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An Analysis of the Technical and Economic Potential for Mid-Scale Distributed Wind

December 2007 – October 31, 2008

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ICF International
Fairfax, Virginia

Subcontract Report
NREL/SR-500-44280
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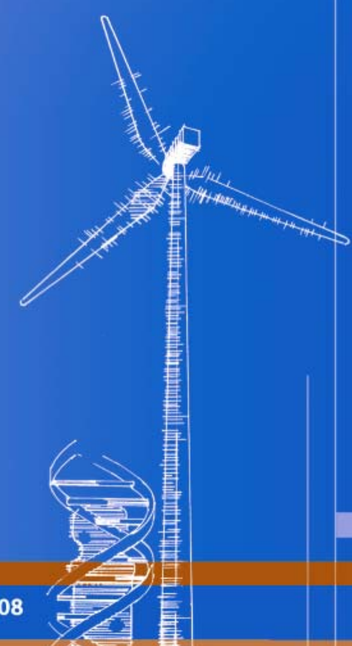

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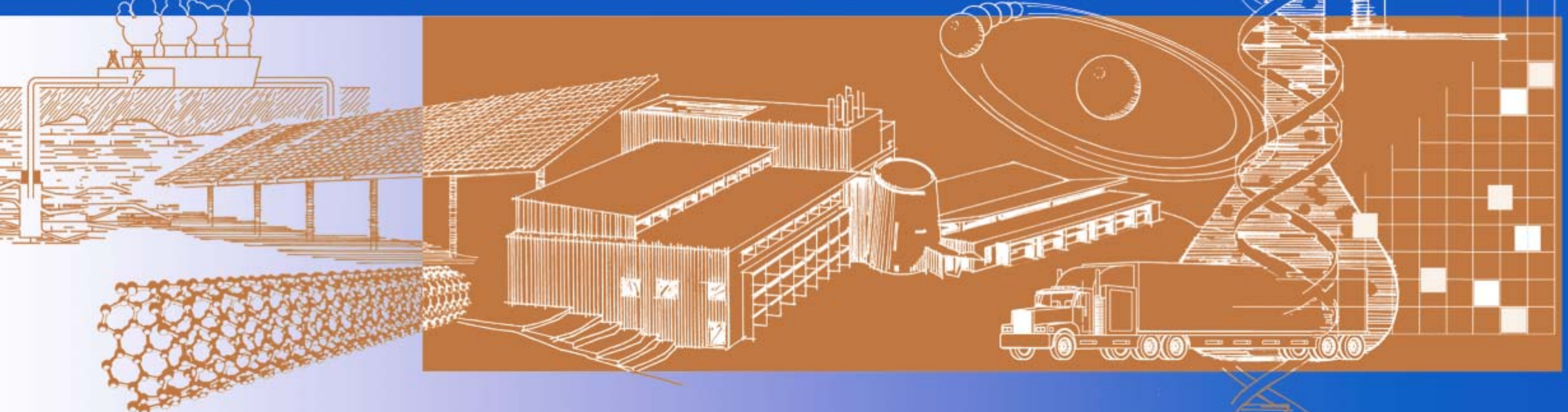

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List of Acronyms

C-BED	Community-Based Economic Development
CBECS	EIA Commercial Buildings Electricity Consumption Survey
CEPD	Commercial Energy Profile Database
CIP	commercial, industrial, and public facilities
CREBs	Clean Renewable Energy Bonds
CW	community wind
D&B	Dun & Bradstreet
D-U-N-S	Data Universal Numbering System
DSCR	debt service coverage ratio
EIA	Energy Information Administration of the U.S. Department of Energy
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
FRCC	Florida Reliability Coordinating Council
GIS	geographic information system
GL	Germanischer Lloyd
HSIP	Homeland Security Infrastructure Protection
HVAC	heating, ventilating, and air conditioning
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronics Engineers
IOU	investor-owned utility
ISO	independent system operator
MACRS	Modified Accelerated Cost-Recovery System
MAIN	Mid-America Interconnected Network
MCPP	Mid-Continent Area Power Pool
MECS	EIA Manufacturing Electricity Consumption Survey
MIPD	Major Industrial Plant Database
NAICS	North American Industry Classification System
NEPOOL	New England Power Pool
NERC	North American Electric Reliability Corporation
Non IOU	non-investor owned utility
NPV	net present value
O&M	operations and maintenance
PTC	Production Tax Credit
R&D	research and development
RDF	Renewable Development Fund
REC	renewable energy certificate
REPI	Renewable Energy Production Incentive
RFP	request for proposal
RPS	Renewable Portfolio Standard
RTO	regional transmission organizations
SBA	Small Business Administration
SCADA	supervisory control and data acquisition

SIC	Standard Industrial Classification
SPP	Southwest Power Pool
UL	Underwriters Laboratories
USDA	United States Department of Agriculture
WECC	Western Electricity Coordinating Council
WPC	wind power class

Executive Summary

This report examines the status, restrainers, drivers, and estimated development potential of mid-scale (10 kW to 5000 kW) distributed wind projects. This segment of the wind market has not enjoyed the same growth that central-station wind has experienced. The purpose of this report is to analyze why, and to assess the market potential for this technology under current market and policy conditions.

As discussed in section 2, one of the most significant barriers to the development of distributed wind is a general scarcity of turbine choices and turbine inventory available for purchase. Most turbine manufacturers have scaled back their involvement in the mid-scale market segments in favor of larger turbines suitable for large, central-station wind farms. Those distributed-scale turbines that are available are often relatively expensive (on a $/kW basis), hard to order in single units or small lots, and suffer from long delivery delays.

Section 3 discusses various other factors—both positive and negative—that affect the viability of distributed wind. In addition to the product scarcity described in section 2, distributed wind is challenged by relatively poor productivity (compared with more modern large turbines), siting issues, burdensome interconnection rules, aesthetic concerns, and fragmented state rules regarding net metering. Several other factors favor distributed wind: areas of high and rising retail electricity prices, increasingly favorable public policies, and greater community interest in the environmental and economic benefits of renewable energy.

As examined in section 4, the study evaluated the economic potential for distributed wind in the contiguous United States, excluding Alaska and Hawaii. The analysis began with a GIS screening process to eliminate areas that are technically impractical for distributed wind. Sites were eliminated in areas where:

- Elevation was too high;
- Slope was too steep;
- Population density was too great;
- Wind Power Class was less than 2; and
- Areas legally excluded from wind-power development, such as national parks.

After screening out ineligible sites, more than 3.6 million surviving sites were evaluated to determine whether distributed wind would be financially feasible. Certain customer types were excluded from the study, such as agricultural, construction companies, and military facilities, because they lacked data necessary for the analysis. The financial model considered:

- Wind resources;
- Wholesale and retail power prices;
- Renewable Energy Credit (REC) prices;
- Customer type (community wind, commercial, industrial, or public facility);

- Project size;
- Turbine technical and financial characteristics;
- Onsite and offsite energy use; and
- Incentives.

The results varied significantly by customer class. Overall, the study showed that 67,100 out of the 3,611,655 sites/areas that were analyzed for economic viability yielded a positive net present value under current market conditions and policies and including all applicable state and federal incentives.

To assess the potential of new technology, two virtual wind turbines—the NREL 250 and NREL 500—were included in the analysis. These virtual turbines were compared to existing 250 kW and 500 kW turbines. Overall, the study showed that 204,677 sites analyzed had positive net present values with the virtual turbines compared with 10,407 economically successful projects with existing 250 kW and 500 kW turbines. These numbers do not include the application of capped state and federal incentives.

The following crucial changes could expand distributed wind development into the future.

- Improvements in technology;
- Reductions in cost;
- Greater productivity at lower wind speeds; and
- Greater policy support.

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1 Introduction

Wind technology has expanded significantly in recent years. Policy makers and the public recognize wind energy as a clean, zero-carbon emitting energy source that drives local economic development. Wind energy is indigenous, diversified, and available for development across much of the United States. Rising concerns about climate change have engendered policies supportive of renewable energy generally—and wind specifically—over the past decade.

Distributed wind energy, however, has not enjoyed the same rapid growth as large, central-station wind energy. This partially is due to the fundamental technical and economic challenges confronting distributed energy resources of any kind, such as poor scale economies and siting difficulties. These challenges are exacerbated by the explosive growth of the large wind market—as large wind has grown, manufacturer and policy maker attention increasingly has shifted towards the central-station paradigm, leaving distributed wind as a comparative backwater.

This report examines the present state of the distributed wind market and the forces that shape distributed wind's prospects. Uniquely, the report estimates the technical and market potential for distributed wind in the contiguous United States. This analysis indicates that there is a large potential market for distributed wind—a market that today depends on public policy support, and one that can grow with greater support and improvements in technology. The harnessing of this potential market, and the benefits that it would bring, depend on the concerted efforts of manufacturers, policy makers, and site hosts who see the value in developing this clean, domestic and distributed resource.

2 Status of the Mid-Scale Turbine Market

This section examines the commercial availability of new and remanufactured turbines in the mid-scale market segment (100 kW to 1,500 kW nameplate capacity for the purposes of this report). Accompanying the analysis is a discussion of the various factors affecting the value of wind turbines, such as price, warranty, and technician availability. The information presented in this section was collected through a literature review and from telephone interviews with several wind turbine manufacturers, remanufacturers, and developers.

2.1 New Turbine Availability

In the distributed wind energy industry, it is widely noted that one of the largest impediments to the industry's growth is a lack of available turbines in the 100 kW to 1,500 kW range. Table 1 presents a list of the current commercially available mid-scale wind turbine models. It is important to note that the table is a refined list that contains only models available for distributed wind energy applications. Information on other turbine models can be found, but research indicates that many of these models no longer are available (such as Suzlon's S33, 600 kW, and 950 kW models), are not suitable for the United States (for example Gamesa's G52-850 and G58-850 only operate at 50 Hz), or are sold in such a way that they are simply unavailable for distributed wind applications (for Fuhrländer to even consider producing its FL 100 and FL 250 turbines, for example, it requires minimum orders of 10 turbines) (Schulte 2007, Graham 2007). Other models (e.g., McKenzie Bay's WindStor, The Wind Turbine Company's 750 kW turbine) were eliminated based on evidence that they are not yet commercially available and it is unclear when they will be available (Bakeman 2007, Miles 2007). In estimating the market potential for small-scale and mid-scale wind (section 4), the project team chose among currently commercially available turbines.

As shown by Table 1, there is a market gap in the 100 kW to 500 kW segment. More models are available in the 600 kW to 1,500 kW segment, however all but two have lead times of between 12 and 16 months. It is worth noting that the majority of wind turbines in this segment are manufactured overseas, utilizing multinational component suppliers. This fact has significant implications for turbine price in U.S. distributed wind applications, due to shipping costs, dollar weakness, and import duty costs.

Table 1. Available New Mid-Scale (100 kW to 500 kW) Wind Turbines*

Nominal, Nameplate Output (kW)	Model	Manufacturer	HQ Country
100	Northwind 100a and 100b	Distributed Energy Systems	USA
225	200-250	Norwin A/S	Denmark
250	GEV MP	Vergnet	France
250	WES30	Wind Energy Solutions	Netherlands
600	E 48	Enertech	USA
600	FL 600	Fuhrländer	Germany
600	PS 47	Vestas RRB[1]	India
750	AWE 52-750	Americas Wind Energy	Canada
750	EcoRX 750	Four Seasons Windpower	USA
750	599-750	Norwin A/S	Denmark
900	AWE 52-900	Americas Wind Energy	Canada
900	AWE 54-900	Americas Wind Energy	Canada
1,000	1000 kW	Mitsubishi	Japan
1,000	N1000	Nordic Windpower	USA
1,200	62/64	Vensys	Germany
1,250	FL 1250	Fuhrländer	Germany
1,250	1.25 MW	Suzlon	India
1,500	70/77	Vensys	Germany
1,500	FL MD 70/77	Fuhrländer	Germany
1,500	FL 1500	Fuhrländer	Germany
1,500	1.5 MW family	GE	USA
1,500	1.5 MW	Suzlon	India

*** This is not a comprehensive list of commercially available wind turbines.**

The two manufacturers that were willing to offer information on the volume of shipments in the past year reported shipping roughly half a dozen units of a particular model (Dickout 2007, Jones 2007).

[1] Vestas RRB is in the process of setting up a U.S. distributor.

2.2 Remanufacturing Potential

The remanufacturing process for a wind turbine typically involves replacing controllers with newer and more modern systems. The best remanufacturers also complete a thorough inspection of the turbine and replace any worn hardware.

Table 2 presents a list of companies that remanufacture and sell turbines in the 100 kW to 1,500 kW segment, and the rated output of the models currently in their inventories. Representatives from all of the companies noted that a variable and limited supply of turbines is available for remanufacturing. Thus, these companies have difficulty predicting their future inventories.

Table 2. Remanufacturers of Mid-Scale Wind Turbines*

Remanufacturer	Rated Output of Current Models (kW)	HQ Country
Enertech	150	USA
Halus Power Systems	90–500	USA
Windbrokers[2]	—	Netherlands
Wind Turbine Warehouse	150,500	USA

*** This is not a comprehensive list of commercially available wind turbines.**

Distributed wind project developers have widely varying opinions regarding remanufactured turbines. Some developers do not see these machines as a viable option for the distributed wind industry, due to questions regarding remanufacturing workmanship and machine dependability. Others acknowledge some of these same limitations and yet view remanufactured machines as the most promising option on the market, due to the associated price reductions which improve project economics. These developers also point to the fact that the long lead times associated with the manufacture and purchase of a new wind turbine are avoided when using remanufactured machines.

2.3 General Factors Regarding Wind Turbine Value

This section discusses several factors that impact the value of mid-scale wind turbines. Details regarding many of these issues and their impacts on mid-scale distributed wind turbine projects also are provided in section 3. The discussion here focuses only on how these factors impact the value of a particular turbine. It is important to note that no particular turbine can fulfill the needs of the entire market. The factors that are perceived as most valuable vary depending upon the situation and location of the project.

2.3.1 Turbine Availability

- Availability of turbines in the 100 kW to 1,500 kW segment is extremely limited. If developers cannot obtain the properly sized turbine, then a project cannot move forward.
- Lead time required varies for different turbine models. A number of factors impact lead times, including a manufacturer's target turbine market (larger manufacturers tend to focus their efforts on utility-scale models where greater worldwide demand exists; this

[2] Windbrokers' remanufactured turbines are not suitable for installation in the United States (50 Hz).

pushes back smaller turbine development), availability of hardware (e.g., there are shortages of bearings and gearboxes, so orders for these items take time to fill), and availability of raw materials (such as metals) for hardware development.

- Certification of new and additional manufacturing capacity can be difficult to obtain. There are some instances where European manufacturers (e.g., Fuhrländer) have prequalified tower manufacturers in the United States, but this is the exception.

2.3.2 Turbine Costs

When all other factors (e.g., performance) are held constant, a lower turbine cost increases the value of a particular turbine by improving project economics (*see* section 4.4.1.1). Several developers noted that the price of wind turbines currently on the market presents a significant challenge for distributed wind applications in the United States (Drouilhet 2007, Godwin 2007, Graham 2007). Several factors have pushed the cost of mid-scale wind turbines higher.

2.3.3 Installation Costs

Larger towers generally require larger transport vehicles and cranes, which can increase transportation and installation costs. New tower technologies—such as self-erecting designs—have the potential to decrease installation costs. Installation costs include those associated with transportation, construction, and interconnection.

2.3.4 Warranty

- A turbine that has a warranty is inherently more valuable than one without a warranty (if all other factors are equal).
- Many lenders require projects to use warrantied turbines.
- Many mid-scale wind turbine manufacturers are small companies, and are unable to support a warranty. If the manufacturer cannot provide a warranty, then the only available warranties are from the individual parts manufacturers.

2.3.5 Availability of Technicians

Developers tend to prefer manufacturers that provide technicians to assist with the installation and maintenance of machines. Many of these manufacturers are small companies, however, and therefore are unable to provide service technicians. In such cases developers must train customers in operations and maintenance (O&M), which can be time consuming and difficult (Schulte 2007).

2.3.6 Availability of Spare Parts

The availability and cost of spare parts affects the value of a particular turbine. It is advantageous to be able to obtain spare parts from several suppliers, as opposed to the original manufacturer only.

2.3.7 Reliability

- As turbine reliability increases, O&M costs fall, time in service rises, and project economics improve.
- Some turbine components—such as gearboxes—are more prone to wear and tear than others. When corners are cut in the design of these components, upfront costs could decrease, but O&M costs rise, lowering return on investment for the owner (Juhl 2007).

Turbines with poorer-quality components are considered less valuable if all other factors are equal.

2.3.8 Noise

- Wind turbines produce two types of noise: one from the equipment inside the nacelle, such as the gearbox, and one from the aerodynamic noise of the rotating blades.
- Turbines that generate more noise tend to raise additional public opposition, so developers try to find low-noise models.

