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WIND PROGRAM

2013 Distributed Wind Market Report

August 2014

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

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2013 Distributed Wind Market Report

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Executive Summary

U.S. Distributed Wind Market Highlights
2013 distributed wind: **30.4 MW, 2,700 units, $90 million value**
2013 turbines greater than 100 kW: **24.8 MW, 18 units, $54 million value**
2013 small wind: **5.6 MW, 2,700 units, $36 million value**
2013 top states for distributed wind: **CO, KS, OH, MA, AK, IN, ND**
2013 top states for small wind: **NV, IA, MN, OK, NY, TX, HI**
2013 small wind turbine exports: **13.6 MW, 2,900 units, $103 million**
2003-2013 cumulative distributed wind: **842 MW**
2003-2013 cumulative small wind domestic sales: **137 MW**
2003-2013 cumulative small wind exports: **73 MW**

In 2013, 30.4 megawatts (MW) of new distributed wind capacity was added, representing nearly 2,700 units across 36 states, Puerto Rico, and the U.S. Virgin Islands (USVI). Since 2003, nearly 72,000 wind turbines have been deployed in distributed applications across all 50 states, Puerto Rico, and the USVI, totaling 842 MW in cumulative capacity. The 83% decline from 2012 to 2013 of distributed wind capacity additions is in line with the 92% decline from 2012 to 2013 in overall U.S. wind capacity deployed.

To compensate for weaker domestic sales, U.S. small wind turbine manufacturers shifted their focus to growing international markets. Exports from U.S.-based small wind turbine manufacturers increased 70% from 8 MW in 2012 to 13.6 MW in 2013. U.S. small wind turbines were exported to more than 50 countries in 2013, with top export markets identified as Italy, UK, Germany, Greece, China, Japan, Korea, Mexico, and Nigeria. In 2013, 76% of U.S. manufacturers' new small wind sales capacity went to non-U.S. markets, a substantial increase from 57% in 2012.

The purpose of this report is to quantify and summarize the 2013 U.S. distributed wind market to help plan and guide future investments and decisions by industry, utilities, state and federal 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 on turbine or project size. While the distributed wind market includes wind turbines and projects of many sizes, this report breaks the market into two segments when appropriate: wind turbines up through 100 kW (in nominal capacity) referred to in this report as "small wind," and wind turbines greater than 100 kW used in distributed applications.

Residential applications accounted for 40% of U.S. distributed wind deployed in 2013, followed by agricultural for 26%, industrial and commercial for 20%, and government and institutional for 14% on a per project basis. Off-grid small wind turbine models continue to account for the bulk of wind turbine *units* deployed in U.S. distributed wind applications, but wind turbines connected to the distribution grid, or "grid-tied" applications, accounted for more than 97% of the annual domestic distributed wind *capacity* (in terms of MW).

U.S. suppliers continued to dominate the domestic market for small wind, claiming 93% of 2013 domestic small wind sales on a unit basis. On a capacity basis, U.S. suppliers claimed 88% of 2013 domestic small wind capacity, up from 86% in 2012. The 2013 combined U.S.

market for new and refurbished small wind turbines accounted for $36 million in investment from nearly 2,700 units sold; however, this represented a 70% decline in capacity from 18.4 MW in 2012 (3,700 units and $101 million in investment) to 5.6 MW in 2013.

Reported 2013 U.S. distributed wind deployments of all sizes encompassed 69 different wind turbine models ranging from 100 watts (W) to 2 MW from 38 suppliers with a U.S. sales presence. Eight of the top ten models of all 2013 wind turbines deployed in U.S. distributed applications (on a unit basis) were manufactured by suppliers headquartered in the United States.

Of the 30.4 MW of distributed wind capacity deployed in 2013, nearly 82% (24.8 MW) is from 9 projects using turbines greater than 100 kW, for a total of 18 units, in Colorado, Kansas, Ohio, Massachusetts, Alaska, Indiana, North Dakota, and Puerto Rico. Nevada, Iowa, Minnesota, Oklahoma, New York, Texas, and Hawaii led the nation for 2013 small wind sales. Texas, Minnesota, and Iowa retained their positions as the top three states with the most distributed wind capacity deployed since 2003. Iowa, Nevada and California remained the leading states for cumulative small wind capacity. A total of 14 states now have more than 10 MW each of distributed wind capacity.

A total of $15.4 million in federal, state, and utility incentives were awarded to distributed wind projects in 2013, but significant imbalances between solar and distributed wind incentive funding levels exist in several states. This total amount contrasts strongly to 2012 during which over $100 million in such incentives were awarded. With respect to the discrepancy between solar PV and distributed wind funding at the state level, New Jersey provides a strong example with $363 million of awards to solar PV projects compared to $6 million to distributed wind projects since 2003.

The capacity-weighted average installed cost of newly manufactured 2013 small wind turbines sold in the United States was $6,940/kW. However, due to substantial differences in the costs of various wind turbine models as well as tower types and heights, foundation requirements, local installation labor, and other issues, installed costs range widely.

Installed cost and wind turbine energy production (i.e., capacity factor) drive a wind project's levelized cost of energy (LCOE). In general, the higher the capacity factor, the lower the LCOE. 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). The capacity-weighted average capacity factor for a selected group of distributed wind projects installed between 2006-2013 analyzed for this report is 15%, and their capacity-weighted average LCOE is 14¢/kWh.

The U.S. distributed wind energy supply chain is comprised of hundreds of manufacturing facilities and vendors spread across at least 34 states, with at least 31 facilities actively assembling, manufacturing, or refurbishing wind turbines used in distributed applications; at least 17 facilities manufacturing wind turbine blades and other composites; at least 12 facilities producing wind turbine towers; at least 10 facilities producing drive trains and other electrical components; dozens manufacturing wind turbine mechanical components; and numerous other facilities involved in the manufacturing supply chain (e.g., materials and construction equipment suppliers, financiers, and insurance and other service providers).

Installed distributed wind capacity is expected to be higher in 2014. Although new capacity additions of all applications of wind turbines were down in 2013, the American Wind Energy Association (AWEA) reported that over 12,000 MW of wind capacity were under construction at the end of 2013 and up to 130 MW of that may be considered distributed wind.

From an industry perspective, distributed wind stakeholders generally agreed that 2013 was a difficult year for the domestic market and that exports "saved the day" for many small wind turbine manufacturers. Most stakeholders interviewed for this report indicated, however, that the next two years should be better, but not dramatically due to barriers such as state incentive programs for distributed wind remaining stalled or lethargic; the expiration of important federal incentives such the ITC for turbines greater than 100 kW, the U.S. Treasury 1603 Program, and bonus depreciation; and the advantages in many applications of solar PV (i.e., better financing, lower prices, easier siting, and technology-specific incentives). However, positive notes include stable funding for U.S. Department of Agriculture Rural Energy for America Program, which will have mandatory funding of $50 million per year for 2014 through 2018, additional wind turbine certifications in process, and new financing models.

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 are allowing purchasers to directly compare products, and helping 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. As of July 2014, 13 small wind turbine models are fully certified to AWEA Standard 9.1 – 2009, 2 medium wind turbine models have published power performance and acoustics certifications to IEC 61400-12-1 (power) and IEC 61400-11 (acoustics), 8 small and medium wind turbine models have limited or conditional certifications, and more than 20 additional wind turbine models have conducted testing or are pending applications.

Building on the success of third-party financing options for solar photovoltaics, several leading distributed wind industry members are now offering long-term leases, with guaranteed performance, warranties, maintenance, and insurance. These dramatically reduce up-front costs to customers. These products address key distributed wind economic and risk barriers including resource uncertainty, site-assessment costs, performance uncertainty, operational maintenance and reliability risks, and the high initial cost of installations. They are also designed to leverage state and federal incentives, site wind resources, and customer interests. Distributed wind industry leaders see innovation in third-party financing as key to maintaining small wind's competitiveness and are eager to expand its reach.

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Acronyms and Abbreviations

AWEA	American Wind Energy Association
CEC	Clean Energy Center
DOE	U.S. Department of Energy
DSIRE	Database of State Incentives for Renewables and Efficiency
DWEA	Distributed Wind Energy Association
GE	General Electric
IEC	International Electrotechnical Commission
ITC	investment tax credit
KEA	Kotzebue Electric Association
kW	kilowatt
kWh	kilowatt-hour
LCOE	levelized cost of energy
m	meter
MACRS	Modified Accelerated Cost-Recovery System
MW	megawatt
MWh	megawatt-hour
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
O&M	operations and maintenance
PNNL	Pacific Northwest National Laboratory
PTC	production tax credit
PV	photovoltaics
REAP	Rural Energy for America Program
SGIP	Self-Generation Incentive Program
SWCC	Small Wind Certification Council
USDA	U.S. Department of Agriculture
USVI	U.S. Virgin Islands
W	watt
WWPTO	Wind and Water Power Technologies Office

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1.0 Introduction

The purpose of this report is to quantify and summarize the 2013 U.S. distributed wind market to help plan and guide future investments and decisions by industry, utilities, state and federal agencies, and other interested parties. Distributed wind is poised to play a growing role in the rapidly expanding distributed generation market, which is expected to contribute an increasing amount of the incremental generation capacity growth in the coming years, according to industry analysts (eFormative 2014). The rise in distributed generation is leading to a fundamental shift in the utility business model, with some utilities responding to the disruptive challenge as an unwanted threat. However, many utility professionals are now viewing distributed generation as an important opportunity for direct involvement (i.e., through owning and leasing distributed assets or through partnerships to supply distributed generation to their customers) and for opening up a new avenue of utility revenue (Utility Dive 2014).

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 on turbine or project size. Distributed wind is the use of wind turbines, off-grid[1] or grid-connected, at homes, farms and ranches, businesses, public and industrial facilities, and other sites to offset all or a portion of the local energy consumption at or near those locations, or 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 subsequent 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-kilowatt (kW) 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 any large facility. On-site distributed wind turbines allow farmers, 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.

1.1 Wind Turbine Size Classification

The distributed wind market includes wind turbines and projects of many sizes, and this report breaks the market into two segments when appropriate: wind turbines up through 100 kW (in

[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.

nominal capacity) referred to in this report as "small wind," and wind turbines greater than 100 kW used in distributed applications.[3]

While international and domestic standards define small wind turbines as having rotor swept areas up to 200 square meters (approximately 50 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, explained in Section 3.1.1. The U.S. Department of Energy's (DOE's) annual *Wind Technologies Market Report* (Wiser and Bolinger 2014) 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.

1.2 Market Application

This report considers four main market applications for distributed wind: 1) residential, 2) agricultural, 3) industrial and commercial, and 4) government and 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 and commercial applications can be large manufacturing facilities, food processing plants, small businesses, oil and gas operations, and telecommunications sites. Government and institutional applications include schools, universities, military sites, and municipal facilities (e.g., water treatment plants). About 99% of 2013 distributed wind projects were single-turbine projects. Figure 1a shows the breakdown of market applications by number of projects; Figure 1b provides a breakdown of market applications by capacity.

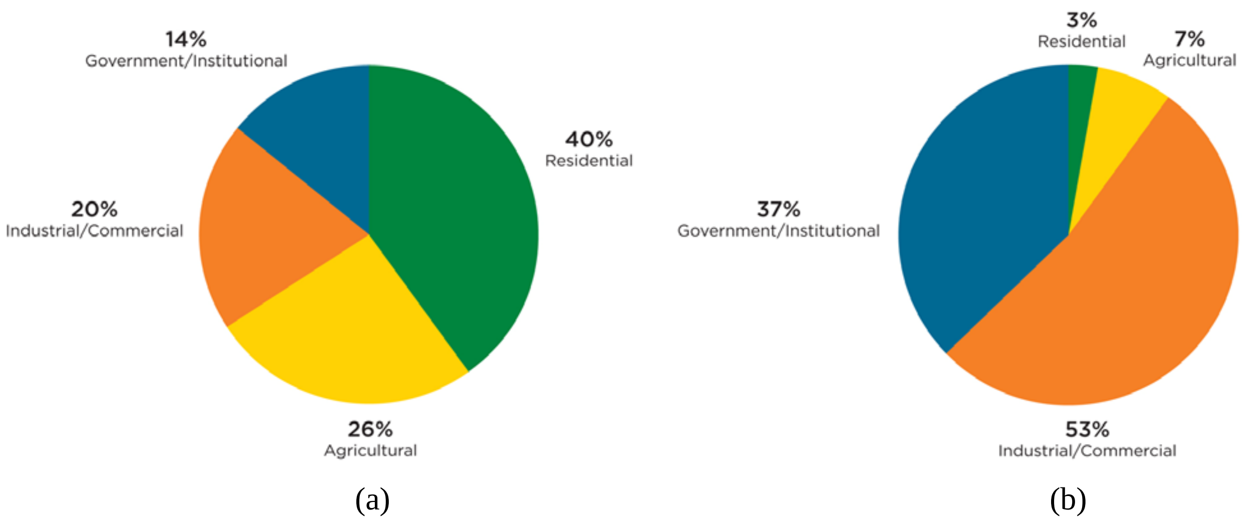


Figure 1: 2013 Distributed Wind Market Applications (a) by Project and (b) by Capacity

[3] In the 2012 report, the market was divided into three groups: small, mid-size (101 kW to 1 MW), and utility-scale (greater than 1 MW). Due to the small amount of projects using turbines greater than 100 kW in 2013, only two market segments were analyzed in this report.

