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FINAL REPORT – EXECUTIVE SUMMARY – 4/4/2016

Project Number: R007-015
Recipient: Posi Lock Puller, Inc.
Award Amount: \$285,373
Total Project Costs: \$713,895

Original Objective/Statement of Work:

This project is to create the most reliable, cost-effective and most efficient small wind turbine on the market and is scalable from 5 – 100 kW. Small wind turbines range up to 100 kW. The design includes several unique features that will allow the turbine to generate energy at speeds that aren't productive today. Their patent-pending "Sliding Stator Technology" provides a load management system that allows for the independent control of the level of generation. Individual coils are customizable and replaceable. It will also have large turbine features such as pitchable blades, active yaw, and computer controls. These features will produce a small wind turbine that has a payback period for the consumer of less than 10 years. Currently, the standard payable period is 25 years.

There were 3 main tasks associated with the project:

1. Duration and stress testing of the existing turbine.
2. Update of major physical components.
3. Software and control hardware configurations.

Results:

First, the project has been officially given a new name: Dakota Turbines. Today Dakota Turbines has far surpassed the original objectives of the project. I will address each one individually and then expand on the more-recent accomplishments. These 3 issues are what the grant dollars helped fund.

1) Duration and Stress Testing

Our system has been formally tested by a Professional Engineer, pursuant to the AWEA 9.1 (Small Wind Certification) specifications for structural analysis. This analysis includes both instantaneous strain and long-duration fatigue testing. There were several points of concern as a result of the initial testing, and quick/simple remedies were executed. The system as it is now has passed structural analysis and we have the PE-Stamped verification to satisfy the Small Wind Certification efforts.

2) Many updates have been carried out. Some minor physical upgrades were a result of the Structural Analysis performed as already mentioned. Other improvements have been made such as:



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- Integrated and more-robust yaw drive system
- Improved coatings for better corrosion protection
- Upgrade to ultrasonic wind instrument for more-reliable performance
- Modifications to allow better access to equipment by service personnel

3) Software and control measures, and their associated hardware components, have also undergone several updates. All control algorithms that control turbine functions and inverter power conversions have been streamlined for better performance, yet simpler in design (lay-out). Inverter issues such as 'stray inductance' within the DC Bus system and bridge-rectifier cooling have been discovered and remedied.

Additional Results:

In addition, we have made advances beyond our original scope of work. These are beyond the original grant project and no grant dollars were spent on these more-recent accomplishments. Some more prominent examples are:

- New remote-monitoring and user-interface software. We have all of our machines networked to our server computer in our office. This monitoring system watches and logs all of the data from all system continuously. If something doesn't seem right, the server system will contact service personnel to investigate. The user-interface software is more advanced and is how our customers can monitor their system performance from the internet. They can run production reports from this platform without taking manual production readings at the site.

- We have developed creative loading algorithms that have eliminated the need for the original 'Sliding Stator' technology. The system is mechanically simpler and less-expensive to produce, while achieving the same goal of super-efficiency and excellent low-wind performance. The Patented Sliding Stator technology still has value as potential solutions for both alternators and motors.

- We have received a patent for our unique blade-pitching system. This innovation is our most highly-prized feature. It has proven itself to be ultra-reliable, having never failed in any of our machines. The system ALWAYS safely parks the turbine, gently shutting the system down, in any fault scenario encountered. It is mechanically very simple and is inexpensive to produce. For this reason, Dakota Turbines can offer a small wind machine with 'large wind' features and benefits.

- We now have 2 additional Patents Pending. One is for our unique inverter cooling system, that utilizes a vertical geo-thermal well to use the earth as a heat-sink. This is in contrast to competitors' inverters that are air-cooled, forcing dirty, humid air into their electronics enclosures and through/around the sensitive electronics.

The other Patent Pending is for our revolutionary stator-coil winding technique. Early in our project, we encountered a phenomenon called 'Eddy Current Losses' which is something that can occur in permanent-magnet alternators like ours. These losses are inherent to the winding



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design and cannot be avoided without a new winding technique that specifically addresses this issue. Nothing on the market, either products or techniques, could solve this for us. So we developed our own winding product and technique that involves using many small wires in parallel, bonded into a flat ribbon and wound-up over a core plug to form the coils. As it turns out, this method is something revolutionary to the winding industry and unique enough to file for a Patent.

- We have developed manufacturing and assembly processes for the entire wind turbine system. Since we manufacture and assemble all of the major design components (turbine, blades, alternators, inverters, etc) this has been a major task. Many manufacturing processes, like the Patent-Pending coil winding previously mentioned, have required innovating completely new techniques and products. Our blade manufacturing area has gone through two major 'resets' since we have moved from our original blade design to a new, highly-improved one. This change required a complete re-tooling of the manufacturing processes.

- Our RPM and Yaw-Position sensing systems have been improved. We have updated the systems to using the most reliable sensing technology available. We use contactless magnetic encoders for the Yaw sensing, which have reliability and robustness advantages over other encoder styles. Our RPM sensors are now induction-style proximity switches which have immunity to electrical noise and mechanical vibrations. The changes have required PCB (Printed Circuit Board) revisions to accommodate the new technology.

- Our inverter is fully-listed to the UL1741 standard. It also is certified for use in Canada.



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Sales and Marketing:

We currently have 40 turbines in operation, sold and installed mostly between 2014 and 2015. These are spread-out among six states: Colorado, Kansas, Nebraska, Iowa, Minnesota and North Dakota. Sales continue to come in but are slowing due to the depressed agriculture economy right now. To combat this, Dakota Turbines is investigating creative financing solutions to help customers with the up-front capital investment. We are also looking at ways to reduce our LCOE (Levelized Cost of Equipment). Currently, our small wind industry in our class-size averages \$0.16 per kwh, and Dakota Turbines stands at approximately \$0.12 per kwh. So we are doing very well to offer an advanced wind turbine with modern features, and coming closer to parity with conventional sources of electricity. As our industry matures and volumes increase, our LCOE will continue to fall amidst rising utility-power prices. Renewable energy is truly on the verge of mainstreaming. This is proven by the advances that the solar industry has made in recent years. The high-volume manufacturing advantages coupled with new and innovative financing packages have caused an industry boom for solar. The same can happen with wind, if Federal and State incentives remain long-enough for our industry to develop a strong foundation and get sales volumes up to drive the costs down further.

Employment and Local Economic Impact:

The Dakota Turbines team currently includes 10 full-time employees. These are good-paying and high-skilled jobs ranging from manufacturing technicians to electrical engineers. Our annual payroll for 2015 alone was \$470,000. In 2015 we spent \$1,150,000 on COGS (inventory) and \$2,000,000 on other expenses (operating, R&D, ETC). The beneficiaries of these expenses are mostly local suppliers of goods and services to Dakota Turbines. This directly benefits the local economy, creating and maintaining many other jobs outside of the Dakota Turbines company.

Any Next Steps:

Next steps in the evolution of Dakota Turbines will be to roll-out new and innovative financing packages to make investments in our equipment even more affordable. Our marketing area needs to grow beyond the Upper-Midwest. We are becoming very active as industry advocates, especially working closely with DWEA, the Distributed Wind Energy Association. We will be working with DWEA and other industry advocates to push for Federal and State policies that are friendly to Distributed Wind. Although we are already among the least-expensive small turbines when comparing the LCOE in our size class, we and other manufacturers in our industry are pushing very hard for further reductions. We need to certify to the new UL6142 standard for small wind systems, just as all of the other manufacturers are working on now. We have plans for more product options such as 3-phase inverters, and one-day we would like to have other sizes of wind turbines available. Also, we want to integrate hybrid technology, incorporating solar and/or energy storage into our small wind systems.



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Final Thoughts:

Dakota Turbines has come a long, long ways in the last few years. We did not realize how long and difficult a project like this would be at the on-set. Developing a small wind turbine is equivalent to designing an automobile to travel 150,000 miles per year, for at least 20 years. And it must do so with minimal maintenance. It must withstand all of the challenges that Mother Nature can produce. We are confident in our design, that it is robust and efficient just as we intended. We have produced numerous novel design elements that have resulted in 2 patents and 2 more patents pending. Our goal of growing the company to need high-skilled employees and becoming a major contributor to our local economy is being realized.

We will never forget the investment that the ND Industrial Commission and Renewable Energy Council have made in our venture. I hope that we have demonstrated a huge success for these grant dollars. I also hope that the tax-payers of this great State see that the investment has already been returned many times by way of our economic impact and investment in our local economy. Again, thank you for your confidence in us. We may not have reached success without your help during the most-critical stages of our development.

Enclosure: DWEA Distributed Wind Vision – 2015 – 2030
Enclosure: Dakota Turbines' DT-30 Power Curve and DT-30 Annual Energy Production
Enclosure: DT-30 Technical Specifications

DWEA Distributed Wind Vision – 2015-2030

Strategies to reach 30 GW of “behind-the-meter” wind generation by 2030

March 2015



DWEA Distributed Wind Vision – 2015-2030

Strategies to reach 30 GW of “behind-the-meter” wind generation by 2030

Executive Summary

Distributed Wind (DW), defined as “behind the meter” wind power, has the potential to create 150,000 jobs and contribute 30 GW of energy supply, spread across all fifty states, by 2030. In 2014 over 90% of the small and medium wind energy systems installed in America were built in America, so Distributed Wind could be the best option for thousands of consumers to produce their own clean energy using equipment “made in America”. And by virtue of the sheer number of homes, farms, businesses, and public facilities that could use Distributed Wind its potential is on par with seabed-anchored offshore wind as well as the existing total U.S. generation capacity of all types. With policy support comparable to that already provided to other clean energy technologies, Distributed Wind could be the next clean tech boom.

