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

2014 Distributed Wind Market Report

August 2015

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2014 Distributed Wind Market Report

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EXECUTIVE SUMMARY

Distributed wind reached a cumulative capacity of almost 1 GW (906 MW) in the United States in 2014, reflecting nearly 74,000 wind turbines deployed across all 50 states, Puerto Rico, and the U.S. Virgin Islands; however, the state of the market is mixed. Installations of large-scale turbines (greater than 1 MW) grew almost threefold from 20.4 MW in 2013 to 57.5 MW in 2014 while the markets for distributed wind systems using small (up through 100 kW) and mid-size (101 kW to 1 MW) wind turbines continued to struggle since achieving record sales in 2008 through 2012. Small and mid-size turbines added only 3.7 and 2.4 MW in 2014, respectively, compared to 5.6 and 4.4 MW, respectively, in 2013.

In total, 63.6 MW of new distributed wind capacity was added in 2014, representing nearly 1,700 units (turbines) and $170 million in investment across 24 states. $20.4 million in federal, state, and utility incentives were awarded to distributed wind projects in 2014, slightly more than the $15.4 million awarded in 2013.

New Mexico, Texas, and California were the top states in 2014 in terms of adding distributed wind capacity. With two large projects totaling 34.8 MW installed in 2014, New Mexico accounted for nearly 55% of the total U.S. annual capacity. Minnesota, New York, Nevada, and Iowa led the nation for the number of small wind turbines deployed in 2014. Currently, 16 states have more than 10 MW of cumulative distributed wind capacity.

Exports remained an important source of revenue for U.S. manufacturers of small wind turbines. Seven U.S. manufacturers exported 11.2 MW in 2014, at a value of $60 million. Although this is down slightly from the 13.6 MW of exports reported for ten manufacturers in 2013, it is up from the 8 MW reported by eight manufacturers in 2012. The top reported export markets in terms of capacity were Italy, United Kingdom, and South Korea.

The outlook for distributed wind in the United States remains mixed, with market drivers including new financing schemes and certification requirements, and new export markets for domestic manufacturers. Challenges continue to be competition from solar photovoltaics, permitting and soft cost barriers, and the low cost of other sources of electricity.

Other highlights of the report include:

- U.S. small wind manufacturers continued to dominate the domestic market, accounting for 82% of the 2014 U.S. new small wind sales on a capacity basis and 98% on a unit (turbine) basis. Sales on a capacity basis are down slightly from 88% in 2013, but 2014 sales on a unit basis are up from 93% in 2013.

- The 3.7 MW of 2014 U.S. small wind sales (including imports) represents over 1,600 units and $20 million of investment. This is down from 2013, in which 5.6 MW from roughly 2,700 units resulted in $36 million of investment, reflecting small wind's continuing competition with solar photovoltaics and the low cost of other sources of electricity.

- In 2014, U.S.-based small wind turbine manufacturers continued to favor U.S. supply chain vendors for most of their wind turbine components. Self-reported domestic content levels ranged from 60% to 100%.

- Capacity-weighted average installed costs of newly manufactured small wind turbines sold in the United States in 2013 and 2014 vary by turbine size. For turbines less than 2.5 kW, the average cost was $8,200/kW, for turbines 2.5 to 10 kW, the average cost was $7,200/kW, and for turbines 11 to 100 kW, the average cost was $6,000/kW. The overall capacity-weighted average installed cost of 2.8 MW of all newly manufactured small wind turbines sold in the United States in 2014 was $6,230/kW, down from $6,940/kW in 2013 based on 5 MW of sales.

- As of July 2015, 13 small wind turbine models are fully certified to American Wind Energy Association Standard 9.1–2009, 4 medium wind turbine models have published power performance and acoustics certifications to International Electrotechnical Commission (IEC) 61400-12-1 (power) and IEC 61400-11 (acoustics) standards, 1 small wind turbine model has limited or conditional certification, and more than 10 additional wind turbine models have conducted testing or have pending applications. Certification bodies continue to provide wind turbine buyers with reliable third-party verification of important safety, acoustic, and performance data and to provide wind turbine sellers the capacity to demonstrate compliance with regulatory and incentive program requirements. Certified ratings allow purchasers to directly compare products, and help funding agencies and utilities gain greater confidence that small and medium turbines installed with public assistance have been tested for safety, function, performance, and durability and comply with standards.

EXECUTIVE SUMMARY

- 58% of the 2014 distributed wind projects on a capacity basis were connected to distribution lines serving local loads, while 42% serve on-site loads, either as behind-the-meter, off-grid, micro-grid, or remote net meter applications. In simple terms, a wind turbine or project is considered to provide distributed energy if it serves an on-site load (i.e., behind the meter, remote net-metered, or off-grid) or if it is connected to the local distribution grid to serve local loads (i.e., the generated energy is not sent past the local substation).

- Residential applications accounted for 36% of U.S. distributed wind deployed in 2014 on a per project basis, but just 1% on a capacity basis. Agricultural applications accounted for 34%, commercial for 8%, and government, institutional, and industrial each for 7% on a per project basis. Off-grid small wind turbines continue to account for the bulk of wind turbine units deployed in U.S. distributed wind applications; however, wind turbines connected to the distribution grid, or "grid-tied" applications, accounted for more than 99% of the annual domestic distributed wind capacity (in terms of MW).

- In 2014, U.S. distributed wind projects encompassed 34 different wind turbine models ranging from 160 W to 2 MW from 21 suppliers with a U.S. sales presence. In contrast, projects using 69 different wind turbine models from 38 suppliers were documented in 2013. Eight of the top ten models of all 2014 wind turbines deployed in U.S. distributed applications (on a unit basis) were manufactured in the United States.

- The capacity-weighted average capacity factor for a sample of distributed wind projects installed in 2013 and 2014 analyzed for this report is 25%. The capacity-weighted average levelized cost of energy (LCOE) for a sample of distributed wind projects installed in 2013 and 2014 analyzed for this report is 12¢/kWh. Installed cost and wind turbine energy production (i.e., capacity factor) drive a wind project's LCOE. In general, the higher the capacity factor, the lower the LCOE, and the lower the cost, the lower the LCOE.

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ACRONYMS AND ABBREVIATIONS

AWEA	American Wind Energy Association
CIP	Competitiveness Improvement Project
DOE	U.S. Department of Energy
DWEA	Distributed Wind Energy Association
FIT	Feed-in-Tariff
GE	General Electric
GW	gigawatt
IEC	International Electrotechnical Commission
ITC	investment tax credit
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
LCOE	levelized cost of energy
m	meter
m^2	square meter
MACRS	Modified Accelerated Cost-Recovery System
MW	megawatt
MWh	megawatt-hour
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
O&M	operations and maintenance
PNNL	Pacific Northwest National Laboratory
REAP	Rural Energy for America Program
SMART	Sustainable Manufacturing, Advanced Research & Technology
SWCC	Small Wind Certification Council
USDA	U.S. Department of Agriculture
PTC	production tax credit
PV	photovoltaics
USVI	United States Virgin Islands
W	watt

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FIGURES

In contrast to energy sent via transmission lines to distant end-users from large wind farms, such as the Stateline Wind Farm seen on the ridgeline, distributed wind energy systems produce electricity that is consumed on site, such as this 20-kW Jacobs 31-20 turbine at a ranch in Eastern Washington state.

1.0 Introduction

The U.S. Department of Energy's (DOE's) third annual Distributed Wind Market Report provides stakeholders with statistics and analysis of the market along with insights into its trends and characteristics. By providing a comprehensive overview of the distributed wind market, this report can help plan and guide future investments and decisions by industry, utilities, federal and state agencies, and other interested parties.

Distributed wind is defined in terms of technology application based on a wind project's location relative to end-use and power-distribution infrastructure, rather than turbine or project size. Distributed wind is

1) The use of wind turbines, either off-grid[1] or grid-connected, at homes, farms and ranches, businesses, public and industrial facilities, or other sites to offset all or a portion of the local energy consumption at or near those locations, or

2) Systems connected directly to the local grid[2] to support grid operations and local loads.

Distributed wind is differentiated from wholesale power that is generated at large wind farms and sent via transmission lines to substations for distribution to loads and distant end-users.

Grid-connected distributed wind systems can be located either physically on the customer side of the meter, or virtually, meaning the credits for wind generation not directly connected to load are applied to customers' bills through remote net metering or meter aggregation. Because the definition is based on where the project is located and how the power is used, the distributed wind market includes wind turbines and projects of many sizes. For example, distributed wind systems can range from a less than 1-kW[3] off-grid wind turbine at a remote cabin or well head, to a 10-kW wind turbine at a home or farm, to several multi-megawatt wind turbines at a university campus, manufacturing facility, or other large facility.

[1]Off-grid wind turbine systems directly serve on-site loads and typically include battery backup or other energy storage as they are not connected to the local distribution grid.

[2]The local grid is defined as distribution lines with interconnected electric load(s), typically at a voltage of 34.5 kV or below.

[3]1 GW = 1,000 MW; 1 MW = 1,000 kW; 1 kW = 1,000 W

1.1 The U.S. Department of Energy's Role

Distributed energy offers solutions to many of the nation's leading energy supply issues by providing resilience against blackouts and brownouts, mitigating energy security concerns and power quality issues, meeting tighter emissions standards, reducing transmission bottlenecks, and allowing greater control over energy costs. In addition to providing greater electricity system benefits, on-site distributed wind turbines allow farms, schools, and other energy users to benefit from reduced utility bills; predictable, controlled costs; and to hedge against the possibility of rising retail electricity rates.

Distributed wind also supports the nation's manufacturing economy as U.S.-based small wind turbine manufacturers rely on a largely U.S. supply chain for their wind turbine components. These manufacturers supply the majority of the small wind turbines deployed domestically and are leading exporters to an expanding global market.

The annual Distributed Wind Market Report supports DOE's effort to increase the deployment of distributed wind across the United States, raise the quality of installed distributed wind products, and grow the nation's domestic energy industry. The report provides key information on current market conditions and regulatory environments that will help stakeholders increase the cost competitiveness of distributed wind systems and build better turbines and components, leading to improved grid integration and increased customer and utility confidence in distributed wind systems.

1.2 Wind Turbine Size Classification

The distributed wind market includes wind turbines and projects of many sizes. This report breaks the market into three turbine size segments when appropriate: wind turbines up through 100 kW (in nominal capacity) referred to in this report as "small wind," mid-size wind turbines 101 kW to 1 MW, and large-scale wind turbines greater than 1 MW.[4]

While international and domestic standards define small wind turbines as having rotor swept areas up to 200 m^2 (approximately 50 to 65 kW) for certification purposes, the U.S. Internal Revenue Service defines small wind as up through 100 kW for the purpose of federal investment tax credit (ITC) eligibility (see Section 4.1.2). DOE's annual Wind Technologies Market Report (Wiser and Bolinger 2015) concentrates only on U.S. wind projects using turbines greater than 100 kW. This report specifically analyzes distributed wind projects and details the annual U.S. small wind market.

1.3 Turbine Types

Turbines can be considered newly manufactured, refurbished, or retrofitted. Newly manufactured wind turbines are used across all market applications; refurbished wind turbines (i.e., reconditioned equipment emerging primarily from California wind farm repowering) are most often seen with agricultural projects. The definition of what constitutes a refurbished (or remanufactured or reconditioned) wind turbine varies. A refurbished turbine may be one that only had a few new parts added to the unit or simply had a change of hydraulic or transmission fluids before being resold. Alternatively, a refurbished turbine could have undergone an extensive remanufacturing process in which all of its parts were fully rebuilt. A retrofitted turbine is typically a newly manufactured turbine (i.e., nacelle, rotor, and generator) installed on an existing tower for a project that has various levels of development, installation, and wiring already completed. For the purpose of federal ITC eligibility, a turbine must be new, where new is defined as having no more than 20% used parts. Therefore, some refurbished and retrofitted turbines qualify for the federal ITC.

[4]Due to the small amount of projects using turbines greater than 100 kW in 2013, only two market segments were analyzed in that report: small wind and turbines greater than 100 kW. Where appropriate, analysis in this report includes projects from both 2013 and 2014 to increase sample sizes.

2.0 U.S. Distributed Wind Deployment

Between 2003[5] and the end of 2014, nearly 74,000 wind turbines were deployed in distributed applications across all 50 states, Puerto Rico, and the U.S. Virgin Islands (USVI), totaling 906 MW in cumulative capacity (Figure 1). In 2014, 63.6 MW of new distributed wind capacity was added, representing nearly 1,700 units and $170 million in investment across 24 states.[6]

Distributed wind experienced a mixed year in 2014 with only some sectors of the market seeing growth. Bolstered by projects in New Mexico, California, and Texas, installations of large-scale turbines (greater than 1 MW) grew almost threefold to 57.5 MW in 2014 from 20.4 MW in 2013. Large-scale turbines thus represent 90% of the total distributed wind capacity deployed in 2014.

In contrast, the markets for distributed wind systems using small (up through 100 kW) and mid-size (101 kW to 1 MW) wind turbines continued to struggle since achieving record sales in 2008 through 2012. Three projects using mid-size turbines in Indiana, Ohio, and Massachusetts installed 2.4 MW of capacity, representing nearly 4% of the total distributed wind capacity deployed in 2014. In 2013, mid-size turbines accounted for 4.4 MW of that year's installed capacity. Small wind turbines also saw a decline in sales, adding only 3.7 MW, or about 6%, of the total 2014 distributed wind capacity, compared to 5.6 MW in 2013. Small wind turbine projects were spread primarily across Alaska, Iowa, Kansas, Minnesota, Nevada, New York, and Texas.

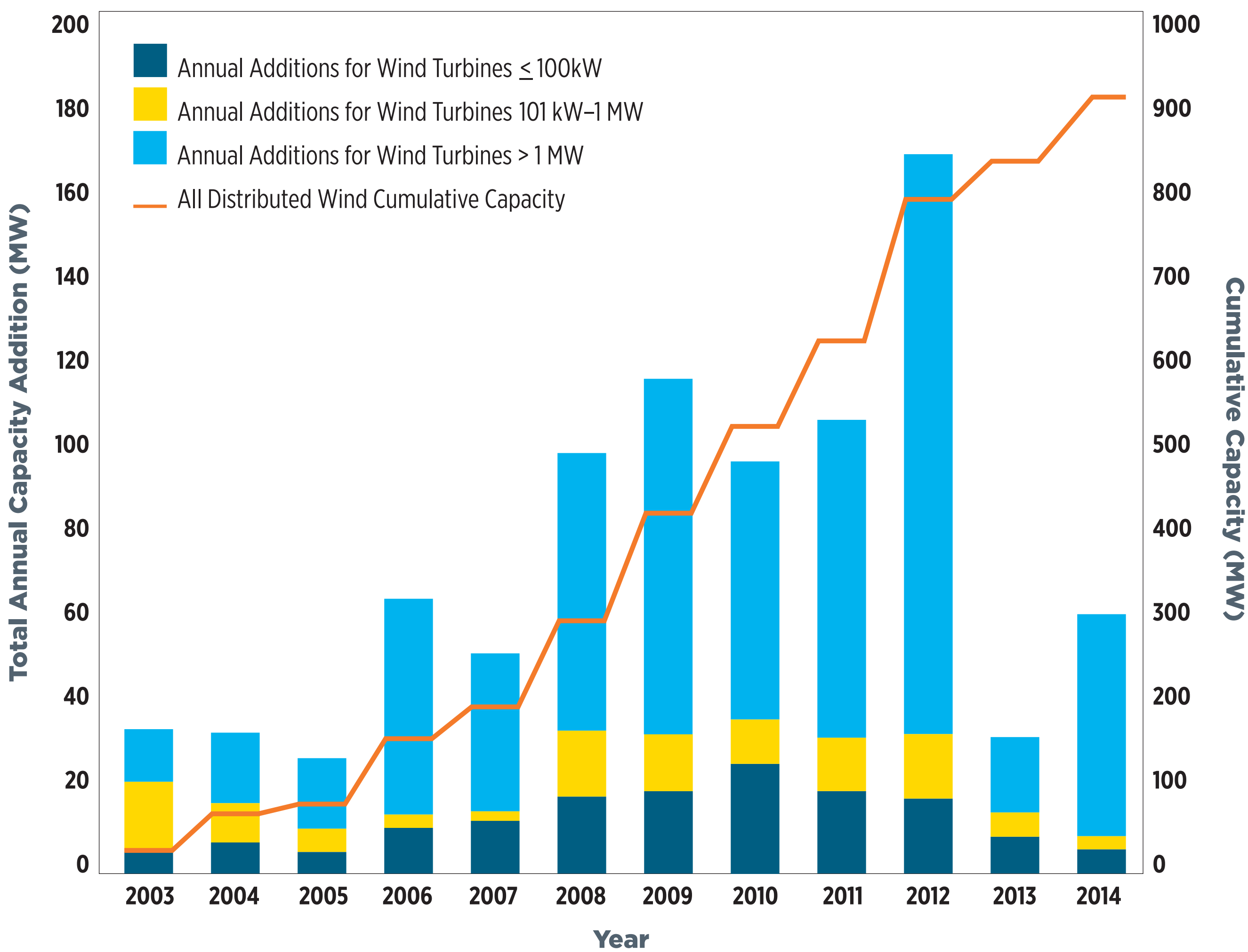


Figure 1: U.S. Distributed Wind Capacity

[5]A starting point of 2003 is used for cumulative capacity discussions in this report based on available and reliable data records.