2.3.9 Certification

One developer noted that certification is an attractive feature of a wind turbine (Schulte 2007). A number of organizations provide wind turbine certifications including: Underwriters Laboratories (UL), a product-safety testing and certification organization in the United States; Germanischer Lloyd (GL) Wind Energy, an internationally operating certification body for wind turbines; International Electrotechnical Commission (IEC), an international standards development group for electrical equipment; and the Danish Energy Authority, the energy office of the Danish government.[3]

2.3.10 Extreme Weather Survivability

Some wind turbines are designed for remote arctic areas or tropical islands. The turbines are designed to survive in extreme weather conditions, therefore developers and owners could face trade-offs such as lower efficiency and greater cost.

2.3.11 Avian

Turbines and towers that have a lesser impact on wildlife are less likely to raise public opposition (e.g., tubular steel is preferable to lattice).

2.3.12 Aesthetics

Mid-scale turbines have aesthetic impacts and, per Federal Aviation Administration (FAA) regulations, also could require lighting if their tip heights are above 200 feet. Although all models have visual impacts, there is some indication that the public is more accepting of those impacts if the machine uses a three-blade design rather than a two-blade design. Different communities raise differing levels of opposition to proposed installations based on aesthetics. Project developers, however, note that it is always important to engage community concerns regarding aesthetics (e.g., impact on historic properties and viewsheds) as part of siting activities.

3 Barriers to and Drivers of Mid-Scale Turbine Distributed Wind Projects

Simplifying somewhat, distributed wind can be understood as the offspring of wind technology and distributed generation. As such, it faces all of the challenges of its two parent technologies and shares only some of the respective advantages. This section examines the barriers to and

[3] For more information on UL certification, visit http://www.ul.com/. For more information on GL certification, visit http://www.gl-group.com/industrial/glwind/3780.htm. For more information on the IEC certification, visit http://www.iec.ch/. For more information on the Danish Certification Scheme that is managed by the Danish Energy Authority, visit http://www.wt-certification.dk/index.htm.

drivers for mid-scale distributed wind projects (100 kW to 5,000 kW nameplate capacity, for the purposes of this section); some of these are common to all wind technologies, others are common to all distributed generation technologies, and others are unique to distributed wind.

The information in this section is derived from a literature review and interviews of 26 individuals involved in the supply chain of the distributed wind market, including state and local government regulators, manufacturers, remanufacturers, project developers, and customers. The customers interviewed represented several groups, including farms, schools and universities, and federal government facilities.

3.1 Barriers to Mid-Scale Turbine Distributed Wind Projects

Although there are numerous barriers to the growth of distributed wind projects using mid-scale turbines, three restrainers overshadow the rest: Challenging project financials, turbine shortages, and a lack of regulatory support for these projects. In individual circumstances and even in certain states, other barriers present significant roadblocks to a project's success, but the deciding factors for the majority of projects boil down to these three issues.

This section provides descriptions of the three dominant barriers as well as the other factors restraining growth of this market. It is important to note that many of the restrainers are strongly interrelated, therefore solutions that are devised to address one barrier actually could address multiple barriers (for example, project financials are inexorably linked to the regulatory environment, so strengthening the regulatory support for mid-class turbine distributed wind projects likely would improve the economics of projects).

3.1.1 Challenging Project Financials

The primary difficulty facing mid-scale distributed wind projects is unfavorable project economics (Schulte 2007, Drouilhet 2007, Graham 2007, Usibelli 2007, Haas 2007, Parry 2007, Juhl 2007). Challenges arise from both the investment cost and net revenue aspects of a typical project pro forma.

3.1.1.1 Investment Cost

The total installed cost of a project refers to all costs associated with the procurement and installation of a turbine; as the total installed cost rises, the project payback period lengthens (assuming all other factors remain unchanged).

Wind projects (not just distributed wind projects) enjoyed 20 years of declining installed costs on a $/kW basis during the 1980s and 1990s (*see* Figure 1). This long-term decline appears to have been driven by greater turbine efficiencies of scale, improved manufacturing processes reflecting greater industry maturity; increased turbine shipment volumes overall, which reduce the marginal costs of manufacturing and distribution; and increased project size, which reduces the marginal costs of materials and construction effort for an individual project.

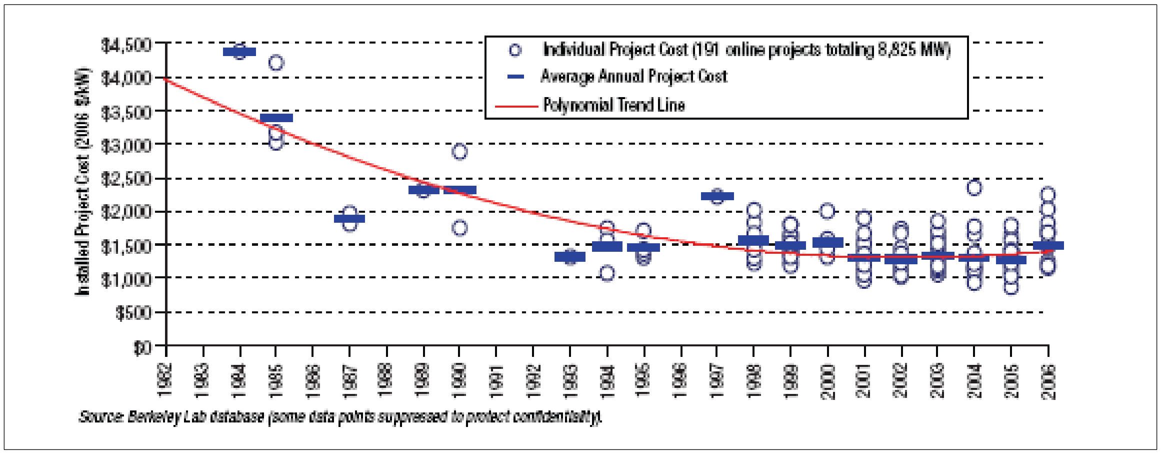

Figure 1. Installed wind project costs over time (NREL 2007)

This 20-year trend bottomed out and reversed during the present decade. Total installed costs began to increase, and rose by about 18% on a $/kW basis for projects completed in 2006 as compared with those completed in 2005. Turbine prices specifically could have increased as much as 60% on a $/kW basis since 2001 (*see* Figure 2). In executing the market potential study, the project team assumed installed turbine costs as low as $18,500 (2 kW capacity), and as much as $9.9 million (5000 kW capacity). See Table 4 for more details.

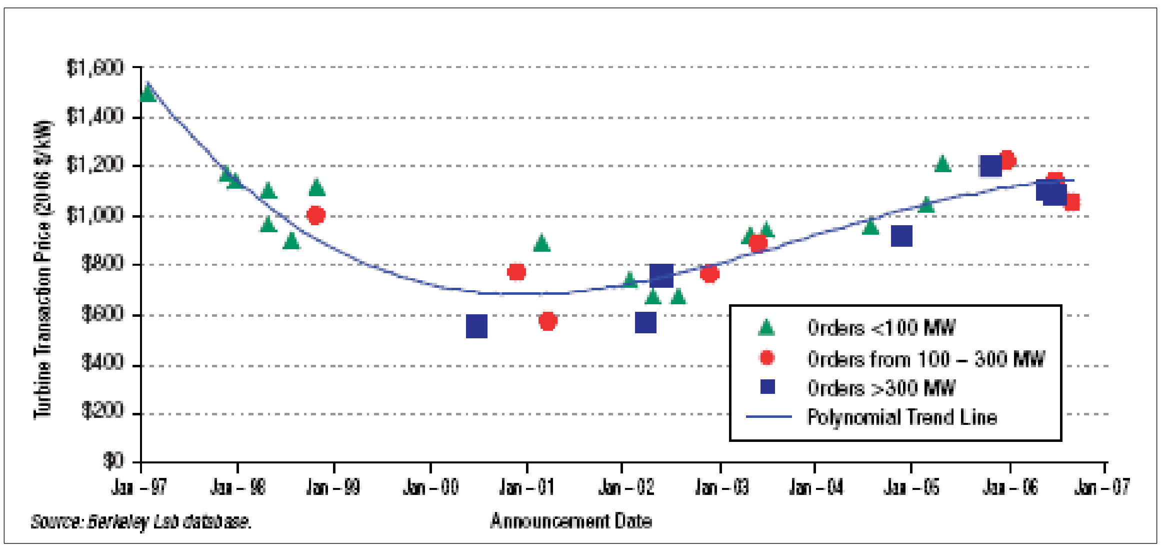

Figure 2. Reported U.S. wind turbine transaction prices over time (NREL 2007)

Distributed wind projects comprise a small fraction of all wind projects, so it can be difficult to draw distinct conclusions about this subset of the wind market. It appears that although distributed wind projects enjoyed some of the price reductions of the broader wind market during the 1980s and 1990s, they could be seeing a proportionately greater price rise in the post-2000 period. To understand the reasons for this situation, it is useful to itemize the factors driving the increase in installed costs and to understand their differential impacts on utility- and distributed-scale wind projects.

3.1.1.1.1 Turbine Costs

The rise in turbine costs appears to be driven by several factors. The start-and-stop nature of the Production Tax Credit (PTC) in the United States has had the effect of driving a frenzy of wind development activity on a two-year cycle. This has had the perverse effect of driving demand for turbines up to the limit of supply during each cycle, while simultaneously slowing the entry of new manufacturers into a boom-and-bust market. Although some new manufacturers and manufacturing capacity has entered the market, it probably is less than it would be if the PTC were authorized for a longer time horizon. For qualified customers modeled in the market potential estimation described in section 4, the analysis assumed that the PTC would offer a $0.02/kWh tax benefit for the first ten years to recipients that generate renewable energy and sell it to a third party. The PTC improved project economics. See 4.3.5.1, Federal Incentives, for details.

Another reason for high turbine costs is the rising cost of raw materials such as copper, which recently has risen sharply. American steel likewise has jumped in price, such that it now costs 200% to 300% more than steel produced in Asia. The cost increase in domestic steel has been so great that manufacturers of utility-scale turbines actually are importing towers from China, despite the shipping costs (Schulte 2007).

Importantly, the wind turbine market is an international market. Worldwide market demand is high, the supply chain is overburdened, and suppliers at different points in the supply chain are reaping extensive economic rent from the supply-demand imbalance.

3.1.1.1.2 Limited Turbine Selection

Although these three factors—boom and bust of the PTC, rising costs of raw materials, and international competition—affect the price for all turbines, other factors have a disproportionate effect on the price of smaller turbines. The limited selection of turbine models in the mid-scale range and the comparatively limited production of those models that are available (discussed in section 3.1) are primary drivers of mid-scale turbine costs. Over the past two decades, as the use of larger turbines has become more economically favorable than the use of mid-scale turbines, fewer mid-scale models have been brought to market (DOE 2006). In the late 1990s, 99% of all turbines sold were in the 0 kW to 1,000 kW range; by 2006, only 11% fell into this range (*see* Figure 3). Some manufacturers simply have exited the mid-scale market entirely. Fewer manufacturers participate in the distributed market segment, and those that do participate offer a limited number of models, therefore this market niche lacks the economies of scale that drive down the costs of utility-scale turbines and induces competitive pricing pressure (DOE 2006). The small supply of mid-scale turbines has contributed to high- and variable-turbine costs, project delays due to long lead times, and a lack of turbine choices to match the needs of different projects (DOE 2006).

Turbine Size Range	1998-99 1,013 MW 1,418 turbines	2000-01 1,758 MW 1,987 turbines	2002-03 2,125 MW 1,784 turbines	2004-05 2,782 MW 1,937 turbines	2006 2,454 MW 1,532 turbines
0.00 to 0.5 MW	1.3%	0.4%	0.5%	1.9%	0.7%
0.51 to 1.0 MW	98.4%	73.9%	44.2%	17.6%	10.7%
1.01 to 1.5 MW	0.0%	25.4%	42.8%	56.6%	54.2%
1.51 to 2.0 MW	0.3%	0.4%	12.3%	23.9%	17.6%
2.01 to 2.5 MW	0.0%	0.0%	0.0%	0.1%	16.3%
2.51 to 3.0 MW	0.0%	0.0%	0.1%	0.0%	0.5%

Source: AWEA/GEC project database.

Figure 3. Size distribution of number of turbines over time (NREL 2007)

3.1.1.1.3 Component Cost

Another cost factor specific to distributed wind turbines is the rising price of components due to a shortage of component parts (DOE 2006). Vestas recently raised the price on its turbines several times, citing the rising cost of parts (Graham 2007). Gearboxes, bearings, and some blade types are in especially short supply for distributed-turbine models, as the manufacturers of these parts are fully committed to filling orders for utility-scale turbines (Graham 2007, Jones 2007). These part vendors often will not even consider accepting small-quantity orders—and sometimes the definition of "small" is the quantity of parts necessary to produce 100 turbines (Jones 2007).

As a result of these and other factors, distributed wind turbine prices—the largest component of installed costs—have risen for some models 30% to 50% over the last few years. Prices for new turbines have reached a level such that some developers consider remanufactured turbines the only viable option in the mid-scale range, due to the reduced costs (Godwin 2007). According to DOE (2006), turbine costs represent the single largest barrier for potential distributed wind customers in industry, agriculture, and small business.

3.1.1.1.4 Transportation Costs

Transportation is another significant cost for all wind projects, but it also can affect distributed-scale projects disproportionately (Schulte 2007, Godwin 2007, Juhl 2007). Although some manufacturing capacity is located domestically, most of the distributed wind manufacturers are located in Europe. The result is that each turbine can have more than $100,000 in shipping costs added to its delivered price (Godwin 2007). Once the turbine arrives in the United States it faces an import duty, which further increases a distributed wind project's cost (Schulte 2007, Juhl 2007). Distributed wind turbines—whether domestic or foreign sourced—also face challenges in internal shipment. Locating a company to transport equipment can be a significant challenge because suitable trucks often are completely booked by utility-scale turbine manufacturers (Juhl 2007).

3.1.1.1.5 Currency Exchange Rates

The distributed-wind market is disproportionately affected by exchange rate movements. Most distributed wind turbines are sourced in Europe, therefore the exchange rate between the dollar and the Euro impacts project costs (Schulte 2007). In July 2002, $1 equaled 1 Euro. In April 2008, $1.59 equaled 1 Euro (X-rates 2007). Turbine manufacturers are concerned with earnings in their domestic currency (in this case, the Euro), therefore U.S. buyers have had to spend 59% more to purchase a European-sourced turbine with a constant Euro price.

3.1.1.1.6 Installation Costs

Installation costs are another component of total installed costs. These include the costs of cranes, which varies by region and project. Mid-size turbine distributed wind projects generally are single-turbine efforts, therefore crane costs can be a significant budget item and are proportionately more expensive than for utility-scale projects (Godwin 2007). In parts of the country that are distant from major cities crane access is limited, leading to much higher costs and project delays of more than a year (DOE 2006, Godwin 2007). The problem is accentuated when large developers and manufactures of utility-scale turbines book all the cranes owned by crane companies (Godwin 2007). For projects sited on remote island locations, crane costs are prohibitively expensive so developers must turn to self-erecting turbine models of which there are few (Drouilhet 2007). At the same time, crane availability and cost is not a major issue in parts of the Northeast that are close to a number of major cities (Schulte 2007).

The cost of foundations also has risen in recent years with the surging price of cement (Godwin 2007), which increased 11% between September 30, 2005 and September 30, 2006 (Brown 2007). In certain extreme cases, such as mid-scale turbine distributed wind projects in Alaska, the entire construction process for the foundation becomes a significant expense because of the difficulty associated with building in permafrost (Petrie 2007). In other instances, specialized foundation design significantly increases costs including, for example, those associated with siting wind turbines on closed municipal landfills or on land underlain by peat.

3.1.1.2 Net Revenue

Net revenue refers to the financial benefit that customers investing in distributed wind projects stand to gain as a result of their investment, and can be calculated as the difference between gross project revenue over time minus gross project expenses. To determine the number of winners in each customer class of the market potential estimation, the project team considered net revenue over time, expressed as net present value (NPV). See section 4 for further details.

3.1.1.2.1 Gross Revenue

Distributed wind projects create the following benefit streams.

- Displacement of electricity that otherwise would be purchased from the electric utility.
- Sale of excess electricity to the grid.
- Sale of renewable energy certificates (RECs), also known in some regions as “green tags.”
- Tax credits such as the federal PTC and accelerated depreciation.
- Other state and federal incentives, such as tax credits, grants, and low-interest loans.

These benefit streams arise from varying mixtures of ordinary market operations and specific governmental policies. Each of these five categories of benefits was included in the market-potential estimation analysis. See section 4.2.8.