Distributed Wind is typically a single or small number of wind turbines serving a local or on-site load. The turbines can be 1 kW for a cabin, a 10 kW for a home, a 50 kW for a farm, a 250 kW for a school, or a 2 MW for a factory. In a windfarm the energy generated is sold to a utility for resale; in Distributed Wind the energy generated is first used in the customer’s home or building and only the excess is sold to the utility. The Distributed Wind Energy Association (DWEA) represents the industry that manufactures, sells, finances, installs, and supports distributed wind energy systems.

DWEA estimates that in 2030 there will be 23.7 million homes and buildings suitable for Distributed Wind and that together they represent a potential for 1,100 GW of generating capacity. DWEA also estimates that other related market segments, such as community wind, wind gardens, and virtual metered systems, could boost the potential for non-windfarm wind energy to 1,400 GW. The energy production potential for the 1,100 GW in 2030 is estimated at 2,900 TWh; which is 70% of the net electricity generation in the U.S. in 2014.

Distributed Wind’s Levelized Cost of Energy (LCOE), which includes the capital, operating, and financing costs of the system over a 25-year operating life, currently ranges from 10¢ – 28¢/kWh but could be reduced to 4.6¢ - 11¢/kWh, as shown in the following table:

Turbine Size	Recommended Height	Typical User	2014 LCOE (¢/kWh)	2030 LCOE Target (¢/kWh)
1 – 3 kW	60 ft.	Off-Grid, Residential	28	11
4 – 15 kW	120 ft.	Residential, Small Farm	20	6.5
16 – 100 kW	150 ft.	Farm, Commercial, Public Facility	16	5.7
101 – 1,000 kW	180 ft.	Commercial, Industrial, Public Facility	12	5.4
1.1 – 2.5 MW	240 ft.	Industrial, Institutional	10	4.6

Smart policies that grow the market and advance the technology of Distributed Wind also provide important benefits in addition to the 150,000 jobs created, including:

- Economic development serving primarily rural areas
- Additional clean energy choices for Americans, promoting competition
- Leveraging America's technology and manufacturing strengths
- Contributing to the renaissance in American manufacturing
- Strengthening the grid and promote resilience
- Ramping faster than some other clean energy technologies
- Placing more wind energy in the public eye, fortifying support for renewables
- Expanding exports

As the price of solar modules have plummeted in recent years, many solar-focused programs have been scaled back and Distributed Wind is beginning to attract increased interest among policymakers. The Indiana utility NIPSCO, for example, two years ago had a Feed-in Tariff (FIT) program that paid solar 30¢/kWh and wind 17¢/kWh, but in recognition of current cost disparities now has a program that pays solar 17¢/kWh and small wind 25¢/kWh. In Japan, the FIT program now pays distributed wind up to 20 kW over twice the rate of solar PV "to encourage technology diversity."

To achieve 30 GW of Distributed Wind by 2030 DWEA recommends the following policies:

1. Remove the 100 kW cap on the wind Investment Tax Credit (ITC) and provide a long-term extension of the ITC
2. Enact a 40% ITC for residential wind systems up to 20 kW as part of the ITC extension
3. Increase the U.S. Department of Energy budget for Distributed Wind RD&D to at least 15% of the DOE wind budget as part of a new focused DOE initiative on distributed wind
4. Maintain funding for the USDA REAP program through and beyond 2019
5. Encourage states and utilities to provide incentives for distributed wind on par with the solar incentives they have successfully employed to grow their solar markets.

Now that windfarms and solar electricity, among other technologies, are well established in the marketplace DWEA believes it is time to bring Distributed Wind to the policy forefront at the federal and state levels.

DWEA Distributed Wind Vision – 2015-2030

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DWEA Distributed Wind Vision – 2015-2030

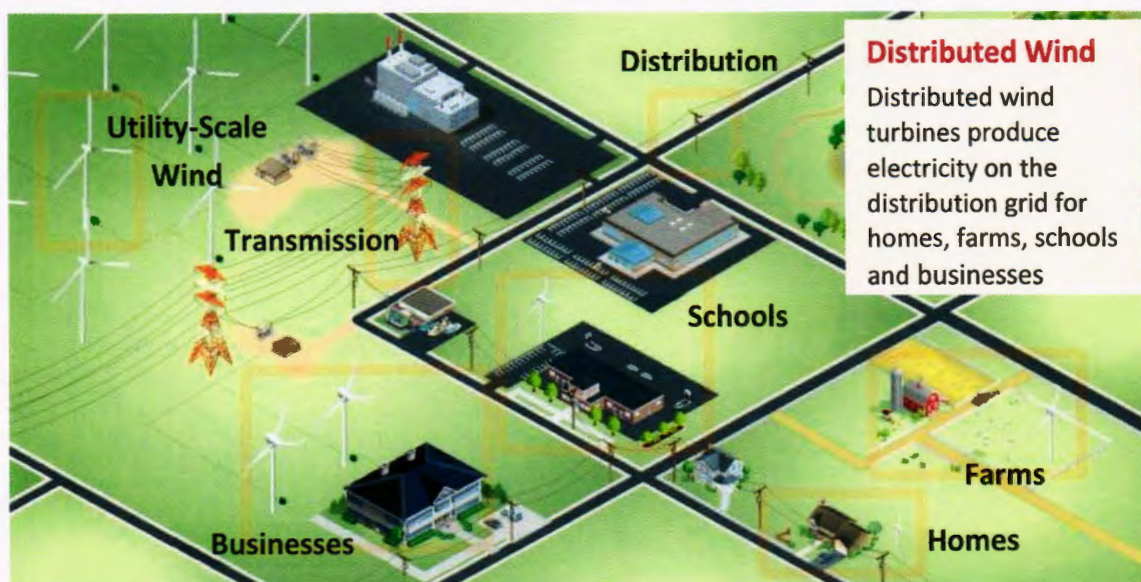
Strategies to reach 30 GW of “behind-the-meter” wind generation by 2030

1. Distributed Wind

1.1 What is Distributed Wind?

Distributed wind (also referred herein as “DW”) energy systems offer reliable “behind-the-meter” electricity generation in a wide variety of global settings, including households, schools, farms and ranches, businesses, towns, communities and remote locations, as depicted below. Distributed wind systems offset all or a portion of local energy consumption at or near the point of end use.

This is in contrast to the recently predominant form of U.S. wind development, the wind farm, where an array of large wind turbines is constructed on windy land and all the energy produced is sold to a utility, which then sells the wind energy to its customers. Distributed and Community Wind projects are typically smaller with different business structures.



Distributed wind turbines on the distribution grid. Source: U.S. Dept. of Energy

The sheer number of sites across the nation with enough space and a productive wind resource is in the tens of millions, giving distributed wind applications the potential to contribute at the thousand gigawatt scale. Installed primarily where people live and work, distributed wind turbines are often the public’s first exposure to wind energy.

Defining Distributed Wind

Strictly speaking, “distributed wind” refers to any wind facility serving local loads. The U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) Wind and Water Power Technologies Office defines distributed wind based on a wind project’s location relative to end-use and power-distribution infrastructure, rather than by technology size or project size. Therefore, the distributed

wind market includes turbines and projects of many sizes, characterized by their proximity to end use and point of interconnection supporting the local grid.

Being connected “behind the meter” at a home, farm, business or facility means that the wind turbine’s output serves primarily to reduce the amount of electricity purchased from the utility company, or in other words, to reduce the electric bill. Wind turbines in distributed applications can vary widely in scale and are typically sized so that all or most of their energy production is consumed directly on-site. Distributed wind systems range from 2 kilowatts (kW) with 6 foot blades at a small home to multiple 2 megawatt (MW) wind turbines with 180 foot blades at a large commercial operation such as a cement plant, manufacturing facility, university campus, medical complex, brewery or retail store.

- Smaller wind turbines commonly up to 50 kW foster energy independence for households, small farms and ranches, small businesses, and other consumers.
-
- Multi-MW distributed wind projects reduce energy costs at or near agricultural, commercial, industrial, and institutional sites and facilities.



The distributed wind sector also includes off-grid systems for battery charging, remote homes, telecommunication facilities, and village power. They account for a significant percentage of export sales, as the largest markets for off-grid wind systems are outside the United States. DWEA member turbines are in places as far reaching as Africa, the Mideast, and Asia.

Ownership and Jobs

Distributed wind systems are typically owned by local entities, for example an individual or family, a school

district or hospital, a farm or ranch, a local business, a municipality, or a Tribe, that uses most, if not all, of the electricity produced on site.

Most distributed wind projects as well as some wind farms are community-owned incorporating local financial participation and control. Some distributed wind projects and most wind farms are owned by outside professionals, such as energy investors or wind farm developers, and the electricity is sold either under a leasing arrangement to energy consumers or in bulk to a utility company.