[6]Details for the wind turbine units, capacity numbers, and figures presented in this report are provided in an accompanying data file, available for download at http://energy.gov/eere/wind/downloads/2014-distributed-wind-market-report. Some numbers presented vary slightly due to rounding.

2.1 Market Application

This report considers six main market applications for distributed wind: 1) residential, 2) agricultural, 3) industrial, 4) commercial, 5) government, and 6) institutional. Residential applications include remote cabins, private boats, rural homesteads, suburban homes, and multi-family dwellings. Agricultural applications include all types of farms, ranches, and agricultural operations. Industrial applications are facilities that manufacture goods or perform industrial processes (e.g., food processing plants and oil and gas operations). Examples of commercial applications include offices, car dealerships, retail spaces, restaurants, and telecommunications sites. Government applications are projects for non-taxed entities such as cities, municipal facilities (e.g., water treatment plants), and military sites. Institutional applications are also for entities that are typically non-taxed and mainly consist of schools, universities, and electric co-operatives.

Although distributed wind projects are not defined by project size, almost 80% of 2014 distributed wind projects were single-turbine projects. Figure 2 shows the breakdown of market applications by capacity and by number of projects.

Figure 2 highlights the disparity between project and turbine sizes in each application. The few projects installed in the institutional and government applications mostly used large-scale turbines, while small turbines dominated deployment in the residential and agricultural applications.

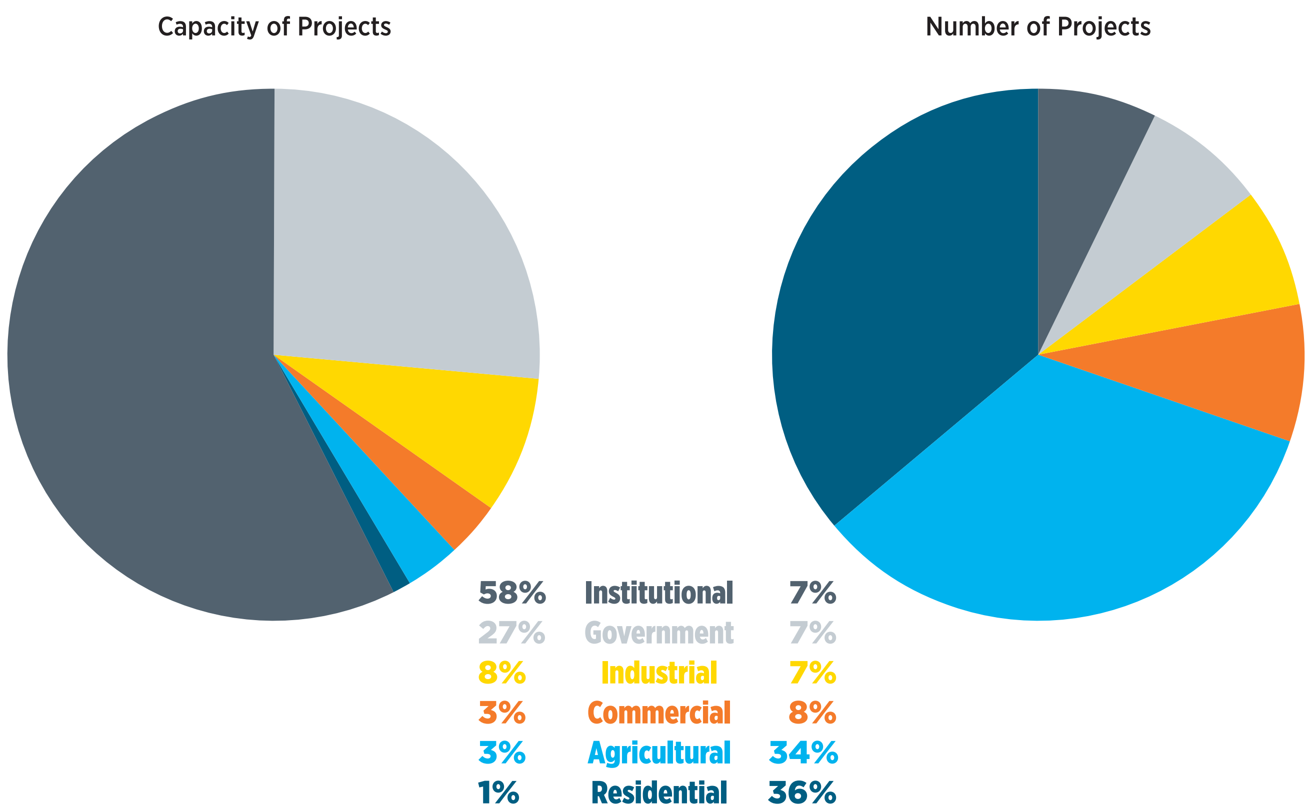


Figure 2: 2014 Distributed Wind Market Applications by Capacity and by Project

This Weaver 5-kW wind turbine is installed at a residence in New York. Photo credit: Weaver Wind Energy

2.2 On-Site and Local Use

In simple terms, a wind turbine or project is considered to provide distributed energy if it serves an on-site load (i.e., behind the meter, remote net-metered, or off-grid) or if it is connected to the local distribution grid to serve local loads (i.e., the generated energy is not sent past the local substation). On a capacity basis, 58% of the documented 2014 distributed wind projects were connected to distribution lines serving local loads in New Mexico, Indiana, and Nebraska. The other 42% served on-site loads, either as behind-the-meter, off-grid, micro-grid, or remote net meter applications across 22 states.

2.3 Off-Grid and Grid-Tied

Off-grid small wind turbine models continue to account for the bulk of wind turbine units deployed in U.S. distributed wind applications. An estimated 83% of turbine units in 2014 distributed wind applications were deployed to power remote homes, oil and gas operations, telecommunications facilities, boats, rural water or electricity supply, and military sites. However, wind turbines connected to the distribution grid, or "grid-tied" applications, accounted for more than 99% of the annual domestic distributed wind capacity (in terms of MW).

2.4 Types of Wind Turbines and Towers

In 2014, reported U.S. distributed wind projects encompassed 34 different wind turbine models ranging from 160 W to 2 MW from 21 suppliers with a U.S. sales presence. In contrast, projects of 69 different wind turbine models in U.S. distributed applications from 38 suppliers with a U.S. sales presence were documented in 2013. Eight of the top ten models of all 2014 wind turbines deployed in U.S. distributed applications (on a unit basis) were manufactured in the United States.

Of the 25 small wind turbine models deployed in the United States during 2014 reported by 15 suppliers, three have nominal capacity ratings less than 1 kW, 17 are rated 1 to 10 kW, and five are rated 11 to 100 kW. The deployed capacity values for these turbines are shown in Figure 3.

The number of mid-size and large-scale wind turbine manufacturers supplying turbines for distributed wind projects has contracted since 2012. In 2012, 27 manufacturers supplied 33 different mid-size and large-scale turbine models for 69 projects. In 2013, there were six manufacturers with eight different turbine models for nine projects. The market situation was similar in 2014 with six manufacturers providing nine turbine models for 12 projects.

A wide range of tower designs and heights were sold for small wind turbine projects. On a unit basis, the most common towers, in order of prevalence, were self-supporting lattice, tilt-up monopole, guyed monopole, self-supporting monopole, and guyed lattice. Reported turbine heights for small wind turbines ranged from 10 to 43 m. For turbines greater than 100 kW, projects with known tower characteristics were all 80-m monopoles.

Consistent with past years, small vertical-axis wind turbine models continue to represent a small portion of the small wind market, about 2% of 2014 U.S. small wind capacity and about 4% of units.

In 2014, the capacity-weighted average size of wind turbines in distributed applications was 37 kW, up from 11 kW in 2013. The jump in size can be explained by the change in the most commonly used turbines in the given years. In 2012, many mid-size and large-scale turbines were deployed in distributed applications. But in 2013, off-grid wind turbines and smaller units represented a greater portion of projects. In 2014, the number of mid-size and large-scale turbines rebounded, increasing the average wind turbine size used in distributed applications. These trends are shown in Figure 4.

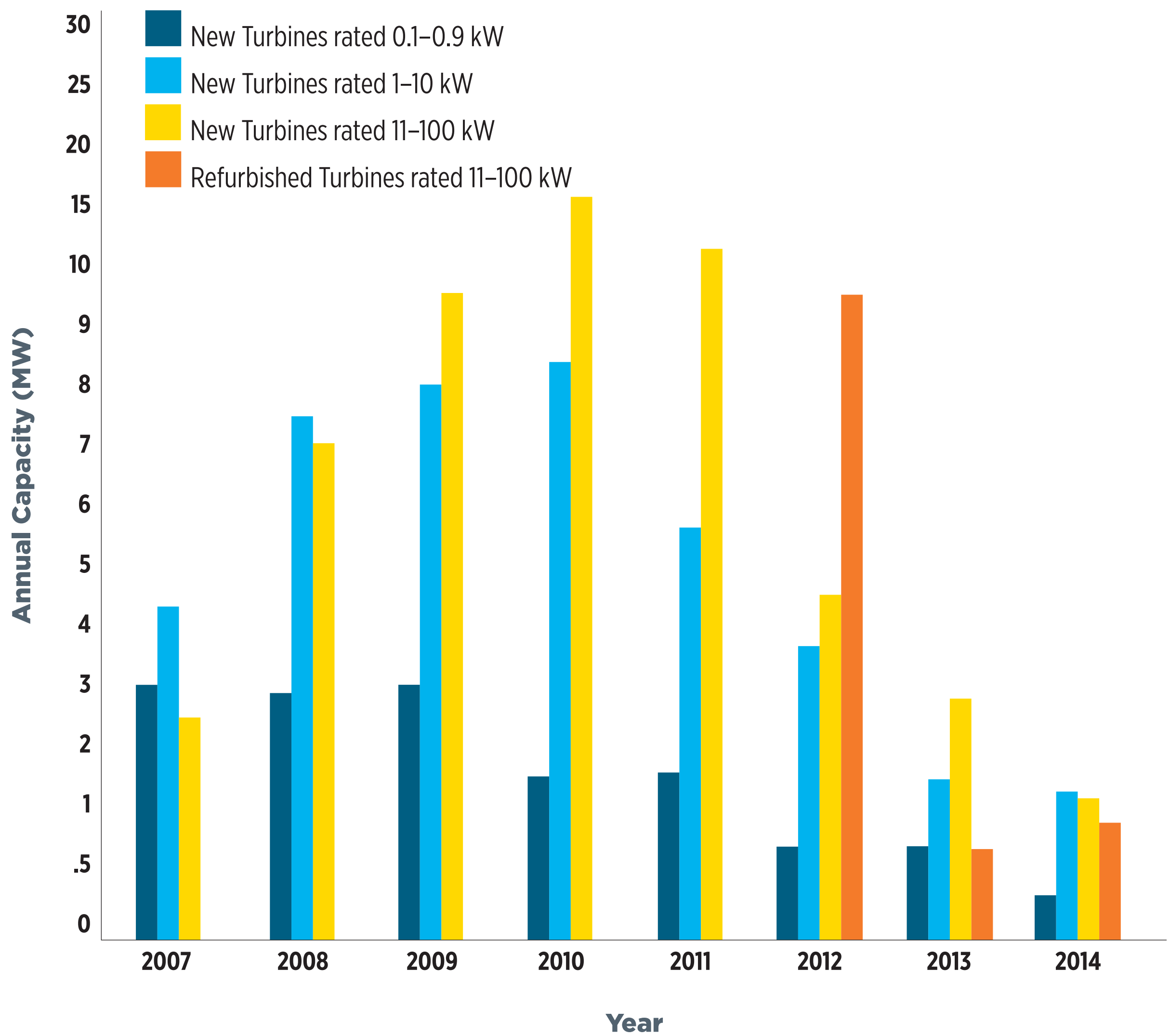
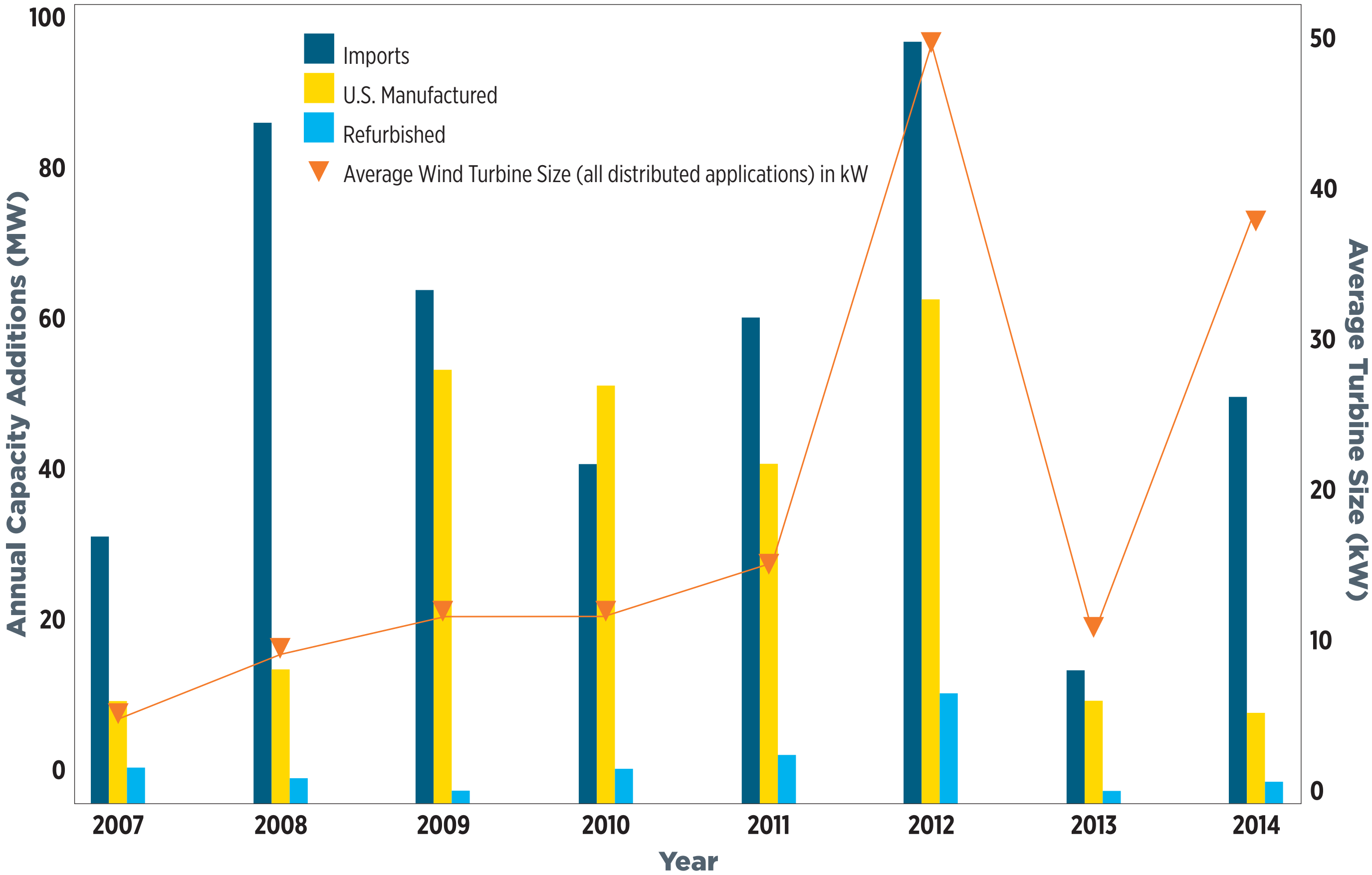


Figure 3: U.S. Small Wind Turbine Sales by Turbine Size



	2007	2008	2009	2010	2011	2012	2013	2014
IMPORTS (MW)								
Small	1.10	4.40	3.60	4.40	3.80	2.70	0.70	0.70
Mid-Size	0.00	13.00	8.30	4.80	7.20	11.70	4.40	2.40
Large Scale	34.8	68.6	52.7	32.8	50.3	85.2	12.0	48.0
U.S. MANUFACTURED (MW)								
Small	8.7	13.0	16.8	21.3	15.3	6.3	4.3	2.1
Mid-Size	0.0	0.0	0.0	2.0	1.8	4.3	0.0	0.0
Large Scale	4.0	3.5	39.0	30.5	26.2	52.7	8.4	9.3
REFURBISHED (MW)								
Small	0.0	0.0	0.0	0.0	0.0	9.6	0.6	0.9
Mid-Size	2.5	1.1	0.6	1.9	3.5	3.1	0.0	0.0
TURBINES (UNITS)								
Small	9,100	10,400	9,800	7,800	7,300	3,700	2,700	1,600
Mid-Size	9	17	15	22	22	31	7	3
Large Scale	22	43	63	34	42	78	11	31

Figure 4: U.S. Distributed Wind Capacity by Type and Average Turbine Size

2.5 Top States for Distributed Wind: Annual and Cumulative Capacity

Distributed wind installations were documented in 24 states in 2014 (Figure 5) and in all 50 states, Puerto Rico, and the USVI since 2003 (Figure 6).

New Mexico, Texas, and California led the United States in new distributed wind power capacity additions in 2014 across all turbine sizes. Minnesota, New York, Nevada, and Iowa led the nation for the number of small wind turbines deployed in 2014.

