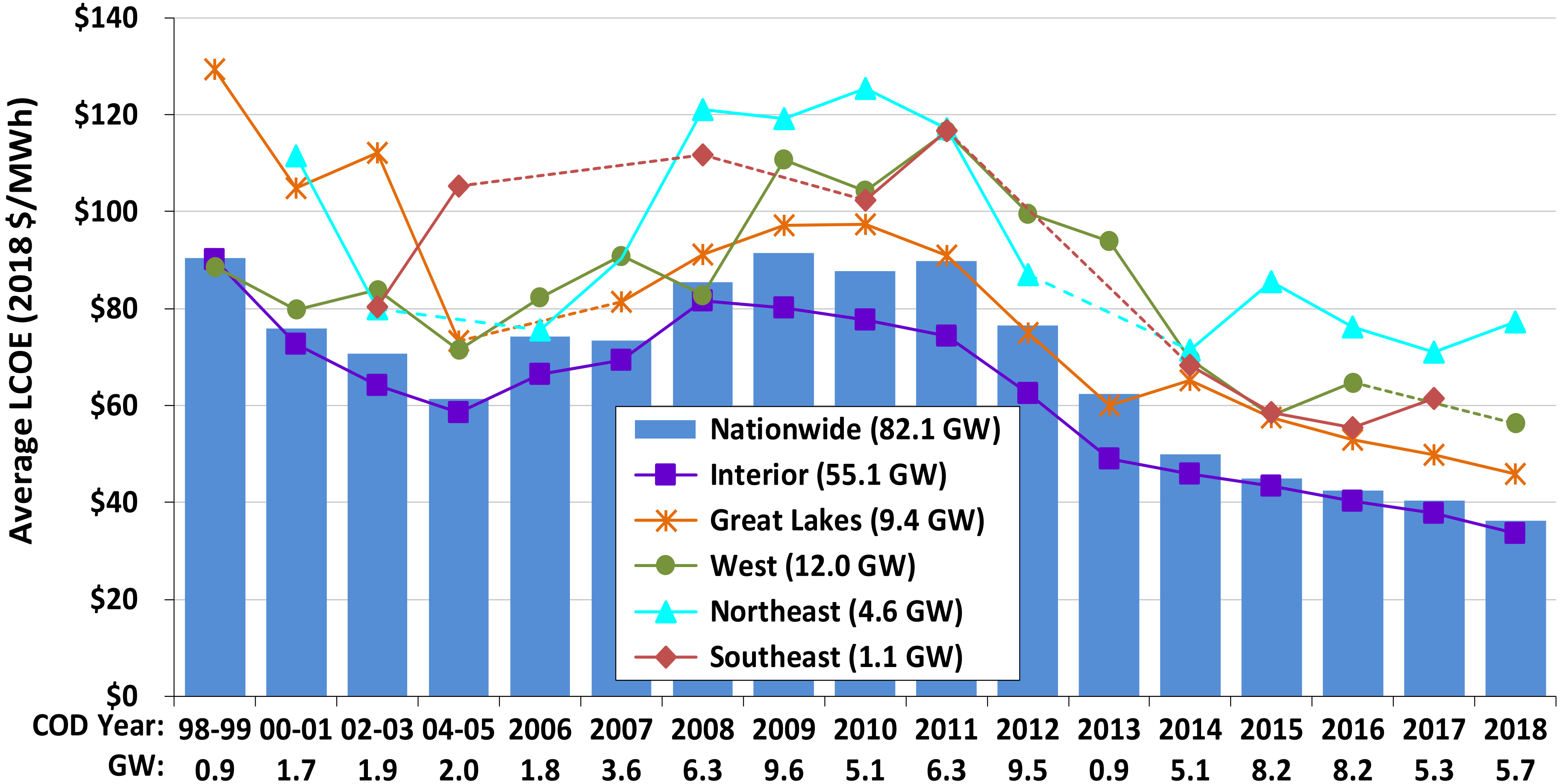

- Market value estimates in 2018 at project level span a wide range, from a low of $6/MWh to a high of $73/MWh, with a weighted-average value of $22/MWh

