2012 WIND TECHNOLOGIES MARKET REPORT

Executive Summary
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Annual wind power capacity additions in the United States achieved record levels in 2012, motivated by the then-planned expiration of federal tax incentives at the end of 2012 and recent improvements in the cost and performance of wind power technology. At the same time, even with a short-term extension of federal tax incentives now in place, the U.S. wind power industry is facing uncertain times. It will take time to rebuild the project pipeline, ensuring a slow year for new capacity additions in 2013. Continued low natural gas prices, modest electricity demand growth, and limited near-term demand from state renewables portfolio standards (RPS) have also put a damper on industry growth expectations. In combination with global competition within the sector, these trends continue to impact the manufacturing supply chain. What these trends mean for the medium to longer term remains to be seen, dictated in part by future natural gas prices, fossil plant retirements, and policy decisions, although recent declines in the price of wind energy have boosted the prospects for future growth.

Key findings from this year’s Wind Technologies Market Report include:

- **Wind Power Additions Hit a New Record in 2012, with 13.1 GW of New Capacity Added in the United States and $25 Billion Invested.** Wind power installations in 2012 were more than 90% higher than in 2011 and 30% greater than the previous record in 2009. Cumulative wind power capacity grew by 28% in 2012, bringing the total to 60 GW.

- **Wind Power Represented the Largest Source of U.S. Electric-Generating Capacity Additions in 2012.** Wind power constituted 43% of all nameplate capacity additions in 2012, overtaking natural gas-fired generation as the leading source of new capacity. This follows the 5 previous years in which wind power represented between 25% and 43% of new U.S. electric generation capacity in each year.

- **The United States Narrowly Regained the Lead in Annual Wind Power Capacity Additions in 2012 but Was Well Behind the Market Leaders in Wind Energy Penetration.** After leading the world in annual wind power additions from 2005 through 2008, and then losing the mantle to China from 2009 through 2011, the U.S. narrowly regained the global lead in 2012. The U.S. market represented roughly 29% of global installed capacity in 2012, a steep rise from the 16% registered in 2011. In terms of cumulative capacity, the U.S. remained the second leading market. A number of countries are beginning to achieve high levels of wind energy penetration: end-of-2012 installed wind power is estimated to supply the equivalent of nearly 30% of Denmark’s electricity demand, compared to approximately 18% for Portugal and Spain, 16% for Ireland, and 10% for Germany. In the United States, the cumulative wind power capacity installed at the end of 2012 is estimated, in an average year, to equate to roughly 4.4% of electricity demand.

- **Texas Added More New Wind Power Capacity than Any Other State, while Nine States Exceed 12% Wind Energy Penetration.** With 1,826 MW installed in 2012, Texas edged out California to reclaim its lead in adding the most new wind capacity. Other leading states in terms of new capacity (each with more than 1,000 MW) included California, Kansas, and Oklahoma. On a cumulative basis, Texas remained the clear leader. Notably, the wind power capacity installed in Iowa, South Dakota, and Kansas as of the end of 2012 is estimated, in an average year, to supply approximately 25%, 24%, and 20%, respectively, of all in-state
electricity generation. As of the end of 2012, a total of nine states had enough wind capacity installed to supply more than 12% of all in-state electricity generation in an average year.

- **No Commercial Offshore Turbines Have Been Commissioned in the United States, but Offshore Project and Policy Developments Continued in 2012.** At the end of 2012, global cumulative offshore wind capacity stood at roughly 5,117 MW, with Europe being the primary locus of activity. No commercial offshore projects have been installed in the United States, and the emergence of a U.S. market faces both challenges and opportunities. Significant strides continued to be made in the federal arena in 2012, both through the U.S. Department of the Interior’s responsibilities with regards to regulatory approvals and the U.S. Department of Energy’s (DOE’s) investments in offshore wind energy research and development (which includes funding seven advanced demonstration project partnerships). Interest exists in developing offshore wind energy in several parts of the country; for example, Navigant Consulting finds that eight projects totaling 2,380 MW are somewhat more advanced in the development process. Of these, two have signed power purchase agreements (PPAs), and the extension of federal tax incentives in early 2013 may motivate both projects to commence construction by the end of 2013.