Texas, Minnesota, and Iowa retained their positions as the top three states with the most distributed wind capacity deployed since 2003 (Figure 7). However, with 34.8 MW of new capacity installed in 2014, New Mexico became the seventh largest state by cumulative capacity, up from 32nd in 2013. Iowa, Nevada, and California remained the leading states for cumulative small wind capacity (Figure 8). A total of 16 states now each have more than 10 MW of cumulative distributed wind capacity.

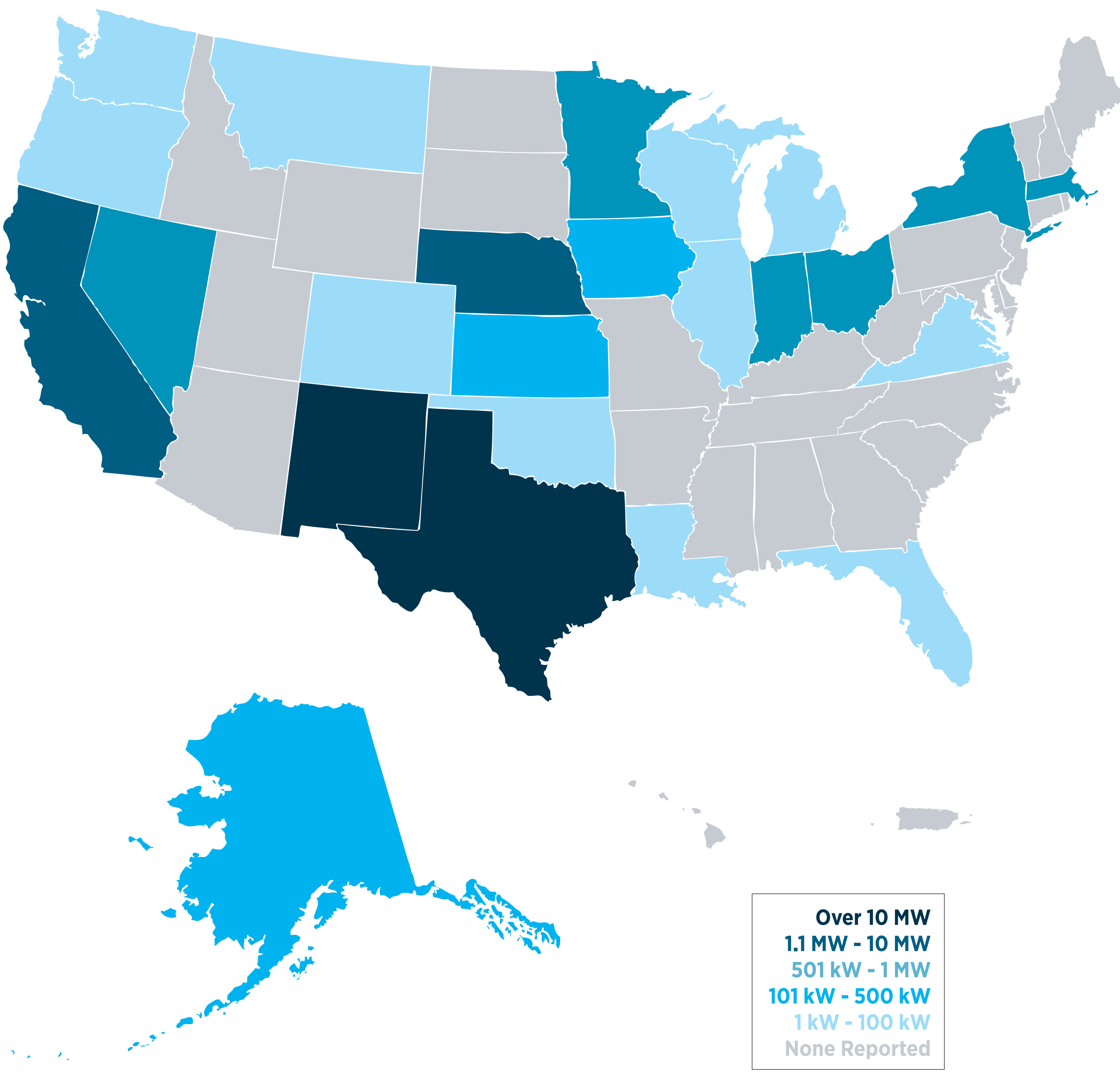


Figure 5: 2014 U.S. Distributed Wind Capacity Additions by State

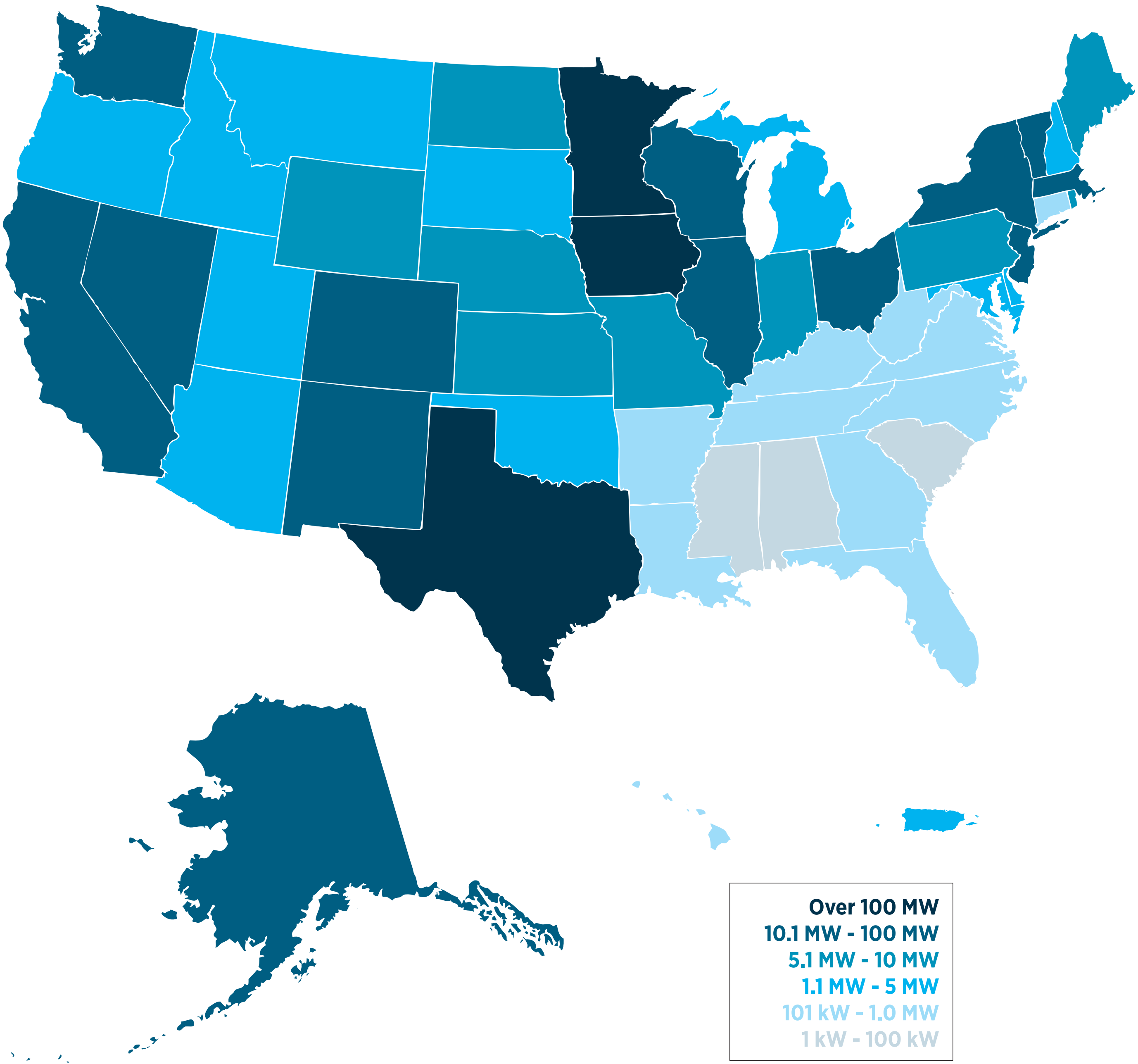


Figure 6: 2003–2014 Cumulative U.S. Distributed Wind Capacity by State

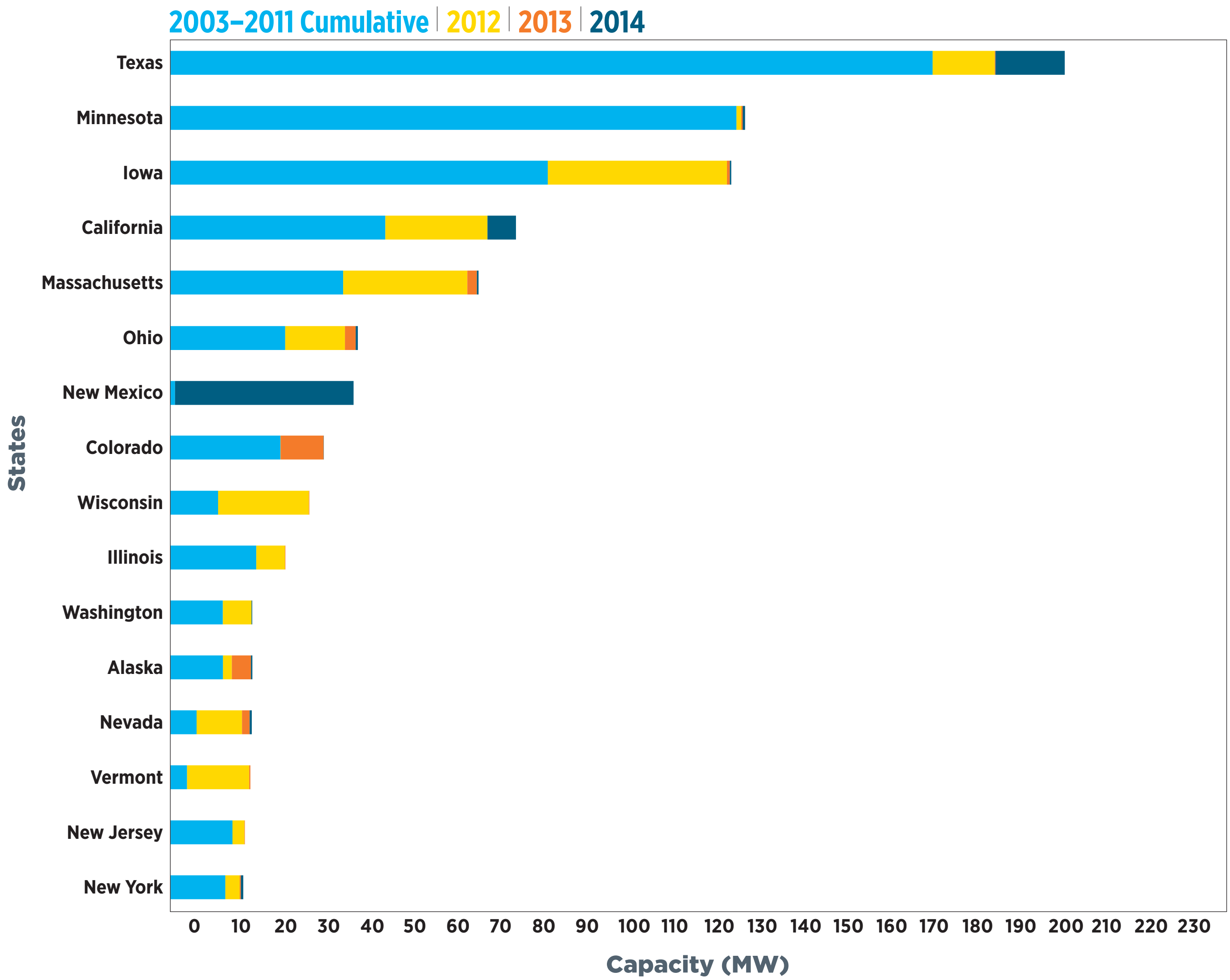


Figure 7: Top States for Distributed Wind Capacity, 2003–2014

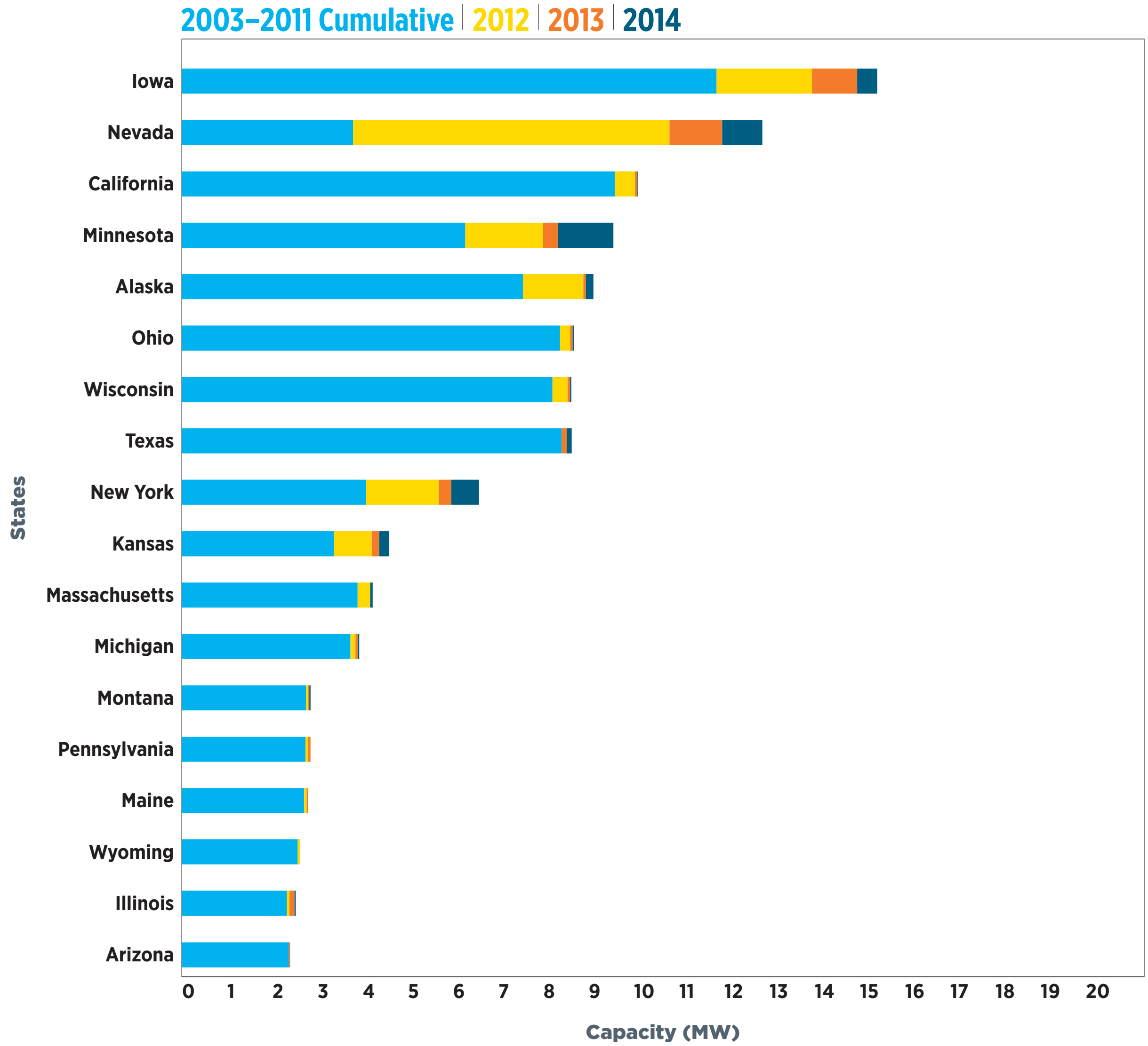


Figure 8: Top States for Small Wind Capacity, 2003–2014

2.6 Suppliers and Manufacturers

The top five U.S. small wind turbine manufacturers and suppliers based on 2014 sales in terms of capacity (MWs of domestic sales and exports) were Northern Power Systems of Vermont; Bergey WindPower of Oklahoma; PowerWorks of California; Primus Wind Power of Colorado; and, Ventera Wind of Minnesota. All U.S. small wind manufacturers and suppliers accounted for in this report are listed in Appendix A.

For this year's report, there were fewer data request responses from non-U.S.-based small wind turbine manufacturers. And of those who replied, fewer reported sales in the United States in 2014. These findings reflect the ongoing contraction of the small wind turbine manufacturing industry and the reduced interest in the U.S. market from non-U.S.-based entities. As a result, this report only accounts for small wind turbine imports from Endurance Wind Power of Canada; Osiris Energy USA of China; Potencia Industrial of Mexico; and, Sonkyo Energy of Spain.

The suppliers of wind turbines greater than 100 kW installed in 2014 U.S. distributed applications were Gamesa, headquartered in Spain; General Electric (GE), headquartered in the United States; PowerWind, headquartered in Denmark; RRB Energy, headquartered in India; Siemens, headquartered in Germany; and Vestas, headquartered in Denmark.

2.7 Distributed Wind Turbine Units

Wind turbines of all sizes in distributed wind applications accounted for 68% of the nearly 109,000 total wind turbines deployed in the United States (on a unit basis) since 2003 (Figure 9). However, a large number of units does not always equate to a large amount of capacity. For example, distributed wind accounted for just over 1% of all wind capacity installed in 2014 and just over 2% in 2013 (AWEA 2015). For context, mid-size and large-scale turbines installed in wind farms (i.e., non-distributed applications) are also shown in Figure 9 and Figure 10.