Distributed, locally-owned and community wind projects typically contribute more to local economic development than conventional wind farms. In fact multiple studies have shown a 2-3x economic

Distributed Wind

Produced locally.

Used locally.

Distributed wind is the use of wind turbines at homes, farms and ranches, businesses, public and industrial facilities, off-grid locations and other sites connected either physically or virtually on the customer side of the meter. These wind turbine installations offset all or a portion of the local energy consumption at or near those locations or feed directly into the local grid to support utility grid operations.

multiplier for such investments.

Community Wind

“Community Wind” is a type of wind project, again of any scale, where the ownership is concentrated locally and therefore the economic benefits are concentrated locally. Unlike distributed wind, however, community wind projects need not produce power “behind the meter” and often sell their production to utility companies or other customers under long-term power purchase agreements. DWEA supports this type of wind development as well.

DWEA’s Focus

The Distributed Wind Energy Association (DWEA) was formed specifically to support the needs of smaller-scale wind projects with a significant element of local ownership and electricity use. DWEA’s primary mission is to promote and foster all aspects of the American distributed wind energy industry.

1.2 Where Does Distributed Wind Fit in America’s Energy Supply Portfolio?

While the U.S. electricity supply has historically been dominated by large central power plants powered by fossil fuels, the fastest growing power generation technologies currently are “central station” wind and solar facilities. Distributed generation technologies, particularly solar, installed throughout the distribution network have seen tremendous growth in recent years and are becoming significant contributors to our national energy supply portfolio. The effects of Hurricane Sandy and other recent natural disasters have highlighted the vulnerabilities of the traditional utility model and infrastructure, and have led to an appreciation of future electricity supply models based on distributed generation, storage, and smart/micro grids that can provide network resiliency and power surety during disturbances. National security interests are also furthered via distributed generation technologies, as they are by definition disbursed, not centrally located. Distributed wind is an important and growing part of this emerging electricity supply model.

Potential

As detailed in Section 4 below, distributed wind, by virtue of the millions of suitable sites, has a technical potential of more than 1,000 GW and a market potential of more than 30 GW by 2030. This puts distributed wind on par with seabed-based offshore wind, combined heat and power (CHP), and non-photovoltaic (non-PV) solar technologies. Distributed wind could, with the right policies in place, be a major contributor to America’s clean energy future.

Benefits

Besides the well-known environmental, security, and price stability benefits of all clean energy technologies, distributed wind has a particularly attractive benefit: it’s made in America. More than 90% of the small wind turbines installed in America over the past decade were built in America. Distributed wind has one of the highest domestic manufacturing content levels of any renewable energy technology. While providing the added benefits of resource diversity and visibility, and at the same time promoting consumer awareness and “buy in” to renewable energy, distributed wind is part of a renaissance in domestic manufacturing. While already employing thousands of people from Maine, Vermont, and New York to Iowa, Minnesota, Colorado, Oregon, Washington and California, Alaska and Hawaii, it has very significant job creation potential in the years ahead. Distributed wind systems are installed in every state, and the opportunities for distributed wind deployment are significant throughout the nation, on both private and public lands.

1.3 Who Buys Distributed Wind Systems?

The markets for distributed wind are primarily in rural and commercial areas with adequate space (one acre or more) for the turbines and towers. These customers are typically homeowners, farmers, and business owners who are looking both to reduce their utility bills now, and to reduce their exposure to rising electric rates in the future. By the time they install wind energy systems these customers have typically already invested in energy conservation measures to reduce their consumption. The wind energy investment is their latest and largest investment in energy security.

The most active U.S. market areas are in states that provide robust incentives and have above average electric rates. Within those states the markets are concentrated in areas with stronger wind resources. A prime example is Wyoming County in New York, which has seen a 300% growth in distributed wind installations over the last year. The New York State Energy Research and Development Authority (NYSERDA) provides incentives through its "Customer-Sited Tier" renewables program and Wyoming County has both electric rates that are 80% above the national average plus good wind resources. Sales of distributed wind systems tend to develop in clusters because visible working small and medium wind systems drive consumer interest. New York, Iowa, Alaska, Minnesota, California, Texas and Illinois are currently among the most active states for distributed wind.

1.4 Who makes and installs Distributed Wind Systems?

Manufacturers

The major U.S. based original equipment manufacturers (OEMs) of wind turbines for distributed wind projects are General Electric with manufacturing in South Carolina and Florida, Northern Power Systems in Vermont, Bergey Windpower in Oklahoma, Xzeres Wind in Oregon, Dakota Wind in North Dakota, Primus Wind Power in Colorado, Pika Energy in Maine, Aeronautica in Massachusetts, Ventera in Minnesota, and Wind Turbine Industries in Minnesota. OEMs with significant sales and offices in the U.S., with substantial U.S. content include Endurance Windpower headquartered in Canada, Eocycle Wind in Canada, and Vergnet in France. These OEMs range in size from a few dozen to several thousand employees and include both privately-held and public companies.

Supply Chain

A wind turbine has hundreds to thousands of parts supported by a large and diverse supply chain. A typical distributed wind turbine manufacturer buys goods and services from several hundred vendors spread throughout the country. DWEA estimates that over 3,000 U.S.-based companies in 30 states are directly supplying parts, materials, or services to distributed wind OEMs.

Ancillary Products and Services

In addition to the wind turbine, a distributed wind installation requires towers, wiring, concrete, trucking, backhoes, trenchers, cranes, and assorted other goods and services. These products and services can account for up to 30% of the installed costs. Each of these system components creates additional domestic, local jobs. Thus dozens of local construction companies in these states support the DW industry.

Developers/Dealers/Installers

Distributed wind systems are sold and installed by nationwide networks of developers, equipment dealers, and installers. Sales, permitting, and installation labor accounts for approximately 20% of the installed cost of a distributed wind system supporting a large number of local jobs. For solar PV this sector accounts for most of the industry's jobs since most solar modules are imported.

Operations and Maintenance (O&M) Providers

Once installed, distributed wind systems must be inspected and maintained regularly to provide high operational availability and maximum performance, requiring ongoing specialized labor support. Distributed wind systems are typically designed to provide at least 20 years of service, but some models are designed to operate for more than 50 years.

Financial Services

Financial and legal services are fast growing segments of the distributed wind industry due to the use of power purchase agreements on larger scale virtually net metered wind projects and the rapid growth in wind leasing for farmers, homeowners, and businesses.

1.5 The five most important things to know about Distributed Wind

Distributed wind is different in many ways from wind farms or industrial wind industry as well as other more mature and developed clean energy sectors and technologies. The defining attributes of distributed wind include:

Quality 1) Distributed wind turbines are Made in the USA

Unlike most other cleantech equipment, a large majority of the small and medium scale wind turbines installed in distributed applications in the U.S. are built here. American OEMs are producing the lowest cost, most reliable, and most popular small and medium scale wind turbines available. These products also supply large and growing international markets, with exports often accounting for 30-50% of unit sales on an annual basis.

Quality 2) Distributed wind has great potential for cost reduction and expansion

Distributed wind has received far less public support and private sector investment than the more developed renewable energy sectors such as wind farms and solar PV, so it's small and medium wind turbine products have lagged in both technology evolution and volume manufacturing. Numerous large cost reductions are available for distributed wind through advanced technology and mass production.

Quality 3) Environmental impacts are low

A wind turbine installed for distributed generation is by its very nature a project on land that has already been disturbed. People already live or work there. The U.S. Fish and Wildlife Service recognizes this and provides relaxed recommendations for distributed wind environmental reviews. A residential wind turbine, for example, is 1/5th the height and 1/200th the size of a typical wind farm turbine. Tall towers (80 – 150 feet) are required, but distributed wind systems are commonly viewed with pride as icons of environmental stewardship and of clean, secure, local energy.

Quality 4) Distributed wind works with and strengthens the existing grid

Distributed wind systems provide generation near the point of end use on utility distribution networks. They do not require new transmission lines, and can improve the quality for service for the utility by providing voltage support and VARs for weak feeders¹. In areas where winds are typically stronger during the winter and evening hours, distributed wind can provide reductions in peak heating loads, and open new “plug and play” opportunities to offset fuel oil and propane.

¹ Integration of Distributed Generation in the Power System, 2011, Bollen & Hassan, ISBN: 978-0-470-64337-2

Distributed Wind actually fits residential demand curves better than solar because the peak occurs after sunset; when wind power is often available but solar power is not. The fast deployment potential for Distributed Wind makes it a valuable tool for addressing grid issues.

Quality 5) Costs are higher, but so is the value of the electricity produced

Distributed wind systems typically have a higher levelized cost of energy (LCOE) than wind farms or other centralized generation technologies, but the value of the energy they produce is also worth more since they are, in effect, selling into retail, rather than wholesale markets. Installed “behind the meter” means that a kilowatt-hour (kWh) of wind power offsets a kWh of purchased electricity at the full delivered retail rate. Distributed wind will always have a higher LCOE than a properly sited windfarm but its return-on-investment can, nonetheless, be comparable or even better because of the difference between retail electric rates and the much lower Power Purchase agreement (PPA) rates paid to windfarm developers.