- **Data from Interconnection Queues Demonstrate that an Enormous Amount of Wind Power Capacity Is Under Consideration but that Relative Interest in Wind May Be Declining.** At the end of 2012, there were 125 GW of wind power capacity within the transmission interconnection queues administered by independent system operators, regional transmission organizations, and utilities reviewed for this report. More than 95% of this capacity is planned for Texas, the Northwest, Southwest Power Pool, PJM Interconnection, the Midwest, the Mountain region, and California. Wind power represented 37% of all generating capacity within these queues at the end of 2012 and was slightly lower than the 130 GW of natural gas in the queues. In 2012, 20 GW of gross wind power capacity entered the interconnection queues, compared to 55 GW of natural gas and 10 GW of solar. Of note is that the absolute amount of wind, coal, and nuclear power in the sampled interconnection queues (considering gross additions and project drop-outs) has generally declined in recent years, whereas natural gas and solar capacity has increased.

- **The “Big Three” Turbine Suppliers Captured more than 70% of the U.S. Market in 2012, yet Diversification Continues.** GE Wind led the U.S. market with more than 5 GW of wind turbines newly installed in 2012, for a 38% market share. Following GE Wind were Siemens (with a 20% market share), Vestas (14%), and Gamesa (10%). There has been a notable increase in the number of wind turbine manufacturers serving the U.S. market; the number installing more than 1 MW increased from just five in 2005 to 25 in 2012. The “big three” turbine suppliers—GE Wind, Vestas, and Siemens—have, however, actually gained market share since 2008/2009. Globally, U.S.-owned GE ascended to an effective tie with Vestas as the top supplier of turbines worldwide in 2012. Chinese turbine manufacturers also continue to occupy positions of prominence in the global ratings, although none of these suppliers made the top five in 2012. To date, their growth has been based almost entirely on sales to the Chinese market. However, 2012 U.S. installations by Chinese and South Korean manufacturers included those from Goldwind, China Creative Wind Energy, Guodian United Power, Sinovel, Hyundai, HZ Windpower, and Sany Electric.

- **The Manufacturing Supply Chain Responded to a Record Year in Wind Power Capacity Additions, but with Substantial Growing Pains.** Wind turbine and component manufacturers met the challenge of supplying a 13-GW market in 2012. Seven of the 10
turbine suppliers with the largest share of the U.S. market in 2012 had one or more operational manufacturing facility in the United States in 2012. In contrast, only 8 years earlier, there was only one active utility-scale turbine manufacturer assembling nacelles in the United States (GE). Despite this significant growth in the domestic supply chain, reduced near-term demand expectations led to a difficult business environment in 2012. Not only did a smaller number of new turbine and component manufacturing facilities open in 2012 than in 2011, but also a number of facilities closed (including the manufacturing facilities of Clipper and Nordic). Even with these adjustments, near-term forecasts for wind power additions in the United States suggest that the market will have an over-capacity of nacelle assembly capability in the short term. The American Wind Energy Association estimates that the entire wind energy sector directly and indirectly employed 80,700 full-time workers in the United States at the end of 2012. Although this is 5,700 more jobs than reported in 2011, wind industry manufacturing jobs saw an overall decrease from 30,000 jobs in 2011 to 25,500 in 2012 due to the severe decline in new orders towards the end of 2012. Manufacturers have now begun receiving orders for 2013 and 2014 delivery, but it is not yet clear to what degree these orders will lead to a recovery of the manufacturing sector in 2013.