And while the annual distributed wind capacity additions doubled between 2013 and 2014, installations on a per unit basis declined by 37% in the same time span. This drop was most impactful in the mid-size turbine range, where installations declined by 57% on a per unit basis compared to 2013 levels. Small wind turbines declined by 39% on a per unit basis. The only turbine size sector that had increased installed units was large-scale turbines, which nearly tripled between 2013 and 2014, accounting for the increase in overall capacity additions over last year.

In contrast, the 2013 annual distributed wind capacity additions declined by 83% compared to 2012 and the number of wind turbine units deployed in distributed wind applications in 2013 dropped by nearly 30% compared to 2012 levels.

The continued downward trend of small and mid-sized distributed wind turbine projects in the United States indicates the market is still struggling since achieving strong sales in 2008 through 2012. Small wind continues to face competition from solar photovoltaics and the low cost of other sources of electricity. Because the federal ITC is only available for tax-paying entities deploying small wind turbine projects, mid-size turbine manufacturers may be somewhat limited to a more narrow market that includes municipalities and schools in addition to (tax-paying) small industrial customers; four out of the seven projects using mid-size turbines in 2013 and 2014 were institutional and government applications. Conversely, the upswing in large-scale distributed wind turbine installations is mirrored by the growth of large-scale non-distributed wind turbines installed in wind farms, which grew more than six-fold between 2013 and 2014, largely because of the extension of the federal production tax credit.

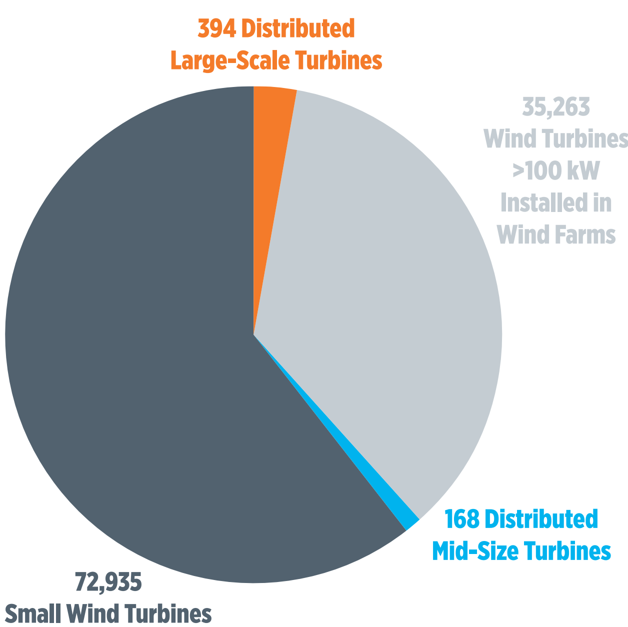


Figure 9: Cumulative Wind Farm and Distributed Wind Turbine Units, 2003-2014

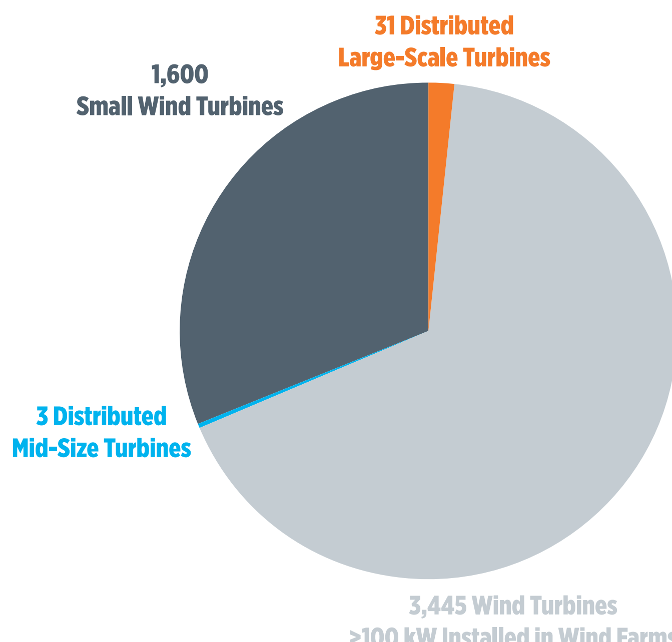


Figure 10: Annual Wind Farm and Distributed Wind Turbine Units, 2014

3.0 Domestic Sales, Imports, Exports, and the Global Market

The 15 distributed small wind turbine manufacturers and suppliers with a 2014 U.S. sales presence accounted for in this report consist of 11 domestic manufacturers and suppliers headquartered in 8 states (California, Colorado, Maine, Minnesota, New York, Oklahoma, Oregon, and Vermont) and 4 importers from Canada, China, Mexico, and Spain. This group reported a total worldwide annual sales value of $142 million, representing nearly 2,900 units and more than 26 MW. Of the 11 U.S. manufacturers, 7 exported small wind turbines outside of the United States. Six manufacturers of turbines greater than 100 kW with a 2014 U.S. sales presence are accounted for in this report, one domestic manufacturer and five importers.

3.1 Domestic Sales

The 3.7 MW of small wind sales in 2014 represents over 1,600 units and $20 million in investment. This is down from 2013, in which 5.6 MW from roughly 2,700 units resulted in $36 million of investment.

While U.S. manufacturers dominate the small wind domestic sales, mid-size and large-scale turbines used in distributed applications in the United States are primarily imports. Five of the six manufacturers of turbines greater than 100 kW with installations in the United States in 2014 were non-U.S.-based, as listed in Section 2.6. With respect to U.S.-based manufacturers of turbines greater than 100 kW, GE is the sole U.S.-based manufacturer with distributed wind installations in 2013 and 2014, while U.S.-based manufacturers Aeronautica, Clipper, GE, and Nordic all had installations in 2012.

Domestic sales from U.S. small wind manufacturers accounted for 82% of the 2014 U.S. small wind sales, slightly down from 88% in 2013 (Figure 11). On a unit basis, U.S. suppliers claimed 98% of the 2014 domestic small wind sales, up from 93% in 2013.

Most refurbished wind turbines sold in 2012 were installed in Nevada and received Section 1603 funding and NVEnergy incentive program funding; thus, the decrease in refurbished turbine installations in 2013 and 2014 is likely related to the reduction in funding available from NVEnergy and the expiration of the Section 1603 cash grant program.

Figure 11 shows annual domestic, export, refurbished, and import sales of small wind turbines.

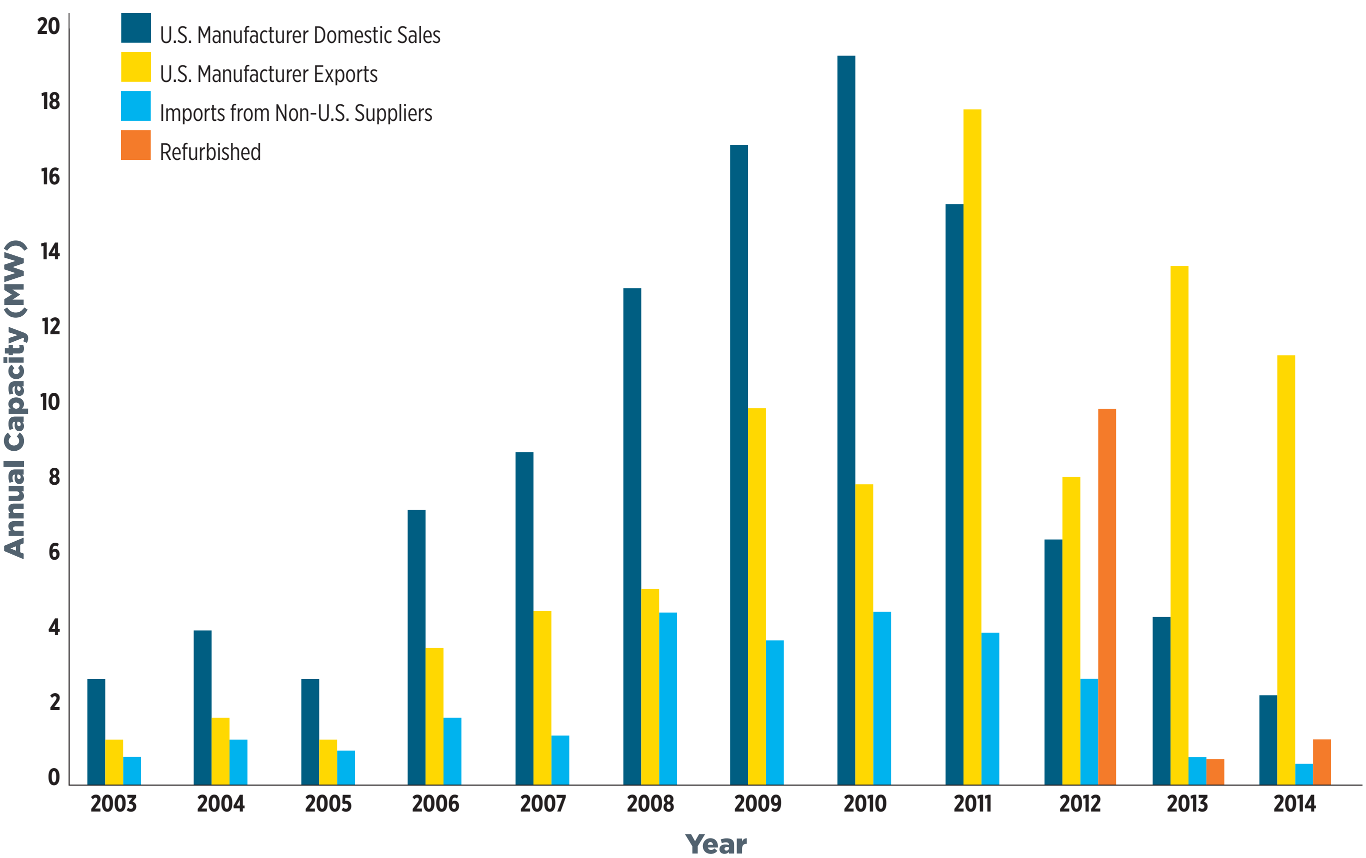


Figure 11: U.S. Small Wind Turbine Sales and Exports, 2003-2014

3.2 Exports

U.S. small wind turbine manufacturers continued to focus on international markets as a source of revenue (see Figure 12). Exports from U.S.-based small wind turbine manufacturers in 2014 were comparable to past years with 11.2 MW in 2014 from seven manufacturers (representing 86% of 2014 sales capacity), 13.6 MW in 2013 from ten manufacturers (76% of 2013 sales capacity), and 8 MW in 2012 from eight manufacturers (57% of 2012 sales capacity). On a per unit basis, 61% of U.S. manufacturers' 2014 new small wind turbine sales were exports, marking an increase compared to 2013 and 2012, in which 54% and 56%, respectively, of new small wind turbine sales were exports. The 11.2 MW of exports represent a $60 million investment from roughly 1,000 units.

The top reported export markets in terms of capacity were Italy, the United Kingdom (UK), and South Korea and Figure 12 shows the primary reported countries that received U.S. small wind exports.

While the UK and Italy have been strong export markets in recent years, new opportunities are arising for U.S. small wind manufacturers in other countries such as Japan and South Korea.

Japan created a feed-in tariff program for renewable energy in 2012 to support energy diversification after the Fukushima Daiichi nuclear disaster in 2011. Small wind turbines less than 20 kW must have ClassNK certification to the Japanese Standards Association JIS C 1400-2 or equivalent standard to be eligible for the feed-in tariff, which mandates electric utilities purchase power generated by grid-connected turbine systems (ClassNK 2015). While the Japanese Ministry of Economy, Trade and Industry reduced the incentives for solar PV since 2012, the rates for onshore wind remain untouched at ¥55/kWh (about 44¢/kWh) for onshore projects less than 20 kW and ¥22/kWh (about 18¢/kWh) for onshore projects 20 kW and greater (METI 2015). The Japanese feed-in tariff thus remains one of the most generous incentives for renewable energy globally (DLA Piper 2014). The Small Wind Certification Council signed a reciprocity agreement with ClassNK to ensure that as much of the work as possible that has been performed by one party is acceptable to facilitate certification by the other party. Some U.S. small wind manufacturers have this certification in place and others are working to obtain it.

South Korea and other parts of Asia are also markets with strong potential. Northern Power, one of the few publically traded U.S. small wind manufacturers,[7] sees opportunity in South Korea's many islands with micro-grids, a market similar to Northern Power's strong and established market in isolated Alaskan villages (AWEA 2014). Northern Power provides an example of a U.S. manufacturer weathering the years of mixed domestic market performance by focusing on international markets. According to U.S. Securities and Exchange Commission filings, 88% of its revenue came from international customers in 2014 and the company expects the majority of its future revenue to continue to be from outside of the United States (SEC 2015).

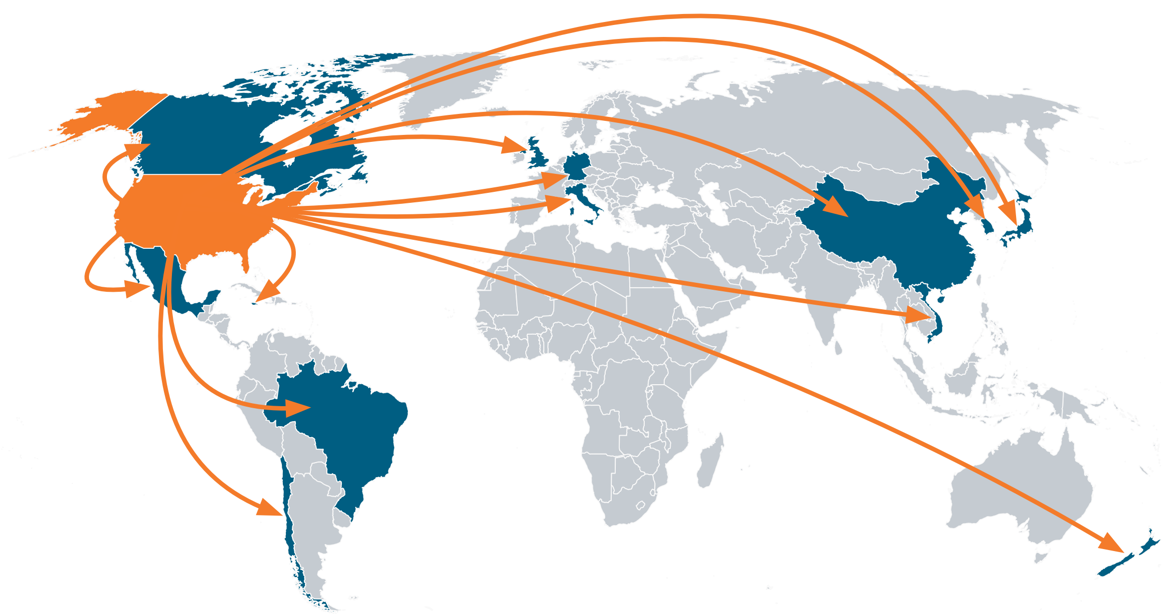


Figure 12: U.S. Small Wind Exports Map

[7]Northern Power filed an IPO with the Nasdaq Capital Market in January 2015, and joined the Toronto Stock Exchange in April 2014.

U.S.-based small wind turbine manufacturers export to countries across the globe. Pictured here is a Bergey 10-kW wind turbine on a 25-m lattice tower in Middlesbrough, UK. Photo credit: Mike Bergey

3.3 Imports

In 2014, reported sales from foreign small wind turbine manufacturers in the United States dropped slightly compared to 2013. Foreign manufacturers from Spain, Mexico, Canada, and China reported 28 units sold for a total of 650 kW of capacity, representing 18% of the 2014 U.S. small wind market.

As mentioned previously, mid-size and large-scale turbines used in distributed applications in the United States are primarily imports. In 2014, 85% of the installed distributed wind capacity using turbines greater than 100 kW was supplied by five non-U.S.-based manufacturers (Gamesa, PowerWind, RRB Energy, Siemens, and Vestas).[7] In 2013, there were also five manufacturers of turbines greater than 100 kW with distributed wind installations that year, but not all the same manufacturers as in 2014 (EWT, PowerWind, Sany, Vergnet, and Vestas). GE was the only U.S.-based manufacturer of large-scale turbines to supply turbines for distributed wind projects in 2013 and 2014. In contrast, there were 27 manufacturers of turbines greater than 100 kW with distributed wind installations in 2012, 23 of which were non-U.S.-based.

The mix of mid-size and large-scale manufacturers in the past two years, especially for mid-size, and the overall drop in number of manufacturers from 2012, suggests no one manufacturer has a strong position in the U.S. distributed wind market. In addition, non-U.S.-based manufacturers commenting for this report indicated that unstable federal and state policies hampered their participation in the U.S. market and they see better sales prospects in international markets, such as the UK, Italy, and other countries with feed-in tariffs.