1.6 Fact-checking the five biggest myths about Distributed Wind

There are, unfortunately, some misconceptions about distributed wind that keep showing up in the media and among important stakeholders, including federal agencies:

Reality 1) Moderately windy sites, not just high wind areas, are suitable for Distributed Wind

Distributed wind systems are designed to operate effectively where people live and work, and those places are typically not the best wind sites in the region. In contrast, central-station wind farms compete with other bulk power generation technologies (i.e., coal and natural gas) at the wholesale level, so project developers need to find the windiest ridges and elevated sites to gain a competitive advantage. But since distributed wind systems offset retail power, even moderate windy resources are adequate. DWEA estimates that approximately half of the rural residential, farm, and commercial sites in the U.S. have wind resources suitable for small and medium wind systems, and that amounts to millions of sites.

Reality 2) Although solar PV prices are low, U.S. small and medium wind turbines can compete

In recent years, the domestic distributed wind market has not kept up with the rapid growth of solar PV. The costs of imported solar PV modules have plummeted, principally due to \$40 billion provided in government-backed soft loans for solar mega-factories in China², causing global oversupply. Selling prices were so low that the U.S. Department of Commerce has imposed hefty import duties on Chinese solar modules. While the lower solar prices have been a boon to U.S. solar retailers and developers, they have posed a severe challenge for distributed wind OEMs to remain competitive. The good news is that the distributed wind industry is becoming more cost efficient and is regaining presence in markets where prior imbalanced incentive policies are being reversed or made more equitable.

Reality 3) Customer-owned wind turbines do not disrupt utility business models

The U.S. utility industry, built on an “exclusive supplier” model, has created a huge and highly reliable electricity supply infrastructure that is a backbone of our economy and helps support one of the highest living standards in the world. In the absence of on-site storage, customer-sited generation, be it wind or solar, does reduce retail energy sales without also reducing the infrastructure for back-up electricity supply. DWEA supports a fair allocation of those costs so long as any “windfall profits” associated with utilities buying excess generation at low “avoided cost”

² Mercom Capital, as reported in “The Reality of China’s Billions in Solar Loans”, Greentech Media, Sept. 28, 2011

rates and selling to the wind customer's neighbors at high retail rates, are also factored in. In the long run DWEA sees tremendous opportunity for utility commissions and utilities to rate base distributed generation assets in the same way that central power plants are financed today. At scale, DWEA believes this would require outsourcing of specialized installation and O&M services such that non-utility businesses would still provide the bulk of the industry employment.

Reality 4) Despite inventions, conventional wind turbine designs remain the most efficient

Every week it seems a new breakthrough small wind technology or product is announced in glowing press releases with compelling claims of vast advantages over conventional wind turbine configurations. These products, typically from non-engineers, make great news appeal, but none of the hundreds of "revolutionary" designs announced over the last decade have succeeded commercially. While the niche market for wind-driven architectural applications at football stadiums, retail chains, and corporate headquarters will likely persist, the true promise for lower cost distributed wind is more advanced technology for horizontal-axis wind turbines installed on tall towers. Turbine certification requirements in particular are helping to ensure that public incentives are only offered to wind turbines that have been shown to be safe and effective. After unfortunate instances of federal agency and military purchases of sub-standard wind products, in 2014 the U.S. Department of Energy sent a memorandum to 13 federal agencies urging them to only use certified wind turbines – models that have been shown to perform and therefore receive a "stamp" of approval. DWEA fully supports this quality assurance guidance.

Reality 5) While distributed wind can work well in many areas, successful rooftop wind applications remain improbable

Rooftop wind is wishful thinking that has caused many headaches. Study after study and trial after trial have shown that the tops of houses and buildings are inappropriate for distributed wind systems, unless they are intentionally meant to be weather vanes, or other "kinetic art." The top of most high-rises are sheltered and have high turbulence, both of which decrease performance significantly. And contrary to the claims of the opportunists (see Reality #4 above) no wind turbine technology exists that can overcome, let alone exploit, these physical realities. The same is true for short towers. The push for green images has inadvertently encouraged "eco-bling" wind installations that may not produce a meaningful amount of electricity. However, thousands of certified distributed wind systems properly sited in open areas – away from tall trees and other obstacles – are successfully producing cost-effective electricity.

2. Current and Future Technology

2.1 How Distributed Wind systems work with the grid

Distributed wind systems are comprised of one or more wind turbines connected to the homes' and facilities' wiring at the breaker panel level. When the wind turbines are not producing power, the homes and facilities draw all of their electrical needs from the utility grid. When the turbines begin producing electricity, the homes and facilities begin drawing less power from the utility. The primary economic benefit from distributed wind systems comes from lower monthly electric bills.

If the wind turbines produce more power than needed by the homes and facilities, then the excess power flows on to the electric grid and is used by neighboring homes or facilities. The right to install and

operate a distributed wind system and to be paid a computed rate for any excess energy produced is provided by federal statute (PURPA, Section 210). At a minimum utilities must pay for the excess energy at an “avoided cost” rate approved by their governing state public utility commission. In practice these buyback rates are typically biased on the low side. In over 40 states, one or more utilities offer net metering options for small distributed renewables, which allow excess power to “run the meter backwards,” essentially banking the energy for periods of lower renewable energy production.

2.2 Small and large wind turbines are different








All wind turbines consist of a rotor that captures the kinetic energy of the wind through aerodynamic blades, which then drive a generator that produces electricity. Large turbines are most often installed in localized arrays of a dozen to hundreds of turbines in “wind farms,” which have a dedicated crew of maintenance workers. Distributed wind turbines, on the other hand, are installed one or two at a time at sites spread over a windy area. Maintenance workers often have to travel hours just to reach the turbine, so maintenance is more of a burden. For this reason many of the best-selling small wind turbines (≤ 100 kW) are much simpler mechanically than large turbines. Many have special-purpose direct drive generators, fixed pitch blades, few sensors, and passive controls, all aimed at reducing the number of moving parts and the need for maintenance. Medium sized wind turbines (100 – 1,000 kW) tend to operate more like megawatt-scale turbines because the cost of maintenance trips is less of a concern due to their higher energy production.

2.3 The technical challenge

A distributed wind turbine will typically operate 6,000 – 8,000 hours per year, which is the equivalent of putting 150,000 miles a year on a car. It needs to do this for at least 20 years with a minimum of maintenance costs. It needs to operate automatically and safely though thunderstorms, damaging winds, hurricanes, ice storms, snow, hail, rain, lightning, earthquakes, sand storms, salt spray, and whatever else nature throws at it. Designing and perfecting a smaller scale wind turbine that can do this is a sizable engineering challenge and one that many, many new entrants in the field have failed to master. The good news is that some distributed wind products have demonstrated operating lives of 35 + years (still operating) and have successfully performed for more than 20 years with 100% availability and near-zero maintenance costs³.

2.4 Examples of Best-Selling Products

More than 99% of the turbines used in distributed wind systems are horizontal-axis turbines, and most use three blades, because this is the most competitive configuration. Vertical-axis wind turbines have not yet progressed past niche architectural applications. Some of the best-selling distributed wind system turbine models include:

						
Pika	Bergey	Endurance	Northern	Vergnet	Aeronautica	GE
1.8 kW	10 kW	54 kW	100 kW	275 kW	750 kW	1.5 MW
2,800 kWh	16,000 kWh	125,000 kWh	165,000 kWh	420,000 kWh	1,100,000 kWh	2,250,000 kWh

³ Overview of Bergey Windpower, corporate presentation, 2011

2.5 Advanced Technology

Due to the lower public investment in small and medium wind technology and deployment, the wind turbine and manufacturing technologies of distributed wind are not as advanced as more developed clean energy technologies, such as wind farms and solar PV. The good news is that significant technology and manufacturing advances that will deliver meaningful cost reductions are within reach. The U.S. Department of Energy's new Competitive Improvement Program (CIP) and the U.S. Department of Commerce-funded Sustainable Manufacturing, Advanced Research and technology (SMART) Wind Consortium are excellent examples of effective cost-shared public/private R&D efforts driving fast paced innovation in the distributed wind technology sector.

Distributed Wind systems have a number of promising areas for technology improvement, including:

- **More effective rotors and blade structure designs:** The rotor system, consisting of two or three blades, is the most critical component of a wind energy system and an area ripe for innovation. Large scale wind systems have benefitted greatly from new airfoils and new blade structural designs that allow larger rotors to be installed on smaller drivetrains, towers, and foundations. So, for very small increases in installed costs, large gains are made in energy production, reducing LCOE. While this basic strategy applies to small and medium wind turbines as well, the scale difference means that different aerodynamic and structural solutions must be developed.
- **More efficient generators designed for higher production volumes:** Generators convert the wind energy captured by the rotor into electricity. As with large wind turbines, some competitive distributed wind turbine models have gearboxes and high speed generators, and some models have low speed generators without gearboxes. At the residential scale, however, most wind turbines have special purpose direct-drive generators representing important opportunities to improve efficiency and designs for higher production volumes.
- **Optimized and simplified power electronics/controls:** Power electronics (inverters) are used to convert the raw electrical output from a variable speed wind turbine into utility-grade power. The power electronics used by the solar industry, and manufactured in high volumes, are similar but are also different in important ways, such as the input interface and the required voltage operating range. The performance of many small wind systems is compromised by having to use inverters designed primarily for use with solar PV modules in order to connect to the grid. Power electronics technology is constantly improving, and numerous opportunities are rapidly emerging to apply state-of-the-art technologies to improve performance and reduce costs of small and medium wind turbines. At the medium scale many wind turbine models are designed to operate a near constant speed and without power electronics, but these "induction generator" designs also need more sophisticated operational controls.
- **Improved tower designs:** Even the smallest distributed wind turbines need to be placed on towers at least 80 feet tall in order to be effective due to diminished wind speeds and turbulence close to the ground. In addition, the industry "rule of thumb" is that the bottom of the rotor should also be at least 30 feet above any obstacles within 500 feet of the turbine. Where there are 100 foot trees, small and medium wind turbines may need 140 – 160 foot towers to be most effective. The near-ubiquitous monopole towers used in the large turbine industry become proportionately more expensive when applied to smaller wind turbines, so lattice and guy-wire supported tower configurations are more often employed. Tower design improvements are needed for small and medium wind systems that use less ground space, have

a more appealing appearance, and cost less to produce and install.