This section focuses on those benefit streams—displacement of electricity deliveries and sale of excess generation—having valuation that can be forecast within the present commercial and policy frameworks. The other benefit streams listed above arise because of more recent (and in some cases more temporary) policy action by governmental entities. These benefit streams are dependent on continuing governmental policy decisions; therefore, they are discussed in greater detail in the section entitled, "Regulatory Support."

3.1.1.2.1.1 Displacement of Utility-Supplied Electricity

Displacing utility deliveries requires no new policy support. In general, no new policy action is required to enable a utility customer to use less utility-delivered electricity (whether through more efficient operation or through distributed generation), and the kW and kWh not used are "priced" according to an established utility tariff. In the market-potential estimation analysis, the percentage of energy used onsite—which varied from 100% to 0%—was one of many factors that helped determine the feasibility of a wind energy project.

In many regions of the country, displacing purchased electricity with distributed wind generation (or distributed generation of any kind) has been an increasingly favorable opportunity in recent years. Increases in the price of utility fuels (especially natural gas) have driven commensurate increases in the final price of electricity charged to customers. As shown in Figure 4, retail electricity prices have risen steadily since 1999 with the exception of a small decrease between 2001 and 2002. In some states (*see* Figure 5, Figure 6), electricity prices have risen even faster than the national averages. Thus, in recent years, each kWh produced by a distributed wind turbine has become increasingly valuable.

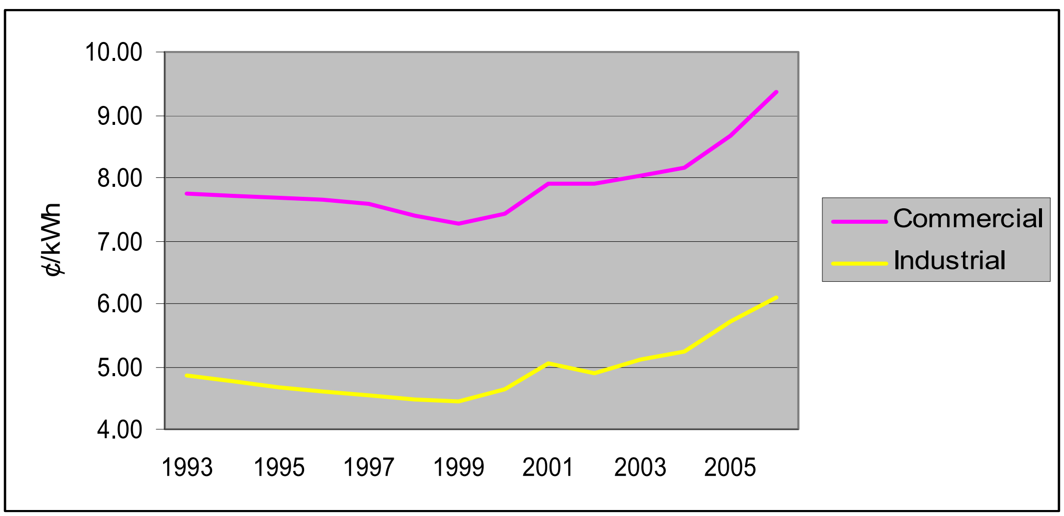

Figure 4. United States average retail price of electricity (¢/kWh) to ultimate customers for commercial and industrial sectors, 1993–2006 (EIA 2007a)

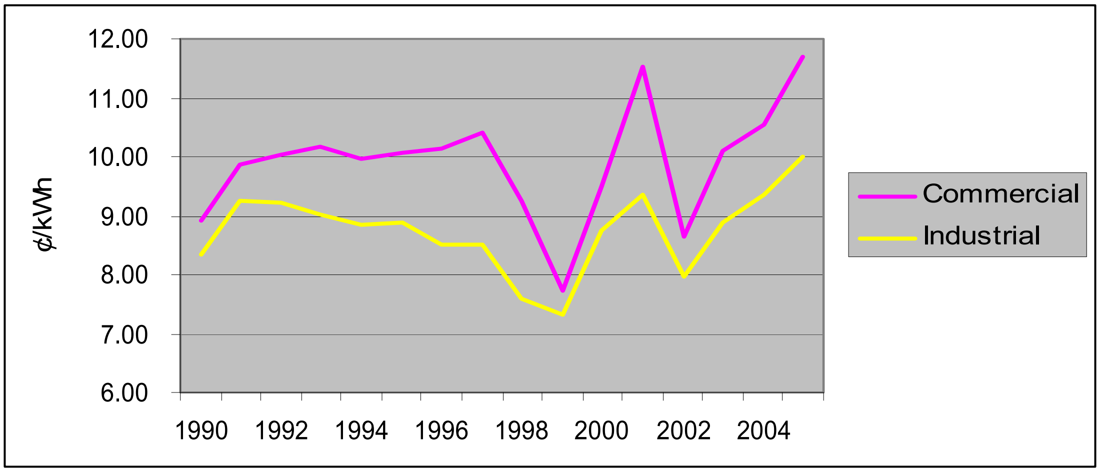

Figure 5. Average retail price of electricity (¢/kWh) to ultimate customers for commercial and industrial sectors in Rhode Island, 1990–2005 (EIA 2006c)

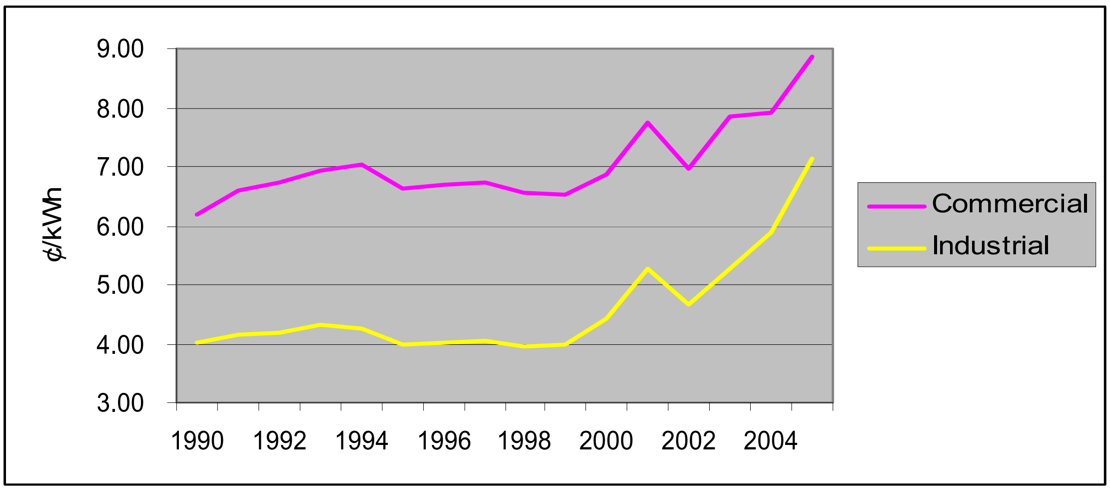

Figure 6. Average retail price of electricity (¢/kWh) to ultimate customers for commercial and industrial sectors in Texas, 1990–2005 (EIA 2006c)

Although this has been a favorable development for distributed wind, this revenue stream likely has not been exploited to its full potential. The reasons are traceable to wind technology itself, and the limited choices of turbines available for distributed wind projects.

The ability of a distributed wind project to maximize the value of purchased-electricity displacement is dependent on several variables. The most important variable is the site's wind resource: the greater the wind resource, the more electricity a given turbine can generate, and the more purchased electricity can be displaced. This naturally leads project developers to seek out sites with strong and steady winds which offer the greatest potential revenue generation. Site selection, in turn, affects turbine selection: a turbine's capacity factor[4] is dependent on the wind

[4] The capacity factor describes the percentage of a turbine's maximum theoretical output that actually can be harvested under the site's wind regime.

regime at a specific site. Other things being equal, a turbine with a higher capacity factor is preferable to one with a lower capacity factor at a given site.

Turbines are designed for specific wind regimes. One turbine, for example, might be designed to maximize the productivity of a low wind-speed regime, while another of the same nameplate capacity might be designed to deliver the highest capacity factor under a stronger wind regime. Both of these designs are useful and help fill the needs of a diverse customer base. As manufacturers have gradually abandoned the distributed wind market, however, the selection of distributed wind turbines has dwindled both in terms of optimization for different wind regimes and variety in nameplate capacities. This has forced project developers to choose turbines that could be sub-optimal for the development site which, in turn, reduces productivity and financial benefits (Godwin 2007, Schulte 2007).

Additionally, even those turbines available in the market have not benefited from the same level of research and development (R&D) investment that utility-scale wind turbines have enjoyed in the past decade (Graham 2007). Comprehensive data are scarce, but it appears that improved technology has allowed utility-scale turbines to increase their capacity factors in recent years, and that distributed wind turbines have not seen similar improvements.[5] One significant advance that has not occurred for distributed wind turbines is availability on taller towers. This feature would improve performance because, as turbine hub height increases, wind speeds are increased and turbulence is reduced (Rhoads-Weaver and Forsyth 2006).

R&D funding shortages might have limited advances in mechanical durability. Mechanical problems not only result in repair expenses (discussed below), they also reduce the turbine's productivity and thus its ability to generate financial benefits. Distributed wind projects are particularly vulnerable to the impacts of mechanical breakdowns given the shortage of skilled technicians, spare parts, and available cranes (DOE 2006).

3.1.1.2.1.2 Sale of Excess Electricity Generation

Existing laws and regulation permit a distributed wind project to sell its surplus electricity generation: If the project is located in an area with competitive wholesale electricity markets, the project can sell its generation to the market directly. Where no such market exists, the project still is entitled to sell its excess generation to the local utility at the utility's avoided cost.

Although sale of excess generation using either of these methods offers a revenue stream for the project, the unit price paid rarely will equal the unit price avoided by displacement of electricity deliveries.[6] Because of this differential, many states are creating policy framework to permit net metering. In its purest form, net metering allows distributed generators to sell excess generation to the utility at the same retail rates that the utility charges the customer for its deliveries. The rules vary considerably across those states that permit net metering. Appendix A summarizes the

[5] Other factors such as larger rotors and taller towers, also have driven improvements in utility-scale capacity factors, but capacity factors appear to have improved even if these two variables are constant.
[6] Electricity prices tend to peak in the summer months, which are also the months when wind speeds and thus excess generation often are least.

relevant policies, and the implications of various net metering rules are discussed in greater detail in section 3.2.1. Table 10 also provides information about net metering limits.

3.1.1.2.2 Gross Expenses

Distributed wind projects must pay the following expenses.

- Operation and maintenance costs
- Standby and backup payments to the utility (for some projects)
- Interest on project debt
- Project management fees (if a third party is hired to manage the project)
- Insurance
- Property taxes
- Financial advisory and legal fees
- REC transaction commissions
- Warranty fees
- Permitting fees (a one-time cost)

Expenses proved to be a significant factor in determining the feasibility of wind project sites included in the market-potential estimation described in section 4 (*see* Table 5 for a description of installed costs). Distributed wind expense categories are similar to those found in utility-scale wind projects; distributed wind projects have expense structures that are relatively similar to those of utility-scale projects[7]. There are differences in a few categories, however. The scarcity of distributed wind installations throughout the United States, along with the long distances between installations, reduces the ability of the industry to support local wind technicians. Manufacturers frequently do not offer service technicians for distributed generation systems, therefore customers are forced to perform some basic maintenance themselves (Schulte 2007). According to DOE (2006), the lack of an operations and maintenance infrastructure represents the second greatest barrier to distributed wind for farmers and small businesses.

Interest costs can be greater for distributed wind projects than for utility-scale projects. At the project-owner level, a large wind developer is likely to have a stronger credit rating and access to broader financial markets than an individual business or farm that is considering the installation of a distributed wind project. At the project level, a lender is more likely to have confidence in a utility-scale developer that can point to a history of successful projects, revenue from a wholesale power agreement, and collateral in the form of a large installation of wind turbines in a desirable location. By contrast, a distributed wind developer and owner likely has a shorter or track record with wind projects (or none at all), a more uncertain revenue stream, and less-valuable collateral in the form a single turbine located on the owner's property.

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[7] Utility-scale projects usually also pay a land-rental fee. Note that distributed wind projects do not pay fuel bills, as do virtually all other distributed generation projects.

3.1.2 Turbine Shortages

As noted in section 2, Table 1, there are slightly more than 20 commercially available distributed wind turbines in the United States when both new and remanufactured machines are considered. This narrow selection has several negative consequences for distributed wind development. First, although new turbines are available in several different capacity ratings gaps exist, most notably between 100 kW and 500 kW (*see* section 3.1). The range also is difficult for remanufacturers to fill due to a shortage of turbines available for refurbishing (Ordon 2007). Due to the unavailability of turbines in the 100 kW to 1,500 kW range it might not be possible to obtain a turbine that has optimal capacity for the selected site. The market-potential estimation analysis assumed that a site would select the project size that would maximize its net financial benefit. See section 4.2.6 for information about how project size was determined.

Using a smaller-than-optimal turbine results in a greater installed cost (in $/kW) and less kWh production per dollar invested, due to the reduced economies of scale of a smaller machine. The installed cost per kilowatt of the smallest project considered in the market analysis (10 kW) was $6,000; the installed cost of the largest project (5,000 kW) was slightly less than $2,000. Likewise, the largest projects produced roughly 700 times more kilowatt hours per year than the smallest projects, when considering kilowatt hours over the same wind power class. See Table 3 and Table 4 for more information.

Using a larger-than-optimal turbine also presents problems. Although a larger turbine should offer greater scale economies, there could be regulatory limitations on the amount of electricity that the project can feed back into the grid, and the unit value of such "exports" might be substantially less than the value of displaced kilowatt hours behind the customer's meter. Larger turbines also could be more challenging to permit, build, and maintain (DOE 2006).

In addition to limited choices, the general shortage of distributed-scale turbines forces distributed wind project developers to confront regularly changing turbine prices and long lead times for delivery—both of which increase the risk that a project will be an economic failure or possibly never launch at all (Godwin 2007, Schulte 2007). Finally, many manufacturers that offer models in the mid-scale range require substantial orders before agreeing to produce the turbines (e.g., Suzlon has rejected orders of more than 30 of its 1.5 MW machines as too small a quantity). The result is that these models essentially are unavailable for small distributed wind projects utilizing one to two turbines (Juhl 2007).

3.1.3 Lack of Regulatory Support

A variety of policies at the federal, state, and regional levels are designed to support renewable energy generally or wind energy specifically. Only rarely are these policies precisely targeted to support distributed wind, with the result that the policies could provide little or no incentive for distributed wind or, in extreme cases, actually could operate as a barrier to distributed wind. In other cases the support provided by a specific policy might be less substantial than it appears. This section describes the cases in which policies either provide less support than needed, provide no support at all, or act as a barrier to distributed wind. Supportive policies are discussed in the drivers section (below). For information about how federal incentives were applied in the market potential estimation analysis, see section 4.3.5.

In terms of federal policy, a critical incentive for renewable energy generation is the Production Tax Credit, which offers an inflation-adjusted credit of approximately $0.02 per kWh for wind-generated electricity sold to third parties. Two key issues have prevented the PTC from fully stimulating the mid-scale distributed wind market. One issue is that to benefit from the PTC a distributed wind project must have a significant tax liability. This is problematic, given that many of the schools, universities, and community organizations that would consider the purchase of mid-scale turbine distributed wind projects are non-profit organizations that pay no taxes (Godwin 2007, Drouilhet 2007, DOE 2006). Although a number of new business models have been developed to enable project owners that don't have significant tax liability to take advantage of tax credits or their equivalents, employing these techniques adds further complexity to the difficult task of developing a mid-scale turbine distributed wind project (We Energies 2007).

The fluctuating status of the federal PTC has served as a barrier to entry into and expansion within the wind turbine manufacturing market, contributing to the current scarcity of mid-scale turbine manufacturers and available turbines on the market (DOE 2006). The on-and-off nature of the PTC has caused a ripple effect throughout the supply chain. The uncertainty this causes contributes to a shortage in turbine components and a lack of wind-industry experts in the maintenance, business, engineering, and legal sectors (DOE 2006).

Another limitation of the federal PTC is that it is only available for power sold to an unrelated third party. If a for-profit business could utilize only 75% of the electricity produced by a wind turbine, for example, then the business would sell the remaining 25% back to the utility, and could claim the PTC only on the 25% of production sold back to the utility. The business cannot claim the Production Tax Credit on electricity used in its own facilities.

A second issue is the Modified Accelerated Cost-Recovery System (MACRS). This is an important federal incentive for wind power; it allows businesses to depreciate renewable energy technology property for tax purposes on an accelerated, five-year schedule (DSIRE 2007). However MACRS, like the PTC, requires that the customer have a great tax liability, which renders it inaccessible to many distributed wind customers.