- **Despite Challenges, a Growing Percentage of the Equipment Used in U.S. Wind Power Projects Has Been Sourced Domestically in Recent Years.** U.S. trade data show that the United States remained a large importer of wind power equipment in 2012 but that growth in installed wind power capacity has outpaced the growth in imports in recent years. As a result, a growing percentage of the equipment (in dollar-value terms) used in wind power projects has been sourced domestically. Focusing on selected trade categories, and when presented as a fraction of total equipment-related wind turbine costs, the overall import fraction is estimated to have declined considerably, from 75% in 2006–2007 to 28% in 2012. Conversely, if one assumes that no wind equipment imports occurred through trade categories beyond those analyzed here, then domestic content has increased from 25% in 2006–2007 to 72% in 2012. Exports of wind-powered generating sets from the United States have also increased, rising from $16 million in 2007 to $388 million in 2012 (all cost and price data in the report are in real 2012$).

- **Although the Average Nameplate Capacity of Installed Wind Turbines Declined Slightly, the Average Hub Height and Rotor Diameter Continued to Increase.** The average nameplate capacity of wind turbines installed in the United States in 2012 was 1.94 MW, nearly the same as in 2011 (when it was 1.97 MW). Since 1998–1999, average turbine capacity has increased by 170%. Average hub heights and rotor diameters have also scaled with time, to 83.8 and 93.5 meters, respectively, in 2012. Since 1998–1999, the average turbine hub height has increased by 50%, while the average rotor diameter has increased by 96%. In large part, these increases have been driven by new turbines designed to serve low-wind-speed sites. Industry expectations as well as new turbine announcements suggest that significant further scaling, especially in rotor diameter, is anticipated in the near term.

- **The Project Finance Environment Held Steady in 2012.** Considerable uncertainty surrounding the fate of the production tax credit (PTC) in 2013 led to lower commitments of both tax equity and debt in 2012. Yields in both markets, however, remained largely unchanged from 2011. In the debt market, a seemingly permanent shift to shorter bank loan tenors has created an opportunity for institutional lenders and bond markets that can offer longer-maturity instruments. Some developers are tapping into hybrid bank/bond instruments.
that play to the strengths of both types of debt in offering what, from the developer’s perspective, appears to be a synthetic, fully amortizing long-term loan.

• **Independent Power Producers Remained the Dominant Owners of Wind Projects while Utilities Took a Breather in 2012.** Independent power producers (IPPs) own 88% of all new wind power capacity installed in the United States in 2012 and 83% of the cumulative installed capacity. In a deviation from what has been a growth trend, utility ownership of new capacity built in 2012 fell to 10%, down from 25% in 2011, while on a cumulative basis utilities owned 15% of total wind power capacity at the end of 2012.

• **Long-Term Contracted Sales to Utilities Remained the Most Common Off-Take Arrangement and Have Gained Ground since the Peak of Merchant Development in 2008/2009.** Electric utilities continued to be the dominant off-takers of wind power in 2012, either owning (10%) or buying (69%) power from 79% of the new capacity installed last year. Merchant/quasi-merchant projects were less prevalent in 2012 than they have been in recent years, accounting for 19% of all new capacity. On a cumulative basis, utilities own (15%) or buy (54%) power from 69% of all wind power capacity in the United States, with merchant/quasi-merchant projects accounting for 23% and power marketers 8%.

• **Wind Turbine Prices Remained Well Below Levels Seen Several Years Ago.** After hitting a low of roughly $700/kW from 2000 to 2002, average turbine prices increased to more than $1,500/kW by 2009. Wind turbine prices have since dropped substantially, despite continued technological advancements that have yielded increases in hub heights and especially rotor diameters. Recently announced turbine transactions have often been priced in the $950–$1,300/kW range. These price reductions, coupled with improved turbine technology and more-favorable terms for turbine purchasers, are exerting downward pressure on total project costs and wind power prices.