- **Streamlined installations:** Installation can cost up to 30% of the total installed cost for a small or medium wind system. Installation costs include excavating, forming, reinforcing, pouring, and finishing concrete foundations; running underground wiring from the tower to the building; assembly and erection of the tower and turbine; mounting of electrical components and switches; interconnection and metering; and commissioning. Installation typically involves heavy machinery such as forklifts, backhoes, trenchers, cement trucks, and one or more cranes. Weather and soil conditions can easily derail installation schedules. Many opportunities exist to develop cement-less foundations or anchoring, labor-saving equipment designs, and system designs that eliminate the need for cranes for distributed wind installations.
- **Leaner operations and maintenance:** Wind turbines require regular inspections and preventive maintenance to achieve high reliability and optimum power production performance. Maintenance costs can be reduced substantially through value-engineering, smart structures, and advanced monitoring.

2.6 Advanced manufacturing

Small and medium wind turbines, towers, and electronics are manufactured in batch processes rather than the near continuous “assembly line” processes of most other consumer and commercial capital goods. Even the simplest of small wind turbines requires dozens of manufacturing processes covering the industrial spectrum of machining, forming, assembly, painting, testing/quality control, and packaging. New advanced manufacturing technologies and processes developed for other types of products hold promise for lowering the cost of small and medium wind systems. These possibilities are being explored by DWEA’s SMART Wind Consortium under funding from the U.S. Department of Commerce National Institute for Standards and Testing (NIST).

3. Current and Future Distributed Wind Costs

3.1 Installed Cost of Distributed Wind Systems

Installed cost, on a dollars per Watt basis, is a common and readily understandable economic figure of merit. While useful, installed cost does not account for a project’s capacity factor, which depends on the renewable resource at the customer’s site, or operating costs and project longevity, which can vary by product and technology. A scale effect is seen with capital costs of distributed wind, with smaller systems costing more on a per kW basis. This is primarily due to higher relative tower and installation costs. A greater range of installed costs is seen at the residential level due to the different tower types and heights available.

The following table provides average installed costs for distributed wind systems in 2014, and the industry's cost targets for 2030:

Turbine Size	Recommended Height	Typical User	2014 Cost/kW	2030 Cost Target
1 – 3 kW	60 ft.	Off-Grid, Residential	\$8,500	\$4,500
4 – 15 kW	120 ft.	Residential, Small Farm	\$7,000	\$3,200
16 – 100 kW	150 ft.	Farm, Commercial, Public Facility	\$6,000	\$3,000
101 – 1,000 kW	180 ft.	Commercial, Industrial, Public Facility	\$4,500	\$2,800
1.1 – 2.5 MW	240 ft.	Industrial, Institutional	\$4,000	\$2,500

This data was compiled by DWEA. Cost savings will be achieved through a combination of technology improvements, advanced manufacturing, higher volume manufacturing, and lowering soft costs.

3.2 Capacity Factors

The economics of distributed wind are also heavily influenced by each installation's capacity factor, or the amount of annual energy produced per kW of installed capacity. One of the best, and worst, aspects of wind energy is the sensitivity of the energy production to the local wind resource and the height of the wind turbine tower. The same distributed wind turbine model could see annual capacity factors ranging from 2% (not recommended) to 40% depending on where it is installed. For reference the average wind farm capacity factor is 36% and solar system capacity factors typically range from 12 – 18%. Distributed wind systems will typically be installed in lower wind resource areas than wind farms because most people do not live and work on the highest elevation and windiest land in the region. The following table provides average capacity factors for distributed wind systems in 2014, and the industry's targets for 2030:

Turbine Size	Recommended Height	Typical User	2014 Capacity Factor	2030 CF Target
1 – 3 kW	60 ft.	Off-Grid, Residential	15%	20%
4 – 15 kW	120 ft.	Residential, Small Farm	18%	30%
16 – 100 kW	150 ft.	Farm, Commercial, Public Facility	20%	30%
101 – 1,000 kW	180 ft.	Commercial, Industrial, Public Facility	20%	32%
1.1 – 2.5 MW	240 ft.	Industrial, Institutional	20%	34%

Higher capacity factors will be achieved through a combination of technology improvements and taller towers. As with large wind turbines, advanced airfoil and rotor technology will allow small and medium turbine rotors to get larger without increasing costs. This increases energy production and lowers LCOE.

3.3 Levelized Cost of Energy

Levelized Cost of Energy (LCOE) is a common reference used to judge the cost competitiveness of an energy generation technology and is the primary economic metric reference for the U.S. Department of Energy. LCOE costs include the total cost of ownership of a generation asset, including opportunity costs (returns available from alternative investments), over the lifetime of the system. The net present value of these costs are then divided by the projected lifetime energy production under the reference wind resource conditions. In theory this allows direct comparisons of generation costs, before applying any subsidies or incentives, between different products and technologies. In practice the baseline assumptions for different technologies can provide some skewing of the results, and the best use of LCOEs lies in gauging the improvements within a technology for various technical or soft cost advances.

Nonetheless, LCOE provides a useful benchmark and does provide an approximate comparison between technologies. The following table provides average LCOEs for distributed wind systems in 2014, and the industry's cost targets for 2030:

Turbine Size	Recommended Height	Typical User	2014 LCOE (¢/kWh)	2030 LCOE Target (¢/kWh)
1 – 3 kW	60 ft.	Off-Grid, Residential	28	11
4 – 15 kW	120 ft.	Residential, Small Farm	20	6.5
16 – 100 kW	150 ft.	Farm, Commercial, Public Facility	16	5.7
101 – 1,000 kW	180 ft.	Commercial, Industrial, Public Facility	12	5.4
1.1 – 2.5 MW	240 ft.	Industrial, Institutional	10	4.6

Lower LCOE's are a combination of improvements in installed costs and capacity factors. For reference, in 2013, according to the EIA, the average cost of residential electricity was 12.1¢/kWh and the average cost of commercial electricity was 10.4¢/kwh.

3.4 Comparison with Other Distributed Generation Technologies

Distributed wind has the potential to be the lowest cost clean energy option for millions of homeowners, farmers, businesses and public facilities and to be economically viable without subsidies.

The following table compares DWEA’s projected costs in 2030 for distributed wind and 2020 US-DOE cost targets for solar:

System Size	Typical User	Wind 2030 LCOE (¢/kWh)	Solar 2020* LCOE (¢/kWh)
1 – 3 kW	Off-Grid, Residential	11	N.A.
4 – 15 kW	Residential, Small Farm	6.5	6.5
16 – 100 kW	Farm, Commercial, Public Facility	5.7	7
101 – 1,000 kW	Commercial, Industrial, Public Facility	5.4	6
1.1 – 2.5 MW	Industrial, Institutional	4.6	5

* DOE SunShot Program targets, assumes CAPEX of \$1.50/W residential, \$1.25/W commercial, and \$1.00/W utility-scale, represent 50% cost reductions

4. 2030 Distributed Wind Potential

4.1 Methodology

The U.S. DOE has established an 8,000 GW potential figure for land-based large-scale wind, derived by looking at the amount of windy land available for development and applying assumptions on exclusions and utilization. In a similar fashion, the DOE’s 4,200 GW potential for offshore wind was derived by looking at the windy acreage available offshore and applying assumptions on exclusions and utilization.

But a different approach is required for distributed wind because every “behind the meter” project requires a home, farm, business or public facility to be connected to. The distributed wind potential, for example, is largely excluded from DOE’s overall wind potential figure because the DOE models exclude much of the land where people live and work. Buildings account for the majority of the electricity consumed in the U.S.

4.2 Distributed Wind Market Potential

Installed “behind the meter,” distributed wind systems serve loads on the customer side of electric meters located at buildings or special purpose electric loads such as pumps. To estimate the potential for distributed wind in the 2030 timeframe, DWEA has used available statistics or best estimates of the number of common categories of buildings, estimated their growth to 2030, applied exclusions for wind resource and other unsuitability factors, and estimated the average size of turbines that would best fit the category. These results are shown below.