Another federal policy is the U.S. Department of Agriculture's Section 9006 program, which can provide farmers and ranchers with grants and loan guarantees, and potentially provide direct loans for renewable energy projects. Although the program has provided substantial funding to wind projects of 100 kW and greater in capacity, using 9006 funds could require an offsetting reduction in the benefits of the PTC due to IRS rules (Bolinger 2006). Further, the grant program is restricted to projects located in rural areas.

The federal Renewable Energy Production Incentive (REPI) provides a $0.015 per kWh inflation-adjusted production credit to those entities that have no tax liability (DSIRE 2007). The impact of this incentive has been limited because funding is dependent on annual congressional appropriations (Bird et al. 2003). Funding is uncertain and limitation can lead to partially funded projects. Thus, project developers cannot be sure that this benefit stream actually will be available for one or more years of the project's lifetime.

3.1.4 Utility-Based Issues

A number of barriers to distributed wind could be found at the interface between the distributed wind project and the local electric utility. Inadequate net metering policies—discussed in detail in section 3.2.1 (Policies that Enhance Financial Returns)—comprise one group of barriers. Another challenging aspect of the interaction between projects and utilities is interconnection of turbines to the electric grid. The highly fragmented nature of the U.S. electric industry has resulted in widely varying interconnection standards and size limitations, or even a complete lack of such standards. In some cases, interconnection requirements are forbiddingly complex and expensive, effectively preventing the development of distributed generation of any type (IREC 2004, NREL 2000).

Over time, however, many utilities have adopted harmonized interconnection standards (as shown in Appendix A), and simplified interconnection procedures for smaller generators. The advances mostly are due to several national policies. In 2003, the Institute for Electrical and Electronics Engineers (IEEE) created federal interconnection specifications for distributed generation (IEEE Standard 1547-2003) (IREC 2004). The Underwriters Laboratories concurrently developed UL Standard 1741, which is a testing procedure for the inverters, converters, and controllers used in distributed generation that enables UL to test and list technology that meets these standards (IREC 2004). In 2005, the Federal Energy Regulatory Commission (FERC) released standard interconnection rules that apply to all generators 20 MW and smaller, along with simplified rules for generation sources that are less than 2 MW (Federal Energy Regulatory Commission 2005). As these improvements in rules and standards have been implemented and utilities have developed more streamlined procedures, the interconnection process has become less burdensome for project developers and customers (Drouilhet 2007, Usibelli 2007, Graham 2007). It is worth noting, however, that some areas still lack standards and that existing standards still vary, which can inhibit the development of certain projects (DOE 2006).

Technical problems have declined, and many of the current interconnection issues are procedural and legal in nature (IREC 2004). On the procedural side, when standardized interconnection agreement rules in a state do not specify time periods for each step in interconnection process, significant time delays can occur—especially when customers struggle to find utility representatives that are familiar with interconnection and net metering (IREC 2004). The legal issues typically pertain to insurance requirements that utilities place on small generators. More and more utilities now require liability insurance as part of interconnection agreements, to cover any accidents associated with a turbine system (Rhoads-Weaver and Forsyth 2006). This does not tend to hurt large businesses that already carry significant liability insurance, however the cost can be significant for smaller entities (IREC 2004). In a few cases utilities have required indemnification against damages, and also that they be listed as an additionally insured party on liability policies (IREC 2004). Although the indemnification and additionally insured listing do not seem to be widespread practices, when they occur they can increase costs for small generators.

Some areas of the country have independent system operators (ISOs) or regional transmission organizations (RTOs). The Federal Energy Regulatory Commission requires ISOs and RTOs to analyze the impact of each new generator on the transmission system. Projects are addressed on a first-applied, first-analyzed basis which can cause two problems. One is that serious developers can find themselves in the queue behind placeholder projects (i.e., projects that are not fully planned), which can lead to project delays. The second issue is that projects in a queue are additive in their transmission requirements. A project further back in the queue therefore can appear to be the one that causes the need for an expensive transmission system upgrade and that project can be billed accordingly. In parts of the country where there are no ISOs and RTOs, similar problems can arise when utilities issue requests for proposal (RFP) for distributed generation. The FERC requires that feasibility and impact studies be conducted in the order that proposals are submitted to utilities—regardless of each developer's interest level or qualifications (Juhl 2007). Consequently, when a utility releases an RFP for new renewable resources, numerous developers—including those who are uncommitted or unqualified—submit project proposals. This can move the more serious developers to the back of the queue (Juhl 2007). In some cases, a utility will withdraw its RFP because receipt of a sound proposal is taking too long (Juhl 2007).

One general advantage of mid-scale turbines as compared to utility-scale turbines is that their limited power production has less impact on the grid, thus reducing the need for expensive studies (DOE 2006). It is important to note, however, that 100 kW to 1,500 kW is a wide range, and those turbines in the more powerful end of the range often are treated differently. In San Diego, California, for example, proposed installations of turbines under 1 MW have access to streamlined interconnection requirements; larger machines are subject to more stringent interconnection requirements that can be cost prohibitive (Bonk-Vasco 2007). Additionally, there is continued uncertainty regarding the ultimate cost of the interconnection study, depending on locale; costs vary by state and generally by utility.

A number of distributed wind interconnection issues center on the fact that much of the country's wind resource is located in rural areas with low population density and less-robust grids. There exist fewer opportunities for interconnection at these locations, and extension of transmission lines is prohibitively expensive for installations of small quantities of turbines (DOE 2006). Rural distributed wind installations also often need additional intermittency effects research, due to the weak nature of the grids in such locations (Parry 2007).

Although distributed wind turbines can benefit utilities by shoring up weak portions of the grid, the lack of a national grid code for voltage support prevents mid-scale turbine distributed wind projects from maximizing the value they could provide (DOE 2006). In some instances only single-phase service exists, which precludes 100+ kW turbine installations unless costly distribution line upgrades are performed. Another difficulty is that many of the sites for distributed wind—including some non-rural locations—do not have access to competitive electricity markets, so they are dependent on the policies of a single utility, including the interconnection and net metering rules (DOE 2006). Finally, certain remote locations present special challenges (e.g., some distributed wind turbine sites in Alaska have to integrate into diesel generation grids, which require additional controls) (Petrie 2007).

Utilities also present other hurdles, aside from interconnection issues. A number of utilities, especially rural electric co-ops (Parry 2007), traditionally have been skeptical of renewable energy and unsupportive of distributed generation (DOE 2006, NREL 2000). The particular hostility of rural electric co-ops toward distributed generation tends to stem from the view that net metering is a subsidy for distributed generators that is funded by other rate payers (Rhoads-Weaver and Forsyth 2006). Some of the reluctance of other utilities is due to a lack of understanding that mid-scale distributed wind projects can support the transmission system, lessening the need for transmission system upgrades and relieving transmission congestion (ECWI 2004, DOE 2006). The result is that some utilities do not include the benefits of distributed wind projects in their economic analyses (ECWI 2004)[8]. Additional reluctance is due to the fact that certain installations of mid-sized distributed wind turbines (e.g., schools, businesses) can impact revenues for small utilities (DOE 2006). The lack of support for distributed wind is manifest in the adoption of unfavorable net metering and interconnection policies (e.g., demand charges, stand-by charges) (Drouilhet 2007) and a lack of utility-sponsored programs and marketing for distributed wind, which contributes to low public awareness as discussed in section 3.1.8 below (DOE 2006).

3.1.5 Siting

Siting a project, which involves dealing with zoning and permitting laws at a local level, is a second-tier barrier to mid-scale turbine distributed wind projects. In general, the permitting process increases dollar and time expenditures necessary for project completion rather than functioning as a project-ending blockade (Rhoads-Weaver and Forsyth 2006).

A number of common siting issues typically revolve around wind turbine height. Zoning ordinances generally forbid the construction of structures more than 35 feet tall, and wind turbines rarely are identified as permitted uses of property (Green and Sagrillo 2005) or defined as allowed as an accessory use. Setback requirements from property boundaries in certain localities also can limit allowable turbine heights (CEC 2003). Anywhere in the country, turbines more than 200 feet tall are required by the Federal Aviation Administration to have aircraft warning lights, which can add to project cost (CEC 2003) and increase aesthetics-based public opposition to projects. Additional FAA siting requirements apply to the construction of turbines near airport facilities (CEC 2003) and local air-traffic controllers can impose restrictions, as has occurred around the Boston Logan Airport control tower.

The degree of difficulty in dealing with these issues varies significantly across—and even within states. Siting generally is a straightforward process in Iowa (Pearce 2007), for example, but county boards in parts of Illinois tend to refuse to approve projects (Haas 2007). Distributed wind projects located in rural areas usually face fewer siting issues (DOE 2006). It frequently is the case that siting difficulties are associated with public opposition based on concerns regarding noise, aesthetics, and avian well-being. As discussed in section 3.1.7 (Concerns Regarding Visual Impacts and Noise) this public opposition often is based on lack of knowledge regarding wind power characteristics. As a result, the effort to overcome siting barriers frequently is an educational endeavor (CEC 2003). Although siting issues can be significant in individual cases, the developers interviewed indicate that siting generally is a manageable issue rather than the most critical barrier to a project.

It should be noted that the existing federal and state financial incentives do not flow back to communities for privately sited distributed generation projects. Wind turbines also are exempt from local property-tax requirements in some states, and therefore do not provide communities with financial benefits through taxes. Some sentiment exists within the general public that the

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[8] It is noteworthy that some utilities (e.g., Bonneville Power Administration) are starting to account for these benefits in their calculations (ECWI 2004).

community should receive some financial benefit if it must bear the aesthetic and other impacts from a purely private distributed generation project.

3.1.6 Technical Turbine Issues

In some cases, technical issues can be an impediment to a successful project, but these issues generally are considered a secondary barrier for the mid-scale turbine distributed wind market. Existing machines typically are based on designs that have been tested over many years and are well built (DOE 2006, Drouilhet 2007, Graham 2007). These models would benefit from further investment from manufactures to take advantage of recent technological advances made in the design of utility-scale turbines (Graham 2007). Following is a list of existing technical issues.

- Lightning strikes—The height of turbines puts them at risk of lightning strikes, and although improvements in design have decreased the risk that a strike will damage a turbine, damage still does occur. (DOE 2006)
- Wind intermittency—Demand charges can be a significant portion of school or large-business electric bills. The intermittent nature of wind, however, reduces the likelihood that a wind turbine's output will be coincident with the customer's peak demand. Only reductions in the peak demand can reduce demand charges. The use of energy storage equipment to achieve coincidence is cost-prohibitive. (DOE 2006)
- Gearbox reliability—The primary point of mechanical failure in a turbine is the gearbox, which drives both maintenance costs and the reduction of time in operation over the course of a year. (Juhl 2007)
- Electronics and software power—A lack of tested and certified remote-monitored controllers for turbine complicates the interconnection process and decreases the ability of mid-scale turbines to support weak portions of the grid (DOE 2006). Many of the existing controllers also have proprietary communication protocols, which make them difficult to integrate into the grid's supervisory control and data acquisition (SCADA) systems. (Drouilhet 2007)
- Self-erecting towers availability—There is a very limited number of self-erecting tower models available on the market. Two advantages of these systems are that they can be installed without a crane (which is ideal for remote applications), and they can be taken down quickly (which is ideal for island applications where hurricanes are a threat). (Drouilhet 2007)
- Tower height—One developer mentioned that, for the turbines currently on the market that have nameplate capacities of less than 600 kW, the towers all are too short. This developer finds that, as a general rule, tower heights of less than 150 feet are a poor investment. Interestingly, the developer also noted that modeling has demonstrated that, despite increased costs such as the need for larger cranes, increasing tower height for a given turbine always generates a greater rate of return. (Godwin 2007)
- Lack of warranty—Another issue faced by developers and customers in the mid-scale turbine market is determining what entity is financing the warranty on a given turbine. Frequently, the manufacturers and remanufactures of the turbines on the market are not able to finance the warranty, so it often is the case that each part is covered by the warranty of its particular manufacturer. Determining the configuration of warranties for a

turbine adds to the complexity of a project and its maintenance issues. (Schulte 2007; Godwin 2007)

- Lack of performance ratings—For customers and developers, the lack of consumer-friendly performance ratings and standards reduces confidence in turbine reliability. (Rhoads-Weaver and Forsyth 2006)
- Distribution system—Certain power-quality issues can arise due the interconnection of many distributed wind systems to weak distribution systems. These power-quality issues include the production of electricity outside acceptable ranges of voltage and frequency, voltage flicker, power factor falling below one, DC injection, and harmonics. Most of the developers interviewed did not indicate that these issues present a major barrier to projects. (IREC 2004)
- Technical issues specific to remanufactured turbines (DOE 2006)
  - Remanufactured machines are made from older turbines therefore many are not optimized for Class-3 wind sites, which reduces the return on investment. They also can lack many of the technical advances that have been made during the last two decades (Graham 2007).
  - According to some developers, there is a general lack of information about the work necessary to remanufacture a turbine—even those from the best remanufacturers (Godwin 2007). The lack of standards and standard reporting requirements creates significant uncertainty regarding the performance history of the machine and any improvements that the remanufacturer has engineered (Godwin 2007). Partly as a result of these concerns, the opinions of developers and customers vary widely with regard to the ability of remanufactured turbines to meet the needs of the mid-scale turbine distributed wind market. Some think that the uncertainty about turbine history and remanufacturing procedures eliminates these turbines from consideration (Graham 2007). Others think that the price discount relative to the new turbines currently on the market makes remanufactured turbines the most viable turbine option available (Godwin 2007). Additionally, the fact that the machines operated in a previous location is for some an indication of proven performance (Parry 2007).
- Technical issues for extreme applications—When turbines are used in island applications, salt and heat often corrode turbine hardware, including guy wires (if used), fasteners, and other small metal parts (Drouilhet 2007). Corrosion of the tower itself will not affect tower performance for many years, but the discoloration can generate complaints related to aesthetics (Drouilhet 2007). In arctic conditions, geotechnical challenges associated with building the foundation in permafrost add to project costs substantially, and extreme temperatures can lead to parts failure (Petrie 2007).

3.1.7 Concerns Regarding Visual Impacts and Noise

In certain cases, when a distributed wind turbine project is proposed neighbors raise concerns over the potential for visual and noise impacts. Generally, as concern regarding a project arises so do the siting barriers for that project. Although circumstances vary within and across states, these concerns generally are considered to be manageable issues rather than significant barriers to a project (Godwin 2007, Schulte 2007, Drouilhet 2007, Graham 2007, Tooze 2007).

A Wisconsin state official noted that the State of Wisconsin has undertaken some statutory initiatives to reduce local opposition to wind energy projects (Helgeson 2007). Oftentimes, community members who are less knowledgeable about—and have less experience with—wind turbines raise concerns, but their opposition typically fades as their knowledge of the industry increases. When projects first were being developed in Alaska, for example, some local residents raised concerns about noise. Once the turbines were installed all opposition dissipated (Petrie 2007). In general, mid-scale turbine distributed wind projects have some advantage over utility-scale projects in that a single turbine presents fewer aesthetic concerns, especially when that turbine is locally owned (Haas 2007), and that many distributed wind projects are sited in rural areas with lower population densities (DOE 2006). One interesting note raised by a single developer is that there appears to be more public opposition (and therefore zoning issues) with two-bladed turbines based on a lack of public familiarity with such designs (Graham 2007). The developer indicated that, as a result, these machines are more popular for less densely populated areas such as farms and ranches (Graham 2007).

3.1.8 Lack of Public Awareness

There is a lack of basic knowledge among the general public regarding the characteristics of wind power and the viability of mid-scale turbine distributed wind projects. Although this issue is not raised as a primary barrier to the mid-scale turbine distributed wind market, low levels of awareness feed into issues regarding visual, noise, and avian impacts that drive siting issues (CEC 2003). The lack of awareness also to a certain degree tempers demand, because in many areas the residents do not realize that they could displace their electric bills through wind installations (Schulte 2007).

3.1.9 Environmental (Avian) Concerns

Sometime community members are concerned about the potential for avian death and injury due to the installation of wind turbines. In Alaska, fish and wildlife agencies require an in-depth, year-long bird study for every 100-kW turbine installed, which increases project costs significantly (Petrie 2007). Although situations such as the one in Alaska arise occasionally, avian concerns in the lower 48 states frequently are considered issues to be managed rather than significant barriers to a project (Godwin 2007, Schulte 2007).

3.1.10 Project Complexity and Timing

The Department of Energy notes that the overall complexity involved in undertaking a mid-scale distributed wind turbine project given the current market conditions is a barrier to growth. Developers are presented with a number of real challenges: Limited availability of turbines; long lead times for turbine acquisition; extreme variability in turbine price; lack of available financing; need for new business model structures to secure financial incentives; and difficulty in accurately projecting project economics due to variability within and across states in turbine price, incentives, and regulations.