3.4 Global Market

Navigant Research (Navigant) estimated that 255 MW of small and medium wind systems (defined as wind turbines up through 500 kW) were installed in 2014 globally (Gauntlett and Asmus 2014). Navigant did not provide separate estimates for small wind turbines alone. Installations in the UK, China, Italy, and the United States constitute over 90% of Navigant's estimate. No turbines in the size range of 101 to 500 kW were recorded as installed by the American Wind Energy Association (AWEA) in the United States in 2014, although some projects were in process and are expected to come online in 2015 (AWEA 2015). According to the World Wind Energy Association (Gsänger and Pitteloud 2015), the United States, UK, and Chinese markets account for 30%, 15%, and 41%, respectively, of the 755 MW of global cumulative installed small wind capacity as of the end of 2013.[8] Based on known 2014 records, the global small wind capacity as of the end of 2014 is estimated to be roughly 810 MW. U.S. domestic cumulative sales and U.S. small wind turbine manufacturer exports in 2014 represent about 30% of this estimated global 2014 small wind market (Table 1).

[8] In all other instances, this market report uses 2003 as the cumulative capacity starting point, but small wind capacity values have been documented since 1980. The small wind cumulative capacity value since 2003 is 140 MW.

Table 1: U.S. Small Wind and the Global Market

	2012 (MW)	2013 (MW)	2014 (MW)
U.S. manufacturers' exports[a]	8	13.6	11.2
U.S. annual sales[b]	18.4	5.6	3.7
U.S. cumulative capacity since 1980[c]	216	222	226
UK annual capacity[d]	28.1	12.9	19.8
UK cumulative capacity since 2005[d]	87	100	120
Italy annual capacity[e,f]	Not Available	13.9	Not Available
Italy cumulative capacity[e,f]	15.2	29.1	Not Available
China annual capacity[e,f]	33.6	31	Not Available
China cumulative capacity[e,f]	274	305	Not Available
Global cumulative capacity[e]	678	755	Not Available

[a] Newly manufactured wind turbines by U.S. manufacturers.
[b] Includes refurbished, imported, and U.S. manufactured small wind turbines.
[c] 2011 capacity value source: AWEA 2011.
[d] Source: Renewable UK 2015.
[e] Source: Gsänger and Pitteloud 2014.
[f] Source: Gsänger and Pitteloud 2015.

U.S. small wind turbine manufacturers exported heavily to countries with feed-in tariffs, renewable portfolio standards, and other incentives policies, such as the UK, China, and Italy.

The UK recorded almost 20 MW of small wind deployed in 2014, reflecting an increase of 53% compared to the 12.9 MW deployed in 2013 (Table 1).[9] Wind turbines of all sizes have been buoyed by the UK's feed-in-tariff program, which provides 20 years of guaranteed revenue for owners of distributed wind turbines (OFGEM 2015). In 2014, the feed-in tariff stood at 46.33¢/kWh for turbines sized 1.5 to 15 kW and 41.87¢/kWh for turbines sized 15 to 100 kW (WWEA 2014) and included a built-in throttle that periodically reduces payments per kWh generated depending on the amount of capacity installed (GOV.UK 2014). Given the UK's large-scale deployment of wind energy, participants in the feed-in tariff have regularly seen annual reductions in incentives by 20%, illustrating both the success of wind deployment in the UK, as well as measures to control the overall cost of renewable energy subsidies (Renewable UK 2015).

China, the world's largest wind market both in terms of cumulative capacity and 2014 installations (Wiser and Bolinger 2015), also recorded a healthy growth in installations of small and medium wind systems (here defined as up through 500 kW capacity). Driven by a feed-in tariff (paying between 8 and 10¢/kWh for onshore projects), as well as other incentives, ranging from corporate income and value added tax reductions to payments for per ton of standard coal saved, the Chinese market added 56.3 MW capacity, growing close to 41% compared to 2013 levels (KPMG 2014, Gauntlett and Asmus 2014).

Italy reported installations of 12.1 MW of small and medium wind capacity, reflecting a growth of 13% compared to 2013 data (Gauntlett and Asmus 2014). The country, which is another top destination of U.S. exports of small wind turbines, greatly scaled back its incentives for renewable energy between 2012 and 2013 to reflect both dwindling fiscal resources and the successful achievement of renewables reaching 28% of the country's electricity mix in 2012—a full eight years ahead of schedule (U.S. Commerce 2015). And with the switch to an auction-based system for its feed-in tariffs, the outlook for further growth in the Italian wind energy is limited, as auctions in the past have pushed down tariff rates for wind energy (O'Brian 2014).

[9] The 2013 report listed higher annual capacity values for the UK because they were inclusive of approved, but not installed, projects.

4.0 Policy and Market Drivers

Policy decisions and market conditions directly influence manufacturers, installers, and buyers of distributed wind turbines. From changes in federal and state incentive levels to innovations in technology and financing, these decisions and conditions impact the U.S. distributed wind market.

4.1 Incentives and Policies

Federal, state, and utility incentives and policies (e.g., rebates, tax credits, grants, net metering, production-based incentives, and loans) continue to play an important role in the development of distributed wind and other renewable energy projects. Incentive programs vary widely with respect to the amount of funding they provide, the total number of projects they support, and the length of time they are available.

Figure 13 provides the number of federal, state, and utility funding awards given in each state for distributed wind projects in 2014; the combined value of all awards equals $20.4 million. This is slightly more than in 2013, when $15.4 million of awards were documented; however, it is less than in 2012, when more than $100 million of distributed wind awards were given.[10]

Incentive funding and commissioning of distributed wind projects often do not overlap. For example, although U.S. Department of Agriculture's (USDA's) Rural Energy for America Program (REAP) grants are recorded for this report in the year they are awarded, they are paid after the project is commissioned. Conversely, U.S. Department of Treasury 1603 program grants are recorded for this report in the year they are paid which is also the year they are reported. For example, the New Jersey project included in Figure 13 received its Section 1603 cash grant funding in 2014, but it was commissioned in 2013.

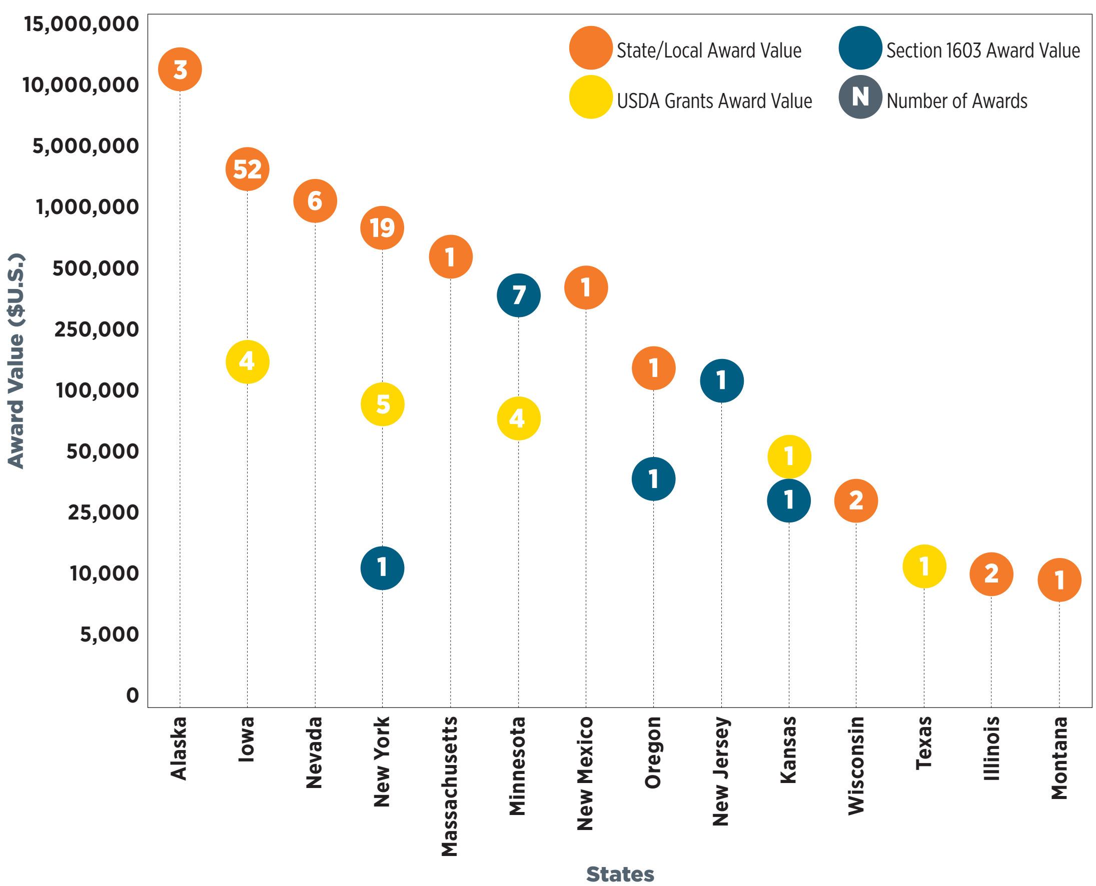


Figure 13: 2014 U.S. Distributed Wind Incentive Awards

[10]In the 2013 report, only the Iowa 476B production tax credit was documented. The 2014 report includes both the 476B and the 476C production tax credits, thus requiring a qualified comparison to last year.

4.1.1 State Policies and Incentives

State funding continues to play an important role in the distributed wind market. Established in 2008, the Alaska Renewable Energy Fund, managed by the Alaska Energy Authority provides grants through a competitive application process. In 2014, three projects received about $11.8 million, or about 60% of all incentive funding tracked for 2014, from a grant initiated during the first funding round of the program in 2008. The tradable Iowa Wind Energy Production Tax Credit (476B) and Renewable Energy Tax Credit (476C) and the New Mexico Renewable Energy Production Tax Credit provided tax credit payments to multiple projects in 2014. The NVEnergy incentive program and the New York State Energy Research and Development Authority's (NYSERDA's) On-Site Small Wind Incentive Program remained important drivers in 2014, although the NYSERDA incentive is set to expire at the end of 2015.

4.1.2 Federal Tax-Based Incentives

The federal Business Energy ITC (26 USC § 48) provides a 30% credit against the capital costs of a project—after the project is placed in service. The ITC expired for wind turbines larger than 100 kW at the end of 2013, but it, and the comparable 30% Residential Energy Tax Credit, are still available for small wind projects placed in service before January 1, 2017. The ITC was temporarily expanded in 2009 to allow for cash payments in lieu of the tax credit, otherwise known as the U.S. Treasury cash grants or 1603 payments. To qualify for 1603 payments, wind power projects must have been under construction or placed in service by the end of 2011 and must have applied for a grant by October 1, 2012. Eligibility for these cash payments has now expired.

Although the cash grant program officially ended, some payments are still being made, as noted in Figure 13, because 1603 payments are made after the project is placed in service, not prior to or during construction. Therefore, some projects that met the "under construction" milestone during the 2009 to 2011 eligibility period did not receive 1603 payments until more recent years when the projects were completed and put into service. In 2012, 201 distributed wind projects received almost $63 million in 1603 payments; in 2013, 36 distributed wind projects received $7.6 million in 1603 payments; and in 2014, 11 distributed wind projects received about $650,000 in 1603 payments (Treasury 2015).

Information on how many small wind projects have claimed the federal Business Energy ITC and the Residential Energy Tax Credit is not public record; however, it is assumed that most grid-connected commercial, industrial, agricultural, and residential projects—but not non-taxed government and institutional projects—take advantage of these tax credits if they did not receive a 1603 payment. Therefore, it is estimated that almost 3 MW of small wind projects installed in 2014 received the 30% federal tax credit, representing a value of roughly $5.4 million.

The federal PTC, the primary federal incentive for large-scale wind, was set to expire at the end of 2012, but in January 2013, Congress extended eligibility for the PTC to projects that had "begun construction" by December 31, 2013 instead of limiting eligibility to only projects "placed in service" by the end of the additional year. The U.S. Internal Revenue Service (IRS) defined starting construction as starting physical work of a significant nature or incurring 5% of the total project cost (IRS 2013). The Tax Increase Prevention Act of 2014 extended the beginning of construction date again to be before January 1, 2015. The IRS issued updated guidance in March 2015 (Notice 2015-25) with respect to this extension and to clarify that the starting construction requirement can be met if a project begins construction prior to January 1, 2015 and is placed into service before January 1, 2017.

Most distributed wind projects do not use the PTC because an additional condition for the credit is that the electricity generated from the project must be sold to a third party. However, some distributed wind projects, such as those providing power to manufacturing plants or schools, may be structured so that an independent power producer owns and operates the on-site project and sells the power directly to the plant or school; therefore, these projects would be eligible for the PTC.

The Tax Increase Prevention Act of 2014 also extended the 50% bonus depreciation provision of the Modified Accelerated Cost-Recovery System (MACRS) depreciation schedule to December 31, 2014. Depreciation allows tax-paying entities to recover investments through depreciation deductions from their taxes. The bonus depreciation provision allows an additional 50% first year depreciation to be taken by eligible renewable energy projects using the five-year MACRS depreciation schedule, enabling additional upfront tax savings.

Distributed wind projects can be found in several applications, including agricultural. Pictured here is a 1.65 MW NEG Micon Turbine in Minnesota. Photo credit: Minnesota Department of Commerce

4.1.3 U.S. Department of Agriculture's Rural Energy for America Program

The USDA provides agricultural producers and rural small businesses grant funding as well as loan financing to purchase or install renewable energy systems or make energy efficiency improvements (USDA 2015). Through REAP, the USDA issues loan guarantees for up to 75% of the project's cost or a maximum of $25 million for renewable energy projects. Grants are issued for up to 25% of the project's cost or a maximum of $500,000 for renewable energy projects. A combination of loans and grants can cover up to 75% of total eligible project costs.

In 2014, USDA REAP funded 15 wind projects with $405,442 in grants, supporting projects costing just over $1.7 million that are expected to generate 840 MWh of energy annually. This reflects a significant decrease from 2013 levels, when USDA provided $1.2 million in grants for 25 wind projects that cost $5.4 million and generated 2,303 MWh of energy annually.

In total, all USDA REAP participants received $12.3 million in grants and $56.4 million in loan guarantees in 2014, which was considerably less than in previous years. This was partially due to the funding for fiscal year 2014 coming out of the remaining funds of the 2008 Farm Bill.

The Agricultural Act of 2014 (the "Farm Bill") authorized sustained funding for USDA REAP grants and loan guarantees, a change from the uncertain schedule and variable authorizations in past years. REAP is now the largest Farm Bill Clean Energy Program with mandatory funding of $50 million per year through 2018. An additional $100 million in five-year discretionary funding is authorized, subject to annual appropriations (ELPC 2014). The sustained and increased levels of funding authorized for REAP by the 2014 Farm Bill will be applied to grant awards starting in the USDA's fiscal year 2015.

While overall funding in 2014 was lower, funding for wind projects was commensurately proportional with previous years. In 2014, wind projects represented 2.8% of all REAP awards (0.6% of REAP funding); energy efficiency projects represented 47% of awards (8% of funding); and solar projects represented 44% of awards (88% of funding). In 2013, wind projects represented 2% of all REAP awards (3% of REAP funding); energy efficiency projects represented 57% of awards (41% of funding); and solar projects represented 31% of awards (35% of funding).

The number of 2014 awards per number of applications was also proportional compared to previous years. In 2014, REAP funding was awarded to 54% of wind project applications (15 awarded projects out of 28 applications), while in 2013, this number stood at 57%. In contrast, while solar projects account for more of the overall awards and funding than wind, the solar award rate in 2014 was 38% (240 awarded projects out of 639 applications).

Since 2003, total REAP grant funding for wind made available has exceeded $70 million, with Iowa ($22.8 million), Minnesota ($20.8 million), Illinois ($4.1 million), Ohio ($2.9 million), and Oregon ($2.8 million) being the top five states in terms of total funding received, as shown in Table 2. The top five states in terms of number of projects awarded were Iowa (262), Minnesota (158), Wisconsin (45), New York (42), and Alaska (29).

Table 2: USDA REAP Wind Funding and Awards, 2003-2014

State	Number of Awards	Grant Amount Awarded 2003-14	Total Loan Guarantee Amount Awarded
IOWA	262	$22,821,574.00	$36,146,394.00
MINNESOTA	158	$20,840,139.00	$323,729.00
ILLINOIS	13	$4,055,337.00	$0.00
OHIO	27	$2,942,698.00	$1,053,851.00
OREGON	26	$2,841,700.00	$2,268,390.00
TEXAS	16	$2,674,495.00	$0.00
WISCONSIN	45	$1,970,563.53	$896,380.00
COLORADO	7	$1,586,066.00	$0.00
IDAHO	10	$1,511,966.00	$0.00
MASSACHUSETTS	17	$1,412,763.00	$1,588,613.00
KANSAS	19	$1,324,247.00	$480,000.00
NEW YORK	42	$898,181.00	$0.00
NEBRASKA	18	$715,837.00	$1,989,250.00
WASHINGTON	7	$661,284.00	$0.00
VIRGINIA	3	$599,960.00	$0.00
OKLAHOMA	16	$572,312.00	$124,750.00
UTAH	4	$539,641.00	$0.00
ALASKA	29	$414,494.00	$0.00
SOUTH DAKOTA	8	$255,727.00	$310,000.00
MICHIGAN	11	$238,220.00	$0.00
NORTH DAKOTA	10	$199,527.00	$100,000.00
NEVADA	6	$150,832.00	$8,319.00
CALIFORNIA	5	$120,014.00	$70,000.00
NEW JERSEY	3	$88,701.00	$0.00
MONTANA	2	$60,250.00	$0.00
ARIZONA	2	$56,214.00	$0.00
MARYLAND	3	$55,191.00	$0.00
RHODE ISLAND	2	$50,991.00	$0.00
CONNECTICUT	1	$49,751.00	$0.00
NORTH CAROLINA	1	$49,625.00	$0.00
MISSOURI	4	$46,975.00	$0.00
NEW MEXICO	1	$38,569.00	$0.00
VIRGIN ISLANDS	2	$34,840.00	$0.00
WYOMING	2	$31,791.00	$0.00
GEORGIA	2	$31,609.00	$63,200.00
INDIANA	2	$31,504.00	$0.00
VERMONT	2	$31,000.00	$0.00
MAINE	1	$14,347.00	$0.00

4.2 Market Drivers

The distributed wind market faces several challenges and opportunities. The relatively low cost of electricity, driven by low natural gas prices, as well as continuing declines in solar PV costs, remain viable threats to the business model of many distributed wind turbine manufacturers, developers, and installers. Problems of acquiring project financing; the ability of small manufacturers and supply chain vendors to remain in business during market downturns; high soft costs, which are non-hardware balance-of-system costs (e.g., permitting); and concerns about actual performance of turbines are keeping the market from expanding at a faster rate. Two concrete examples from the 2014 Distributed Wind Market Report data-collection process illustrate some of these issues. A small wind turbine manufacturer reported that for one project, permitting costs increased the overall project cost by 50%. Another manufacturer reported that insurance premiums for its installer tripled when it switched from general construction insurance to wind-specific insurance coverage.