# Renewable Energy Certificate (REC) Prices in RPS Compliance Markets Remained Low in 2018




- REC prices vary by: market type (compliance vs. voluntary); geographic region; specific design of state RPS policies

# The Levelized Cost of Wind Energy Is at an All-Time Low: Nationwide Average of $36/MWh for Projects Built in 2018




- Estimates reflect variations in installed cost, capacity factors, operational costs, cost of financing, and project life; include accelerated depreciation but exclude PTC

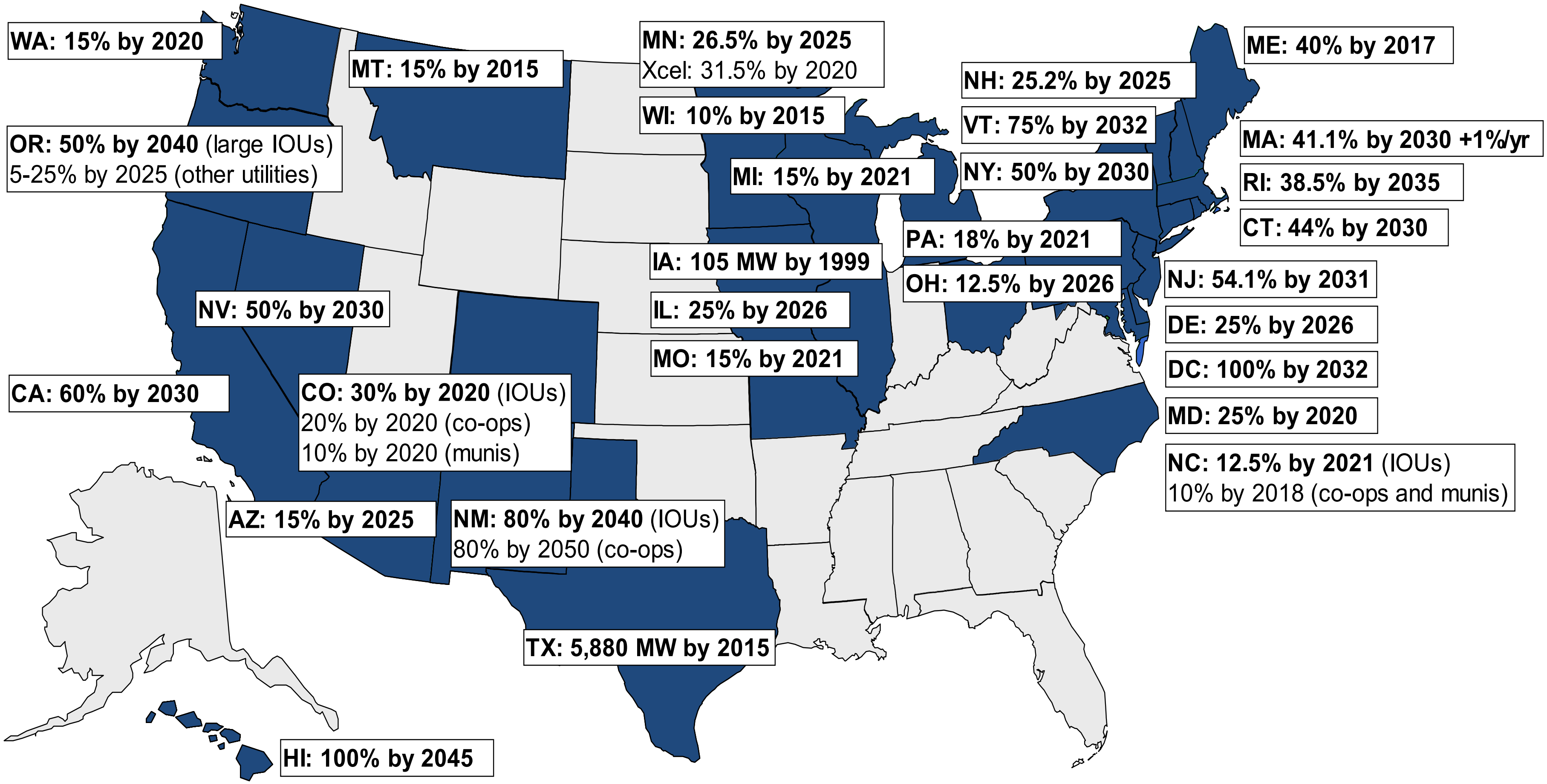
# Policy and Market Drivers

# The Federal Production Tax Credit (PTC) Remains One of the Core Motivators for Wind Power Deployment

| Legislation | Date Enacted | Start of PTC Window | End of PTC Window | Effective PTC Planning Window (considering lapses and early extensions) |
|---|---|---|---|---|
| Energy Policy Act of 1992 | 10/24/1992 | 1/1/1994 | 6/30/1999 | 80 months |
| *>5-month lapse before expired PTC was extended* | | | | |
| Ticket to Work and Work Incentives Improvement Act of 1999 | 12/19/1999 | 7/1/1999 | 12/31/2001 | 24 months |
| *>2-month lapse before expired PTC was extended* | | | | |
| Job Creation and Worker Assistance Act | 3/9/2002 | 1/1/2002 | 12/31/2003 | 22 months |
| *>9-month lapse before expired PTC was extended* | | | | |
| The Working Families Tax Relief Act | 10/4/2004 | 1/1/2004 | 12/31/2005 | 15 months |
| Energy Policy Act of 2005 | 8/8/2005 | 1/1/2006 | 12/31/2007 | 29 months |
| Tax Relief and Healthcare Act of 2006 | 12/20/2006 | 1/1/2008 | 12/31/2008 | 24 months |
| Emergency Economic Stabilization Act of 2008 | 10/3/2008 | 1/1/2009 | 12/31/2009 | 15 months |