In particular, the timing requirements of certain steps in the project planning process can be challenging given the current shortage of available turbines. Once a project is set up to receive the PTC, for example, a number of financing, permitting, and construction steps, including the arrangement of a set delivery date for the turbine, must be completed within the short window of time during which the PTC is available. The difficulty in arranging all of these steps is accentuated for distributed wind projects as compared to utility-scale projects, because the limited scale of the projects reduces the developer's leverage with the other parties involved. The challenge of pulling together all of the complex project pieces and dealing with these timing issues requires significant leadership, which can be exhausted prior to project completion because of the lengthy nature of these efforts. (DOE 2006)

3.1.11 Other Barriers

Other factors are restraining the growth of the mid-scale turbine distributed wind market. One barrier is growing competition from other distributed generation technologies, particularly given the difficulties faced by the mid-scale turbine distributed wind industry (DOE 2006). A second barrier is the lack of quick and easy methods for determining the characteristics of a given wind regime for distributed generation sites (Rhoads-Weaver and Forsyth 2006, DOE 2006). Although wind maps generally are available, most investors often still desire onsite measurement of wind resources. This requires a meteorological tower for a single location—another expense that cannot be spread over multiple turbines. Even with onsite data collection it is necessary to compute the annual output, capacity factors, project costs, and overall project financial benefits.

3.2 Drivers for Mid-Scale Turbine Distributed Wind Projects

Mid-scale turbines are in demand as long as project economics are positive (Godwin 2007). Other principal drivers include local economic stimulation, educational opportunities for students, and promotion of environmental objectives. This section provides descriptions of the drivers for the growth of this market.

3.2.1 Policies that Enhance Financial Returns

A consistent theme of the interviews conducted is that the principal driver for mid-scale turbine distributed wind projects is a positive economic return for the investor. When project economics are positive, the market responds with rapid growth (Pearce 2007, Schulte 2007). In essence, the barriers to market growth that are discussed in section 3.1 become only secondary concerns when the economics are favorable (Tooze 2007).

As noted in section 3.1.1.2.1, Gross Revenue, some of the benefits streams arising from a distributed wind project depend, at least in part, on supportive policies at the federal and state levels. Some industry participants view these policies as the most important driver of growth in the mid-scale turbine distributed wind market (Drouilhet 2007, Pearce 2007).

At the federal level, the main incentive policies include the PTC, MACRS, the Section 9006 program, and the new Clean Renewable Energy Bonds (CREBs) program. All of these incentives were included in the market potential estimation and are detailed in section 4. The PTC is a tax credit worth approximately $0.02 per kWh (inflation adjusted) for the first 10 years of a project's lifetime for electricity sold to third parties. The MACRS is an accelerated depreciation option that allows for a five-year depreciation of a commercial or industrial distributed wind project, which improves its life-cycle economics. Section 9006 is a grant and loan program for renewable energy projects developed by rural farmers and ranchers. The CREBs program provides low-interest loans for the renewable energy projects of organizations without tax liability and is especially supportive of distributed generation projects because it funds small projects first.

The PTC and MACRS favor project owners with significant tax liabilities, and thus significant appetites for tax credits. They were not designed with distributed wind projects in mind, however new business models such as flip ownership structures allow community wind investors to access the PTC by joining with a tax-paying equity investor (Bolinger and Wiser 2004). Under the flip model, a distributed wind project is built with majority ownership by a corporate entity seeking tax credits and minority ownership by the project host. After the PTC period lapses, the corporation either sells its share to the project host or reverts to a minority-ownership share. The flip structure permits the project to harvest all of the tax credits available.

At the state level, although support still is fairly limited there is a wider variety of policies than found at the federal level. A number of these state policies are included in the list below. The market potential analysis discussed in section 4 considered a variety of cost- , capacity- , and production-based incentives available on a state-specific basis throughout the country. Please see Appendix B for detailed information on state incentives. According to the market analysis, the impact of state incentives varied significantly by customer type. See section 4.4, Results and Analysis, for more information.

Favorable net metering rules have the potential to be one of the most important policies support mid-scale distributed wind (DOE 2006). A project's economics improve if surplus electricity is being sold to the utility at $0.10 per kWh rather than to a wholesale market at $0.05 per kWh (*see* Figure 7, EIA wholesale generation price forecast by power pool). As shown in Appendix A and Table 10, however, net metering provisions differ significantly between states. A critically important point to consider for mid-scale wind turbine installations is that only 11 states allow net metering for systems greater than 100 kW and, of these, only three states (Maryland, New Jersey, and Colorado) have project caps that reach 2 MW (DSIRE 2007). The result is that net metering provisions in most states do not support mid-scale turbines. Many programs also adopt policies that limit the incentives provided by net metering, such as the use of monthly accounting rather than the more customer-friendly annualized accounting and reimbursing customers at the "avoided cost" rate for power provided to the grid rather than the retail rate (IREC 2004, DSIRE 2007). Finally, the lack of consistency in net metering across states—or even within states—complicates valuation for developers, because sites with similar characteristics can have vastly different values (DOE 2006).

A number of other state-level policies help drive the development of distributed wind.

- Renewable Portfolio Standards (RPSs) are established in many states. These standards require electricity providers (typically utilities) to provide an increasing percentage of their electricity deliveries from renewable resources. An RPS creates market demand for renewably generated electricity.
- Production incentives such as the Washington Renewable Energy Production Incentives, which provides up to $2,000 per year for distributed renewable generation, encourage renewable generation (DSIRE 2007).
- Tax-based incentives also are used by states to support wind projects. These policies can come in the form of production tax credits (e.g., Iowa's Renewable Energy Tax Credit), sales-tax exemptions for renewable equipment (e.g., Washington's Sales and Use Tax Exemption), or property-tax exemptions (e.g., Indiana's Renewable Energy Property Tax Exemption) (DSIRE 2007).

- The establishment of a development fund for clean energy, such as Minnesota's Renewable Development Fund (RDF), can provide capital support for mid-scale turbine distributed wind projects (DSIRE 2007).
- State initiatives such as the 800 MW goal set by the governor of Minnesota for Community-Based Economic Development (C-BED) projects can help drive wind projects (DOE 2006); although, in the case of this initiative, the program primarily has supported utility-scale turbine installations (Haase 2007).
- The creation of state- or utility-run grant and loan programs can provide an additional source of funding for projects (for example, Massachusetts, via the Massachusetts Technology Collaborative, provides grants to distributed wind projects through the Large Onsite Renewables Initiative) (DSIRE 2007).
- The establishment of statewide standard interconnection procedures, such as those used in California (DSIRE 2007), can remove a barrier to distributed wind.
- Mandatory utility purchases of green power (e.g., Iowa's Mandatory Utility Green Power Option) are a method for stimulating demand for wind installations (DSIRE 2007).

The market for renewable energy certificates can provide an additional revenue stream for distributed wind projects (Rodgers 2007, Schulte 2007). Although the definition of a REC varies by jurisdiction, it can be understood to represent the positive environmental attributes (or absence of negative environmental attributes) arising from the generation of each MWh of renewable electricity. RECs can be separated from the electric commodity and, in many cases, it is the RECs—rather than delivered renewable electricity—which electricity suppliers use to satisfy state RPS requirements (Holt and Wiser 2007). Additionally, many electricity customers who want to "green up" their electricity supply purchase RECs in an amount equivalent to 5%, 10%, or even 100% of their electricity requirements. These so-called voluntary purchases of RECs raise the market price for RECs which, in turn, means greater revenue for renewably generated electricity projects. The REC market offers some benefits to distributed wind generators: The host/owner can choose to sell the RECs from their project and earn an additional revenue stream. Distributed wind projects likely will have higher unit transaction costs in the REC market, however, than would be the case for larger REC market participants.[9] The market potential analysis incorporated unique REC prices based on the latest statewide information available. RECs played a role in determining the feasibility of wind projects. See section 4.2.8.2.2 (Renewable Energy Certificate Value) for more details.

A number of commercial, utility and governmental programs stimulate voluntary demand for renewably generated electricity and unbundled RECs. The Environmental Protection Agency's Green Power Partnership, for example, has recruited nearly 1,000 partners that collectively purchase nearly 15 billion kWh of renewably generated electricity each year (EPA 2007). More than 600 utilities now offer renewable electricity tariffs, whereby customers can choose to

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[9] The benefits of RECs could be enhanced if certain clarifications were made at the state level, including the exact environmental attributes included in a REC, and whether RECs sold through voluntary programs can be included under RPSs (Holt and Wiser 2007). Standardization across the states in the approach to these issues also would improve the benefits (Holt and Wiser 2007).

purchase renewable electricity for all or a portion of their electricity consumption. These programs sold more than 2.5 billion kWh of electricity in 2005 (Bird and Swezey 2006). Independent marketers of RECs and green electricity (the latter only in competitive electricity markets) also have stimulated demand for renewable electricity, and sold an estimated 6 billion kWh in 2005 (Bird and Swezey 2006).[10]

All of these programs help support renewable energy generally and sometimes even distributed wind specifically, but they are not widely adopted across the states and, in some cases, they fail to support mid-scale turbine distributed wind projects. The Minnesota C-BED initiative has not generated additional interest in mid-scale turbines, for example, but rather it has garnered additional interest in utility-scale machines that provide better returns and allow utilities to make larger gains with fewer projects (Johnson 2007, Haase 2007, DOE 2006).

In states that have no RPS, it is in theory possible to generate greenhouse-gas emissions reductions credits for either domestic or international trading purposes as an additional revenue source. Although the project team has found no distributed generation project that has attempted to register greenhouse gas credits, quantification of the displaced emissions benefit can be monitored and verified to a great degree, and therefore in some instances a potential market for these credits can be generated. Regulatory policy still is evolving in many regions (such as California and the ten eastern states of the Regional Greenhouse Gas Initiative) in this area, therefore this revenue stream currently is uncertain.

3.2.2 Local Economic Development

The second most important driver of mid-scale distributed wind projects is the desire by individuals, groups, and the government to stimulate local economic development. Distributed wind projects create local jobs during construction, and locally owned projects create new revenue streams in the community.

In Iowa, Illinois, Wisconsin, and Minnesota, a primary driver of distributed wind and in particular community-owned[11] distributed wind projects has been the desire to increase rural income (Bolinger and Wiser 2004). Washington State also has seen significant distributed wind activity driven by economic development considerations (Usibelli 2007). The Northwest Sustainable Energy for Economic Development, for example, promotes distributed wind applications as a means for economic development in the state's rural communities (Usibelli 2007). In Bellingham, another group, A World Institute for a Sustainable Humanity, has installed small-scale projects in low-income communities with the goal of generating a revenue stream (Usibelli 2007). Although financial returns for the investor and environmental benefits have been the primary drivers of mid-scale distributed wind projects in the state, economic development also has been an important driver (Usibelli 2007).

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[10] These numbers are not additive. Some of the utility sales and much of the REC marketer sales are to corporations and institutions in the EPA's Green Power Partnership.

[11] "Community wind" can refer to wind projects owned by a municipal government (http://www.masstech.org/renewableenergy/Community_Wind/index.htm (accessed October 20, 2008)) or it can refer to distributed wind projects owned by a consortia of local investors with significant local benefits (http://www.windustry.org/communitywind (accessed October 20, 2008)).

In South Dakota, a group called the Miner County Community Revitalization supported distributed wind projects to promote local economic development by creating local jobs that provide good wages and encouraging affordable housing (Parry 2007). Energy costs, the existence of the PTC, and environmental concerns also were motivators, but the primary driver was local economic development (Parry 2007).

3.2.3 Educational Value

Another driver for mid-scale turbine distributed wind projects is the desire to use a project to educate students, demonstrate the viability of wind projects to surrounding communities, and study the performance of a particular machine. For Laq qui Parle Valley High School in Madison, Minnesota, financial factors dominated its decision to take on a distributed wind project, but the desire to educate students and benefit the environment also played a role (Munsterman 2007). Similarly, some projects are designed to demonstrate distributed wind technology, such as the single turbine installed by the Rosebud Tribal Utility Commission in the late 1990s. This project was undertaken with the goals of demonstrating to other tribes the viability of wind energy and contributing to efforts to address climate change (Rodgers 2007). In certain cases, projects also can be initiated to test the performance of a technology, such as the use of European 50 Hz turbines in the 60 Hz North American environment (Johnson 2007).

3.2.4 Environmental Benefits

The desire to take action against global warming and other environmental concerns through the creation of clean, renewable energy projects is another driver of the mid-scale turbine distributed wind market. Although this desire typically serves as a secondary motivation (Usibelli 2007), in certain cases, such as the Rosebud Tribal Utility Commission project noted above, it is considered one of the primary drivers (Rogers 2007). Also, in Massachusetts a local developer of a condominium complex on a redeveloped brownfield site is combining the green architectural design of the condos with a distributed generation wind turbine and marketing the complex to those individuals who desire a sustainable lifestyle. These environmental issues become more and more intertwined with economic considerations based on the expectation that there will be a market for carbon credits that will further improve wind economics (Pearce 2007). Whether wind and other renewables do in fact benefit from carbon emission regulation depends on the policies and regulations adopted.

4 Market Potential Estimation for Mid-Scale Wind

The purpose of this analysis is to estimate the technical and economic market potential for mid-scale distributed wind turbine installations in the lower 48 states and the District of Columbia (referred to as the contiguous United States herein). The analysis assumed that distributed wind turbines that were technically and financially feasible under current market and policy conditions would be installed, and those that were not feasible would not be pursued. It is important to note, however, that even when wind turbines are uneconomic some customers will install distributed turbines to demonstrate their energy security, environmental and social benefits, and the owner's commitment to these goals.

The analysis evaluated turbine packages between 10 kW and 5,000 kW, using prices, market conditions, laws, regulations, and availability of turbine models as of June 2008. Additionally, two "virtual" wind turbines were included in this study. These virtual turbines incorporate the technology improvements anticipated through further R&D, and through technology transfer from larger, more modern turbines. These two turbines are referred to here as the NREL 250 and the NREL 500. A full discussion of these turbines is provided in section 4.5.

4.1 Summary of Methodology

To assess the technical and economic potential for distributed wind, the project team employed the following two-step analysis.

1. **Evaluate the parameters that affect the economic consequences of installing mid-scale distributed wind projects**. The project team ran a standard pro forma financial analysis model to calculate the net present value of installing a distributed wind project under a variety of project conditions. The analysis examined input assumptions including customer type, retail electric rate, available wind resource, and size of the turbine installation. In total the different input assumptions formed 7,777,770 combinations, each a unique scenario for which the model calculated a corresponding NPV. Some of the scenarios yielded a net financial benefit, others a net financial loss. See section 4.2 for a presentation of the financial analysis.
2. **Analyze millions of existing sites to identify those which would benefit financially from the installation of a mid-scale distributed wind project**. This analysis had four principal steps.
    A. First, a GIS-based analysis screened 21,900,000 organizations and 2,840,000 raster cells (areas of one square mile) covering the entire contiguous United States. The analysis employed simple screening criteria to eliminate those which could not conceivably benefit from the installation of distributed wind. *See* section 4.3.2.

    B. Second, the project team reviewed the technical and financial characteristics of each site that survived Step 2A, and matched each site with the appropriate scenario created in Step 1. *See* section 4.3.3.

    C. Third, the analysis totaled the sites having characteristics that matched one of the scenarios with a net financial benefit, to estimate the market potential for mid-scale distributed wind installations. *See* section 4.3.5.

    D. Fourth, the project team conducted an automated analysis of the results of Step 2B to account for budget-capped state and federal government incentives, such as grants and feed-in tariffs, which only are available to some of the qualifying applicants. The capped incentive analysis produced additional sites with a positive NPV, increasing the tally of "winning" sites. *See* section 4.3.5.

4.2 Financial Modeling

The economic viability of a distributed wind project is determined by numerous factors, including wind resource, the turbine, the site energy consumption, electricity prices, and incentive levels. In a country as large and diverse as the United States, these factors can be found in millions of combinations. A site in New York might have poor wind resources, high electric rates, and significant state incentives, for example, whereas a site in Wyoming might have excellent wind resources and lower electric rates and fewer state incentives. To ensure that every possible combination of factors was available for consideration, the project team developed a methodology (described below) to identify a reasonable range of values for each factor. For some factors, such as wind resource, only a handful of possible values exist. For others, such as retail electricity price, dozens of possible values were found. Nearly 8 million different combinations of factors exist—each of which yielded its own NPV.

It is important to note, however, that many of these combinations, whether yielding a positive or negative NPV, do not exist in reality. The financial analysis developed an NPV for a project located in Alabama in wind power class (WPC) 7, for example, even though WPC 7 cannot be found anywhere in Alabama. By providing outputs for all scenarios, the project team ensured that no scenario that could exist at a particular site was omitted.