Market Segment	2014 Size, Units	Data Source	2030 Size, Units	Percent Suitable	2030 Potential Installed Units	Average Size (kW)	Potential (MW)
Buildings	8,900,000	Census, 2008	14,300,000	20%	2,860,000	275	786,500
Rural Residences	24,900,000	AHS, 2013	34,200,000	35%	11,970,000	12	143,640
Farms	2,100,000	USDA, 2012	2,000,000	40%	800,000	100	80,000
Public Buildings	750,000	DWEA Estimate	875,000	20%	175,000	300	52,500
Schools	140,000	NCES, 2010	165,000	35%	57,750	400	23,100

Total Potential (MW): 1,085,740

The sheer number of homes, farms, commercial buildings, schools, and facilities with enough space and a usable wind resource, numbering in the tens of millions, gives distributed wind applications the potential to contribute at the gigawatt scale. The 1,100 GW potential of distributed wind is on par with the 1,100 GW potential that U.S. DOE has estimated for offshore wind for water depths up to 30 m. The U.S. currently has 1,100 GW of installed generating capacity from all sources.

DWEA's estimate above does not include special purpose loads such as pumps and irrigation systems. Nor does it include community wind projects, wind gardens, or additional projects made feasible by virtual net metering, which several states are implementing. DWEA estimates that these additional market segments could boost distributed wind's potential by 25% to approximately 1,400 GW.

Navigant Research recently published a report predicting the distributed market worldwide for small and medium wind up to 500 kW at 3.2 GW worldwide by 2023.

4.3 Energy Production Potential

Distributed wind turbines currently operate at capacity factors in the range of 15 – 20%, which while greater than solar for much of the U.S., is less than the average capacity factor for wind farms of 36%. Over the next 15 years DWEA predicts the average capacity factor for DW turbines will increase to 30% as shown in Section 3.2 above. This equates then to a theoretical annual generation potential of 2,900 TWh in 2030. The net electricity generation in the U.S. for 2014 was 4,100 TWh. Distributed wind has the potential to make a significant contribution to the U.S. electricity supply portfolio.

4.4 Additional Benefits

In addition to its clean energy contributions, distributed wind provides a number of other significant side benefits, including:

- **Rural Economic Development:** Solar funding at the state and federal levels overwhelmingly supports projects in urban and suburban areas, whereas distributed wind primarily supports projects in rural areas. The customer savings, construction labor, materials and services, and the long-term operations and maintenance support translate to local jobs and help keep energy costs circulating in the local community. Distributed wind development can help improve the balance and distribution of benefits from clean tech policies providing rural voters and their representatives a firmer basis for supporting policies favoring cleantech.
- **Promotes More Energy Choices for Americans:** Consumers benefit and resources are more efficiently allocated when multiple cleantech technology choices are available. Wind, solar, and hydro resources vary greatly from region to region across the United States. Land availability

and priorities for its use vary. Consumers place different priority on where a product is manufactured. No one technology is optimal for everyone, everywhere. Greater cleantech technology diversity will increase private sector investment in clean energy. Notably this consumer choice issue truly resonates with citizens irrespective of party affiliation.

- **Plays to American Technology and Manufacturing Strengths:** American small and medium wind manufacturers have world-leading technology and command significant global market shares. The domestic market share for U.S. based manufacturers exceeds 90%. Distributed wind is part of the renaissance in American manufacturing and nurturing the DW industry will drive long-term job creation throughout the U.S. The DW industry supply chain currently extends to more than thirty states.
- **Strengthens Exports:** The worldwide market for small and medium wind systems is growing and exports are a significant market for U.S. distributed wind manufacturers and systems integrators. In some years total export sales exceed domestic sales and exports have been as high as 80% of total sales. U.S. manufactured small and medium wind turbines have been installed in over 130 countries. The UK, Italy, and Japan are the largest export markets in 2015. We know from the history of large wind and solar that robust domestic markets help manufacturers leverage export sales through increased cost competitiveness and market development resources. Growing the U.S. distributed wind market will also grow exports.
- **Strengthens the Grid:** Significant amounts of distributed wind also improve grid power quality, provide opportunities to improve customer electric reliability, complement solar by providing winter peak shaving, and support the development of micro-grids. Distributed wind encourages private sector investment in clean energy infrastructure and helps customers hedge against rising electric rates.
- **Shorter Project Cycles:** The distributed wind project cycle is typically 2-9 months, compared to 2-4 years for land-based windfarms and 8-12 years for offshore windfarms. The U.S. Fish and Wildlife Service recognizes the lower environmental impacts of distributed wind compared to wind farms.
- **Places more Wind Energy in the Public Eye:** Distributed wind is installed where people live and work. It is more “present” and visible to many more people than the remotely located windfarms that make up the bulk of America’s wind energy portfolio. Familiarity can dispel concerns and misinformation promoted extensively by the opponents of wind power. In this way small and medium wind can lead to greater acceptance and development of large wind.

5. Barriers

Distributed wind faces similar cost and consumer acceptance barriers that most emerging technologies face, but significant policy barriers also pose unique challenges for distributed wind. Understanding those barriers is a prerequisite to plotting an effective path to greater utilization and a greater role in our nation’s energy supply portfolio.

5.1 Imbalanced Renewable Energy Policies

Some of the policies that have been instrumental in growing the solar market have had the unintended consequence of retarding the growth of the distributed wind market. Examples include:

- Solar-only carve-outs in Renewable Portfolio Standards (RPS) programs in states such as NJ, CA, and MA.
- Solar-only Renewable Energy Credit (S-REC) programs where the REC's can sell for 100 times the price of wind generated RECs (e.g., NJ).
- Solar-only state initiatives such as A37/SB 05-143 in Colorado (providing >\$100 million in solar rebates, zero for wind).
- Solar-specific utility rebate programs offered by a large number of utilities around the country and numerous solar-focused programs of all types that have provided incentives 2- 10 times as high as for distributed wind.

As solar module prices have plummeted in recent years, many of these imbalanced solar programs have been scaled back and an emerging trend is a reversal of the bias. The Indiana utility NIPSCO, for example, two years ago had a FIT program that paid solar 30¢/kWh and wind 17¢/kWh, but in recognition of current cost disparities now has a program that pays solar 17¢/kWh and small wind 25¢/kWh. In Japan, the FIT program now pays distributed wind up to 20 kW over twice the rate of solar PV "to encourage technology diversity".

5.2 Cost

As with other renewable energy technologies, the primary reason that more customers do not buy or invest in distributed wind is that it currently costs too much. Cost reduction is the highest priority of the distributed wind industry because it directly affects business prospects, and because there is a general understanding that the products and industry must at least achieve parity with conventional energy if it is to survive long term. Technology improvements will play an important role in lowering costs and, as discussed in Section 2.5 above, distributed wind has several areas with good prospects for improving performance and lowering manufacturing costs. But it is important to remember the powerful role that manufacturing and installation volume play in total costs to the end user. Simply stated: "More people would buy them if they cost less, but they won't cost much less unless more people buy them." Addressing this chicken-and-egg challenge is where smart subsidies can build markets and industries.

5.3 Zoning Rules and Permitting

Rural areas in the U.S. have a long history with widespread use of water-pumping windmills and small wind turbines, so DWEA believes it is safe to assume that permitting ultimately will not prove to be a significant barrier to utilization. In the near term, however, it is a very significant barrier. Small wind turbines need towers that are 80 – 180 feet in height, but also need building permits in counties and cities that have 35 foot height restrictions and no special exemptions for individually owned wind turbines. The ubiquitous 35 foot height restriction has its origins in the fire safety of inhabited structures over a century ago, but its persisting impact on small and medium wind turbine permitting cannot be overstated. It can, and often does, throw the approval process for small wind turbines into the same zoning processes used for high rise buildings, liquor stores, adult entertainment venues, and oil refineries. It can take more man-hours to obtain a permit to install than it does to manufacture, deliver and install a small wind turbine. With over 25,000 separate zoning jurisdictions in the U.S., DWEA estimates that addressing each zoning ordinance individually would take more than one million person-hours and cost more than \$250 million.

Similar, though less stark, barriers exist for solar and are a major target of the U.S. DOE's SunShot Initiative. As part of efforts to reduce "soft costs," the DOE is funding tens of millions of dollars of state and local programs aimed at innovative and replicable approaches to streamlining the permitting of solar installations. A similar opportunity exists for federal support of initiatives to streamline permitting for Distributed Wind systems.

5.4 RD&D Lost in the Shadow of Wind Farms

Since the mid-1980's the U.S. DOE wind energy RD&D (Research, Development, & Deployment) program has heavily concentrated its programs and funding on reducing the costs of large wind turbines in wind farm applications. In recent years U.S. DOE has added a major focus on offshore wind development. This 30-year effort has played an important role in the success of wind power in the United States: 75 GW of installed capacity at the end of 2014 and 177 TWh of generation in the 12 months ending in August 2014, representing 4.3% of total U.S. electricity production.

This focus, however, has meant that small and medium wind technology has lagged behind the technical and market development of other distributed renewable and cleaner energy technologies. For example, the U.S. DOE solar RD&D budget for FY15 is over \$300M, while the DOE distributed wind budget is estimated at under \$3M out of its \$109M overall wind energy program⁴. This is why increasing U.S. DOE funding for distributed wind is a high priority for DWEA.