A significant innovation seen as able to increase the number of distributed wind installations in the United States is the third-party leasing model. Lease arrangements, and other third-party ownership models, allow a customer to host a wind turbine installed and owned by a third-party on the customer's property. The customer then makes monthly payments for the energy produced on-site that displaces the customer's electricity consumption and bills from the utility.

The lease can include guaranteed performance, warranties, maintenance, and insurance—thereby transferring some of the key economic and risk barriers of distributed wind, including resource uncertainty, site-assessment costs, performance uncertainty, operational maintenance and reliability risks, and the high initial cost of installations, from the customer to the lessor company.

United Wind, a main player in this space, provides an example of the impact the leasing model could have on the market. With a slower than expected start, United Wind financed five projects in New York in 2014 according to NYSERDA records. However, as of May 2015, 27 projects have been commissioned per United Wind records and NYSERDA reported receiving 40 applications so far in 2015 for program incentives for projects financed with a United Wind lease. While only demonstrated in New York thus far, distributed wind industry leaders see innovation in third-party financing as key to increasing small wind's competitiveness and are eager to expand its reach.

The Tamástslikt Cultural Institute installed a 50-kW Endurance E-3120 wind turbine in March 2014 at its Eastern Oregon location.

5.0 Project Installed and Operations and Maintenance Costs

Cost data in this section were derived from manufacturers, state and federal agencies, project owners and developers, installers, and news reports.

5.1 Installed Costs for Small Wind Turbines

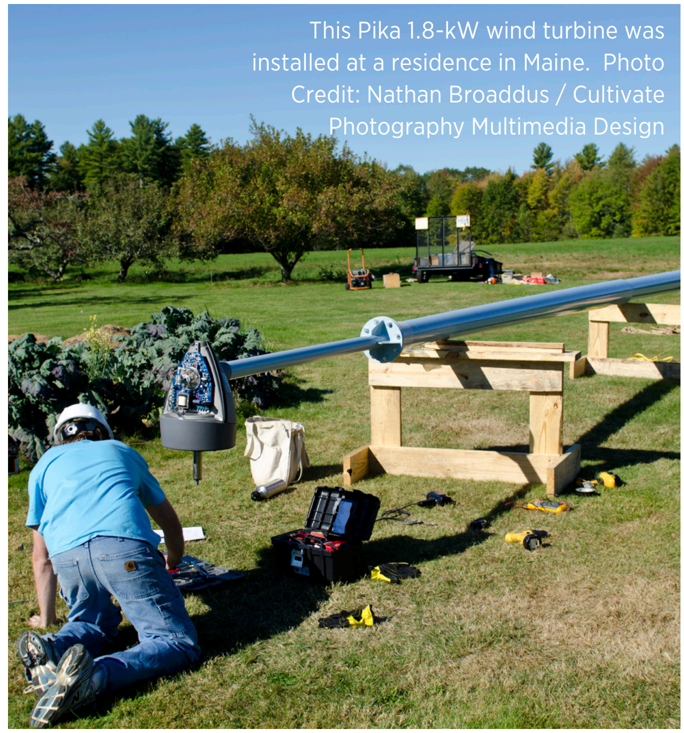
Due to substantial differences in costs of various wind turbine models, tower types and heights, and manufacturer methodology for setting nominal power ratings and estimating installation expenses, a wide range of costs were reported in 2014 for wind technologies used in distributed applications. In addition, small wind turbines range from less than 1 kW in size up to 100 kW. This large size range also dictates a large cost range. Subsequently, it is appropriate to examine costs of small wind turbines in smaller groups. Further, because of the low number of sales both in 2014 and 2013,[11] installed cost records for both years were combined to calculate the capacity-weighted average installed costs for newly manufactured small wind turbines shown in Table 3.

Table 3: 2013 and 2014 Small Wind Turbine Installed Costs

Size Range (kW)	Sample Size (kW)	# of Units	Average Cost ($/kW)
Less than 2.5	1,145	3,864	8,200
2.5 — 10	2,557	358	7,200
11 — 100	4,024	95	6,000

It is more informative to look at costs grouped by these smaller size ranges, but the average cost of all small wind turbines is a common metric. Based on small wind turbine manufacturers' reports, the overall capacity-weighted average installed cost of 2.8 MW of newly manufactured small wind turbines sold in the United States in 2014 was $6,230/kW, down from $6,940/kW in 2013 based on 5 MW of sales.

When asked what the biggest factor affecting installed cost is, U.S. manufacturers, non-U.S.-based manufacturers, and installers of small wind turbines agreed that installed cost is primarily affected by the components of the actual wind turbine (e.g., the costs of the generator/alternator, blades, tower, and gearbox/mechanical system).



This Pika 1.8-kW wind turbine was installed at a residence in Maine. Photo Credit: Nathan Broaddus / Cultivate Photography Multimedia Design

For small wind turbine models sold in the United States in 2013 and 2014, Figure 14 shows reported project-specific installation costs for a sample of projects (3.4 MW, 129 wind turbines, across 26 states). Note, this figure does not include all small wind projects installed in 2013 and 2014, only those for which cost information was available, and the project costs are before any incentives.

While only a sample of projects is represented, the data suggest a few trends. First, larger wind turbines generally exhibit a tighter range of costs and a lower cost per kW, as shown in Table 3. Second, project installed costs can range widely because of site-specific issues (e.g., foundation and construction requirements, local installation labor, and permitting requirements).

Two different projects, each deploying the same 100-kW turbines, are examples of how site-specific issues can impact a project's installed cost. The reported cost of a two turbine (200 kW) project in Alaska was almost 500% higher than the manufacturer's reported average installed cost on a per kW basis because of the construction, mobilization, road improvement, and interconnection costs required for the remote location. Another project, in an urban location, was 50% higher than average because of extensive permitting requirements.

[11]Refer to Appendix A in this report and the 2013 Distributed Wind Market Report for turbine models included in these cost estimates.

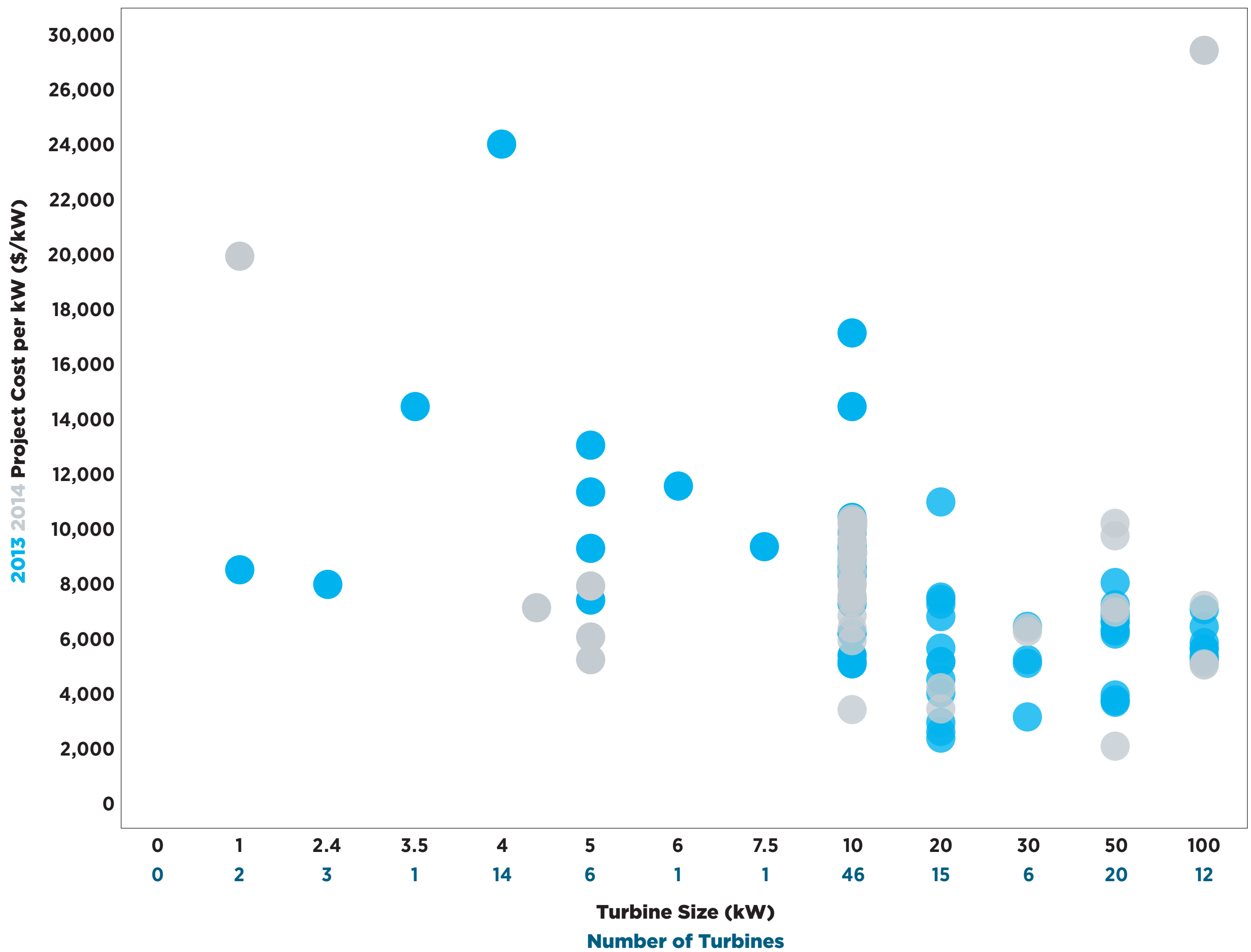


Figure 14: 2013 and 2014 Small Wind Turbine Project Costs

5.2 Installed Costs for Wind Turbines Greater than 100kW

DOE's annual Wind Technologies Market Report (Wiser and Bolinger 2015) analyzes all wind projects using turbines greater than 100 kW, including those considered to be distributed. That report presents annual installed costs in terms of both project size and individual turbine size. In both presentations, the installed costs of distributed wind projects fall within the capacity-weighted average project costs reported and typically populate the high end of those cost ranges.

The distributed wind projects tend to populate the high end of the cost ranges for two main reasons. First, with respect to project size, distributed wind projects often employ a small number of turbines, or even a single wind turbine, and these projects do not benefit from the economies of scale available to larger projects. Second, distributed wind projects using larger turbines are often installed in remote or unique locations that necessitate additional costs, such as islands (which require increased transportation costs), military installations, and manufacturing facilities (where limited site accessibility may increase labor costs).

For turbines greater than 100 kW installed in the United States in 2013 and 2014, Figure 14 shows reported project-specific installation costs for a sample of projects (24 MW and 16 turbines across 9 states). Note, this figure does not include all large-scale projects installed in 2013 and 2014, only those for which cost information was available. While Figure 15 only has a small sample size, it also demonstrates that, in general, larger wind turbines exhibit a tighter range of costs and a lower cost per kW.

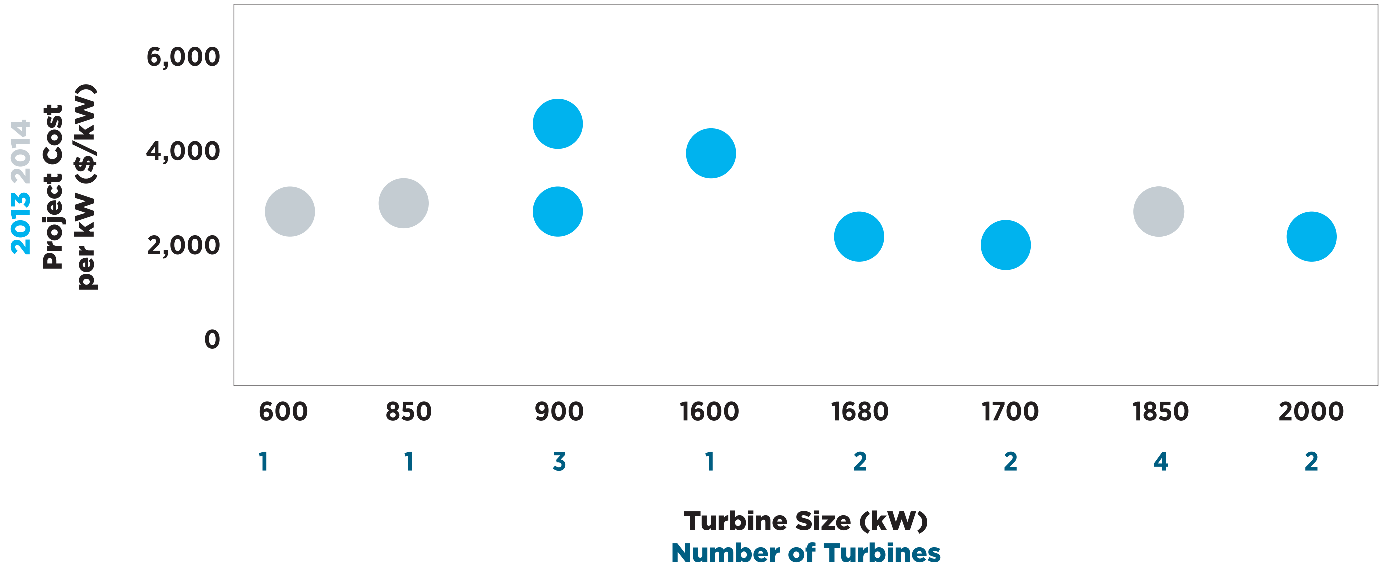


Figure 15: 2013 and 2014 Project Costs for Turbines Greater than 100 kW

5.3 Operations and Maintenance Costs

While substantial research and data-collection efforts are focused on examining project operations and maintenance (O&M) costs for large-scale wind projects, parsing out O&M costs for distributed wind projects is challenging. No distributed wind industry-standard reporting method exists for O&M costs. O&M costs can be reported on a per kW basis, a per kWh basis, or on a total annual basis and vary widely depending on the O&M provider's proximity to the project site (i.e., travel costs), support from the wind turbine manufacturer (i.e., availability of spare parts), the complexity of maintenance or repairs, and other issues. In addition, as mentioned previously, distributed wind projects typically do not benefit from the scale economies available to larger projects. For example, state labor regulations may require two technicians to be on site for a maintenance visit for safety purposes. Two technicians can service 50 turbines, but two are still required if the project has just 3 turbines.

O&M cost data for distributed wind projects collected for the National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impact model and for this and past reports from a variety of O&M service providers and wind turbine manufacturers indicate the average annual O&M cost ranges shown in Table 4. These O&M cost ranges are used in the levelized cost of energy (LCOE) calculations in Section 7.0.

Table 4: O&M Costs for Distributed Wind

Size Range (kW)	Cost Range ($/kW)
Less than 5 kW	60 — 120
5 – 10 kW	10 — 30
11 – 49 kW	20 — 25
50 – 100 kW	35 — 50
101 – 999 kW	25 — 35
Greater than 1 MW	25 — 50

6.0 Performance

A wind project's capacity factor is one way to measure the project's performance. Capacity factor is a function of a project's actual annual energy production divided by its annual potential energy production if it were possible for the wind turbine to operate continuously at its full nominal capacity.[12]

The capacity factors for a sample of 2013 and 2014 projects were calculated based on projected performance reports from developers, installers, USDA REAP, and state incentive programs (see Figure 16). The sample size is 19.3 MW from 120 projects using turbines ranging in size from 0.4 kW to 2 MW in 15 states. While covering a range of turbines, this sample only represents about 20% of the distributed wind capacity installed in 2013 and 2014. The capacity-weighted average capacity factor for these 120 projects is 25%.

The project-specific details that drive each project's capacity factor are not known, but the amount of annual energy production that can be achieved by a distributed wind project is driven by many variables, primarily the project's available wind resource and siting (e.g., tower height, local obstructions, and other micro-siting issues). For example, the capacity factors for the 44 projects using 10 kW wind turbines in this selected group of projects range from 7% to 46%, supporting the idea that siting issues strongly influence capacity factors.