Newly manufactured wind turbines are used across all market applications; refurbished wind turbines (i.e., reconditioned equipment emerging primarily from California wind farm repowering)[4] are most often seen with agricultural projects.

[4] 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. In any case, a refurbished wind turbine is not a newly manufactured turbine and is typically sold by a third-party company, not the original manufacturer.

2.0 U.S. Distributed Wind Deployment

Between 2003[5] and the end of 2013, nearly 72,000 wind turbines were deployed in distributed applications across all 50 states, totaling 842 megawatts (MW) in cumulative capacity (Figure 2). In 2013, 30.4 MW of new distributed wind capacity was added, representing nearly 2,700 units across 36 states, Puerto Rico, and the U.S. Virgin Islands (USVI).

The 83% decline from 2012 to 2013 of annual distributed wind capacity additions is in line with the 92% decline from 2012 to 2013 in overall U.S. wind capacity installations, reflecting changes to, and the expiration of, the federal production tax credit (PTC), in addition to the phased-out U.S. Treasury 1603 Program (i.e., the cash grant in lieu of the 30% ITC) and other reduced state and federal programs.

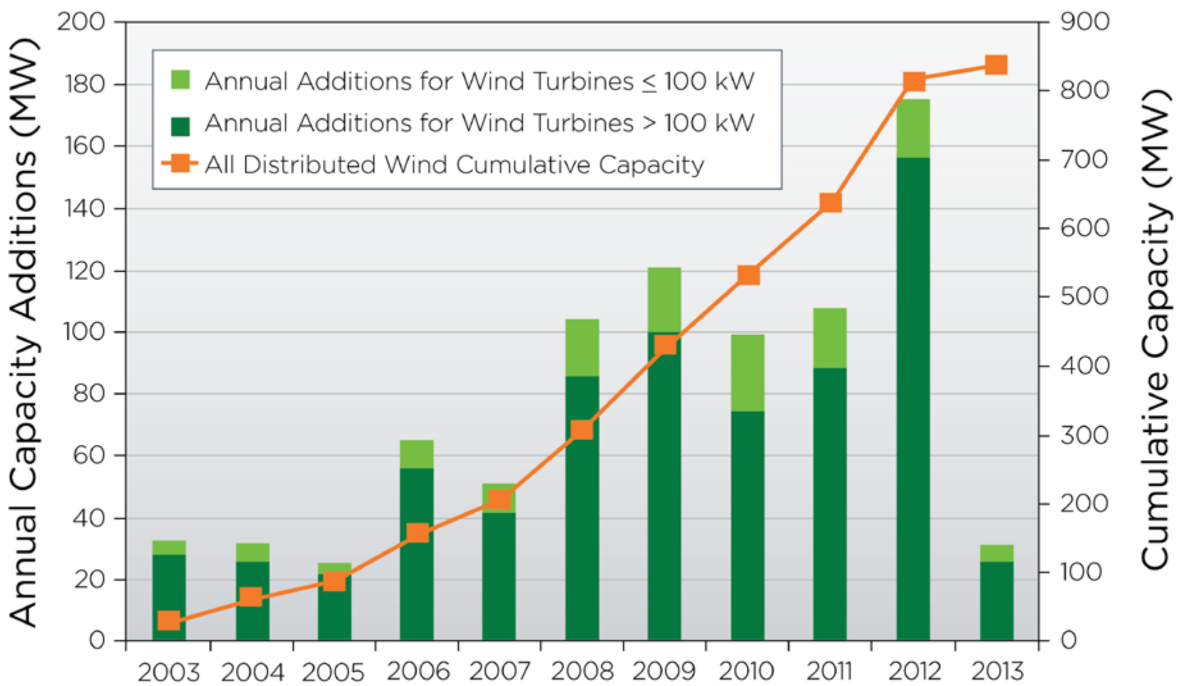


Figure 2: U.S. Distributed Wind Capacity

Of the 30.4 MW of distributed wind capacity deployed in 2013, nearly 82% (24.8 MW) are from 9 projects using turbines greater than 100 kW, for a total of 18 units, in Colorado, Kansas, Ohio, Massachusetts, Alaska, Indiana, North Dakota, and Puerto Rico. The remaining 5.6 MW were for projects using small wind turbines up through 100 kW, representing the balance of the nearly 2,700 units deployed in 2013, spread primarily across Nevada, Iowa, Minnesota, Oklahoma, New York, Texas, Hawaii, and USVI.

[5] The starting point of 2003 is used in most cumulative capacity discussions for this and the 2012 report in order to capture at least a decade of distributed wind history from available and reliable data records.

Deployments of wind turbines of all sizes in distributed wind applications accounted for 69% of the nearly 104,000 total wind turbines deployed in the United States (on a unit basis) since 2003 (Figure 3). For context, utility-scale turbines installed in wind farms—non-distributed applications—are also shown in Figures 2 and 3.

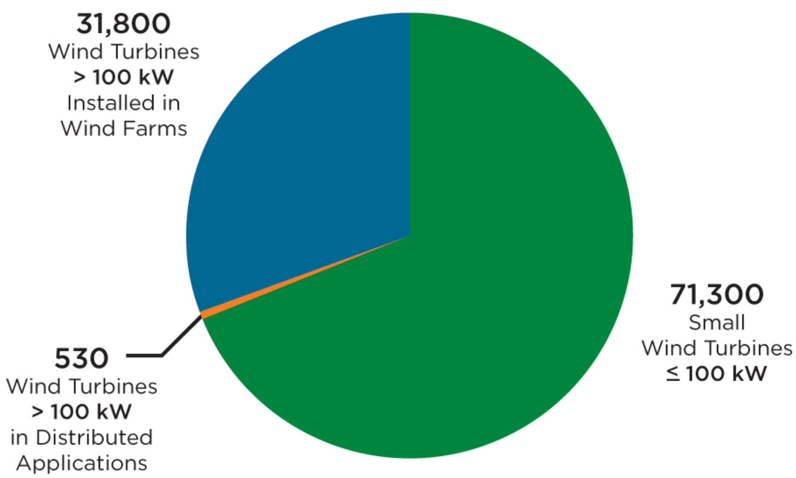


Figure 3: Wind Turbine Deployments (units), 2003–2013

Distributed wind capacity additions in 2013 represent approximately $90 million in domestic investment.[6] While the annual distributed wind *capacity* additions declined 83% from 2012, the number of wind turbine *units* deployed in distributed wind applications in 2013 only dropped by nearly 30% from 2012. In addition, the number of off-grid wind turbines sold in the United States decreased by 16%, the number of wind turbines greater than 100 kW installed in distributed applications decreased by 88%, and the number of small wind turbines sold decreased by 27%. The demand for remote power, primarily provided by off-grid wind turbines and smaller units, may be less sensitive to inconsistent incentives and policies and other market drivers, thus making the drop in off-grid and smaller wind turbines sales from 2012 to 2013 less severe than for other wind turbines.

Because the number of small wind units sold dropped less drastically than the number of turbines greater than 100 kW, small wind increased from less than 40% of all U.S. wind units deployed in 2012 to more than 80% of units deployed in 2013 (Figure 4).

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

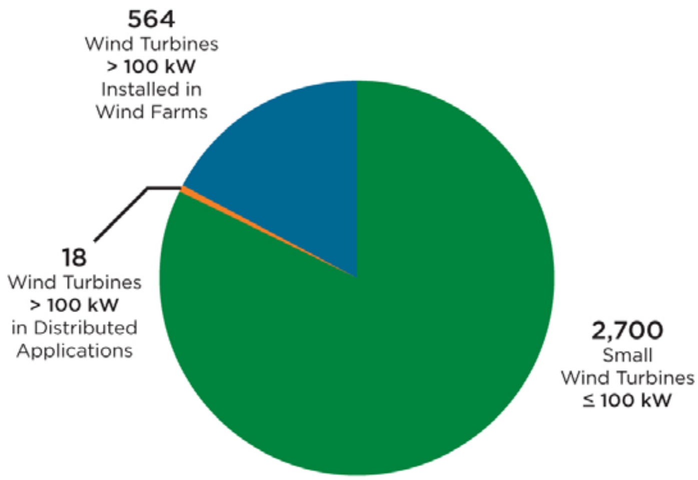


Figure 4: Wind Turbine Deployments (units), 2013

2.1 Small Wind Turbines

Sales of newly manufactured small wind turbines (i.e., up through 100 kW) installed in the United States decreased by 44% from 8.9 MW in 2012 to 5.0 MW in 2013. Nine small wind manufacturers headquartered in the United States and one small wind importer reported 2013 U.S. sales greater than $1 million, down from 17 such suppliers in 2012. The 2013 combined U.S. market for new and refurbished small wind accounted for $36 million in investment from nearly 2,700 units sold; however, this represented a 70% decline in capacity from 18.4 MW in 2012 (3,700 units and $101 million in investment) to 5.6 MW in 2013. But compared to 2012, the 2013 U.S. market for newly manufactured small wind systems declined much less dramatically than the overall U.S. wind market, which decreased from 13.1 GW deployed in 2012 to 1.1 GW in 2013 (Wiser and Bolinger 2014).

With 112 MW in cumulative domestic sales, U.S. suppliers have claimed 82% of the cumulative 137 MW of domestic small wind capacity since 2003, and the 73 MW of U.S. small wind manufacturers' exports since 2003 represent 35% of the 209 MW of combined domestic and exported capacity (Figure 5).

Sales of wind turbines less than 1 kW remained relatively stable, declining 3% on a capacity basis and 9% on a unit basis. Wind turbines sized 1 to 10 kW decreased 58% on a capacity basis and 62% on a unit basis, and turbines sized 11 to 100 kW declined the most, by 75% on a capacity basis and 66% on a unit basis. However, the bulk of the decrease was in refurbished turbine installations, which claimed just 11% of 2013 U.S. small wind capacity additions, down from 50% in 2012 (Figure 6).[7]

[7] Most of the refurbished wind turbines sold in 2012 were installed in Nevada and received 1603 funding, so the decrease in 2013 is likely related to the reduction in both programs.