• **Reported Installed Project Costs Continued to Trend Lower in 2012.** Among a large sample of wind projects installed in 2012, the capacity-weighted average installed cost stood at nearly $1,940/kW, down almost $200/kW from the reported average cost in 2011 and down almost $300/kW from the reported average cost in both 2009 and 2010. Whereas turbine prices peaked in 2008/2009, project-level installed costs appear to have peaked in 2009/2010. That changes in average project costs would lag changes in average turbine prices is not surprising; it reflects the normal passage of time between when a turbine supply agreement is signed and when those turbines are actually installed. Anecdotal indications from a handful of projects currently under construction and anticipating completion in 2013 suggest that average installed costs may decline further.

• **Installed Costs Differed By Project Size, Turbine Size, and Region.** Installed project costs exhibit some economies of scale, at least at the lower end of the project and turbine size range. Additionally, among projects built in 2012, the windy Interior region of the country was the lowest-cost region.

• **Operations and Maintenance Cost Varied By Project Age and Commercial Operations Date.** Despite limited data availability, it appears that projects installed over the past decade have, on average, incurred lower operations and maintenance (O&M) costs than older projects in their first several years of operation, and that O&M costs increase as projects age.

• **Trends in Sample-Wide Capacity Factors Were Impacted by Curtailment and Inter-Year Wind Resource Variability.** Wind project capacity factors have generally been higher on average in more recent years (e.g., 32.1% from 2006–2012 versus 30.3% from 2000–2005), but time-varying influences—such as inter-year variations in the strength of the wind
resource or changes in the amount of wind power curtailment—have tended to mask the positive influence of turbine scaling on capacity factors in recent years. Positively, the degree of wind curtailment has declined recently in what historically have been the most problematic areas (e.g., West Texas) as a result of concrete steps taken to address the issue.

- **Average Capacity Factors for Projects Built After 2005 Have Been Stagnant: Turbine Design Changes Boosted Capacity Factors, while Project Build-Out in Lower-Quality Resource Areas Pushed the Other Way.** Even when controlling for time-varying influences by focusing only on capacity factors in 2012 (parsed by project vintage), it is difficult to discern any improvement in average capacity factors among projects built after 2005. This is partially attributable to the fact that average “specific power”i remained largely unchanged from 2006–2009, before resuming its downward trend with 2010-vintage projects. At the same time, the average quality of the wind resource in which new projects are located has declined; this decrease has been particularly sharp since 2008 and has counterbalanced the drop in specific power. Controlling for these two competing influences of specific power and wind resource quality confirms this offsetting effect and shows that turbine design changes are driving capacity factors higher for projects located in fixed wind resource regimes.

- **Regional Variations in Capacity Factor Reflect the Strength of the Wind Resource.** Based on a sub-sample of wind power projects built from 2007 through 2011, average capacity factors in 2012 were the highest in the Interior region (36%) and the lowest in the Southeast (23%) and Northeast (24%) regions. Not surprisingly, these regional rankings are roughly consistent with the relative quality of the wind resource in each region.

- **Wind Power Purchase Agreement Prices Generally Have Been Falling Since 2009 and Now Rival Previous Lows Set a Decade Ago (Despite the Trend Towards Lower-Quality Wind Resource Sites).** After topping out at nearly $70/MWh in 2009, the average levelized long-term price from wind PPAs signed in 2011/2012—many of which were for projects built in 2012—fell to around $40/MWh nationwide. This level approaches previous lows set back in the 2000–2005 period, which is notable given that installed project costs have not returned to 2000–2005 levels and that wind projects increasingly have been sited in lower-quality wind resource areas. Clearly, turbine scaling has more than overcome these headwinds to drive PPA prices lower. PPA prices are generally lowest in the Interior region, highest in the West, and in the middle ground elsewhere.