ICF International, Inc. analyzed the 8 million scenarios using a wind project analysis model recently developed and released by the non-profit group Windustry. The project team modified the model based on the particular needs of the study and used it for the financial analysis.[12] Windustry's model uses several input assumptions, described below, to calculate NPV over a 20-year horizon.

4.2.1 Wind Power Class

A site's wind power class is related to its typical wind speed, measured at 10 meters and at 50 meters above the site. WPC ranges from 1 to 7, with WPC 1 offering the least wind power and WPC 7 the most. A higher WPC increases the potential electricity production from a specific wind turbine. Table 3 presents the study's assumptions about the relationship between WPC and turbine production. The project team eliminated areas in WPC 1 from the analysis, therefore WPC accounted for six variants in the model.[13]

4.2.2 Wholesale Power Price

When distributed wind projects export power to the grid (as opposed to displacing site load), the utility usually pays using wholesale market rates. The Energy Information Administration of the U.S. Department of Energy (EIA) disaggregates the contiguous United States into 13 wholesale electric power pools, each with its own prices. The boundaries of these power pools typically follow utility rather than state boundaries. To simplify the analysis, however, the project team assigned each state to the power pool which contained the largest fraction of the state's territory. *See* Figure 11.

The EIA projects electricity generation costs in each power pool over a 20-year horizon. The project team inflated these constant-dollar values to produce future nominal dollar values. Figure 7 (below) depicts EIA's projections of future wholesale generation prices (NERC 2007, EIA

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[12] Windustry Wind Project Calculator (http://www.windustry.org/calculator/default.htm). Windustry's model is based in Microsoft Excel. To manage the millions of records that the model analyzed, the project team used Microsoft Excel 2007; SAS software, version 9.1, SAS Institute Inc., 20022003; and Oracle Database 10g, Release 2, Standard Edition 2005.

[13] Before conducting the study, the project team ran a preliminary analysis of the model. The results of this analysis revealed that there are very few scenarios for which project economics are favorable in WPC 1.

2007b). Note that the difference between the lowest and highest priced power pools is typically $0.04 to $0.05 per kWh in any given year.

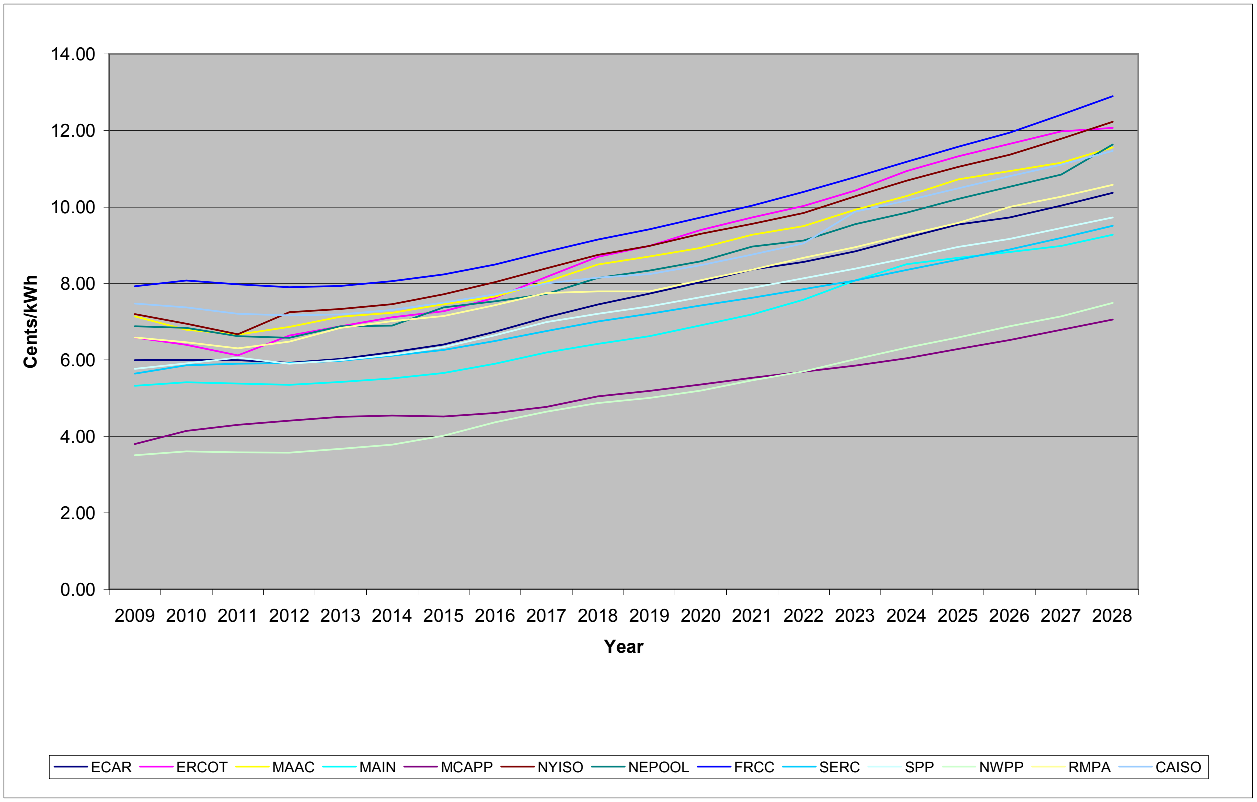

Figure 7. EIA wholesale generation price forecast, by power pool, nominal dollars (EIA 2007b)

4.2.3 Customer Type

The financial analysis estimated the potential for distributed wind for four different customer types: commercial, industrial, public facilities, and community wind.[14] The project team excluded certain customer types from the study, such as agricultural and military facilities, because they lacked data necessary for the analysis. Customer type affected all of the input assumptions (below). Table 7 outlines the impact of customer type on these input assumptions.

4.2.4 Retail Electric Rate

A distributed wind turbine's greatest economic benefit to commercial, industrial, and public facilities customers is the displacement of electricity purchased from the electric power company at the retail electric rate. (Community wind is unaffected by retail electric rates because these installations do not displace onsite consumption.) A distributed wind turbine creates a greater economic benefit when it displaces high-cost power than when it displaces lower-cost power.

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[14] The study defined public facilities as public administration institutions (such as government offices and agencies), and non-governmental organizations (NGOs) (such as faith-based organizations, and civil and social non-profit groups).

In the contiguous United States, most retail electric rates range from $0.04/kWh to $0.40/kWh on an "all-in" basis (i.e., including all charges by the utility to the customer).[15] The analysis ran 37 variants at $0.01 increments within this range. While retail rates vary by season and time of day, this level of detail was beyond the scope of the study and thus not included in the analysis. These retail electric rates were modified to account for the fact that distributed wind installations do not displace all of the components of a customer's electric bill. These components typically include the following.

- A monthly charge that a customer is required to pay to remain connected to the electric utility.
- A peak demand charge based on the customer's peak level of demand (measured in kilowatts) during the billing period. Although it is possible that a distributed wind turbine can reduce a customer's peak demand if the turbine is generating power during the customer's peak demand period, it is difficult to predict this coincidence in advance, or to guarantee that it will occur every month during the 20-year analysis period.
- An energy charge which compensates the utility for the amount of energy the customer consumes (measured in kilowatt hours) over a specified time period. A distributed wind turbine can reduce the energy charge: each kilowatt hour of electricity production by the turbine can eliminate a kilowatt hour of energy purchased from the utility.
- A social benefit charge that many utilities also collect to contribute to the utility's or the state's energy efficiency, renewable energy, and fuel poverty programs. These charges typically are assessed based on the customer's energy consumption and can be reduced in the same manner as the energy charge.

The analysis assumed that installing an onsite wind project would affect only the energy charge and social benefit charge components of the electric bill, both of which are measured in kWh. The project team then applied this decision to the "all-in" electric rates obtained from EIA to determine what fraction of these all-in rates were avoidable through the installation of distributed wind. The team estimated that these components would constitute 60% of a commercial customer and public facility's all-in retail electric rate, and 80% of an industrial customer's rate. These estimates are based on the typical load factor characteristics of commercial and industrial operations.[16] Commercial facilities typically have a lesser load factor than that of industrial facilities, and thus a larger fraction of their overall bill is driven by the peak demand charge.

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[15] Given the diversity of billing structures used by more than 3,000 U.S. utilities, this analysis used a simplified electric rate which relied on data reported by utilities on the Energy Information Administration (EIA) Form 861. Using Form 861, utilities report gross revenues and megawatt hours sold by customer class. Dividing revenues by megawatt hours yields an "all-in" rate in cents per kilowatt hour for that customer type, capturing both energy-based revenue and demand-based revenue. Form 861 is available from EIA (http://www.eia.doe.gov/cneaf/electricity/forms/eia861/eia861.pdf). Data collected from the nation's utilities using Form 861 are compiled in U.S. Department of Energy, *Electric Sales and Revenue 2005* (http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html).

[16] Load factor is the ratio of actual kWh used in a measurement period divided by the potential kWh used if the customer maintained its peak demand throughout the measurement period. A low load factor causes more of the bill to be related to kW-based charges; a high load factor causes more of the bill to be related to kWh-based charges.

4.2.5 Net Metering

As discussed in section 3, properly designed net metering rules enhance the financial returns from distributed wind power. Net metering rules vary by state and customer type. In many states, net metering only applies to investor-owned utilities (IOUs). For simplicity's sake, the analysis assumed that if net metering was available to a state's IOUs, then it also was available to the state's municipal and co-op utilities. The analysis considered every combination of state and customer type to represent net metering rules as of June 2008. It also was assumed that community wind projects would export all energy produced onsite, therefore net metering is not a relevant consideration for this customer type.

4.2.6 Project Size

The financial analysis examined the installation of nine possible distributed wind power project sizes, ranging between 10 kW and 5,000 kW. In addition to these nine, two "virtual" turbines—the NREL 250 and NREL 500—also were analyzed. The sizing of the projects and the assignment of each site to a project size relied on assumptions about turbine availability (the supply side) and about how customers would select available turbines to install (the demand side).

4.2.6.1 Supply Side

The analysis assumed that seven turbine models were available, with nameplate capacity ratings of 10 kW, 50 kW, 100 kW, 250 kW, 500 kW, 750 kW, and 1,000 kW. The analysis examined how the turbines between 10 kW and 1,000 kW could be deployed in the non-residential market. The two NREL virtual turbines also were considered, and two multi-turbine configurations were developed for the non-residential market: 2 x 1,000 kW turbines and 5 x 1,000 kW turbines. Table 4 lists the turbine models used for this study, their capacity, and their placement within the mid-scale wind markets.

4.2.6.2 Demand Side

The analysis calculated the economics for each turbine available to a site based on the factors described below.

- **Net annual production.** A turbine's electricity production varies by WPC. The analysis created scenarios for every combination of project size and WPC.[17] Table 3 presents net annual electricity production for each combination of project size and wind power class.
- **Project costs.** The analysis assumed installed project costs and annual ongoing costs as shown in Table 4 and Table 5, respectively.[18] Table 4 illustrates the economies of scale of distributed wind; project cost per installed kilowatt decreases as the project size increases.
- **Community wind.** The analysis assumed that community wind projects export 100% of the energy produced onsite to the grid. This assumption distinguishes community wind from the other customer types in the model. Due to economies of scale and an onsite

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[17] Each project size uses only one type of turbine model, therefore the analysis could accurately calculate a project's net annual production using a turbine model's nameplate capacity rating. See Table 4 for the relationship between turbine models and project sizes.

[18] The project team gathered these data from market research and via conversations with industry experts.

consumption of 0%, net financial benefit increases with project size. The analysis therefore assigned the largest project size in the model (5,000 kW) to all community wind sites.

- **Commercial, industrial, and public facilities.** These customer types had access to eight different turbine packages and two NREL virtual turbines. The project team considered all appropriate turbines sizes for each customer. Two opposing factors are important considerations. First, as shown in Table 4, capacity costs ($/kW) generally decline with increasing project size. Conversely, for any given customer, as project size increases an increasing fraction of the turbine's output is exported offsite and valued at wholesale rates, which generally are less favorable than retail rates.

Table 3. Net Annual Electricity Production (kWh) in the First Year of Operation by Project Size and by WPC

	Project size								
NREL WPC	**10 kW**	**50 kW**	**100 kW**	**250 kW**	**500 kW**	**750 kW**	**1,000 kW**	**2,000 kW**	**5,000 kW**
2	10,021	104,528	155,387	384,076	728,579	1,099,432	1,374,759	2,749,518	6,873,795
3	13,038	133,198	198,548	493,223	955,680	1,425,200	1,811,915	3,623,830	9,059,575
4	15,370	155,250	232,487	580,166	1,135,119	1,684,812	2,159,847	4,319,694	10,799,235
5	17,405	174,556	262,742	658,003	1,294,107	1,916,307	2,469,839	4,939,678	12,349,195
6	19,782	198,212	300,437	756,259	1,491,512	2,205,694	2,855,960	5,711,920	14,279,800
7	24,759	253,771	398,549	1,015,119	1,987,834	2,941,286	3,826,780	7,653,561	19,133,902

Table 4. Installed Costs in Relation to Turbine and Project Sizes

Project Size (kW)	Number of Turbines in Project	Example Turbine	Installed Cost per Turbine	Installed Cost of Project	Installed Cost per kW
10	1	BWC 10	$60,000	$60,000	$6,000
50	1	EW15	$250,000	$250,000	$5,000
100	1	Northern Power NW 100/21	$450,000	$450,000	$4,500
250	1	Fuhrländer FL 250	$800,000	$800,000	$3,200
500	1	Vestas V39	$1,400,000	$1,400,000	$2,800
750	1	Norwin 46-ASR-750	$1,900,000	$1,900,000	$2,533
1,000	1	Nordic 1000L	$2,300,000	$2,300,000	$2,300
2,000	2	Nordic 1000L	$2,300,000	$4,200,000	$2,100
5,000	5	Nordic 1000L	$2,300,000	$9,900,000	$1,980

Table 5. Annual Ongoing Expenses by Customer Type

	Unit	Commercial, Industrial, and Public Facilities	Community Wind
Operations & maintenance	$/kWh	$0.0100/kWh	$0.0100/kWh
Operations & maintenance contingency fund	$/kWh	$0.0030/kWh	$0.0030/kWh
Insurance	$/kW	$8.00/kW	$8.00/kW

	Unit	Commercial, Industrial, and Public Facilities	Community Wind
Property tax	$/kW	$6.00/kW	$6.00/kW
Administrative/financial/legal management	$/kW	$1.00/kW	$1.00/kW
Production tax expense	$/kWh	$0.00	$0.00
Warranty expense	$/kW	$13.00/kW	$13.00/kW
Decommissioning fund pre-warranty expiration	$/kW	$0.00	$0.00
Decommissioning fund post-warranty expiration	$/kW	$1.00/kW	$1.00/kW
Other expenses	$/kW	$2.00/kW	$2.00/kW

4.2.7 Onsite Energy Use

The electricity produced by a distributed wind turbine can be used onsite to displace deliveries from the electric utility or, if the turbine's production exceeds the site's consumption, the excess can be exported offsite to the grid. The unit prices ($/kWh) of displaced and exported electricity can differ by a substantial amount, thus it is important to evaluate the partition of the turbine's electricity production between these two destinations to correctly value the turbine's output. The onsite ratio—the percentage of turbine production that is used to displace utility deliveries—is a function of customer type, customer electricity consumption (both total load and seasonal and diurnal consumption patterns), turbine size (make and model), and the wind resource (winds speed distribution and seasonal and diurnal variation).

- **Community wind (CW).** Community wind projects were assumed to export all of their production to the grid; thus they had no onsite consumption.
- **Commercial, industrial, and public facilities (CIP).**
    - **Scenarios with net metering.** To create cases representative of all possible on-site ratios that might be encountered in the real world, the analysis started with a stepped series of values for onsite electricity consumption for commercial, industrial, and public facilities. These values were used as the numerators of the onsite ratios. For the denominators the analysis used the production of each of the nine eligible turbine packages operating at a 25% capacity factor. The ratio of electricity consumption to electricity production was computed for each combination of production and consumption. In this analysis, all ratios greater than one were adjusted to 100% and all ratios less than one were rounded to the nearest tenth of a percent (e.g., 77% was rounded to 80%). This resulted in 11 possible onsite ratios for the CIP sector (0% to 100%).
    - **Scenarios with no net metering.** If a site does not have net metering rules, it is necessary to estimate the extent to which the turbine's production will be coincident with the site's consumption. Only coincident generation is valued at retail rates; any generation produced beyond onsite consumption within the metering interval is exported to the grid at wholesale rates. The analysis assigned a coincidence factor of 35% to each turbine. The project team estimated this factor based on a review of several real-world project pro formas and on conversations with industry experts. While an assigned coincidence factor was

necessary for the analysis, the project team understands that the coincidence factor depends on the relative size of the turbine energy production and the site load. The greater the production compared to the load, the smaller the coincidence factor. Conversely, the smaller the production compared to the load, the greater the coincidence factor.