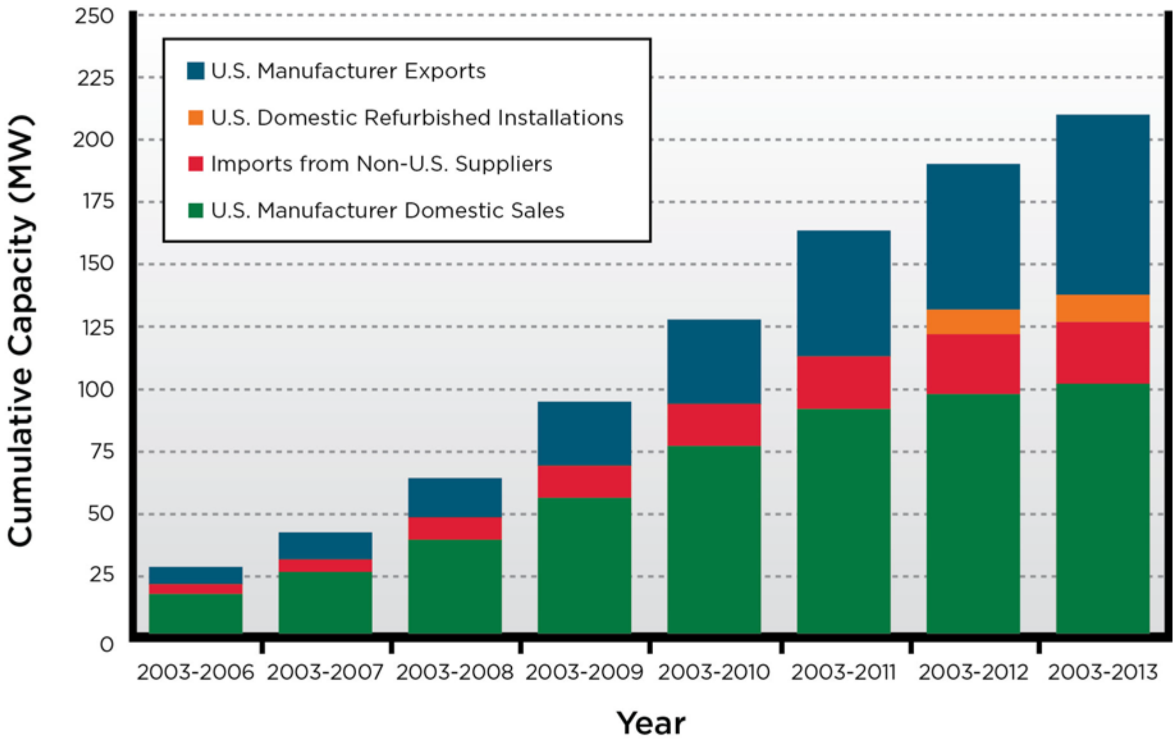


Figure 5: U.S. Small Wind Domestic, Imports, and Export Sales, 2003–2013

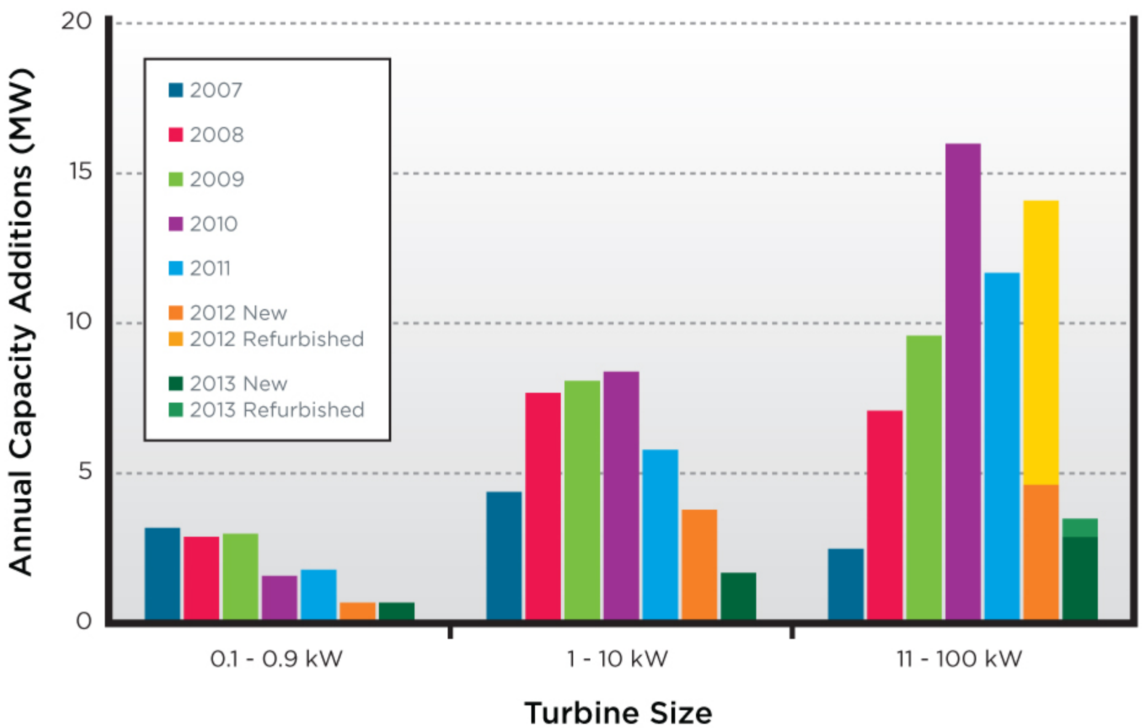


Figure 6: U.S. Small Wind Turbine Sales by Turbine Size, 2007–2013

2.2 Off-Grid and Grid-Tied Wind Turbines

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 85% of the turbines in 2013 distributed wind applications were deployed to power remote homes, oil and gas operations, telecommunications facilities, rural water supply, military, and other off-grid sites.

Wind turbines connected to the distribution grid, or "grid-tied" applications, accounted for more than 97% of the annual domestic distributed wind *capacity* (in terms of MW). A total of 65% of grid-tied applications were used to meet on-site demand at residences, farms, schools, businesses, and other facilities across 35 states and 2 U.S. territories, primarily in the Midwest, New England, and Alaska. The remaining 35% of 2013 grid-tied distributed wind projects were connected to distribution lines serving local loads in Colorado and Alaska.

2.3 Types of Wind Turbines and Towers

In 2013, reported U.S. distributed wind deployments encompassed 69 different wind turbine models ranging from 100 watts (W) to 2 MW[8] from 38 suppliers with a U.S. sales presence. Eight of the top ten models of all 2013 wind turbines deployed in U.S. distributed applications (on a unit basis) were manufactured in the United States.

The widest variety of wind turbine and tower designs are for turbines rated less than 20 kW. Only a few turbines larger than 10 kW are not configured as 3-bladed horizontal-axis units installed on self-supporting tubular towers. Self-supporting lattice and guyed monopole towers were reported as the most popular designs for U.S. residential-scale wind turbine models, with vertical-axis and rooftop models representing about 1% of 2013 U.S. distributed wind capacity and less than 9% of units. A wide range of tower designs and heights were sold for small turbine projects, including guyed lattice and monopole (including tilt-up designs[9]) and self-supporting lattice and tubular towers.

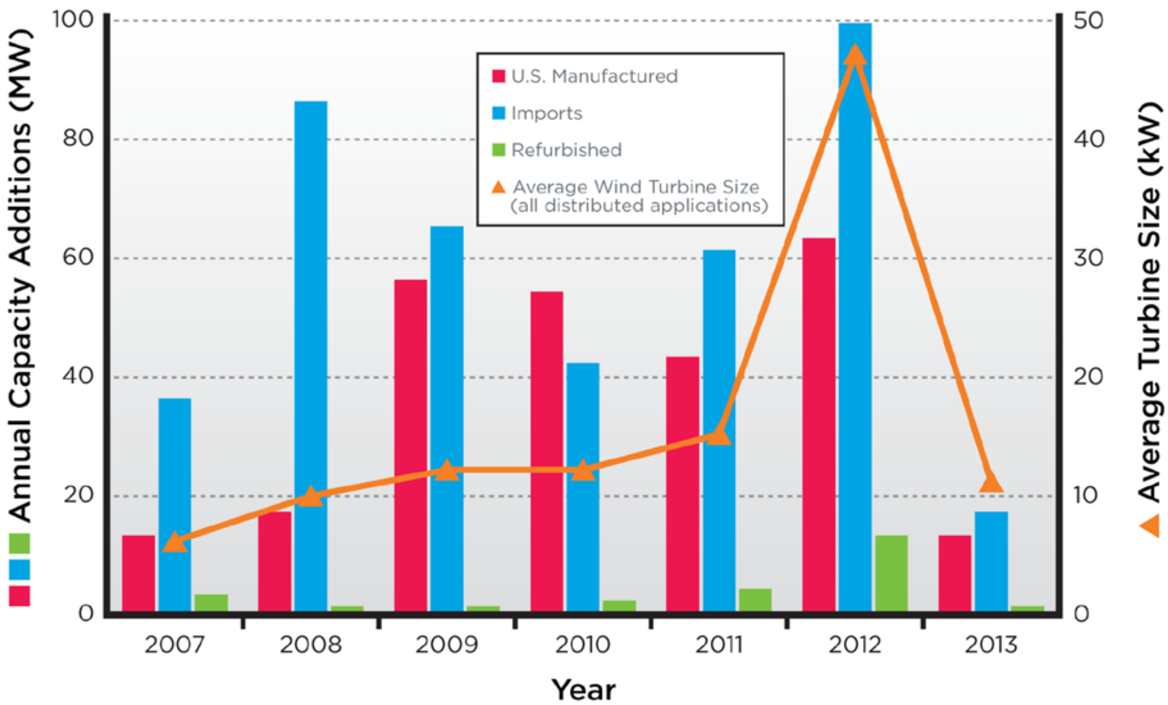
Reported tower heights ranged from 5 to 42 m for small wind turbines and from 50 to 85 m for wind turbines greater than 100 kW in distributed applications, with most 2013 grid-tied distributed wind installations featuring hub heights of 15 to 80 m. The capacity-weighted average hub height for all 2013 distributed wind projects with turbines greater than 100 kW was 77 m.

The capacity-weighted average size of wind turbines across all distributed wind sectors decreased by 76% between 2012 and 2013, from about 47 to 11 kW (Figure 7). This decrease is a result of off-grid wind turbines and smaller units representing a greater portion of 2013

[8] 1 MW = 1,000 kW = 1,000,000 W

[9] A tower design with a gin pole attached to the tower base at a 90-degree angle as shown on page 27 to allow the wind turbine to be tilted down and serviced while on the ground.

deployments than in 2012. While the capacity of off-grid turbines decreased slightly by 13%, the capacity of imported distributed wind turbines decreased by 83%, the capacity of domestic wind turbines greater than 100 kW installed in distributed wind applications decreased by 85%, and the capacity of refurbished turbines reported sold during 2013 decreased by 95%.



	2007	2008	2009	2010	2011	2012	2013
Imports (MW)							
Small Wind Turbines ≤ 100 kW	1.1	4.4	3.6	4.4	3.8	2.6	0.7
Wind Turbines > 100 kW	34.8	81.6	61.0	37.6	57.5	96.9	16.4
U.S. Manufactured (MW)							
Small Wind Turbines ≤ 100 kW	9	13	17	21	15	6.3	4.3
Wind Turbines > 100 kW	4	4	39	33	28	57	8.4
Refurbished (MW)							
Small Wind Turbines ≤ 100 kW	0	0	0	0	0	9.6	0.6
Wind Turbines > 100 kW	3	1	1	2	4	3.1	0.0
Units							
Small Wind Turbines ≤ 100 kW	9,100	10,400	9,800	7,800	7,300	3,700	2,700
Wind Turbines > 100 kW	31	60	78	56	64	109	18

Figure 7: U.S. Distributed Wind Capacity by Type and Average Turbine Size

In addition, the portion of grid-tied wind turbines in U.S. distributed applications decreased from 28% of units deployed in 2012 to 15% in 2013. The average size of grid-tied turbines deployed in U.S. distributed applications of all sizes decreased from 156 kW in 2012 to 74 kW in 2013 (weighted by the multi-MW projects), while the average size of off-grid units sold in the United States in 2013 remained stable at about 380 W.

2.4 Top States for Distributed Wind: Annual and Cumulative Capacity

Distributed wind installations were documented in 36 states, Puerto Rico, and the USVI in 2013 (Figure 8) and in all 50 states, Puerto Rico, and the USVI since 2003 (Figure 9).