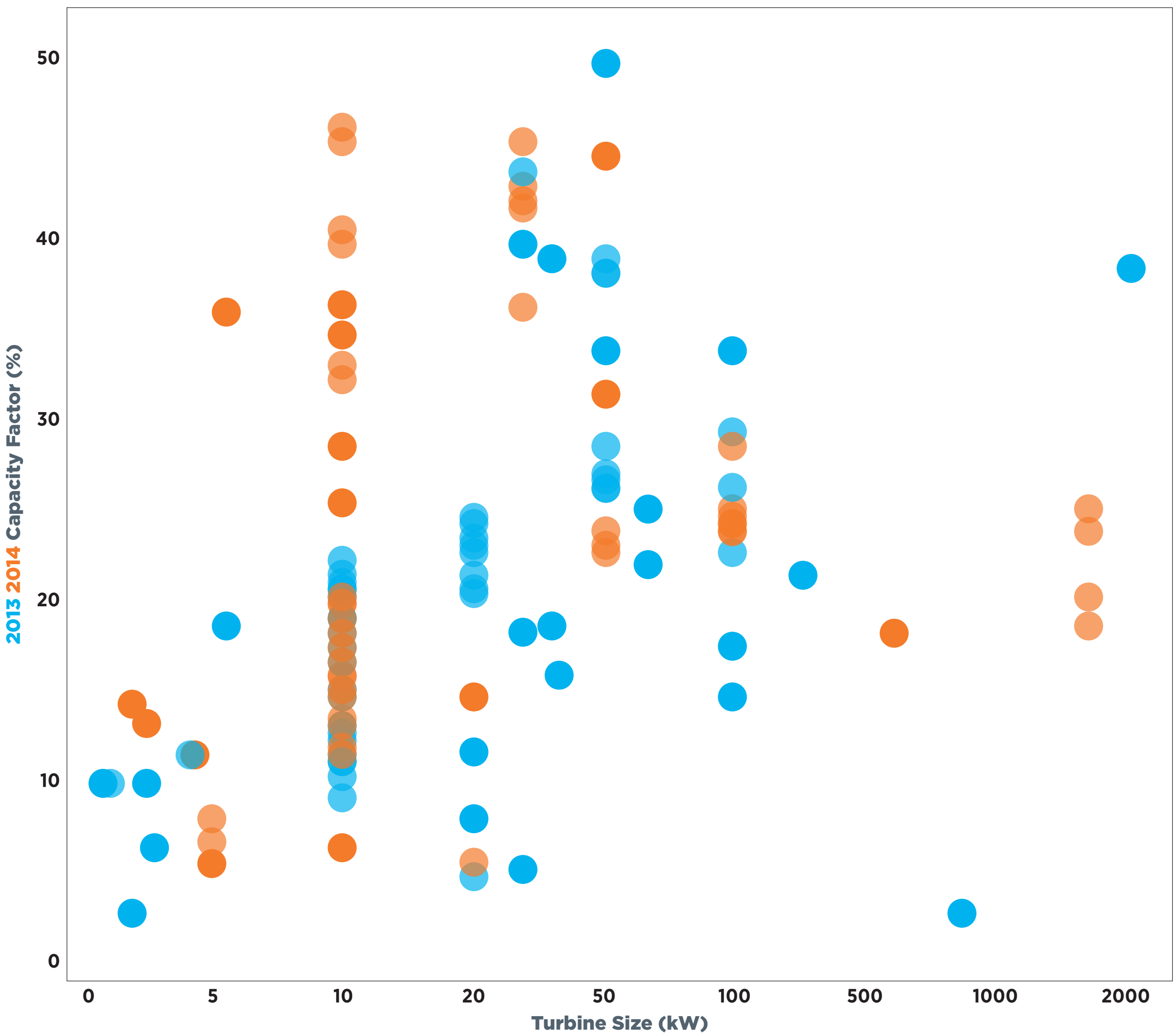


Figure 16: Capacity Factors for Selected 2013 and 2014 Distributed Wind Projects

[12]The capacity factor calculation in this report uses the turbine's nominal, nameplate capacity, not its rated capacity. A turbine's rated capacity is its power output at 11 m/s per AWEA Standard 9.1–2009.

7.0 Levelized Cost of Energy

The installed cost of the wind turbine and its performance, or capacity factor, are drivers of the project's LCOE.

LCOE is a function of a project's costs (capital and O&M) divided by its annual energy production and is therefore expressed in \$/kWh or ¢/kWh. Appendix B describes NREL's recommended method and assumptions used to calculate distributed wind LCOE (NREL 2013).

The LCOEs for a sample of 2013 and 2014 projects were calculated using records from USDA REAP and state incentive programs. The sample size is 1.45 MW from 73 projects using turbines ranging in size from 2.4 to 100 kW in 15 states. This sample size is limited to projects for which installed cost, incentive value, and generation amount were available. All dollar amounts were brought to 2014 values. O&M cost estimates were based on the ranges presented in Section 5.3. The installed capital cost for each project is reduced by the incentive award (i.e., upfront rebate or grant) for the LCOE calculation. The results of this analysis are shown in Figure 17.

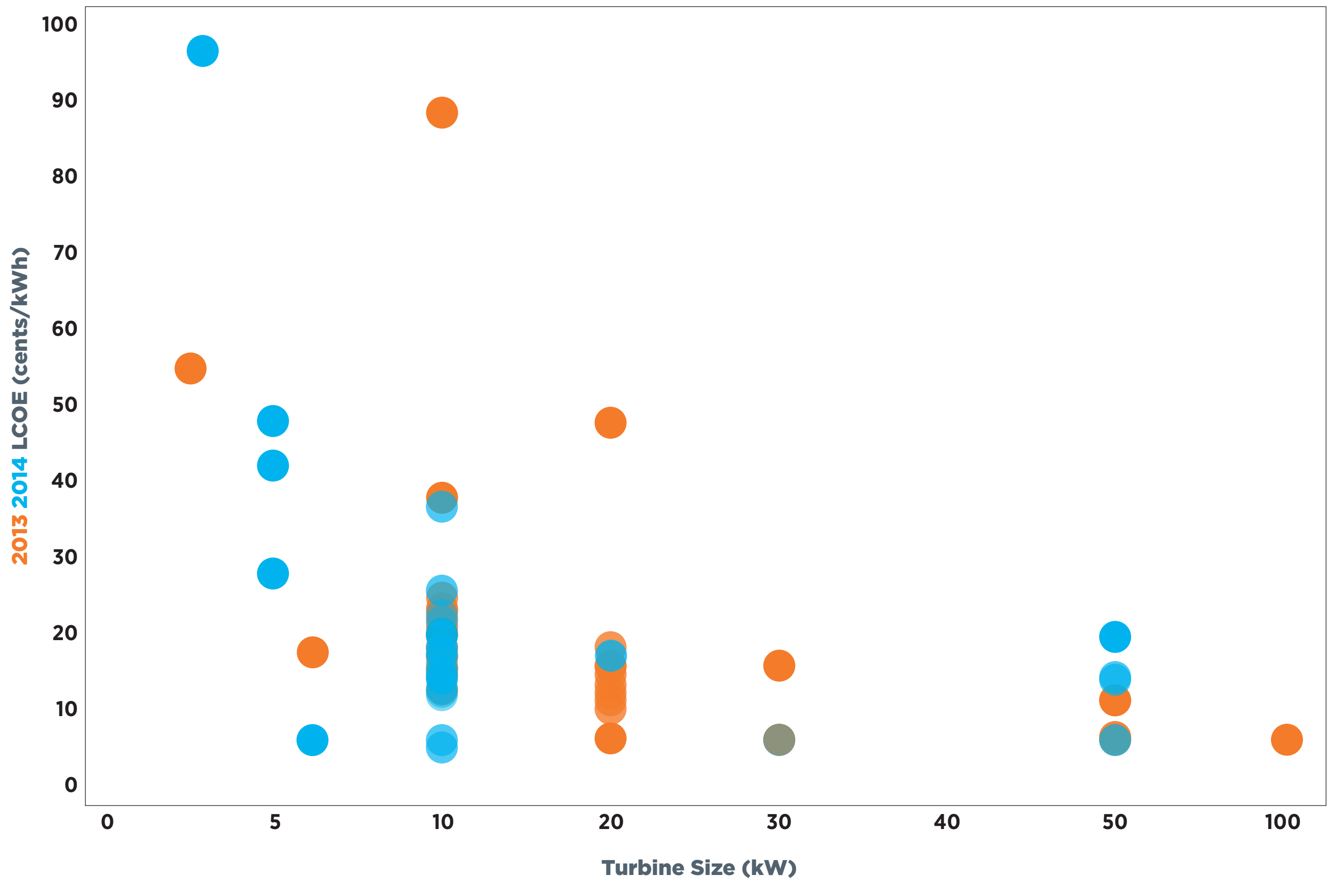


Figure 17: Levelized Costs of Energy for Selected 2013 and 2014 Distributed Wind Projects

The capacity-weighted average LCOE for these 73 projects is 12¢/kWh, but the LCOEs shown in Figure 17 vary widely because of the different installed costs and capacity factors for each project. In general, the higher the capacity factor, the lower the LCOE (as shown in Figure 18), and lower installed costs help lower the LCOE as well.

One way to lower the installed cost for the system owner is through incentives. A rebate or grant that reduces the upfront cost for the wind turbine owner significantly decreases the project's LCOE. All of the projects in this sample received this type of incentive and as a result, the average LCOE for these project owners was reduced by 30%.

According to the U.S. Energy Information Administration, average residential retail electric rates range from 8 to 20¢/kWh in the continental United States, with higher rates in Hawaii, Alaska, Puerto Rico, and the USVI (EIA 2014). The average LCOE of 12¢/kWh from these sample projects indicates that distributed wind has the potential to be cost competitive with retail electricity rates.

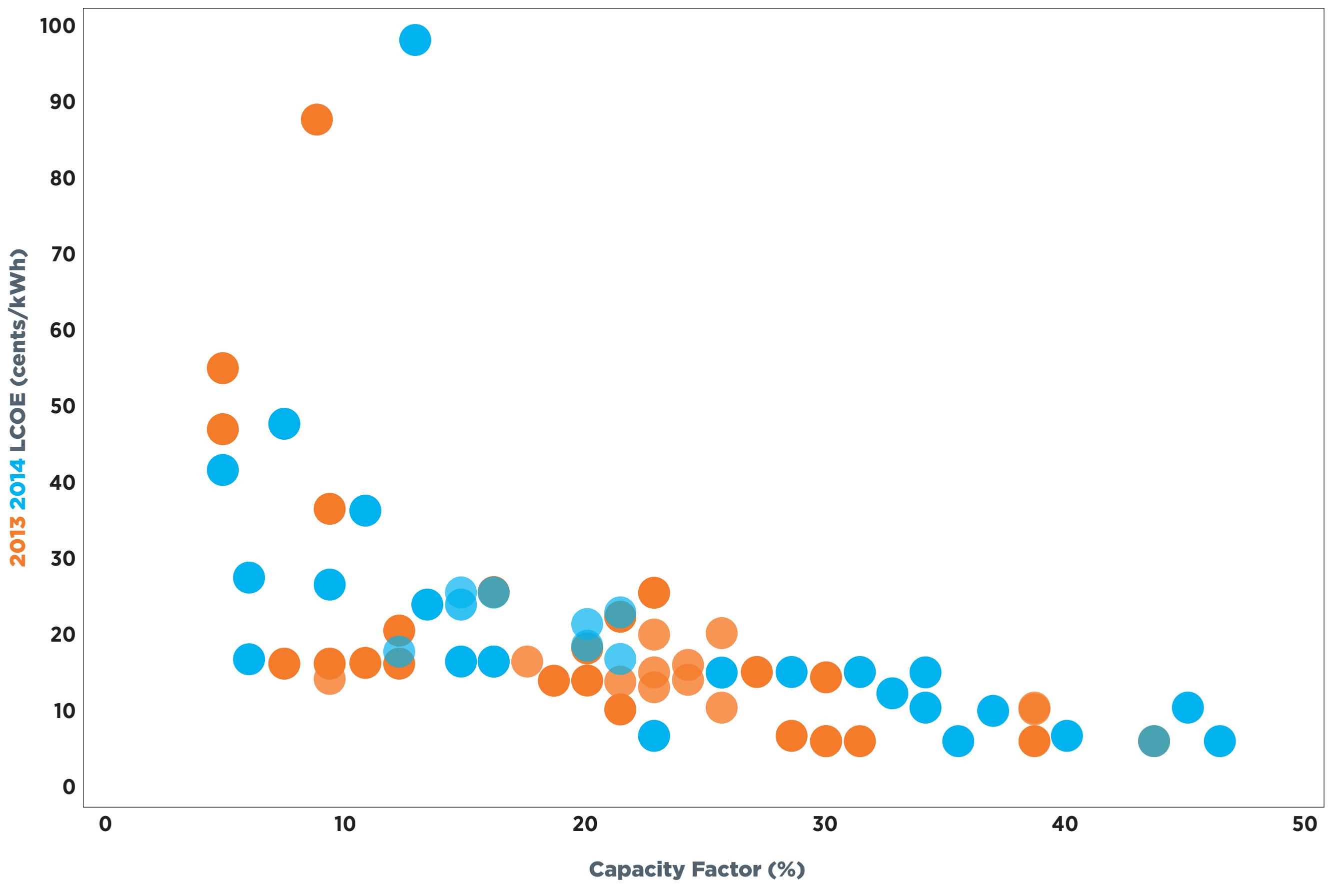


Figure 18: Levelized Costs of Energy and Capacity Factors for Selected 2013 and 2014 Distributed Wind Projects

8.0 Certification and Reliability

Building on small wind turbine certification programs initiated in 2012, the certification and reliability tracking of small and medium wind turbines continued in 2014.

8.1 Certifications and Standards for Small and Medium Turbines

Certification, or quality assurance, requirements can help prevent unethical marketing and false claims, thereby ensuring consumer protection and industry credibility.

International and domestic certification standards define wind turbines based on their rotor swept area, rather than their nominal capacity. For certification purposes, small wind turbines are those having rotor swept areas up to 200 m^2 (approximately 50 to 65 kW) and medium wind turbines are those having rotor swept areas greater than 200 m^2.

In response to market challenges related to untested technologies, unverified claims about turbine performance, and high-profile equipment failures, DOE's Wind Program has made significant investments in establishing a certification process for small and medium wind turbines, including technical standards, an accredited independent product certification body, national and regional wind turbine test facilities, and competitively awarded grants for wind turbine testing.

The Small Wind Certification Council (SWCC) (an accredited certification body), Intertek (a Regional Test Centers partner and accredited test and certification body), and other testing laboratories provide third-party verification of safety, acoustic, and performance data for small and medium wind turbines. The certifications issued by these parties allow wind turbine sellers to demonstrate compliance with regulatory and incentive program requirements. Certified ratings allow purchasers to directly compare products and funding agencies and utilities to gain greater confidence that small and medium turbines installed with public assistance have been tested for safety, function, performance, and durability and comply with standards.

As of July 2015, Interstate Renewable Energy Council reports (IREC 2015) the following certification milestones have been reached for both U.S. manufactured and imported wind turbines deployed in the United States:

- 13 different small turbine models are fully certified to AWEA Standard 9.1–2009 (as listed in Table 5)
- 4 medium wind turbine models have published power performance and acoustics certifications to International Electrotechnical Commission (IEC) 61400-12-1 (power) and IEC 61400-11 (acoustics)
- 1 small wind turbine model has limited or conditional certification
- more than 10 additional wind turbine models have conducted testing or have pending applications.

The number of turbine models in each category fluctuates at any given time. A manufacturer may have received conditional certification, but then did not meet additional requirements to obtain full certification. In addition, the SWCC requires an annual renewal of certification, and a manufacturer may opt not to renew a certification.

Table 5: Certified Small Wind Turbines (IREC 2015)

Applicant	Turbine	Certifier	Rated Annual Energy @ 5m/s	Rated Sound Level	Certified Power Rating @11 m/s
Bergey Windpower	Excel 6	SWCC	9,920 kWh	47.2 dB(A)	5.5 kW
Bergey Windpower	Excel 10	SWCC	13,800 kWh	42.9 dB(A)	8.9 kW
Endurance Wind Power	Endurance S-343	SWCC	8,910 kWh	46.4 dB(A)	5.4 kW
Eveready Diversified Products	Kestrel e400nb	SWCC	3,930 kWh	55.6 dB(A)	2.5 kW
Kingspan Environmental	KW6	SWCC	8,950 kWh	43.1 dB(A)	5.2 kW
Osiris Technologies	Osiris 10	Intertek	23,700 kWh	49.4 dB(A)	9.8 kW
Sonkyo Energy	Windspot 3.5	Intertek	4,820 kWh	39.1 dB(A)	3.2 kW
Sumec Hardware & Tools Co. LTD	PWB01-30-48	Intertek	2,920 kWh	41.1 dB(A)	1.2 kW
Sumec Hardware & Tools Co. LTD	PWA03-44-250	Intertek	6,400 kWh	40.9 dB(A)	3.2 kW
Sumec Hardware & Tools Co. LTD	PWB02-40-48	Intertek	4,660 kWh	36.9 dB(A)	1.7 kW
Sumec Hardware & Tools Co. LTD	PWA05-50-280	Intertek	9,240 kWh	42.0 dB(A)	5.0 kW
Xzeres Wind Corporation	442SR	SWCC	16,700 kWh	48.5 dB(A)	10.4 kW
Xzeres Wind Corporation	Skystream 3.7	SWCC	3,420 kWh	41.2 dB(A)	2.1 kW

8.2 Reliability

Performance, reliability, and safety data specific to distributed wind projects are difficult to isolate as distributed wind projects are typically owned by individuals, and there is no common reporting system to capture distributed wind project operations data.