| The American Recovery and Reinvestment Act of 2009 | 2/17/2009 | 1/1/2010 | 12/31/2012 | 46 months |
| *2-day lapse before expired PTC was extended* | | | | |
| American Taxpayer Relief Act of 2012 | 1/2/2013 | 1/1/2013 | Start construction by 12/31/2013 | 12 months (in which to start construction) |
| *>11-month lapse before expired PTC was extended* | | | | |
| Tax Increase Prevention Act of 2014 | 12/19/2014 | 1/1/2014 | Start construction by 12/31/2014 | 2 weeks (in which to start construction) |
| *>11-month lapse before expired PTC was extended* | | | | |
| Consolidated Appropriations Act of 2016 | 12/18/2015 | 1/1/2015 | Start construction by 12/31/2016 | 12 months to start construction and receive 100% PTC value |
| | | | Start construction by 12/31/2017 | 24 months to start construction and receive 80% PTC value |
| | | | Start construction by 12/31/2018 | 36 months to start construction and receive 60% PTC value |
| | | | Start construction by 12/31/2019 | 48 months to start construction and receive 40% PTC value |

- 5-year extension of PTC in 2015, plus guidance allowing 4 years for project completion after the start of construction
- PTC phase-out, with progressive reduction in the value of the credit for projects starting construction after 2016
- PTC phases out in 20%-per-year increments for projects starting construction in 2017 (80% PTC value), 2018 (60%), 2019 (40%)

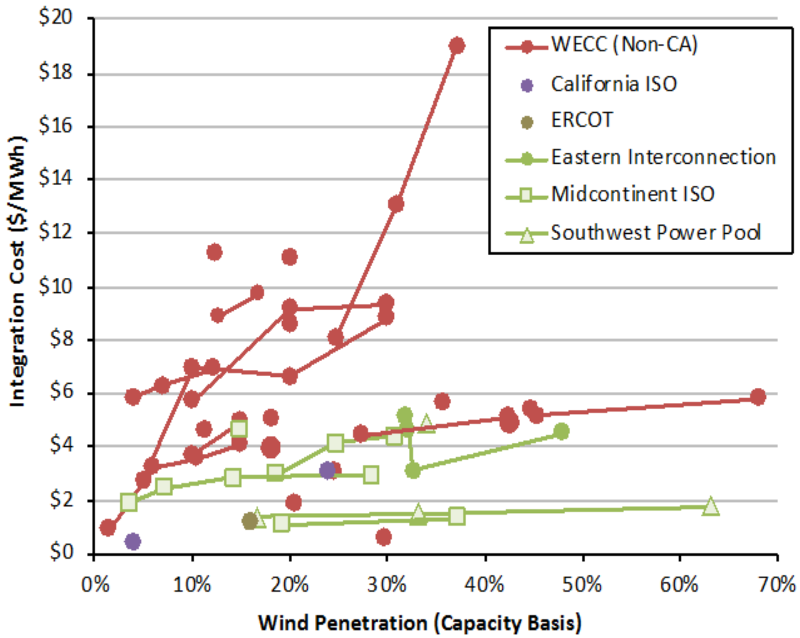
# State Policies Help Direct the Location and Amount of Wind Development, but Wind Growth is Outpacing State Targets