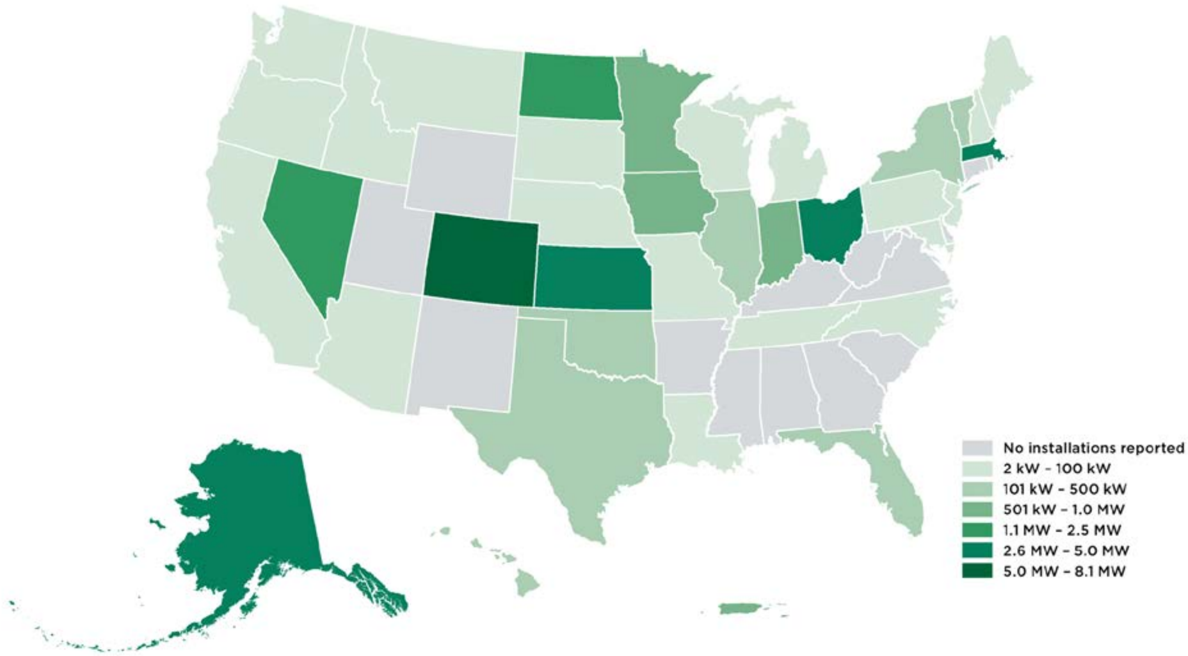


Figure 8: 2013 U.S. Distributed Wind Capacity Additions

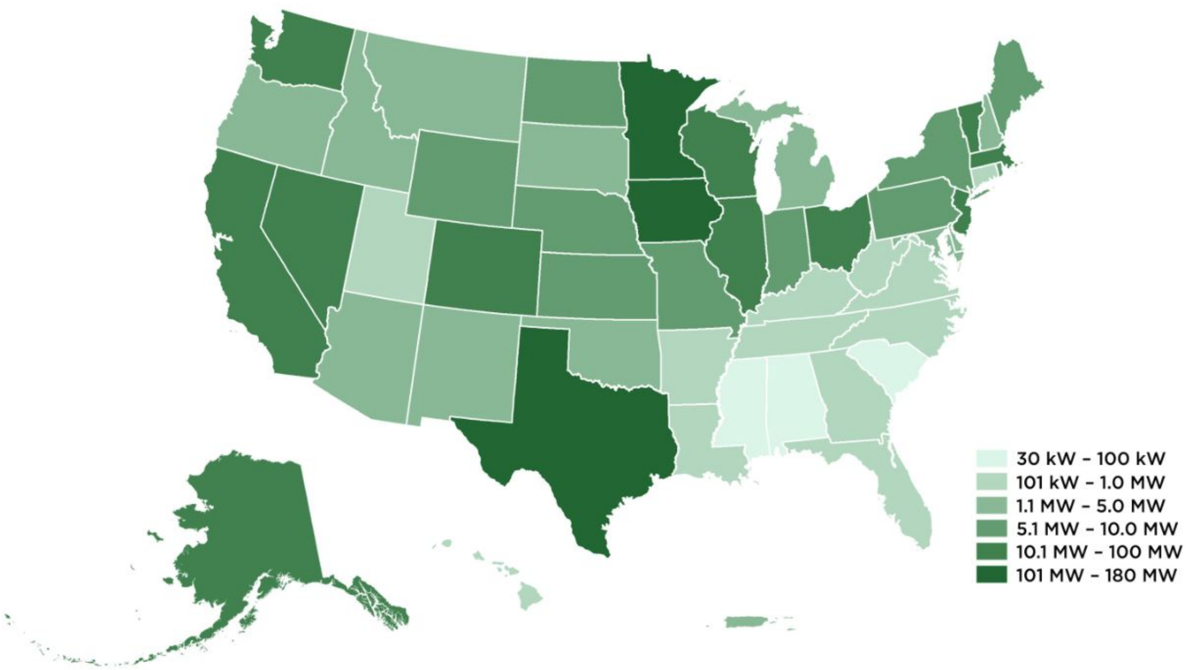


Figure 9: 2003–2013 Cumulative U.S. Distributed Wind Capacity

Colorado, Kansas, Ohio, Massachusetts, and Alaska led the United States in new distributed wind power capacity additions in 2013 across all turbine sizes. Nevada, Iowa, Minnesota, Oklahoma, New York, Texas, and Hawaii led the nation for 2013 small wind sales.

Texas, Minnesota, and Iowa retained their positions as the top three states with the most distributed wind capacity deployed since 2003 (Figure 10). Iowa, Nevada and California remained the leading states for cumulative small wind capacity (Figure 11). A total of 14 states now each have more than 10 MW of distributed wind capacity.

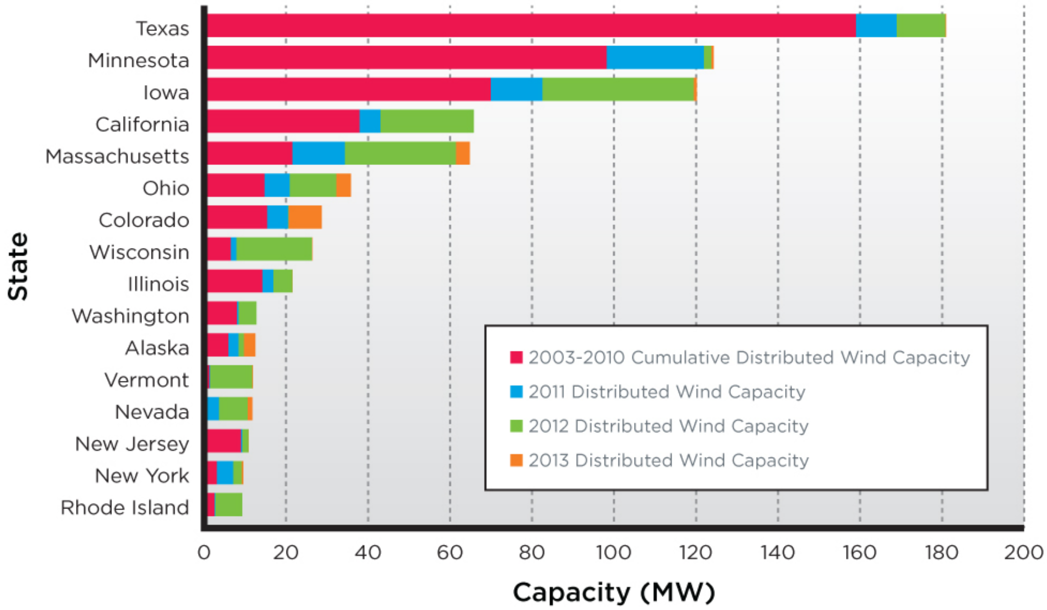


Figure 10: Top States for Distributed Wind Capacity, 2003–2013

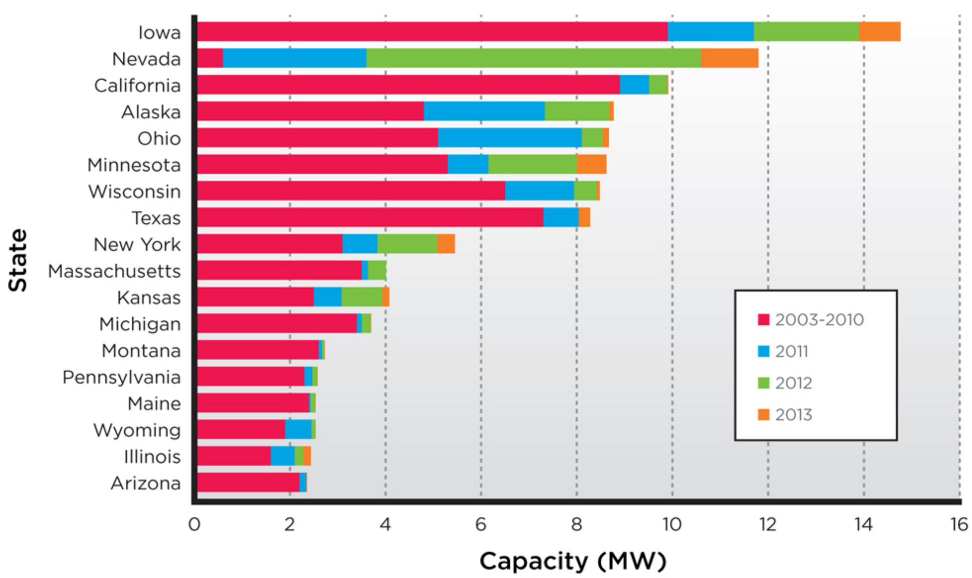


Figure 11: Top States for Small Wind Capacity, 2003–2013

2.5 Top Suppliers and Manufacturers

The top U.S. small wind turbine manufacturers in terms of total 2013 capacity sales (MWs of domestic and exports) were Bergey Windpower, headquartered in Oklahoma; Dakota Turbines of North Dakota; Northern Power Systems of Vermont; Polaris America, LLC of New Jersey; and Primus Windpower of Arizona. Leading importers were Endurance Wind Power of Canada; Gaia of the United Kingdom; and Kestrel of South Africa.

The suppliers of wind turbines greater than 100 kW installed in 2013 U.S. distributed applications were General Electric (GE), headquartered in the United States; EWT Americas of the Netherlands; PowerWind of Denmark; Sany of China; Vergnet of France; and Vestas of Denmark.

Wind Energy at Fort Buchanan

In 2013, U.S. Army Garrison Fort Buchanan in Puerto Rico installed two 275-kW Vergnet wind turbines on base. The turbines were installed as a part of a multi-project Energy Savings Performance Contract. An Energy Savings Performance Contract is a partnership between the Army and an energy services company, in this case, Johnson Controls, in which the energy services company implements and maintains energy and water efficiency and renewable energy projects on behalf of the Army and is then compensated from the generated savings. The two wind turbines at Fort Buchanan are expected to generate 1,000 MWh annually, for an estimated annual savings of $178,500 in avoided electricity purchases.

Second grade students and teachers from the Antilles Elementary School on a Green Energy Awareness Trip to see Fort Buchanan's wind turbines and to the nearby ground-mounted solar panel field. (Photo Credit: José L. Lopez)

3.0 Domestic Supply, Imports, and Exports

Domestic sales from U.S. small wind manufacturers accounted for 86% of the 2013 U.S. new small wind capacity, up from 71% in 2012 (Figure 12). On a unit basis, U.S. suppliers claimed 93% of 2013 domestic small wind sales, up from 91% in 2012. Imports declined more sharply than domestic sales, down 74% from 2012.[10] Importers interviewed for this report indicated that they spent their efforts in more promising international markets (such as the UK, Italy, and other countries with feed-in tariffs) as it was hard to justify sales efforts in the United States without consistent policy support at the federal, state, and utility levels (eFormative 2014).

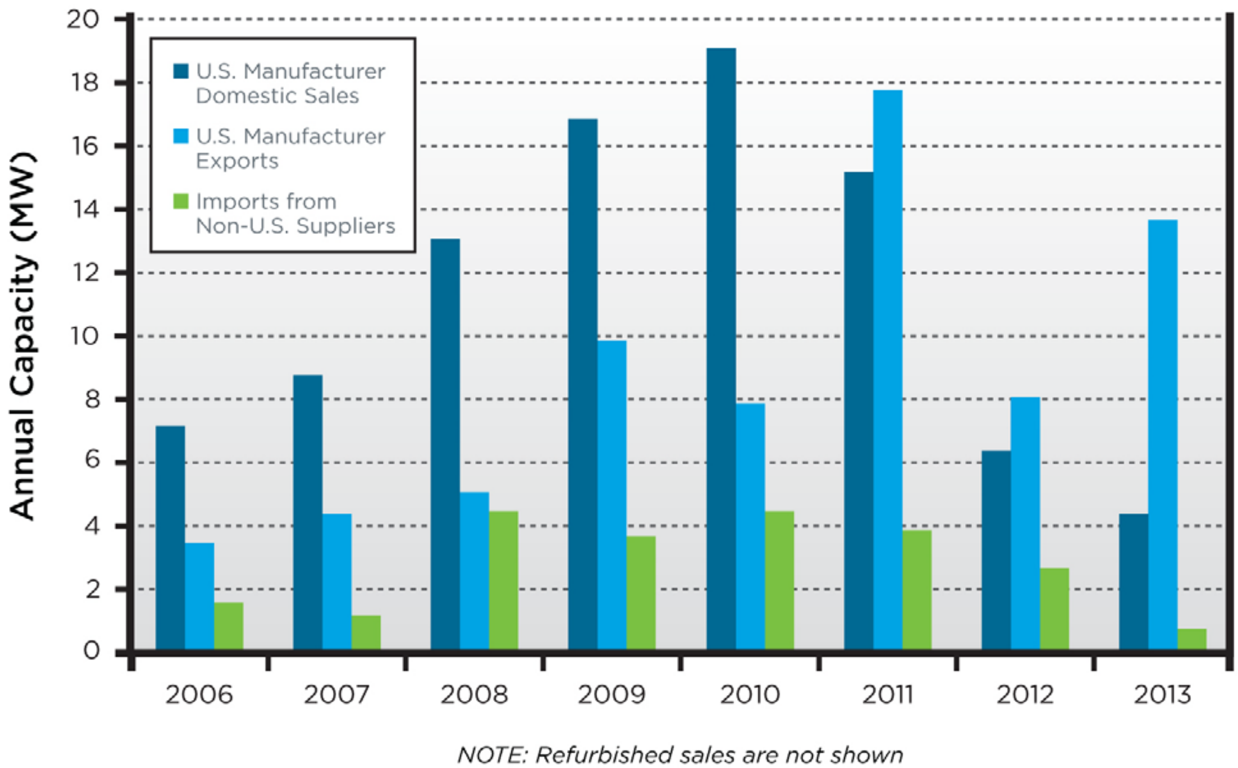


Figure 12: Small Wind Turbine Sales

To compensate for weaker domestic sales, U.S. wind turbine manufacturers shifted their focus to growing international markets. Exports from U.S.-based small wind turbine manufacturers increased 70% from 8 MW in 2012 to 13.6 MW in 2013. U.S. small wind turbines were exported to more than 50 countries in 2013, with top export markets identified as Italy, UK, Germany, Greece, China, Japan, Korea, Mexico, and Nigeria. In 2013, 76% of U.S. manufacturers' new small wind turbine sales capacity went to non-U.S. markets, a substantial increase from 57% in 2012. However, because of the increase in the average capacity of small

[10] Of the total annual domestic distributed wind capacity (including wind turbines greater than 100 kW), imports accounted for 56%, down from 60% in 2012.

wind turbine models exported, mainly due to a greater number of 100 kW units, in terms of units, just 54% of U.S. manufacturers' 2013 new small wind turbine sales were exports, down slightly from 56% in 2012.