A condition of SWCC certification and its annual renewal is that each certification holder (i.e., wind turbine manufacturer) must report to SWCC all complaints and disputes made against the certification holder by the wind turbine owner or any third party. To renew the certification, the certification holder must report all abnormal operating experiences, equipment failures or malfunctions, or other problems experienced over the prior year in its annual certification report. Intertek has its own certification and renewal process, which is similar to the SWCC's. Because of the relative newness of certification processes, only five small wind turbine certifications were renewed by SWCC in 2014. As the number of certified wind turbines increases, the amount of data available from the renewal process will increase, providing more insight into the reliability of small and medium wind turbines.

A certified small wind installer and tower climber performed maintenance on a Bergey 10-kW wind turbine in New York. Photo Credit: Roy Rakobitsch / Windsine Inc.

9.0 Manufacturing, Domestic Supply Chain, and Jobs

U.S.-based small wind turbine manufacturers continued to favor U.S. supply chain vendors for most of their wind turbine components. Self-reported domestic content levels for 2014 ranged from 60% to 100%. While some manufacturers reported that all of their supply chain vendors were within the United States, they did acknowledge that some U.S.-based vendors must source some of their materials from outside of the United States. In particular, while magnets were reported to be 10% or less of the overall cost of small wind turbines, all were reported as sourced from outside the United States, although sometimes obtained through U.S.-based vendors.

Manufacturing facilities and supply chain vendors for the U.S. distributed wind market are widespread. U.S. manufacturers, international manufacturers, O&M providers, installers, and developers interviewed for this report support jobs in at least 22 states.

The distributed wind industry continues to seek ways to improve its manufacturing processes to help industry drive down the cost of wind turbine components, reported to be the biggest factor affecting small wind turbine installed cost. Government support includes 1) DOE's Competitiveness Improvement Project (CIP), which aims to expand and revitalize U.S. leadership in domestic and international distributed wind markets by helping U.S. manufacturers lower the cost of energy from their turbines and 2) the Department of Commerce-funded Sustainable Manufacturing, Advanced Research & Technology (SMART) Wind Consortium led by the Distributed Wind Energy Association, launched in 2014.

CIP ENABLES COMPANY TO DEVELOP ADVANCED MANUFACTURING PROCESS THAT DRAMATICALLY REDUCES COSTS

The DOE's CIP aims to help U.S. manufacturers that produce distributed wind systems to lower the cost of energy from their turbines and increase their market competitiveness. By focusing on component and manufacturing process improvements and turbine testing, the cost-shared CIP awards help small and mid-size wind turbine companies improve their system designs and earn certification that shows they have met performance and safety requirements.

Funding awarded under the CIP to Pika Energy of Westbrook, Maine enabled the company to develop an advanced blade manufacturing process that dramatically lowered manufacturing costs and to develop, test, and successfully commercialize a new small wind system.

One key technology breakthrough was Pika Energy's low-cost, high-performance injection-molded wind turbine blade. Conventional wind turbine blades are a major cost driver, requiring significant manual craftsmanship to achieve aerodynamic performance, structural integrity, and low weight. Pika's innovation was to develop a tooling design and cooling strategy that enables them to produce blades using injection-molded plastic—a low-cost, mass-manufacturing process.

Pika Energy's injection molding tool for manufacturing wind turbine blades. Photo Credit: Pika Energy, NREL 33941

Pika sent their state-of-the-art blades to the National Wind Technology Center at the NREL where they were subjected to millions of cycles of fatigue testing that demonstrated their endurance and ability to operate reliably for decades. The company then incorporated the new blades on its T701 wind system that was sent to the High Plains Regional Test Center for certification testing and the turbine was successfully commercialized in 2014.

The CIP funding provided by DOE and the technical support provided through DOE by NREL were key to enabling Pika Energy to develop and test its innovative manufacturing process that reduced the end-user cost of its wind turbine by more than $3,000.

COMMERCE DEPARTMENT FUNDS DWEA TO DEVELOP CONSORTIUM-LED SMART WIND ROADMAP

The U.S. Department of Commerce's National Institute of Standards and Technology (NIST) awarded the Distributed Wind Energy Association (DWEA), supported by eFormative Options and Wind Advisors Team, a two-year grant to form an industry-driven consortium of distributed wind turbine and component manufacturers, academic researchers—and stakeholders throughout the entire supply chain—to address high-priority research challenges, drive growth of U.S. advanced manufacturing, and sustain an edge in a growing global market.

DWEA's team has convened a targeted SMART Wind Consortium and is working to develop a consensus-based, shared-vision Distributed Wind Technology Roadmap that identifies common distributed wind near-term technology and manufacturing gaps and barriers, prioritizes solutions to those gaps, and facilitates a rapid transfer of innovation for the full lifecycle of the wind turbine into American-manufactured products.

The goal of all SMART Wind Consortium activities is to identify and prioritize technical and manufacturing breakthrough opportunities for cost reduction of U.S.-manufactured goods sold, strengthening the capacity and success of U.S. manufacturers.

Project objectives include:

- Identifying and addressing major technological and related barriers that inhibit the growth of advanced U.S. distributed wind manufacturing by building an industry-based Consortium with all of the industry's key stakeholders to reach consensus on near-term research and advanced manufacturing opportunities and actions.

- Connecting more than 100 existing and new collaborators to form consensus on near-term and mid-term actions needed to increase cost competitiveness through advanced manufacturing techniques and other strategies identified in the Roadmap.

- Accelerating university-based research to develop innovative technology solutions and facilitate deployment into U.S. design that is supported through advanced U.S. manufacturing, increasing the number of American jobs throughout the distributed wind supply chain.

- Reducing the LCOE of installed distributed wind turbines by at least 25%, with a goal of achieving parity with U.S. retail electricity grid rates in more markets.

- Integrating NIST work with other federal and state government opportunities, namely to unite strategies and complement DOE's distributed wind efforts.

The SMART Wind Consortium has hosted five face-to-face meetings with 110 unique attendees from October 2014 through March 2015, a Launch meeting and four subgroup kickoff meetings, and plans to host a meeting and survey tools to assist with roadmap prioritization. In addition, monthly virtual meetings are convened with members of the four Consortium subgroups: mechanical systems, support structures, electrical systems, and composites to discuss specific topics identified.

Each of these SMART Wind Consortium subgroups includes U.S. distributed wind original equipment manufacturers, U.S. component manufacturers, and university and laboratory researchers. The goal of these meetings, along with follow-up conference calls, is to become acquainted with the interested stakeholders and to brainstorm possible cost-reducing strategies that will lead to evolutionary product and manufacturing improvements.

Troy Patton, CEO of Northern Power Systems noted that in order for the U.S. distributed wind industry to remain leaders in this important space, it is critical to increase collaboration and improve product offerings through the advancement of technology while driving down component costs. Representatives from Northern, Bergey Windpower, Pika Energy, Primus Wind Power and several other leading original equipment manufacturers are serving as advisors for the SMART Wind Consortium and the Roadmap.

The SMART Wind Roadmap, the final project deliverable to be completed in Spring 2016, will help federal project managers select future funding opportunities that move U.S. distributed wind manufacturers into a more globally competitive position.

10.0 Outlook

After the precipitous drop of installations from 2012 to 2013, the U.S. market for distributed wind systems may be making its way towards a new normal. Fewer domestic and international companies reported sales in the United States, while important incentive programs, including the U.S. Treasury Section 1603 cash grant payments, have ended, leading to a consolidation of the industry and reduced installations compared to the 2008 through 2012 timeframe. At the same time, new financing schemes and certification requirements, continued success in exports, and the continuation of existing grant and loan programs are shaping the future of the U.S. distributed wind market.

A boost for the domestic market could come from wind lease programs expected to see growth in 2015. Industry stakeholders see innovation in wind financing from third-parties as key to maintaining small wind's competitiveness.

Another driver is the U.S. Internal Revenue Service's requirement as of February 2015 that small wind turbines meet either the AWEA Small Wind Turbine Performance and Safety Standard 9.1–2009 or the IEC 61400-1, 61400-12, and 61400-11 standards to be eligible for the federal 30% ITC. Small wind turbines are the only technology that has a certification requirement to qualify for the ITC. This is in contrast to other competing technologies; for example, solar PV, which have suffered performance issues (Woody 2013). Meeting performance and quality standards through the certification process presents both challenges and opportunities for manufacturers and is likely to affect the small wind industry in several ways. From raising the competitiveness, to increasing consumer, government agency, and financial institution confidence in distributed wind projects, this measure might strengthen the industry and further deployment, but undergoing the certification process is a business investment decision that can be costly for a manufacturer.

Exports continue to provide a steady source of revenue for U.S. small wind turbine manufacturers who see growing potential in the opening and expansion of markets abroad, such as Japan and South Korea. Northern Power has made inroads in South Korea, where it is building wind turbines in a series of wind-diesel hybrid system that also incorporate solar PV and energy storage (Wijnberg 2014). The success of these efforts could both strengthen U.S. manufacturers and support the U.S. goal of increasing the number of U.S.-based companies competing in overseas markets.

Funding for wind projects from USDA REAP grants was considerably lower than in previous years, but the stable and increased levels of funding authorized for 2015 and beyond provide a positive future outlook for the U.S. distributed wind market. These new funding levels are vital for distributed wind projects in the agricultural sector, which represented 34% of all distributed wind projects in 2014.

The outlook for the distributed wind market remains mixed, with several factors able to either grow or impede the market. Positive market drivers include wind lease programs, the IRS certification requirement, and new export markets for domestic manufacturers. Negative market drivers include the low price of substitutes, most notably solar PV, the inability of some supply chain vendors and manufacturers to weather market lulls, and the lack of stable state and federal policies. More U.S manufacturers of small and mid-sized turbines may follow the example of international manufacturers and further rely on non-U.S. sales to maintain steady business levels.

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APPENDIX A WIND TURBINE MANUFACTURERS AND SUPPLIERS

This report reflects 2014 sales and installations from the manufacturers and suppliers listed below. Others who provided information and/or only had international sales are recognized in the Acknowledgments section.

Manufacturer	Model Names	Headquarters
U.S. SMALL WIND TURBINES (UP THROUGH 100 KW)		
Bergey Windpower	Excel 1, 6, R, 10	Oklahoma
Halus Power	Refurbished Vestas V17	California
Northern Power Systems	Northern Power 100-21C, 100-24C	Vermont
Pika	T701	Maine
PowerWorks	PowerWorks 100 (new/rebuilt)	California
Primus Windpower	AIR 30/AIR X Marine, AIR 40/AIR Breeze	Colorado
UGE International	HoYi!, VisionAIR3, VisionAIR5, UGE-4K, eddyGT	New York
Ventera Wind, Inc	VT10-240-4	Minnesota
Weaver Wind Energy	Weaver 5	New York
Wind Turbine Industries Corp.	Jacobs 31-20	Minnesota
XZERES (partial)	442, Skystream	Oregon
INTERNATIONAL SMALL WIND TURBINES		
Endurance	E-3120, X-29	Canada
Osiris	Osiris 10	China
Potencia	Hummingbird 5, 10	Mexico
Sonkyo Energy	Windspot 3.5	Spain
WIND TURBINES (GREATER THAN 100 KW) IN 2014 U.S. DISTRIBUTED PROJECTS		
Gamesa	G114-20, G52-850	Spain
GE Energy	1.85-82.5, 1.85-87	United States
PowerWind	56-900	Denmark
RRB Energy	PS-600	India
Siemens	SWT-2.3-101	Germany
Vestas Wind Systems	V100-2.0, V82	Denmark

APPENDIX B METHODOLOGY

The Pacific Northwest National Laboratory (PNNL) team issued data requests to more than 150 distributed wind manufacturers, suppliers, developers, installers, operations and maintenance (O&M) providers, state and federal agencies, utilities, and other stakeholders and compiled responses and information from the sources listed in the Acknowledgments section to tabulate the deployed U.S. and exported distributed wind generation capacity and associated statistics at the end of 2014.

Most of the data used in this study were obtained directly from industry members and agencies through email contact, telephone interviews, or both. For distributed wind projects using turbines greater than 100 kW, the PNNL team reviewed the American Wind Energy Association's (AWEA's) project records, verified project details, and provided feedback to AWEA as needed. Some decommissioned and pending projects were not included in the cumulative tally, based on operational status noted in the AWEA database; however, the cumulative figures principally represent annual capacity additions rather than confirmed operating installations.

A master project database was created to capture all known projects installed in 2014. Projects recorded in the master database were assessed on a per project basis to determine if they met the U.S. Department of Energy definition of distributed wind. Records from manufacturers and suppliers, O&M providers, AWEA, and agencies were combined into the master database with a row for each 2014 project reported. Sales and installation reports from manufacturers, dealers, and developers were cross-referenced with records provided by agencies to identify and combine information from duplicate records. Notes were made in instances of conflicting information (e.g., incentive award amounts, installed costs, and installation dates) as to which sources were used. The PNNL team also reviewed and cross-checked wind project listings published by Open Energy Information, Federal Aviation Administration, U.S. Geological Survey, U.S. Energy Information Administration, U.S. Environmental Protection Agency, and other sources. Installation dates for any projects identified that were not already in AWEA records or reported by manufacturers or agencies were verified and added to the master database. Projects reported for 2014 were cross-checked against previous records to avoid double counting.

For small wind turbines (i.e., those up through 100 kW), this study reports capacity figures for the same calendar year as the reported sales for the purpose of tallying annual deployed capacity. However, some installations occur after the calendar year in which the wind turbines were sold. Small wind turbine sales for which there are project-specific records are also added to the master database. U.S. sales presence for small wind turbines is defined as suppliers documenting at least one sale in the United States in 2014.

The total number small wind turbine units, total capacity deployed, and the estimated investment value were based on suppliers' sales reports. Project records from agency reports were the primary source for the state breakdowns of small wind turbine capacity. Incentive payments and reports often lag behind, though they occasionally pre-date sales reports; however, incentive payments are tallied and reported for the year in which they are granted, regardless of time of installations, based on the best information available at the time of the report.

Cross-referencing data sources allows for greater certainty, but a data gap remains regarding the tally of units deployed per state. The 2014 master database documents slightly greater total capacity than the total 2014 small wind sales capacity reported by manufacturers and suppliers, but the database still only captures about 24% of the 1,700 units reported sold. Most of the 2014 units sold were not tracked on a project basis. The PNNL team used a variety of public (as listed in the Acknowledgments section) and some private sources of data to compile the installed costs. In some instances, installed cost figures are estimated based on reported incentive values.

Quantitative data requested for 2014 included the number of units sold of each model both in and out of the United States, capacity installed, project locations (city or county and coordinates), estimated installed costs and O&M costs per year, production data or estimates, installer or developer, power purchaser/utility, tower heights and types, top export markets, application type, breakdowns of project and wind turbine cost components, and employment estimates. Qualitative questions included details about funding available, project financing mechanisms, interconnection types, ownership structures, solar-specific incentives and installations, and remanufacturing. The level to which all of these questions were answered varied among responders, thus sample sizes are included with certain analysis presentations as needed.

The levelized cost of energy (LCOE) calculations in Section 7.0 used the following formula:

$$\mathrm{LCOE} = \frac{(\mathrm{FCR} \times \mathrm{ICC})}{\mathrm{AEPnet}} + \mathrm{AOE}$$

WHERE
FCR = fixed charge rate = (0.05), representing a 20-year project life
ICC = installed capital cost ($)
AEPnet = net annual energy production (kWh/yr)
AOE = annual operating expenses ($/kWh) ≡ O&M + LRC
O&M = levelized O&M cost ($/kWh)
LRC[1] = levelized replacement/overhaul cost ($/kWh)

[1]For simplicity, and lack of data to determine what an appropriate LRC would be, the LRC is excluded from the LCOE calculations in this report.

RESOURCES

AMERICAN WIND ENERGY ASSOCIATION
awea.org

DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY
dsireusa.org

DISTRIBUTED WIND ENERGY ASSOCIATION
distributedwind.org

DISTRIBUTED WIND POLICY TOOL
windpolicytool.org

INTERSTATE TURBINE ADVISORY COUNCIL
cesa.org/projects/ITAC/itac-unified-list-of-wind-turbines/

INTERTEK SMALL WIND CERTIFICATION PROGRAM DIRECTORY
intertek.com/wind/small/directory/

LAWRENCE BERKELEY NATIONAL LABORATORY
lbnl.gov

NATIONAL RENEWABLE ENERGY LABORATORY
nrel.gov

PACIFIC NORTHWEST NATIONAL LABORATORY
pnnl.gov

SMALL WIND CERTIFICATION COUNCIL
smallwindcertification.org

U.S. DEPARTMENT OF ENERGY WIND PROGRAM
wind.energy.gov

Cover Photo: This 100-kW Northern Power Systems wind turbine is installed at a recycling facility in Brooklyn, New York. Photo credit: Aegis Renewable Energy; Waitsfield, Vermont.

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

FOR MORE INFORMATION, VISIT: energy.gov/eere/wind/distributed-wind

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