- 29 states and D.C. have mandatory RPS programs, which can support ~5 GW/yr of renewable energy additions on average through 2030 (less for wind specifically)

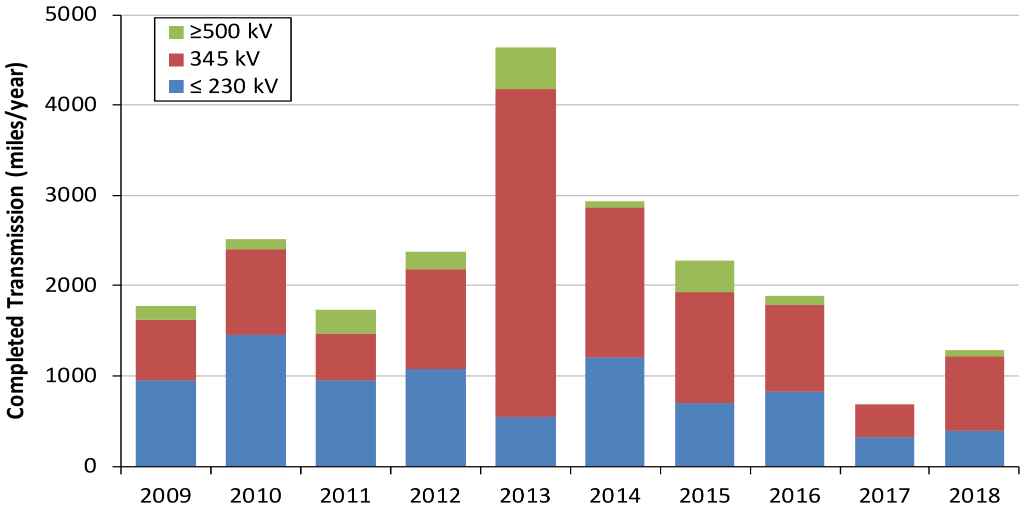
# System Operators Are Implementing Methods to Accommodate Increased Penetrations of Wind

Integrating wind energy into power systems is manageable, but not free of additional costs