- **Low Wholesale Electricity Prices Continued to Challenge the Relative Economics of Wind Power.** Average levelized wind PPA prices compared favorably to yearly wholesale electricity prices from 2003 through 2008. Starting in 2009, the sharp drop in wholesale electricity prices squeezed average wind PPA prices out of the wholesale price range on a nationwide basis. Wind PPA prices then fell and, in 2011 and 2012, reconnected with the upper end of the wholesale power price range. Based on our sample, wind PPA prices in 2011/2012 were most competitive with wholesale prices in the Interior region (where PPAs signed in 2011/2012 generally ranged from $20–$40/MWh) and were least competitive in the West (with a PPA price range of less than $50/MWh to more than $90/MWh), with the Great Lakes and Northeast regions falling in between (with PPA prices of roughly $50–$70/MWh).

- **Short-Term Extension of Federal Incentives for Wind Energy Has Helped Restart the Domestic Market.** In January 2013, the PTC was extended, as was the ability to take the

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i A wind turbine’s specific power is the ratio of its nameplate capacity rating to its rotor-swept area. All else equal, a decline in specific power should lead to an increase in capacity factor.
30% investment tax credit (ITC) in lieu of the PTC. Wind power projects that begin
construction before the end of 2013 will now be eligible to receive the PTC or ITC. These
provisions helped restart the domestic wind market and are expected to spur capacity
additions in 2014 as projects that begin construction in 2013 reach commercial operations.

- **State Policies Help Direct the Location and Amount of Wind Power Development, but Current Policies Cannot Support Continued Growth at Recent Levels.** As of June 2013, RPS policies existed in 29 states and Washington D.C. From 1999 through 2012, 69% of the wind power capacity built in the United States was located in states with RPS policies; in 2012, this proportion was 83%. However, given renewable energy growth over the last decade, existing RPS programs are projected to drive average annual renewable energy additions of just 3–5 GW/year between 2013 and 2020 (only a portion of which will be from wind), less than the amount of wind capacity added in recent years, thus demonstrating the limitations of relying exclusively on RPS programs to drive future deployment.

- **Solid Progress on Overcoming Transmission Barriers Continued.** During the last 5 years, more than 2,300 circuit miles of new transmission additions were constructed per year, and an additional 18,700 circuit miles are planned for the next 5 years. The wind industry has identified near-term transmission projects that—if all were completed—could carry almost 70 GW of wind power capacity. The Federal Energy Regulatory Commission continues to implement Order 1000, which requires public utility transmission providers to improve intra- and inter-regional transmission planning processes and to determine cost-allocation methodologies for new transmission facilities. States, grid operators, utilities, regional organizations, and DOE also continue to take proactive steps to encourage transmission investment. Additionally, construction and development progress was made in 2012 on a number of transmission projects designed, in part, to support wind power. Despite this progress, siting, planning, and cost-allocation issues remain key barriers to transmission investment, and wind curtailment continues to be a problem in some areas.

- **System Operators Are Implementing Methods to Accommodate Increased Penetration of Wind Energy.** Recent studies show that wind energy integration costs are almost always below $12/MWh—and often below $5/MWh—for wind power capacity penetrations of up to or even exceeding 40% of the peak load of the system in which the wind power is delivered. The increase in balancing reserves with increased wind penetration is projected, in most cases, to be below 15% of the nameplate capacity of wind power and typically considerably less than this figure, particularly in studies that use intra-hour scheduling. Moreover, a number of strategies that can help to ease the integration of increasing amounts of wind energy—including the use of larger balancing areas, the use of wind forecasts, and intra-hour scheduling—are being implemented by grid operators across the United States.

Although federal tax incentives are now available for wind projects that initiate construction by the end of 2013, it will take time to recharge the project pipeline. As a result, 2013 is expected to be a slow year for new capacity additions, lowering not only U.S. but global growth forecasts. The year 2014, on the other hand, is expected to be more robust as developers commission projects that began construction in 2013. Projections for 2015 and beyond are much less certain. Despite the improved cost, performance, and price of wind energy and the prospect for fossil plant retirement, federal policy uncertainty—in concert with continued low natural gas prices, modest electricity demand growth, and the aforementioned slack in existing state policies—may put a damper on medium-term growth expectations.