4.2.8 Project Financing

Table 7 presents the input assumptions that the project team developed around project financing. This section highlights key assumptions.

4.2.8.1 Discount Rate

The discount rate is a powerful—and often contentious—element in project financial analysis. It is used to discount future cash flows, both costs and benefits, to their present-day equivalents. There are several different approaches to defining and choosing discount rates for a particular financial analysis. For this study, the approach taken was that the discount rate should reflect the investor's alternative investment opportunities (or borrowings) at a comparable level of risk. The analysis developed different discount rates for different customer classes, described below.

- Public facilities: 4.90%. This rate is equivalent to the interest rate on 20-year, AAA-rated tax-exempt insured municipal bonds in June 2008 (Bloomberg 2008).
- Commercial and industrial customers: 7%. This rate is two percentage points greater than the U.S. prime lending rate in June 2008.
- Community wind: 8.25%. This rate is 3.25% more than the U.S. prime lending rate in June 2008, and is intended to address the larger investment scale and more complex ownership structure of these projects.

Greater or lesser discount rates would produce fewer or more winning projects, respectively.

4.2.8.2 Project Ownership and Capital Structure

The analysis assumed that the owner of the property also would own the distributed wind installation. All projects were assumed to be equity funded and to have no debt.

4.2.8.2.1 Tax Depreciation Schedule

The U.S. income tax code provides for the Modified Accelerated Cost-Recovery System to be used to accelerate asset depreciation. The analysis assumed that MACRS is available to all tax-paying commercial and industrial customers. Public facilities, as tax-exempt entities, do not benefit from MACRS.

4.2.8.2.2 Renewable Energy Certificate Value

As discussed in section 2, renewable energy certificates offer an additional revenue source for wind projects. The value of RECs varies across states as a result of many factors, including each state's particular Renewable Portfolio Standard (RPS) program and the level of demand from the voluntary market. States having policies that restrict REC eligibility in the state's RPS typically have greater REC prices than found in states that have less restrictive RPSs or no RPS at all. States were assigned REC prices based on REC broker quotes. For states that did not have a state-specific broker quote, the analysis assumed a default value of $0.0057/kWh—the price of a national Green-e Energy certified REC (Spectron 2008, ICAP 2008).

Table 6. National and State-Specific REC Adder Values

Value Area	REC Value ($/kWh)
Default (All states except those listed below)	$0.0057
Connecticut, Maine, New Hampshire, Vermont[19]	$0.042
Massachusetts, Rhode Island[20]	$0.045
Maryland	$0.00175
New Jersey	$0.022
New York	$0.015
Pennsylvania	$0.004
Texas	$0.00563
Western Electricity Coordinating Council (WECC)[21]	$0.00715

4.2.8.2.3 Federal Government Incentives

The federal government offers incentives for the development and operation of renewable energy facilities. The project team divided these incentives into two categories: incentives with programmatic caps, budget caps, or restrictions (such as budget-limited grant programs), and incentives without any caps (such as the federal Production Tax Credit). The project team did not include capped incentives in the main financial analysis because that would have led to an overestimate of the number of economically successful sites. Instead, the project team integrated these capped incentives into the results through a subsequent "capped" analysis, discussed in section 4.3.5. The main financial or "uncapped" analysis did include the PTC, the only uncapped federal incentive.

The analysis assumed that the PTC would offer a $0.02 per kWh tax benefit for the first 10 years that recipients generate renewable energy and sell it to a third party. The project team escalated the PTC at a 3% inflation rate. The PTC is available to all tax payers producing mid-scale wind power—commercial and industrial facilities, and community wind.

4.2.8.2.4 State Government Incentives

The project team created a standardized listing of state incentives offered for the installation and operation of distributed wind (DSIRE 2008). The team conducted follow-up research using online resources and through conversations with government officials and stakeholders. As with federal government incentives (*see* section 4.3.5.1), the project team omitted capped incentives from the main financial analysis and integrated them into the model through a subsequent capped analysis (discussed in section 4.3.5.1).

The project team included uncapped, unrestricted state incentives in the main financial analysis. State sales- and property-tax exemptions also were included according to state rules. If an

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[19] All onsite wind projects in ISO-NE are eligible to qualify for the Connecticut REC market. Thus Maine, New Hampshire, and Vermont have Connecticut values.
[20] It is assumed Rhode Island RECs have the same value as Massachusetts RECs, because the states have virtually the same eligibility rules.
[21] Western Electricity Coordinating Council includes Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming.

incentive applied to the majority of a state (for example, to the customers of a specific utility that provides service to most of the state), then the project team applied the incentive statewide. The analysis included policies in effect as of late June 2008. Each incentive was applied according to its rules, such as whether the incentive was cost based or production based, how many years the site could qualify for the incentive, and the monetary value of the incentive.[22] Appendix B provides a complete list of state incentives included in the financial analysis.

Table 7. Project Financing Assumptions by Customer Type

	Commercial/ Industrial	Public Facility	Community Wind
Discount rate	7.00%	4.90%	8.25%
Capital Structure	100% equity	100% equity	100% equity
Annual escalation rate	4%	4%	4%
Line extension cost	No	No	5% of project cost
REC value	*See* Table 6	*See* Table 6	*See* Table 6
Federal income taxes included	Yes	No	Yes
Federal tax rate	35%	No	35%
Production tax credit utilized	Yes	No	Yes
MACRS utilized	Yes	No	Yes
State incentives	Varies by state	Varies by state	Varies by state
Retail electric rate	Varies by utility	Varies by utility	N/A
Energy charge as percentage of retail electric rate	60% commercial, 80% industrial	60%	N/A
Net metering	Varies by state	Varies by state	N/A
Turbine assignment methodology	10 kW, 50 kW, 100 kW, 250 kW, 500 kW, 750 kW, 1,000 kW turbines tested for all sites; NREL 250 and NREL 500 also tested	10 kW, 50 kW, 100 kW, 250 kW, 500 kW, 750 kW, 1,000 kW turbines tested for all sites; NREL 250 and NREL 500 also tested	5,000 kW tested for all sites
Onsite ratio	Consumption divided by turbine production rounded to the nearest 10%; varies by individual site	Consumption divided by turbine production rounded to the nearest 10%.; varies by individual site	N/A

[22] All capacity-based incentives had a budget cap and therefore were excluded from the capped analysis.

4.2.8.3 Summary of the Financial Analysis

To summarize, the project team ran the "uncapped" financial analysis against every possible combination of the following variants.

- Six WPC
- Five customer types (the residential segment is not described separately in this report, however it was analyzed so that its results could be used in section 4.3.5)
- Thirty-seven retail electric rates
- Forty-nine states (the choice of state, with the District of Columbia included, also determined values such as wholesale power prices, the nature and magnitude of state incentives, REC prices, and net metering rules)
- Thirteen project sizes (including two turbine sizes specific to residential customers)
- Eleven onsite ratios

These variants created a total of 7,777,770 scenarios, and either a positive or a negative NPV was calculated for each. As noted, many of these combinations—whether yielding a positive or negative NPV—do not exist in reality.

4.3 Preparation of Real-World Data for Comparison to the Financial Model

The second step in estimating market potential involved taking real-world data on U.S. organizations and communities, and preparing it so the model could match each site to one of the scenarios generated by the financial analysis. The data preparation process involved four major steps: (1) preparing the data by customer type; (2) conducting a GIS-based analysis to eliminate sites based on established parameters for available wind resource, population density, elevation and slope; (3) assigning the "surviving" sites to turbine project sizes; and (4) assigning characteristics pertaining to the financial model to surviving sites, such as retail electric rate.

4.3.1 Preparing the Data by Customer Type

4.3.1.1 Commercial, Industrial, and Public Facilities

To collect the necessary data for commercial, industrial, and public facilities, the study used the Homeland Security Infrastructure Protection (HSIP) Gold database, a collection of dozens of public and commercial databases licensed for federal government use by the National Geospatial Intelligence Agency. The U.S. Department of Energy provided a copy of the HSIP Gold database to the project team under the terms of the database license. One of the databases within HSIP Gold is the Dun & Bradstreet (D&B) file of U.S. organizations, believed to be the most extensive available databases of U.S. organizations (D&B 2006). Certainly there are organizations that are not listed in the D&B database, but most organizations with significant participation in commercial or regulatory transactions eventually obtain a Data Universal Numbering System (D-U-N-S) identifier from D&B and are included in the database. This database includes organizational characteristics (e.g., name, 4-digit Standard Industrial Classification (SIC) code, 6-digit North American Industry Classification System (NAICS) code, employee count) and the geospatial location (latitude and longitude) of 22,600,000 organizations in the United States. Of the 22,600,000 organizations, 21,900,000 qualified as commercial, industrial, or public facilities for this study. Using the latitude and longitude data, the project team mapped commercial, industrial, and public facilities as points on a map of the contiguous United States.

4.3.1.2 Community Wind

No database of community wind sites exists, therefore the project team instead used an area-based approach to identify suitable locations for distributed wind for this customer type. The project team assembled a map of the contiguous United States in raster format, creating a grid of 2,840,000 cells representing one square mile each. Each raster cell was evaluated as a suitable site for a community wind project.

The project team identified each raster cell by its centroid (center point) and assigned the centroid's characteristics (e.g., state, wind power class, electric utility) to the entire raster cell. In reality, however, some geospatial characteristics (e.g., WPC, electric utility) might vary across a one-square-mile raster cell.

4.3.2 Geographic Information System Analysis

For the second step in the data preparation process, the project team conducted a geographic information system (GIS) analysis to identify and eliminate sites and raster cells where the elevation was so high that installation of a wind turbine would be unlikely; the slope of the terrain was greater than 10% making the area too steep for installation of a wind turbine; the population density suggested that there would not be a suitable amount of available open space for the installation of one or more wind turbines; regulations prohibit the installation of wind turbines; and the available wind resource is not great enough to provide favorable project economics.

4.3.2.1 Elevation

The GIS analysis identified areas in 11 western states areas at elevations higher than the elevations listed in the table below. The analysis assumed that these areas would likely be too difficult to access or otherwise unsuitable for wind turbine installation.

Table 8. Elevation Exclusions by State

State	Elevation Cap (ft)
WA	7,000
OR	8,000
ID	8,000
MT	8,000
WY	9,000
CA	9,000
NV	9,000
UT	9,000
CO	10,000
AZ	9,000
NM	9,000

4.3.2.2 Slope

The GIS analysis next screened for those areas of the country with a slope of 10% or greater and eliminated them. A 10% slope is the approximate grade of the steepest mountain roads. The project team assumed that these sites likely would be too difficult to reach and too costly for wind turbine installation.

4.3.2.3 Site Size

The GIS analysis then screened for site size and eliminated those sites that would not be suitable for distributed wind.

4.3.2.3.1 Developing a Site-Size Proxy

Ideally, the study would geo-locate business sites to their actual land parcel to determine whether sufficient area was available to install one or more wind turbines, given issues such as zoning, safety regulations, and aesthetic concerns. Such data are not available on a national scale; instead, the analysis used Census Block Group–level population density data as a proxy for site size.[23]

The study assumed that Block Groups with a population density greater than 500 people per square mile would be too built-up and too densely populated to allow for the installation of distributed wind turbines. To develop this assumption, the project team produced maps at the U.S. Census Block level for a few selected areas (covering dozens of Blocks) familiar to it, and examined the maps in light of local knowledge. Even Blocks—the smallest level of U.S. Census disaggregation—can have significant heterogeneity. The team occasionally found potentially suitable distributed wind sites in Blocks with a population density greater than 250 people per square mile. Although a cutoff of 250 people per square mile appeared appropriate at the Block level, the project team selected a more generous cutoff of 500 people per square mile for the Block-Group level, to acknowledge the potential for greater heterogeneity in a larger geographical unit.

4.3.2.3.2 Screening for Site Size

To conduct the site size screening, the analysis used U.S. Census Bureau population density data at the Block-Group level to create a population density polygon file and converted the file into a raster format (Geolytics 2000). The analysis layered the surviving sites (point files and raster cells) from the wind resource screening on top of the population density raster file to eliminate sites located in areas with a population density greater than 500 people per square mile. The remaining sites or raster cells were deemed "survivors" and moved on to the next step in the screening process.

Figure 8 delineates U.S. population density by 500 people per square mile, the cutoff for all customer types. Figure 9 shows that the majority of the country's land area has a population density less than this cutoff; eliminated areas correspond to large urban areas.

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[23] Census Blocks are the most granular level of geography in the U.S. Census' publicly available datasets. For a city, a city block might be a Census Block. For rural areas, a Census Block can cover many square miles. Multiple U.S. Census Blocks are contained within a Census Block-Group. Block-Groups generally contain between 600 and 3,000 people, with an optimum size of 1,500 people.

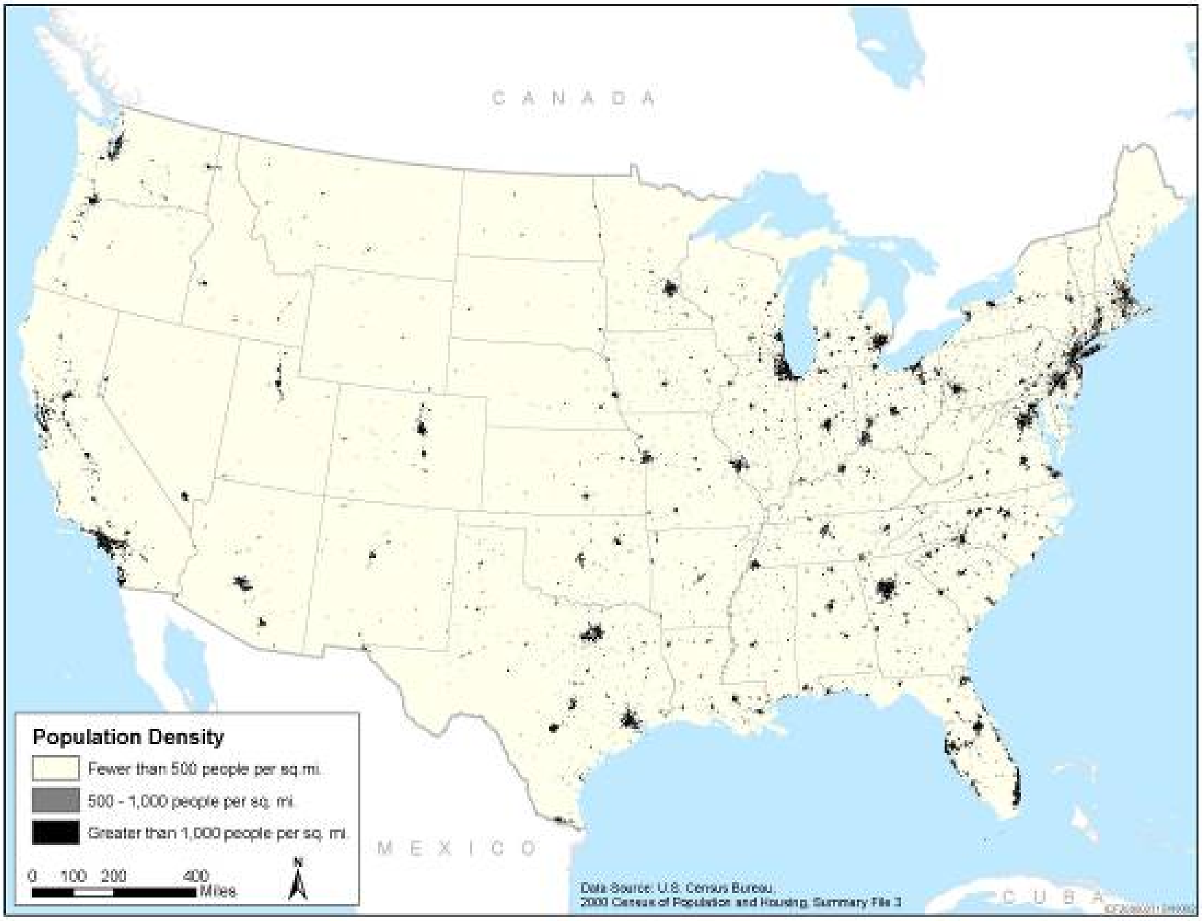

Figure 8. United States population density (ICF International 2008)

4.3.2.4 Wind Resource

The screening process also eliminated sites located in areas designated WPC 1. This screening step had important implications; as Table 9 illustrates, approximately half of the land area in the contiguous United States has wind resources in WPC 1. Figure 9 provides a map of U.S. wind resource.