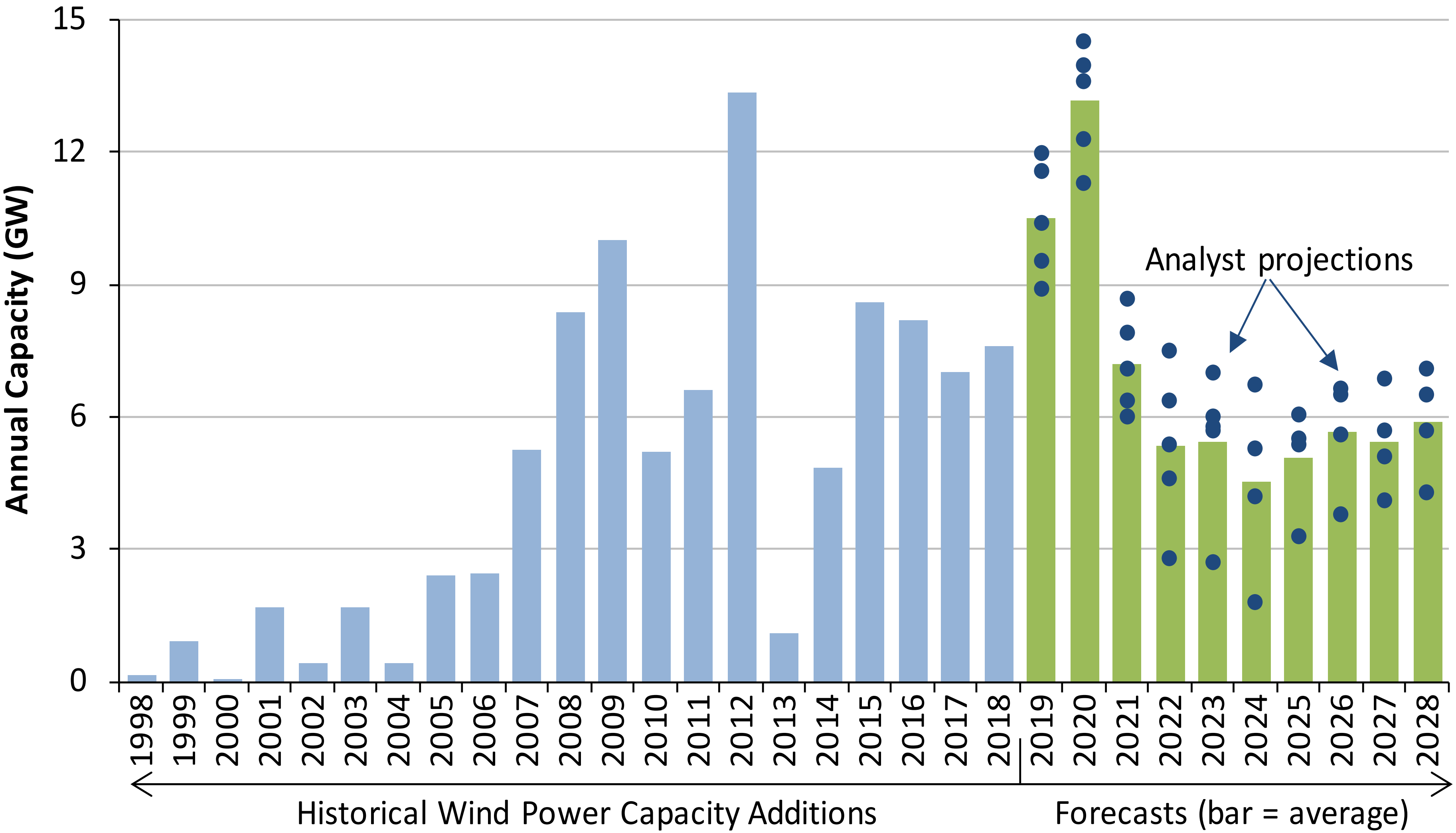

*Notes: Because methods vary and a consistent set of operational impacts has not been included in each study, results from the different analyses of integration costs are not fully comparable.*

## Transmission Barriers Remain



# Future Outlook

# Sizable Wind Additions Anticipated for 2019–2020 Given Federal Tax Incentives; Downturn and Greater Uncertainty Beyond 2020



## Current Low Prices for Wind, Future Technological Advancement, and Direct Retail Sales May Support Higher Growth in Future, but Headwinds Include:

- Phase-out of federal tax incentives
- Continued low natural gas and wholesale electricity prices
- Potential decline in market value as wind penetration increases
- Modest electricity demand growth
- Limited near-term demand from state RPS policies
- Limited transmission infrastructure in some areas
- Growing competition from solar in some regions

# Conclusions

- Wind capacity additions continued at a robust pace in 2018, with significant additional new builds anticipated in near-term in part due to PTC
- Wind has been a significant source of new electric generation capacity additions in the U.S. in recent years
- Supply chain is diverse and multifaceted, with strong domestic content for nacelle assembly, towers, and blades
- Turbine scaling is significantly boosting wind project performance, while the installed cost of wind projects has declined
- Wind power sales prices and levelized cost of energy are at all-time lows, enabling economic competitiveness (with the PTC) despite low gas prices
- Growth beyond current PTC cycle remains uncertain: could be blunted by declining federal tax support, expectations for low natural gas prices and solar costs, and modest electricity demand growth

# For More Information

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

- windreport.lbl.gov

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