6. Policy Drivers

Policy, especially financial incentives, determines the pace of market development for clean energy technologies. While distributed wind incentives have lagged other clean energy technologies, they are now beginning to catch up and markets are growing. Non-financial policies that encourage or ease the use of distributed wind are also important. The following policy drivers are listed in the approximate order of their impact on the development of distributed wind markets.

6.1 Federal Tax Credits

For the U.S. market the most important policy driver, by far, is the 30% Investment Tax Credit (ITC): Section 48 of the tax code for commercial installations and Section 25 for non-commercial (residential) installations. For distributed wind up to 100 kW, the ITC was enacted in 2009 and expires in 2016. The ITC for wind turbines over 100 kW is tied to the Production Tax Credit (PTC, Section 45), which expired at the end of 2014. The market for medium-scale wind turbines for behind the meter applications is currently stalled due to the unavailability of the ITC, placing a real hardship on manufacturers and project developers in the over 100 kW distributed wind space. The industry has already seen business failures and exits from these U.S. companies.

DWEA believes that extension of the ITC past 2016 and raising its size limitation past 100 kW for wind are essential to the development of Distributed Wind in the U.S. The PTC does not apply to distributed wind because energy is not sold to an independent third-party. An upfront tax credit, such as the ITC, is a more effective incentive structure for Distributed Wind due to the market sensitivity to capital costs and payback period. DWEA has supported PTC/ITC extensions since 2009 that have included a provision

⁴ "EERE FY 2016 Budget Request", Dr. David Danielson, Feb. 2, 2015, stakeholder presentation

(Section 48) allowing taxpayers to take the 30% ITC in lieu of the PTC. This has allowed the over 100 kW Distributed Wind market to develop. DWEA has also supported legislation, such as HR. 4761 (Blumenauer / Cole) in the last Congress, and S. 1741 (Franken/Tester) in the 112th Congress, which would raise the size limit of the wind ITC to 20 MW.

The Distributed Wind industry has only had a federal incentive since 2009 and it would be very unfortunate and a failure of smart energy, environmental, and industrial policy to let the ITC expire in 2016 and not address the unfair limitation to 100 kW. It is also worth noting that DW has not had the market acceleration of either wind farms or solar PV and the fiscal impact of an ITC extension for distributed wind would be a very small fraction of the costs for solar PV, wind farms, or other energy sources including fossil fuels. Given the GW potential for Distributed Wind and the modest fiscal impact of an extension, DWEA believes further federal investment in this sector is well justified. The ITC extension and/or expansion is DWEA's #1 Policy Priority in 2015.

In January 2015 the Internal Revenue Service issued certification requirements for the small wind ITC that will help ensure the products supported are safe and effective.

6.2 State Rebates and Other Financial Incentives

A handful of states, including NY, OR, CA, MA, MD, and NC, offer additional financial incentives such as rebates, tax credits, or production based payments, however these programs are highly variable and often short-lived. Where these incentives are robust, such as in New York State, the distributed wind market is growing more rapidly due to the more favorable economics. Prior to the enactment of the federal ITC in 2009, these state incentives were the only ones available and distributed wind had no national market. The number and scope of state incentive programs for distributed wind have declined in recent years due to the recession, different priorities of governors and legislatures, and other factors.

6.3 USDA REAP Grants

Since 2002 the U.S. Department of Agriculture has offered competitively-awarded grants up to 25% of project costs for renewable energy and efficiency projects for farms and rural businesses. While this program has largely funded efficiency and solar projects in the recent past, reforms were implemented in 2015 and are likely to encourage expanded use of the program by farmers and rural businesses. The U.S. Congress, via the Agriculture and Appropriations Committees, has re-authorized and funded the popular program through 2019. DWEA strongly supports REAP and maintaining farm bill mandatory funding, as well as additional discretionary dollars, to the extent feasible.

6.4 Net Metering

On any "behind the meter" renewable energy system sized appropriately for the local load, there will be times when the output exceeds the home or facilities demand. This excess generation flows into the utility's distribution network and is immediately sold to a neighboring home or facility. Federal law (PURPA Section 210) requires all utilities to pay for this excess energy, but at a rate that is generally less than the retail rate. Net metering is a state or utility policy that allows excess energy to be "banked" for times of insufficient generation, usually handled by allowing the utility meter to turn backwards. For residential-sized wind turbines, net metering produces savings to utilities due to lower administration costs. In utility territories with low "avoided cost" rates, net metering can have a significant impact on the system economics. In several states, such as NY, VT, and MA, virtual net metering is allowing farmers to share the benefits of a single larger wind turbine over several electric meters on their property or even on different properties they own.

Net metering policies are currently under attack in several states. As previously stated (see Section 1.6), DWEA supports fair net metering policies. For the smallest of systems, up to ~ 25 kW, DWEA believes that annualized net metering is justified on the basis of utility savings on meter reading, accounting, and check writing.

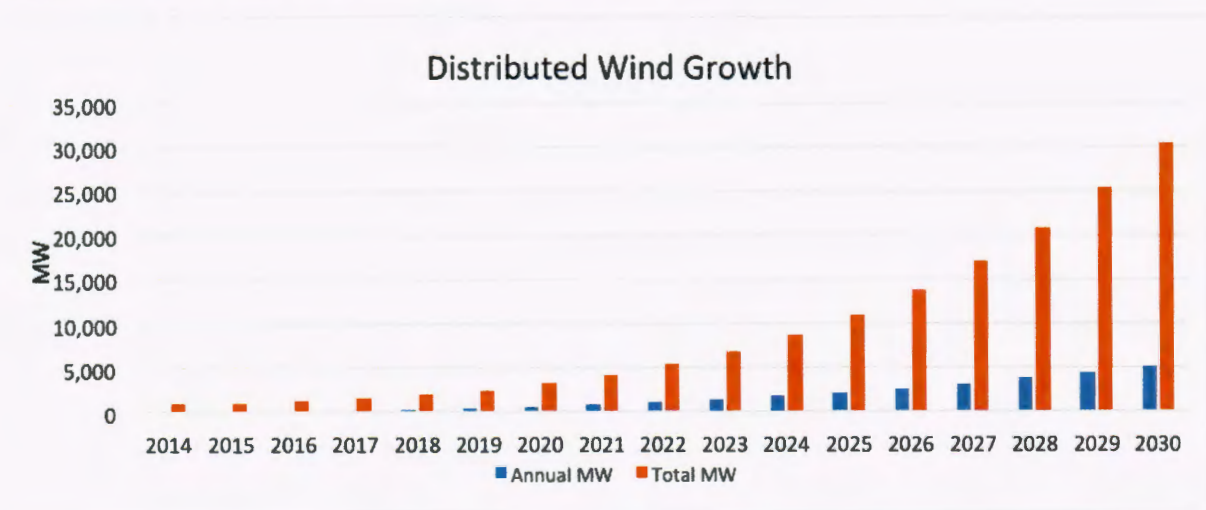
6.5 Interconnection Requirements

Utilities set requirements for equipment and customers that connect to their distribution network. When these requirements are reasonable and standardized they serve to streamline the interconnection approval. However, in some cases the requirements are excessive and serve to raise customers' costs. These anti-competitive practices have on occasion served to stop wind and solar projects by making them uneconomic. An example is the special \$1M liability insurance requirement imposed by many rural electric cooperatives (but not by investor-owned utilities).

7. The DWEA “30 GW by 2030” Initiative

A recent public survey showed that 90% of Americans want increased development of solar and wind – 80% want solar and wind to “increase a lot” and 10% want it to “increase somewhat.” Distributed wind is a technology/market that has superior growth potential over the next 15 years. It is literally the “low hanging fruit” of clean energy in the United States.

The DWEA “30 GW by 2030” initiative has the goal of reaching 30 GW, or 30,000 MW, of distributed wind capacity in the U.S. by 2030. Starting with 1 GW in 2015 and averaging 30% annual growth, the DWEA plan would result in 30.5 GW of distributed wind by 2030.



By 2030 the distributed wind industry is projected to reach annual revenues of \$12.7 billion, employing over 150,000 people. The nearly half a million distributed wind turbines would be producing more than 66 TWh of pollution-free electricity, enough for over 5.8 million homes. The environmental benefit of 30 GW of distributed wind installations in 2030 represents the displacement of 44,800,000 tons of carbon dioxide and 11.5 million cars. While it may not be possible to maintain the current 90%+ domestic content, DWEA believes that with the policy leadership it will take to achieve this growth, the domestic content in 2030 could exceed 80%.

The policies that form the foundation of the DWEA “30 GW by 2030” plan include:

- Extending the existing ITC for distributed wind for several years, or removing the 100 kW limit for the federal Investment Tax Credit (matching solar) and providing a long-term extension.
- Providing a 40% ITC for residential wind systems up to 20 kW as part of the ITC extension
- Increasing the U.S. DOE budget for distributed wind RD&D to at least 15% of the overall wind energy research budget, with a range of activities paralleling the DOE solar program and investments made in prior years for larger land-based and offshore wind.

- Maintaining the USDA REAP program through and beyond 2019 at current or higher funding levels while ensuring it aggressively incentivizes DW pro-actively.
- Encouraging rural electric cooperatives to sell and finance distributed wind systems to their members.
- Supporting exports of American-made distributed wind technology via international agencies and the White House Rural Export Initiative.