The 38 distributed wind turbine suppliers with a 2013 U.S. sales presence consisted of 17 domestic manufacturers and 3 suppliers of refurbished wind turbines headquartered in 16 states (Arizona, California, Georgia, Maine, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Dakota, Ohio, Oklahoma, Oregon, Vermont, Washington, and Wisconsin), as well as 18 importers from China, Europe (UK, Denmark, France, Ireland, Netherlands, and Spain), Canada, Mexico, and South Africa (Figure 13).

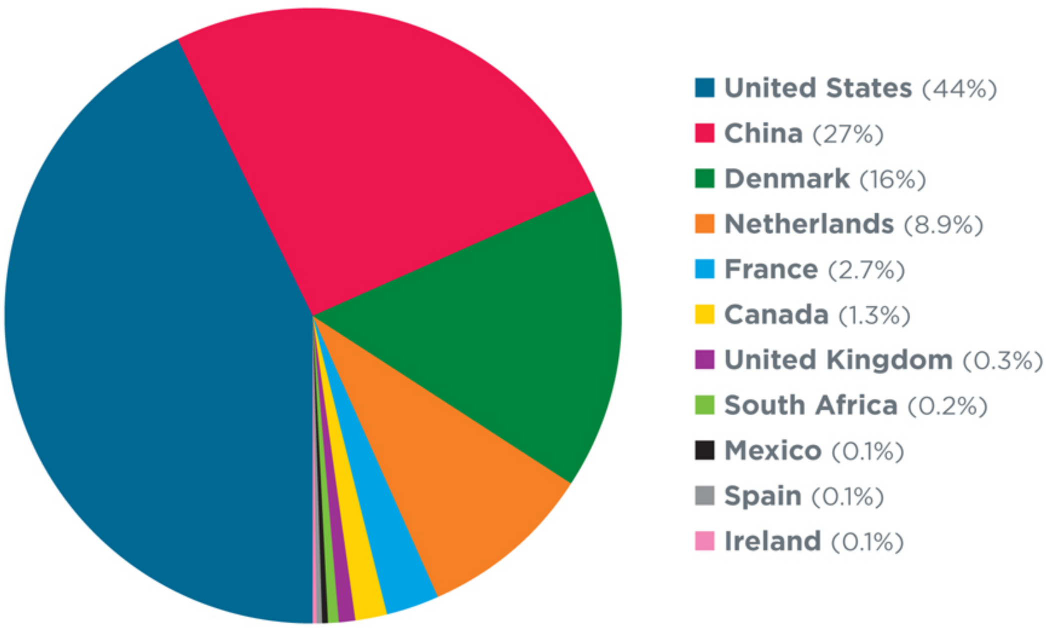


Figure 13: Manufacturer Country of Origin Market Shares for 2013 U.S. Distributed Wind Deployments by Capacity

While imports from China, Denmark, and Netherlands accounted for more than 50% of the overall 2013 domestic distributed wind deployments (Figure 13), U.S. manufacturers and refurbished suppliers claimed 88% of 2013 small wind sales capacity, and Canada was the largest 2013 small wind importer at nearly 7% of annual domestic small wind sales capacity (Figure 14).

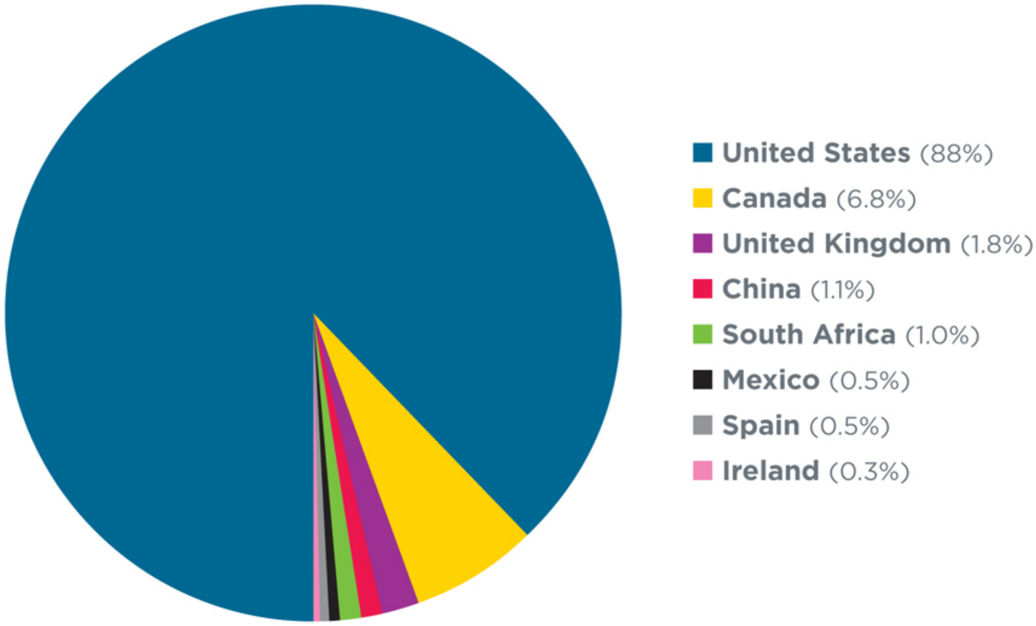


Figure 14: Manufacturer Country of Origin Market Share for 2013 U.S. Small Wind Turbine Sales by Capacity

Of the 69 wind turbine models deployed in distributed wind applications worldwide during 2013 (62 models in the United States) reported by 38 suppliers with a U.S. sales presence, 17% of these models have nominal capacity ratings less than 1 kW, 42% are rated 1 to 10 kW, 24% are rated 11 kW to 100 kW (including three refurbished models), and 16% are rated more than 100 kW (including two refurbished models).

4.0 Policy and Market Drivers

The distributed wind market is influenced by the frequent modifications and suspensions of various federal, state, and local policies and incentives, along with other factors. In addition, 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. Other drivers include the rapidly expanding distributed generation market spurred by substantial cost reductions of solar photovoltaics (PV), electric vehicles, and advances in smart grids; challenges of permitting and financing; and market factors, such as prices of natural gas and agricultural commodities.

4.1 Incentives and Policies

Federal, state, and utility incentives and policies—rebates, tax credits, grants, net metering, production-based incentives, loan funds, and other incentives—continue to play an important role in the development of distributed wind and other renewable energy projects.

Figure 15 provides an overview of the federal, state, and utility funding provided for distributed wind projects in 2013 and shows that the total number of awards given in the top states (by 2013 funding levels) totaled $15.4 million. This contrasts strongly to the scale of distributed wind awards given in 2012, which totaled more than $100 million including award values of more than $5 million in 6 states. This decline is mainly due to the expiration of the U.S. Treasury 1603 program and available funding going to other types of energy projects, as explained in the following sections.

In Figure 15, it is important to note that while these awards were granted in 2013, $7.8 million, or 49%, of the total 2013 funding shown applies to projects installed in prior years, primarily for 1603 payments to projects in Iowa, Nevada, New York, Rhode Island, and Massachusetts (Treasury 2014).

For 2013, the tradable Iowa state PTC and NVEnergy rebates remained important, and the New York State Energy Research and Development Authority's (NYSERDA's) On-Site Small Wind Incentive Program emerged as one of the most significant state programs for distributed wind with the most 2013 incentives awarded of any state. NYSERDA's incentive is seen as effectively stimulating the distributed wind market by building a strong framework to balance financing, administrative, and quality hurdles that have historically constrained the adoption of distributed wind. NYSERDA has been able to ensure substantial benefit from its public investments by providing: (1) an upfront cash grant based on expected production, (2) a dedicated program administrator who is empowered to ease the cost and burden of applying for incentives, and (3) only allowing incentive funds to be used on certified wind turbines installed by verified installers.

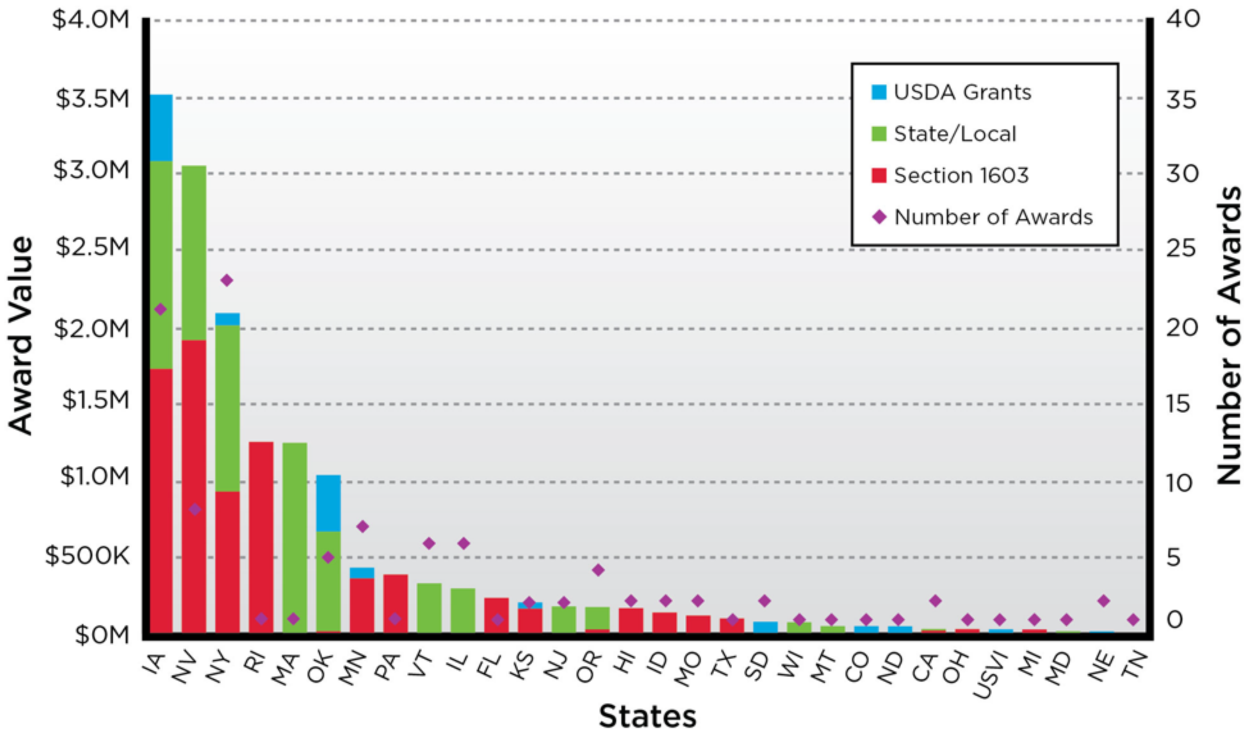


Figure 15: 2013 U.S. Distributed Wind Incentive Awards

4.1.1 Federal Policies and 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 on or before December 31, 2016. 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 is now expired.

Although the cash grant program officially ended, some payments are still being made, as noted with Figure 15, 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 2009-2011 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, only $7.6 million in payments were made to 36 distributed wind projects.

Information on how many small wind projects have claimed the federal Business Energy ITC and the Residential Energy Tax Credit is not public record, but 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, approximately two-thirds of 2013 grid-connected small wind projects totaling 3.6 MW are estimated to have received the 30% federal tax credit, representing a value of roughly $7 million.