The future of distributed wind is where its LCOE is competitive with the grid in a large enough market for the industry to grow and thrive. State and federal subsidies are the bridge to that future by enabling the industry to reach volumes that bring down the total project costs to offset the eventual loss of these subsidies. The DWEA “30GW by 2030” plan would create that bridge and make distributed wind a significant long-term contributor to America’s clean energy future.

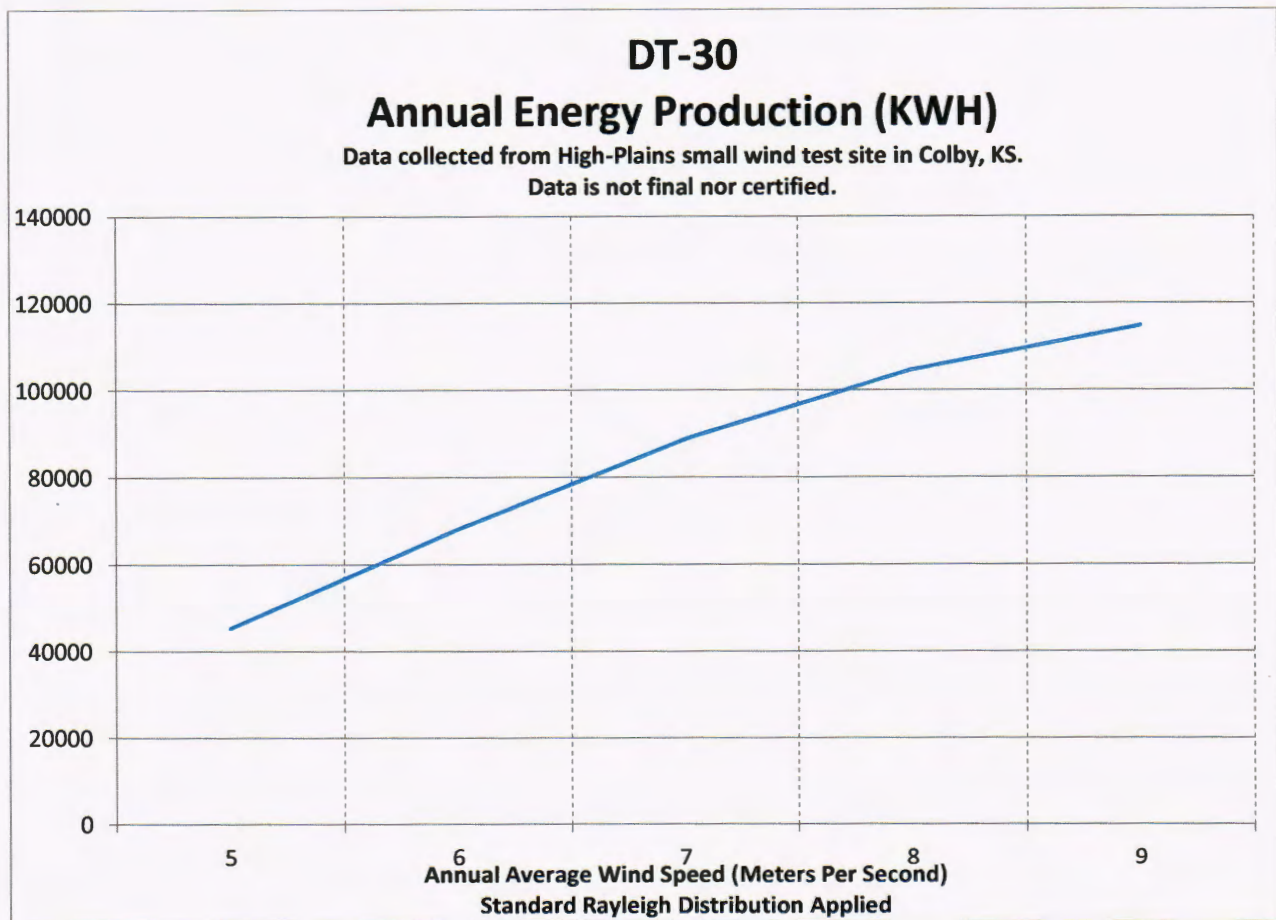
8. Conclusion

DWEA believes that small and medium wind energy systems in behind-the-meter applications have sufficient potential, at the gigawatt scale, to warrant a concerted fifteen year effort at the federal and state levels to accelerate the development of the technology, manufacturing, and deployment of distributed wind systems. By 2030 these initiatives could create over 150,000 new skilled jobs, give consumers more choices for clean energy, greatly expand exports, and contribute significantly to environmental goals. The benefits of distributed wind are concentrated in rural areas and will be felt in every state. Now that windfarms and solar electric, among other technologies, are well established in the market place DWEA believes it is time to bring distributed wind to the policy forefront.



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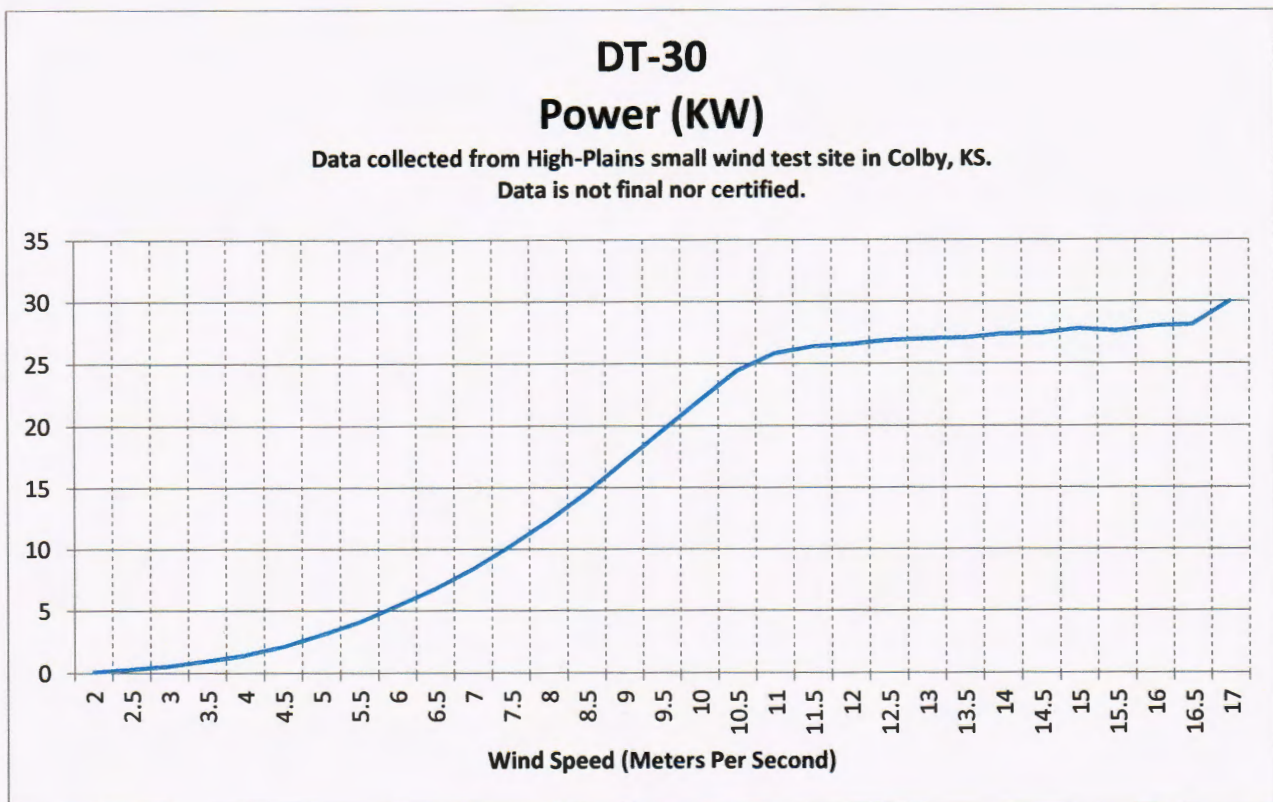
Dakota Turbines DT-30 Estimated Annual Energy Production





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Dakota Turbines DT-30 Power Curve





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DT-30 TECHNICAL SPECIFICATIONS

GENERATOR	SYSTEM
Type: Permanent Magnet Variable Speed Core: Patent-Pending Windings, Iron-Less Air Core Rated Output: 30 KW Continuous RPM: 0 - 180	Type: Utility Interactive Operating Temps: -40 to 120 Degrees F. Yaw System: Active Tower: 80 – 165 Ft Available Turbine Weight: 3,500 Lbs Listings: UL1741
ROTOR	PROTECTION
Configuration: Up-Wind Horizontal Axis Rotor Diameter: 42 Ft Swept Area: 1,385 Sq Ft	Stage 1: Active Blade Pitch Stage 2: Patented, Passive Fail-Safe Blade Park System Stage 3: Generator Dump Load Stage 4: Active Yaw
BLADES	INVERTER
Length: 18.5 Ft Material: Composite Airfoil: Proprietary	Voltage: 240, 277 Single Phase Frequency: 60 Hz Technology: High Speed IGBT Cooling: Patent-Pending Geo-Thermal Water Cooling System