The federal PTC, the primary federal incentive for utility-scale wind, expired on December 31, 2012. However, in January 2013, the U.S. Congress extended the deadline to December 31, 2013, and revised the previous requirement that wind projects must be *operational* by the deadline to qualify for the credit, to a new requirement that wind projects must *start construction* by the deadline. The U.S. Internal Revenue Service has defined starting construction as starting physical work of a significant nature or incurring 5% of the total project cost (IRS 2013).

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, are structured so that an independent power producer owns and operates the onsite project and sells the power directly to the plant or school; therefore, these projects would be eligible for the PTC.

Another federal incentive that expired at the end of 2013 that affects the distributed wind market is bonus depreciation for the Modified Accelerated Cost-Recovery System (MACRS) depreciation schedule. Depreciation allows tax-paying entities to recover investments through depreciation deductions from their taxes. The bonus depreciation provision allowed an additional 50% first year depreciation to be taken by eligible renewable energy projects using the 5-year MACRS depreciation schedule, enabling additional upfront tax savings.

The U.S. Department of Agriculture (USDA) Rural Energy for America Program (REAP) provides financial assistance to agricultural producers and rural small businesses to purchase, install, and construct renewable energy systems, along with other energy efficiency and renewable energy endeavors. Loan guarantees are issued 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.

The USDA REAP funded 25 wind projects with $1.2 million in grants in 2013 with an estimated total capital investment of $5.4 million, compared to 57 wind projects with $2.6 million in grants in 2012. The total USDA REAP grant amount for wind projects was $1.7 million in 2011 and $8.5 million in 2010 (AWEA 2012). No loan guarantees were awarded for wind projects in 2013. REAP funding was awarded to 57% of wind project applications, compared to 90% of all technology applications. Wind projects represented 2% of all 2013 REAP awards (and received 3% of REAP funding); energy efficiency projects represented 57% of awards (41% of funding) and solar projects represented 31% of awards (35% of funding).

4.1.2 State Policies and Incentives

Several states across the nation have implemented policies that support the installation of a variety of distributed generation, renewable or otherwise. One example is California's Self-Generation Incentive Program (SGIP), which provides incentives to support existing, new, and emerging distributed energy resources. Administered by the California Public Utilities Commission, the SGIP is intended to support wind turbines, fuel cells, waste heat to power technologies, pressure reduction turbines, internal combustion engines, micro turbines, gas turbines, and advanced energy storage systems. In 2013, the SGIP provided a total of $10,686 for wind—to a single small wind turbine. SGIP's predecessor program (the Emerging Renewables Program) provided approximately $500,000 in incentive funding to 25 small wind projects in 2012 and $9.9 million to 632 small wind projects between 1998 and 2011.

Massachusetts has separate incentive programs for wind and solar PV. In 2013, the Massachusetts Clean Energy Center (CEC) provided $1.2 million to one 3.3-MW distributed wind project and more than $5.1 million in rebates to 2,506 PV projects totaling 15.7 MW. In 2012, the Massachusetts CEC provided $12.9 million to 36 distributed wind projects totaling 55 MW and $5.7 million in rebates to 2,407 solar projects totaling 15 MW.

Similar imbalances between solar and distributed wind funding levels exist in several states. For example, Wisconsin's Focus on Energy, a statewide energy efficiency and renewable resource program, paid $75,000 in incentives for distributed wind in 2013 compared to $600,000 in incentives for solar projects. Similarly, a Montana utility, NorthWestern Energy, provided incentives to 18 solar projects in 2013 and just 3 distributed wind projects.

The state that most clearly illustrates the difference between solar and wind incentive funding is New Jersey. In 2013, distributed wind received $87,998 in funding from the New Jersey Clean Energy Program. Since its inception in 2003, this program has paid over $6 million in incentive programs for 42 wind projects, both distributed and wind farms; however, in July 2013 it stopped accepting new wind applications. As of November 2013, New Jersey had spent over $363 million on solar incentives supporting 25,346 projects. These incentives helped New Jersey to become one of the national leaders in solar energy and to rank fifth in capacity for solar electricity installed in 2013 (SEIA 2013).

One of the reasons for New Jersey's leadership in solar deployment is the state's renewable energy standard, which requires utilities' power portfolios to include 22.5% of renewables by 2021 and includes a solar-specific provision that requires suppliers and providers to procure at least 4.1% of sales from qualifying solar electric generation facilities by 2028 (DSIRE 2013).

The assessment of solar-specific incentives and the total solar incentive funding compared to funding and incentives for distributed wind illustrates a growing discrepancy between the availability and usage of incentives for renewable energy. This gap may continue to widen as a result of additional states, such as Massachusetts, passing solar carve-out programs specifically targeting PV capacity levels and policy objectives to support an in-state solar PV industry, rather than the general distributed generation industry (Dewees and Duffy 2014).

However, the rapid growth and cost reductions in solar PV are leading to an expanded overall distributed generation market, opening new opportunities for distributed wind. For example, in perhaps the most significant legislative development for distributed wind during 2013, the distributed generation requirement in Colorado's renewable portfolio standard was expanded to apply to cooperative utilities, requiring even those with fewer than 10,000 customers to ensure than 0.75% of their retail electricity sales come from distributed generation by 2020.

Net metering and associated interconnection policies also continue to be useful for distributed wind projects, where they are available. In 2013, New York, Massachusetts, Minnesota, New Hampshire, and Idaho made improvements and expansions to their net metering programs. Further, while some form of meter aggregation[11] is allowed in a growing number of states and by a growing number of utilities, net metering policies are facing increased scrutiny, fees, and legislative constrictions in other states. Monthly rollover of credits for excess generation at full retail value (annual net metering)[12] is allowed in portions of only 30 states, and only ten of these states (i.e., California, Delaware, Hawaii, Louisiana, Maine, Maryland, New Hampshire, Vermont, Washington, and West Virginia) have truly "statewide" net metering policies that cover all types of public and private utilities (including rural electric cooperatives[13]). Rural electric cooperatives in 5 additional states (i.e., Arizona, Arkansas, Kentucky, Virginia, and Wyoming) offer limited rollover credits at the retail rate, with required timing for annual true-ups that often has a greater impact for wind than solar PV due to seasonal differences in wind resources.

4.2 Market Drivers

In addition to state and federal policies and incentives, market drivers seen as building consumer interest in distributed wind include growth in demand for electric vehicles, advances in smart grids, and expanding utility involvement in a wide variety of distributed energy resources.

However, substantial challenges contributing to distributed wind's sluggish market remain: permitting barriers, unreliable performance predictions, and the lack of available financing. Distributed wind continues to face challenging permitting processes in many states as local governments often do not have experience or information about distributed wind or established policies to efficiently permit new installations. To counter this, organizations such as the

[11] Aggregated, remote, or group net metering authorizes participants to jointly benefit from a single net metered renewable system that is not directly connected to each of the customers' own meters.
[12] Utility billing arrangement that allows 1:1 credits for electricity generated on-site that exceeds immediate on-site demand to offset subsequent months' usage for a full year or more.
[13] The majority of distributed wind sites are in rural areas; thus, the policies of rural electric cooperatives are important to the distributed wind market.

Distributed Wind Energy Association have developed model ordinances and siting guidelines that can be adopted by local governments to ensure safe, effective, and efficient installations of distributed wind energy systems. Unlike wind farm projects that rely on a long-term data-collection plan to measure the wind speeds at a project site, distributed wind projects typically rely on wind resource maps and modeling tools to estimate a site's wind resource and therefore the turbine's performance. Estimated performance may be higher or lower than actual performance, especially on an inter-annual basis. Industry stakeholders continue to develop ways to improve this estimation process while striving to keep the process cost-effective.

Solar PV provides competition as a leading alternative to distributed wind due to PV's dramatically falling prices, easier siting and permitting, technology-specific incentives, new finance mechanisms, and substantial research and development investments. The economic competitiveness of distributed wind has been negatively affected by low natural gas prices, which have depressed utility rates. In addition, the reduced income of farmers, due to lower agricultural commodity prices, has led to a reduction in their capital expenditure purchases, further dampening market demand for distributed wind.

Building on the success of third-party financing options for PV, several leading distributed wind industry members are now offering long-term leases and "no money down" options, with guaranteed performance, warranties, maintenance, and insurance—immediately reducing costs to electric customer hosts. These products address key distributed wind economic and risk barriers including resource uncertainty, site-assessment costs, performance uncertainty, operational maintenance and reliability risks, and the high initial cost of installations. Industry stakeholders interviewed for this report identified a need to improve performance predictions to confirm whether sites can meet minimum production thresholds. Improved performance predictions and reliance on certified wind turbine models with solid track records are expected to increase customer confidence in distributed wind, to better support production-based incentive programs, and to allow for more robust performance guarantees for the leasing model. Lease arrangements and other third-party ownership models are designed to leverage state and federal incentives, site-specific wind resources, and customer interests. Distributed wind industry leaders see innovation in third-party financing as key to maintaining small wind's competitiveness and are eager to expand its reach.

Wind Leasing

One wind leasing company reported securing $25 million in financing and signing its first ten leases in 2013, offering 10% to 30% annual electricity payment reductions for farmers, homeowners, and businesses. The wind lease economic model is dependent on leveraging the federal ITC, available through 2016, and is affected by the 2013 expiration of bonus depreciation, which is up for renewal by Congress. The wind lease market has initially focused on the state of New York, due to its combination of attractive incentives, favorable wind resources, and reasonable permitting regulations, with an initial limited portfolio of wind turbine models with proven reliability and performance. Marketing efforts for distributed wind leases are expanding to additional states with a combination of enabling incentives and good wind resources.

The following illustrates two payment options and resulting savings for a 10-kW wind turbine on a 100-ft (30.5-m) tower in a 5 m/s hub-height wind resource.

	Upfront Payment ($)	Monthly Payment ($)	Installed Cost[(a)] ($)	Value of ITC ($)	NYSERDA Incentive ($)	MACRS Depreciation	Turbine Production (kWh/yr)	20-year Energy Cost Savings ($)
Zero Down	0	125	100,000	30,000	40,000	Included	15,000	15,000
Partial Pre-Paid	5,000	70	100,000	30,000	40,000	Included	15,000	22,000

(a) Includes O&M, sales tax, developer fee, and any interconnection or permitting fees.

These scenarios were developed using the Distributed Wind Policy Comparison Tool, Version 3.0, last DSIRE update 8/16/13 (www.windpolicytool.org) to demonstrate the leasing model. Additional inputs and assumptions (e.g., escalation, discount, and electricity rates) not shown in the table are the default values for New York state in the Distributed Wind Policy Comparison Tool. Actual lease agreements from vendors will differ from these sample scenarios.

4.3 Global Market

The 31 manufacturers and suppliers of small wind turbines with a 2013 U.S. sales presence reported a total worldwide annual sales value of $217 million, representing nearly 7,900 units and more than 32 MW. Small wind turbines sold during 2013 resulted in cumulative U.S. sales of an estimated 222 MW, representing more than 157,000 total units sold and $1 billion in domestic investment[14] since 1980. Six small wind manufacturers, including two U.S.-based manufacturers, each reported 2013 global sales greater than 1 MW.

According to the World Wind Energy Association (Gsänger and Pitteloud 2014), the U.S., UK, and Chinese markets account for 80% of the global small wind market, which stood at 678 MW in 2012 and is therefore estimated to be approximately 800 MW in 2013. U.S. sales and exports represent about 30% of this estimated combined global 2013 small wind market (Table 1).

[14] Inflation-adjusted to 2013 dollars.

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

	2012 (MW)	2013 (MW)
U.S. manufacturers' exports[a]	8.0	13.6
U.S. annual sales [b]	18.4	5.6
U.S. cumulative sales	216	222
UK annual deployments [c]	28.5	26
China annual deployments [d]	33.6	Not Available

(a) Newly manufactured wind turbines by U.S. manufacturers.
(b) Includes refurbished, imported, and U.S. manufactured small wind turbines.
(c) Sources: RenewableUK 2013, GOV.UK 2014.
(d) Source: Gsänger and Pitteloud 2014.

Exports Case Study: Northern Power

Northern Power 100 kW turbines in Bisaccia, Italy. (Photo Credit: Northern Power Systems)

Northern Power was one of the leading exporters of distributed wind turbines in 2013. To realize sales opportunities in Italy and the UK, Northern Power's predominant export markets in 2013, the company received financing from the Export-Import (Ex-Im) Bank, the official export credit agency of the United States. Northern Power received $3.6 million in financing from Ex-Im Bank, which supported $13.3 million in total export sales in 2013 (Ex-Im Bank 2014). The Ex-Im Bank credit facility allowed Northern Power access to working capital from commercial banks for turbine production, which according to Northern Power's CEO Troy Patton, "levels the playing field" in the competition for capital, enabling access to foreign markets.

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, 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 2013 for wind technologies used in distributed applications. Based on small wind turbine manufacturers' reports, the capacity-weighted average installed cost of newly manufactured small wind turbines sold in the United States in 2013 was $6,940/kW, roughly the same as in 2012.[15]

For small wind turbine models sold in the United States in 2013, Figure 16 shows reported project-specific installation costs for a sample of projects and the manufacturers' reported average installed costs for those wind turbine sizes. Note, this figure does not include all small wind projects installed in 2013, only those for which cost information was available.

While only a relatively small sample size is represented (i.e., 2.2 MW and 85 wind turbines), the data suggest a few trends. First, project installed costs can range widely because of site-specific issues such as foundation requirements and local installation labor. Second, larger wind turbines generally exhibit a tighter range of costs and a lower cost per kW.

Of the 29 small wind turbine manufacturers whose sales data are included in this report (Appendix A), 15 also provided input on installed cost drivers. Most responses indicated that installed cost is primarily affected by the components of the actual wind turbine such as the costs of the generator/alternator, blades, and gearbox/mechanical system. Other main factors driving installed costs include the tower/support structure, permitting, and other soft costs.

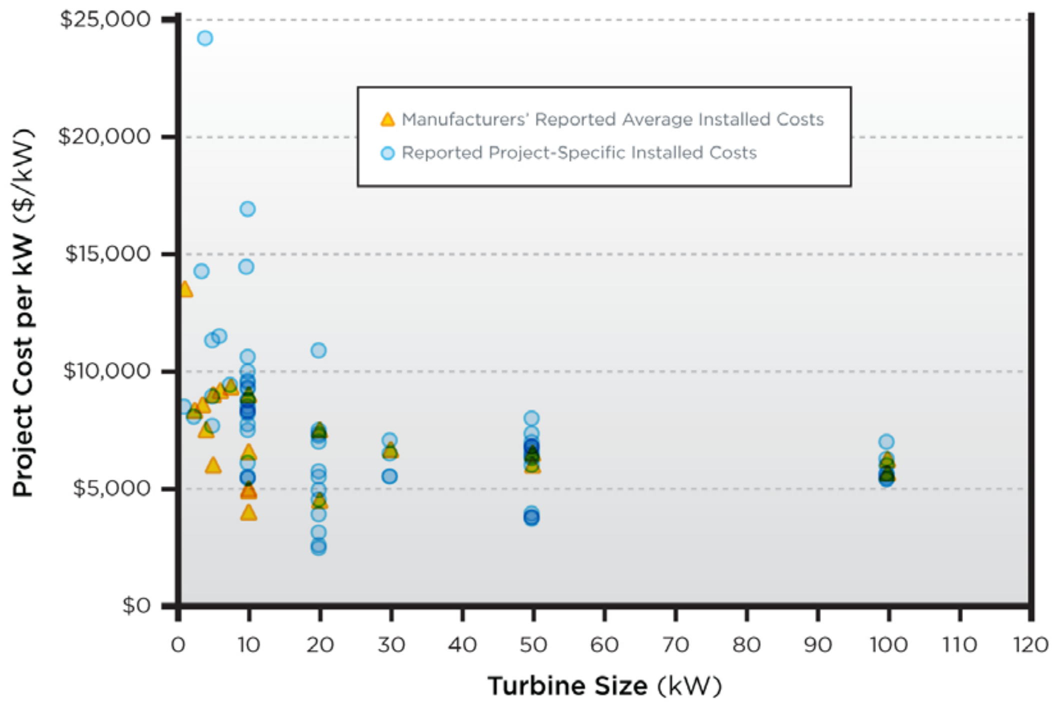
Manufacturer responses varied on the effects of the foundation cost on overall installed cost; most agreed foundations were the second largest factor in installed costs, but some attributed almost no effect. Manufacturers of larger small wind turbines with free-standing monopole and lattice towers reported that foundations had a larger effect on cost.

A detailed review of cost-component breakdowns of 18 leading small wind turbine models indicated that foundations and towers typically account for roughly 35% of small wind turbine costs; with lattice and guyed options typically costing less than monopoles. Costs for

[15] The reported capacity-weighted average installed cost for U.S.-based manufacturers' 2013 new small wind turbine sales was $6,960/kW, based on data for about 2,500 turbines totaling 4.3 MW, 2% higher than for 2013 small wind turbine imports.

foundations and towers are a relatively higher percentage (30% to 55%) of the installed cost for smaller wind turbines less than 50 kW and a smaller percentage (15% to 30%) for the 50 to 100 kW sizes.

Representative costs, broken down by major components, for a typical 10-kW small wind installation are shown in Table 2. Installation costs are higher for non-guyed, lattice towers due to the heavier towers and much larger foundations.



Turbine Size (kW)	1	2.4	3.5	4	5	6	7.5	10	20	30	50	100
Turbines with Reported Costs	1	3	1	14	3	1	1	21	13	4	15	8

Figure 16: 2013 Small Wind Turbine Installed Costs

Table 2: Typical Installation Costs for a Residential Wind Turbine, Two Tower Options

	10-kW Wind Turbine, 31-m Guyed Tower ($)	**10-kW Wind Turbine, 31-m Lattice Tower ($)**
Tower	14,145	16,795
Foundation	3,280	13,300
Setup/crane	4,000	6,000
Turbine (including dealer markup)	31,770	31,770
Wiring kit, wire run	4,325	4,325
Shipping & delivery	1,800	2,000
Electrical contractor	6,375	6,375
Permitting & misc.	2,500	2,500
Total cost	68,195	83,065

5.2 Installed Costs for Wind Turbines Greater than 100 kW

Of the 24.8 MW of distributed wind projects using turbines greater than 100 kW installed in 2013, four used turbines between 101 kW and 1 MW and five used turbines greater than 1 MW. Five projects were in the Midwest, two projects were in Alaska, one was in Massachusetts and one was in Puerto Rico. Because of this small sample size, and because three of the nine projects were installed in remote locations, drawing conclusions on estimated installed costs for this subset of 2013 projects is of limited value.

Installed costs for these and other past wind projects are examined in DOE's annual *Wind Technologies Market Report* (Wiser and Bolinger 2014), which 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. 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 scale economies available to larger projects. Further, with respect to turbine size, most distributed wind projects use turbines less than 1 MW which have higher per kW costs.

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. In addition, 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.

O&M cost data for distributed wind projects collected for the National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impact project (Tegen 2014) and for this report from a variety of O&M service providers indicate average annual O&M costs of $10/kW to $80/kW for wind turbines less than 1 MW, and $30/kW to $50/kW for wind turbines greater than 1 MW. These O&M cost ranges are used in the levelized cost of energy (LCOE) calculations in Section 6.3.

Distributed Wind in Alaska

25-kW Eocycle in Kotezbue, Alaska. (Photo Credit: Eocycle Technologies, Inc.)

Alaska has a rich history of distributed wind projects dating back to the 1980s, when utility leadership, perseverance, innovation, and government investments combined to help the state become a leader in distributed wind deployment. The state's initial single, small wind turbine installations projects fared poorly, mainly due to a lack of maintenance infrastructure. However, driven by rising diesel prices, the predominant fuel for electricity generation in Alaska's isolated communities, the state has since seen sizeable growth in distributed wind installations.

With the help of federal and state funding, several rural electric cooperatives investigated their wind resources and the Kotzebue Electric Association (KEA) and Alaska Village Electric Association began assessing the wind resources in their villages, leading to KEA installing three 50-kW wind turbines in the mid-1990s at Kotzebue and seven more 50-kW wind turbines in the late-1990s. The native Tanadgusix Corporation also installed the first U.S. commercial high-penetration, no-storage wind-diesel system on St. Paul Island in the 1990s to provide power and space heat to its industrial facility.

These early projects fared successfully and led to further, larger deployments of distributed wind in Alaska, such as six 1.5-MW turbines installed by KEA, and also large wind farms, most notably the 17.6-MW Fire Island project and the 24.6-MW Eva Creek project.

The Renewable Energy Alaska Project emerged in 2004 to promote the use of renewable energy and remains central in organizing renewable energy education and outreach in the state. In 2008, Alaska established a renewable energy grant fund facilitated by the Alaska Energy Authority which has provided $250 million to help foster renewable energy development in recognition of the value wind and other renewable energy technologies offer in moderating the risk of diesel fuel costs and the diversity in applications that wind offers to rural communities.

Across Alaska, over 13 MW of distributed wind capacity has been deployed, reflecting the consensus across communities, government, and utilities to invest in distributed wind as a solution for Alaska's energy needs.

6.0 Performance, Reliability, and Safety

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. This section discusses certifications and standards, reliability tracking, and distributed wind performance in terms of capacity factors and LCOE.

6.1 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 square meters (approximately 50 kW) and medium wind turbines are those having rotor swept areas between 201 and 1,000 square meters (approximately 50 kW to approximately 500 kW).

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-sized 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), Intertek (a Regional Test Centers partner and accredited test and certification body), and other nationally recognized testing laboratories continue to provide wind turbine buyers with reliable third-party verification of important safety, acoustic, and performance data and wind turbine sellers the capacity 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.

In 2013, the SWCC expanded its program to include certification of medium-sized wind turbine models. As of July 2014, the following certification milestones have been reached for both U.S. manufactured and imported wind turbines:

- 13 small wind turbine models are fully certified to AWEA Standard 9.1 – 2009.
- 2 medium wind turbine models have published power performance and acoustics certifications to IEC 61400-12-1 (power) and IEC 61400-11 (acoustics).
- 8 small and medium wind turbine models have limited or conditional certifications.
- More than 20 additional wind turbine models have conducted testing or have pending applications.

6.2 Reliability

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. And 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 small and medium wind turbine certifications, only a small number of wind turbine models have entered the certification renewal process, but the amount of data on renewals will increase as the number of certified wind turbines continues to grow.

6.3 Distributed Wind Performance and Levelized Cost of Energy

LCOE is a function of a project's costs 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).

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 at its full nominal capacity.

Multiple states provide production-based incentives for distributed wind and therefore have information on projects' installed costs, incentive awards, and estimated annual energy productions. Massachusetts, Oregon, New York, and Minnesota are some of these states that have had or currently have such incentive programs. Production and cost records were compiled from 59 distributed wind projects installed in these four states between 2006 and 2013 using wind turbines ranging from 2.4 to 900 kW.[16] A total of 16 of these projects were installed in 2013, 2 in 2012, 4 in 2011, with the other 37 installed prior to 2011. The 16 projects installed in 2013, totaling 1.1 MW, represent about 4% of the 2013 reported U.S. distributed wind capacity wind projects; all 59 projects, totaling 5.3 MW, represent less than 1% of the 753 MW of reported U.S. distributed wind capacity over the 8-year period (2006–2013). All dollar amounts were brought to 2013 values. O&M cost estimates were based on the ranges presented in Section 4.3. The installed capital cost for each project includes the incentive award for the LCOE calculation. The results of this analysis are shown in Figure 17.

While data points show some scatter, the plot clearly shows the correlation between capacity factors and LCOE, i.e., the higher the capacity factor, the lower the LCOE. The capacity-weighted average capacity factor for these 59 projects is 15%. The capacity-weighted average LCOE is 14¢/kWh.

[16] Wind turbine sizes included are 2.4, 4.25, 5, 6, 6.5, 10, 15, 20, 50, 100, 600, 660, 850, and 900 kW.

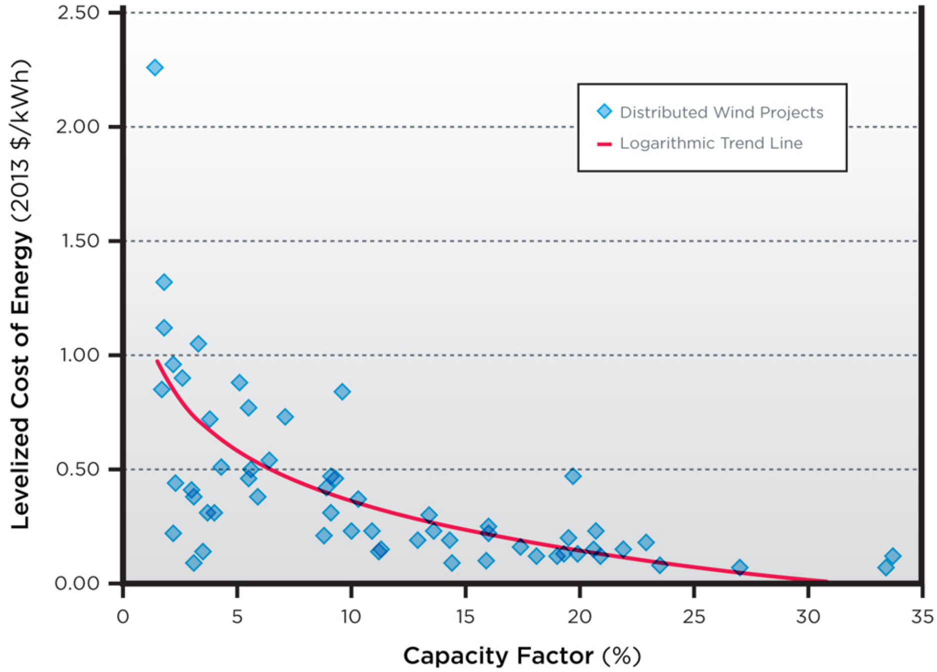


Figure 17: Levelized Costs of Energy and Capacity Factors for Selected Distributed Wind Projects

The project-specific reasons for the low capacity factors were not available for review; 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 30 projects using 10-kW wind turbines in this selected group of projects range from 1.7% to 21.9%, supporting the idea that siting issues strongly influence capacity factors.

Production-based incentives are meant to promote well-sited projects, i.e., a project that produces more energy receives more incentive funding. An effective incentive also reduces the upfront cost for the wind turbine owner and therefore significantly decrease the project's LCOE. For projects installed in 2013, the average reduction in LCOE as a result of incentives was 40%. As noted in Section 5.1, installed costs for small wind turbines can vary significantly; thus, a lower installed cost is a driver of a lower LCOE. Capacity factor is also a driver of LCOE. With respect to the four states included in this analysis, all or most of the incentive funding is paid upfront based on *expected* and *estimated* performance, not actual performance. The upfront payment provides critical financing for the system owner, but because the incentive is based on estimated performance, it still creates the potential for poorly-sited projects that underperform and therefore have high LCOEs.

7.0 Manufacturing, Domestic Supply Chain, and Jobs

The U.S. distributed wind energy supply chain is comprised of hundreds of manufacturing facilities and vendors spread across at least 34 states, with at least 31 facilities actively assembling, manufacturing, or refurbishing wind turbines used in distributed applications; at least 17 facilities manufacturing wind turbine blades and other composites; at least 12 facilities producing wind turbine towers; at least 10 facilities producing drive trains and other electrical components; dozens of facilities manufacturing wind turbine mechanical components; and numerous other facilities involved in the manufacturing supply chain (e.g., materials and construction equipment suppliers, financiers, and insurance and other service providers).

Leading U.S.-based small wind turbine manufacturers continued favoring U.S. supply chain vendors for most of their wind turbine components, with 2013 self-reported domestic content levels of 80% to 95%, up from 80% to 85% in 2012. A total of 13 manufacturers, representing half of 2013 U.S. small wind sales capacity, reported sourcing more than two-thirds of their generator/alternator and electrical systems and blades domestically. A total of 60% of the tower/support structures were reported to be imported. While magnets were reported to be a very small factor in the overall cost of small wind turbines, all were reported as sourced from outside the United States.

Employment in the U.S. distributed wind energy industry, to support both domestic and exported wind turbines and components, includes jobs across a wide variety of sectors seen in most major capital-intensive and heavy manufacturing industries. These jobs are summarized in Table 3.

Table 3: Representative Jobs in the U.S. Distributed Wind Energy Industry

Industry Area	Description
Development	Site selection, siting and permitting, biology and ecology, real estate, land agents, resource assessment, site resource and load profile review, and incentive qualification
Engineering	Civil, mechanical, and electrical
Construction	General contracting, project management, equipment operators, iron workers, and millwrights
Transportation	Truck, rail, and barge
Manufacturing and supply chain	Research and development, raw materials, welding, fabricating, machining, and assembly
Finance	Project finance, insurance, and risk assessment
Asset management and operations	Wind technicians, field and regional managers; component repair and monitoring, and control room operators

8.0 Future Outlook

Distributed wind is part of the rapidly expanding distributed generation market, which is expected to contribute an increasing amount of the incremental generation capacity growth in the coming years. Although new capacity additions of all applications of wind turbines were down in 2013, AWEA reported that over 12,000 MW of capacity was under construction at the end of 2013 (AWEA 2014). Up to 130 MW of that may be considered distributed wind, so installed capacity is expected to be higher in 2014.

From an industry perspective, distributed wind stakeholders generally agreed that 2013 was a difficult year for the domestic market and that exports “saved the day” for many small wind turbine manufacturers. Most stakeholders interviewed for this report indicated, however, that the next two years should be better, but not dramatically due to barriers such as state incentive programs for distributed wind remaining stalled or lethargic; the expiration of important federal incentives such as the ITC for turbines greater than 100 kW, the U.S. Treasury 1603 Program, and bonus depreciation; and the advantages in many applications of solar PV (i.e., better financing, lower prices, easier siting, and technology-specific incentives) (eFormative 2014). In addition, low natural gas prices have depressed utility rates and decreased distributed wind’s economic competitiveness, while decreased agricultural commodity prices have left farmers with less income for capital expenditures.

The European market for U.S. exports, particularly Italy and the UK, remains relatively strong, but influenced by changes to policies such as feed-in tariffs. Japan, which created a feed-in tariff program for renewable energy in 2012 to support energy diversification after Fukushima, may offer opportunity, albeit possibly limited by import restrictions. The Caribbean market also remains promising.

Positive notes include stable funding for USDA REAP, additional wind turbine certifications in process, and new financing models. The Agricultural Act of 2014 (the “Farm Bill”) authorizes sustained funding for USDA REAP grants and loan guarantees, a substantial improvement over 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 for 2014 through 2018. An additional $100 million in five-year discretionary funding is authorized, subject to annual appropriations (ELPC 2014).

Wind turbine certification programs are expected to continue and be very active in 2014 with more than a dozen wind turbines in the certification queue, an expanded scope for medium-sized wind turbines, international reciprocity, and additional test sites. The U.S. Treasury is considering requiring certification to be eligible for the ITC, which would be an important step in reducing current reliability issues.

The most promising 2013 development was the initial emergence of third-party financing offerings for distributed wind. Most industry leaders consider leasing and related business models as a primary opportunity for reducing the resource, financial, and operational risks to customers and supporting a more level playing field, building on the success of solar PV. With several of the leading North American manufacturers involved in such schemes, most industry observers see third-party financing as one of the biggest factors enabling distributed wind's recovery in the domestic market.

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Appendix A: Wind Turbine Manufacturers and Suppliers

This report reflects 2013 deployments from the suppliers listed below.

Manufacturer	Model Names	Headquarters
U.S. Small Wind Turbines (sized up through 100 kW)		
Ark Alloy	Windspire v1.2, v4.0	U.S.-Wisconsin
Bergey Windpower	Excel 1, 6, R, 10	U.S.-Oklahoma
Black Island	HR3	U.S.-Massachusetts
Dakota Turbines	DT-30	U.S.-North Dakota
Dyocore	SolAir 400II	U.S.-California
Franklin	Hopeful	U.S.-Michigan
Home Energy USA	V100, V200	U.S.-Washington
Northern Power Systems	Northern Power 100-21, 100-24	U.S.-Vermont
Pika	T701	U.S.-Maine
Polaris America	P10-20, P19-50	U.S.-New Jersey
Primus Windpower	AIR 30/AIR X Marine, AIR 40/AIR Breeze	U.S.-Arizona
Renewtech	Renewtech	U.S.-Minnesota
Urban Green Energy	UGE-200, 600; 1K, 5M, 4K (on/off)	U.S.-New York
Ventera Wind, Inc	VT10	U.S.-Ohio
Wind Turbine Industries Corp.	Jacobs 31-20	U.S.-Minnesota
XZERES	442, Skystream	U.S.-Oregon
International Small Wind Turbines		
Ampair	Ampair 100, 300, 600	UK
Eclectic Energy	Sail-Gen	UK
Endurance	E-3120, X-29	Canada
Eocycle Technologies	EOCYCLE 25	Canada
Evance	R 9000	UK
Gaia-Wind	GW133	UK
Kelso Energy	Vbine	Canada
Kestrel	e160i, e230i, e300i, e400nb	South Africa
Kingspan Wind	KW3, KW6	UK
Osiris	Osiris 1.6, 10	China
Potencia	Hummingbird 5kw, 10kw	Mexico
Sonkyo Energy	Windspot 3.5	Spain
Zehang Huaying Wind Power	HY30-AD12.5	China
Refurbished Wind Turbines		
Halus Power	Vestas V17, V27	U.S.-California
PowerWorks	PW	U.S.-California
Talk Inc.	Windmatic	U.S.-Minnesota
Wind Turbines (greater than 100 kW) in 2013 U.S. Distributed Projects		
GE Energy	1.68-82.5, 1.6-82.5, 1.7-100	U.S.
EWT	DW52/54	Netherlands
PowerWind	56-900	Denmark
Sany	SE100020IIIE-3	China
Vergnet	MP-C	France
Vestas Wind Systems	V100-2.0	Denmark

Appendix B: Methodology

The Pacific Northwest National Laboratory (PNNL) team issued data requests and questionnaires to more than 100 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 more than 70 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 2013.

For the most part, this study used data 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 added entries as needed. Records dating back to 2003 were assessed on a per project basis to determine whether projects met the U.S. Department of Energy definition of distributed wind. A few 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 deployments rather than confirmed operating installations. For small wind turbines (i.e., those up through 100 kW), this study reports deployments as 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.

The PNNL team also reviewed and cross-checked wind project listings published by Open Energy Information, Federal Aviation Administration, U.S. Geological Survey, Energy Information Administration, 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 created for this report. Projects reported for 2013 were cross checked against previous records to avoid double counting.

Records from suppliers and agencies were combined into a master database with a row for each 2013 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.

For both this report and the report covering the 2012 distributed wind market, the total number small wind turbine units and capacity deployed, as well as 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. Although the 2013 master database documents slightly greater total capacity than the total 2013 small wind sales capacity reported by manufacturers and suppliers, it captures only about 20% of the 2,700 units reported sold. More than 93% of the 2013 units sold were less than 10 kW and not necessarily tracked on a project basis. While the full annual manufacturer-reported capacities for 2012 and 2011 were also documented in the master database, state allocations for about half of the 2003 to 2010 small wind capacity are scaled based on known installations, including product registration card zip codes (with each known project assigned an annual scaling factor representing the difference between total reported locations and total reported sales capacity).

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.

More details were requested and received from both industry members and agencies this year than in previous years. Quantitative data requested for 2013 included the number of units sold of each model, capacity installed, project locations (city or county and coordinates), quarter online, estimated installed costs and O&M costs per year, production data or estimates, installer or developer, power purchaser/utility, tower heights and types, exported capacity and top export markets, application type, breakdowns of project and wind turbine cost components, and labor estimates. Qualitative questions included details about funding available, interconnection types, ownership structures, solar-specific incentives and installations, remanufacturing, and case studies. The level to which all of these questions were answered varied among responders, thus sample sizes are included with certain analysis presentations as needed.

For the purpose of tabulating small wind turbine models for this report, U.S. sales presence is defined as suppliers documenting specific 2013 U.S. sales, in contrast to past years when reports of multiple sales were required for inclusion. Reported sales outside the United States by three non-U.S. small wind manufacturers without documented 2013 U.S. sales were not included in the global market discussion.

The levelized cost of energy (LCOE) calculations in Section 6.3 used the following formula:

$$\text{LCOE} = \frac{(\text{FCR x ICC})}{\text{AEPnet}} + \text{AOE}$$

where

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: www.awea.org
Database of State Incentives for Renewables & Efficiency: www.dsireusa.org
Distributed Wind Energy Association: www.distributedwind.org
Distributed Wind Policy Tool: www.windpolicytool.org
Interstate Turbine Advisory Council: http://www.cesa.org/projects/ITAC/itac-unified-list-of-wind-turbines/
Intertek Small Wind Certification Program Directory: http://www.intertek.com/wind/small/directory/
Lawrence Berkeley National Laboratory: www.lbnl.gov
National Renewable Energy Laboratory: www.nrel.gov
Pacific Northwest National Laboratory: www.pnnl.gov
Small Wind Certification Council: www.smallwindcertification.org
U.S Department of Energy Wind & Water Program Distributed Wind Energy: www.energy.gov/eere/wind/distributed-wind

Cover Photos Credits/Acknowledgments: 160-W Primus Air Breeze wind turbine on sailboat, courtesy of Primus Wind Power; 1.8-kW Pika wind turbine with solar panel in Gorham, Maine, courtesy of Nathan Broaddus / Cultivate Photography Multimedia Design; 10-kW Bergey wind turbines at Dull Homestead Farm, Brookville, Ohio, courtesy of Bruce Hatchett / Energy Options; Two 1.68-MW GE, one 1.5-MW GE, and one 1.5-MW Fuhrlaender wind turbines, courtesy of Jeremiah Walsh / Massachusetts Army National Guard.

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