Table 9. Distribution of Land Area in the Contiguous United States by WPC

Wind Power Class	Percentage
1	46.6%
2	22.8%
3	18.2%
4	8.7%
5	2.6%
6	0.8%
7	0.3%

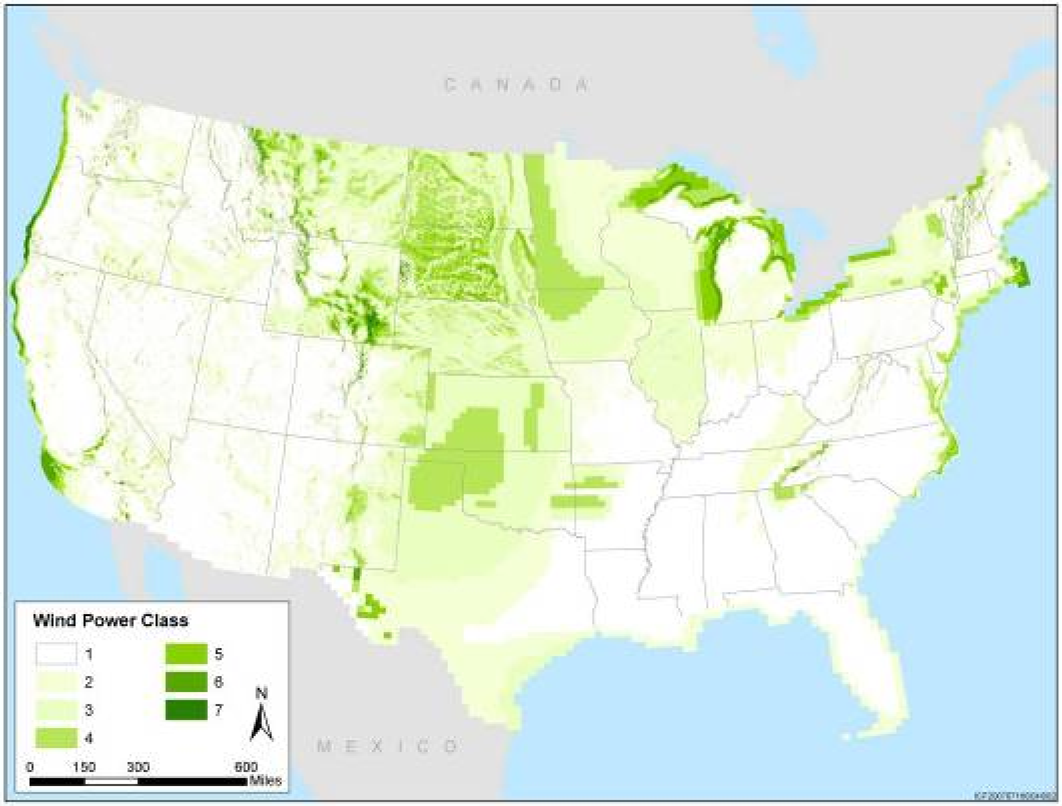

Figure 9. United States wind resource by wind power class (ICF International 2008)

To screen commercial, industrial, and public facilities, the project team layered the D&B point files on top of a wind resource polygon file to assign sites to the WPC at their specific location (NREL 2008). To screen raster cells for the analysis of community wind, the project team converted the polygon file into a raster format and layered the community wind raster cells on top to assign each raster cell to the WPC present at its centroid. The screening process eliminated sites with a WPC of 1 from further consideration. Sites with WPC of 2 or more continued to the next step in the screening process with their assigned WPC.

The WPC elimination process should be viewed with some caution. State-level wind maps, even those certified by NREL, still are relatively coarse in scale, rely on various models to interpolate wind resources between monitoring locations, and can use inconsistent methods from state to state. It is important to note the sharp WPC boundaries between New York and Pennsylvania and between Illinois and Missouri and to consider their implications for the quality and consistency of state-level wind maps.

4.3.2.5 Excluded Lands

The analysis eliminated lakes and rivers from the screening process, as well as certain lands based on their legal status. Regulations, either explicitly or indirectly, prohibit the installation of wind turbines on national and state park grounds, and on fish and wildlife refuges (Tele Atlas, ESRI). Figure 10 identifies the excluded lands eliminated from the screening process and those lands included in the analysis.

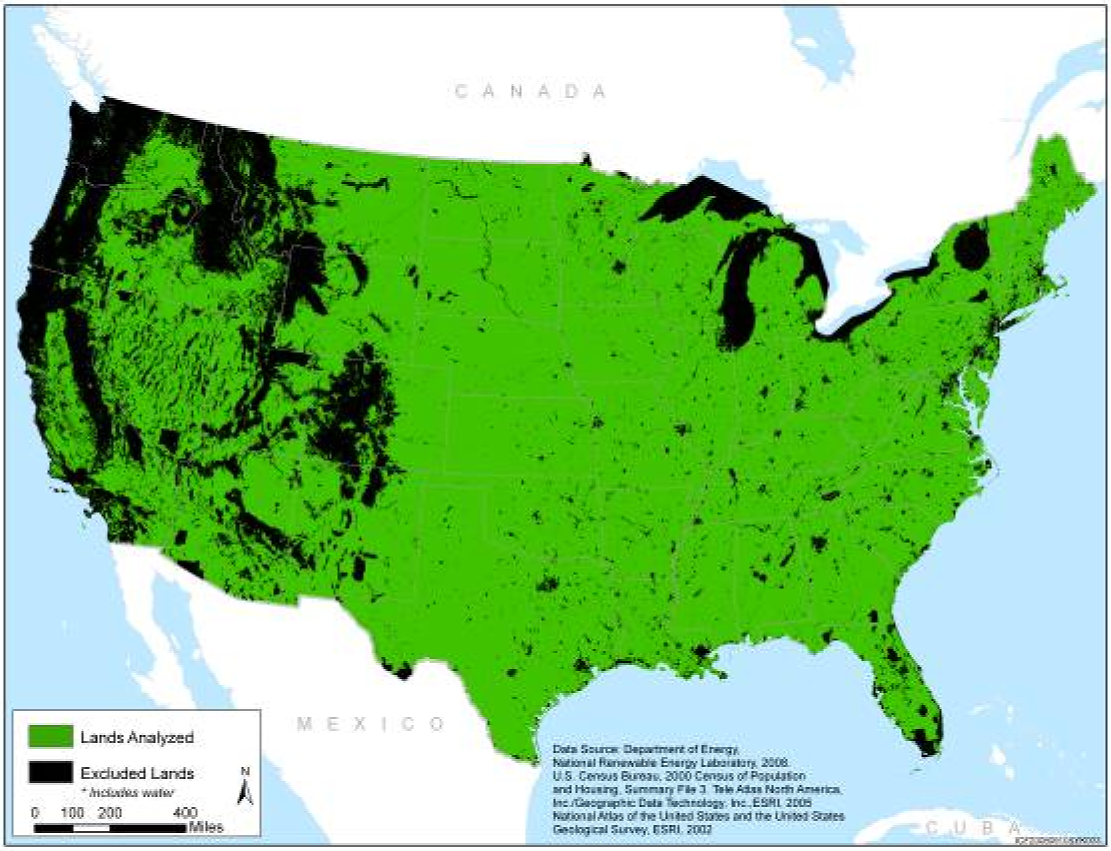

Figure 10. Excluded and analyzed lands (ICF International 2008)

4.3.2.6 Assigning Electric Power Company and Wholesale Power Region

As the final step, the GIS analysis assigned each surviving site and raster cell to its associated electric power company and state. The analysis used this information in the data preparation process to match the appropriate retail and wholesale electric rates to each surviving site (*see* section 4.3.4.1) as well as the correct REC price and state incentive policies (*see* sections 4.2.8.2.2, 4.2.8.2.4, 4.3.5.2).

The analysis used the Platts geospatial data layers for Electric Investor Owned Utility (IOU) Service Territories and Electric Non-Investor-Owned Utility (Non IOU) Service Territories to create a polygon file of Platts Electric Service Territories (Platts 2008). The project team layered the point files and raster cells for the surviving sites on top of the polygon file to assign the correct electric power company to each site.

Next, data from the North American Electric Reliability Corporation (NERC) and the Energy Information Administration was used to assign the correct wholesale power region to each state ((NERC 2007, EIA 2007b). The analysis matched states in multiple wholesale regions with the region occupying the largest portion of the state. Figure 11 shows the assignment of wholesale power regions by state.

Figure 11. Simplified assignment of states to wholesale power regions (ICF International 2008)

4.3.3 Analyzing Surviving Sites

Following the completion of the GIS analysis, each surviving site was analyzed based on the appropriate turbine installation project size.

4.3.3.1 Using Annual Electricity Consumption Data to Analyze Turbines for Commercial, Industrial, and Public Facility Customers

Two physical characteristics drive the economics for a specific turbine at a specific site, the site's wind resources and the site's electricity consumption. The D&B database does not contain electricity-consumption data of a quality suitable for a study of this nature. The project team had two options for obtaining an estimate for each site's annual electricity consumption: Purchase a proprietary database from a company that collects annual electricity consumption data by SIC/NAICS code; or develop an algorithm to estimate annual electricity consumption based on an organization's employee count and SIC/NAICS code.

IHS' Commercial Energy Profile Database (CEPD) and Major Industrial Plant Database (MIPD) provide annual electricity consumption data for commercial and industrial organizations, respectively, by 4-digit SIC code.[24] The cost of this data, however, exceeded the project budget, so the project team instead developed an algorithm. To run the algorithm, the project team had to find suitable data to develop annual kilowatt-hour consumption per employee figures for each NAICS code. For the industrial sector, the 2002 Census of Manufacturing and 2002 Census of Mining provided data for total annual electricity consumption and total number of employees by 6-digit NAICS code (Census 2002). The EIA Manufacturing Electricity Consumption Survey (MECS) supplied data on the percentage of electricity consumption attributable to HVAC (heating, ventilating, and air conditioning) by 3-digit NAICS code (EIA 2006a).

For the commercial sector and public facilities, the project team reviewed the EIA Commercial Buildings Electricity Consumption Survey (CBECS), but the data structure in CBECS proved to be too broad for the purposes of this study (EIA 2006b). Additionally, the data set does not include information for retail establishments. The team instead used the D&B Sales & Marketing Solutions 2003 MarketPlace database, which includes total annual electricity consumption and number of employees by 4-digit SIC code for most relevant industries. The team ensured that the MarketPlace data were consistent with other industry estimates by cross-checking sources, including a small subset of the IHS CEPD data previously purchased by the project team, and EIA's CBECS data. Data was not available for a modest number of NAICS codes, so the team used its best professional judgment to assign appropriate kilowatt hour per employee data based on data drawn from similar NAICS codes. The EIA Annual Energy Outlook supplied data on the percentage of electricity consumption attributable to HVAC by 3-digit NAICS code (EIA 2008).

No electricity consumption data were available for the construction industry. Construction organizations typically do not consume large amounts of electricity at organization locations, so it was assumed that they had no electricity consumption.

The analysis calculated electricity consumption for all surviving sites as follows.

- It matched each site with the appropriate kilowatt hour per employee consumption factor, variable by NAICS code.
- It modified the kilowatt hour per employee consumption factor based on the percentage of electricity consumption attributable to HVAC (which is variable by state).
- It multiplied the modified kilowatt hour per employee figure by the number of employees at the site to estimate the site's annual electricity consumption.
- It then considered all turbines available to that customer type as described in section 4.2.6.

4.3.3.2 Analyzing Turbines for Community Wind

The study assigned all community wind sites the largest turbine package of 5,000 kW. As explained in section 4.2.6.2, this decision was based on financial factors. Unlike the other

[24] IHS provides information related to energy, product lifecycle, security, and environment. http://www.ihs.com.

customer types analyzed, community wind does not have a retail energy charge to displace. All the electricity produced is exported to the grid at the wholesale power rate. Thus, for community wind, a project's net financial benefit is optimized by following the economies of scale. Installing the largest project size available—5,000 kW—maximizes profits (from kilowatt hours generated) relative to project costs (measured as dollars per kilowatt). The economies of scale of distributed wind are illustrated in Table 4.

4.3.4 Assigning Additional Characteristics to Surviving Sites

The final step in the data preparation process was to assign additional utility, state, and regional characteristics to the surviving sites, so that they could be compared to the financial model scenarios. The characteristics included retail and wholesale electric prices, the value of renewable energy certificate sales, the presence and level of net metering, state sales and property tax exemptions, and some state and federal government incentives.

4.3.4.1 Retail Electric Rates and Wholesale Power Prices

The GIS analysis assigned each surviving site to its electric power company and wholesale power region as described in section 4.3.2.6. Using this information, each site was assigned a wholesale power price and a retail electric rate by customer type (excluding community wind). The analysis eliminated those sites for which a retail electric rate was unavailable.

4.3.4.2 Presence and Level of Net Metering

Table 10 presents the net metering data assigned to surviving sites based on the site's state, project size, and customer type. Each surviving site was assigned to a level of net metering (0 kW if the site was not eligible) based on the data in Table 10.[25]

Table 10. Maximum Capacity Allowed to Net Meter by State and Customer Type

State	Commercial/ Industrial	Public Facility
AL		
AZ		
AR	300 kW	300 kW
CA	1,000 kW	
CO	2,000 kW	
CT	2,000 kW	2,000 kW
DC	100 kW	
DE	2,000 kW	2,000 kW
FL	2,000 kW	2,000 kW
GA	100 kW	
ID	100 kW	
IL	40 kW	40 kW
IN	N/A	10 kW

[25] See Appendix A for more comprehensive information about U.S. net metering by state. Please note that Appendix A was updated in May 2007; Table 10 was updated in late June 2008, and it contains the most current information.

State	Commercial/ Industrial	Public Facility
IA	500 kW	
KS	30 kW	30 kW
KY		
LA	100 kW	
ME	100 kW	
MD	2,000 kW	2,000 kW
MA	60 kW	
MI	30 kW	30 kW
MN	40 kW	
MS		
MO	100 kW	100 kW
MT	50 kW	
NE		
NV	1,000 kW	
NH	100 kW	
NJ	2,000 kW	
NM	80,000 kW	
NY		
NC	100 kW	100 kW
ND	100 kW	
OH	No limit specified	
OK	100 kW	
OR	2,000 kW	2,000 kW
PA	3,000 kW	3,000 kW
RI	1,000 kW	1,650 kW
SC		
SD		
TN		
TX	50 kW	
UT	2,000 kW	2,000 kW
VT	250 kW	250 kW
VA	500 kW	500 kW
WA	100 kW	
WV	25 kW	
WI	20 kW	
WY	25 kW	

Of the 21,900,000 organizations pulled from the D&B dataset, 2,343,310 progressed to the financial analysis stage, representing a survival rate of 10.7%. Of the 2,840,000 raster cells representing community wind, 1,265,345 cells survived the screening process, representing a survival rate of 44.55%. Table 11 outlines the sequential attrition of each customer type.

Table 11. Sequential Attrition Prior to Comparison to the Financial Analysis

Customer Type	Sequential Attrition of Sites or Raster Cells Due to:										
	Geospatial Unit	Sites/ Cells Screened	Elevation	Slope (> 10%)	Population Density	WPC < 2	Excluded Lands	Data Errors	Total Eliminated Sites (Millions)	Total Surviving Sites	Survival Rate
Commercial, Industrial, and Public Facility	Point	21,900,000	650,047	92,329	12,516,638	5,303,439	N/A	995,361	19.56	2,343,310	10.70%
Community Wind	Raster cell	2,840,000	371,205	33,024	76,439	1,050,220	40,932	N/A	1.57	1,268,345	44.55%

4.3.5 Comparison of Real-World Data to Financial Model

The analysis matched each one of the surviving sites or raster cells to the appropriate financial model scenario and retrieved the NPV for each. Sites with a positive NPV became "winners" of the study. After completing the model, the project team calculated budget-capped and restrictive incentives and incorporated them into the results.

4.3.5.1 Federal Incentives

The team collected information about these incentives from DSIRE and conducted follow-up research using online resources and via conversations with government officials and stakeholders (IRS 2007, DSIRE 2008, Department of Agriculture 2007). The team included the following incentives in the capped analysis.

4.3.5.1.1 Clean Renewable Energy Bonds

Clean Renewable Energy Bonds (CREBs) provide qualifying public facilities with interest-free financing. CREBs has a budget of $400,000,000 each year for all types of renewable technology. The project team calculated the annual CREBs budget for wind at $83,600,000, based on wind's share of the overall number of projects (not the megawatt share) that have been awarded each year since the program's inception. To calculate the impact of interest-free CREBs on distributed wind projects, the project team chose a "model" public facility project of 50 kW, located in an area with WPC 4, and with retail electric rates of $0.08/kWh. This project size was chosen by reviewing the public facilities that survived the population density and WPC elimination process and reviewing their characteristics to determine the most common project size. These projects have an installed cost of $250,000 (*see* Table 4). The present value of the interest of a $250,000 bond was calculated to be $47,152 over a 20-year period. This is the financial benefit of using a CREB instead of an ordinary interest-bearing bond to finance a distributed wind project. To determine the number of public facility projects that could be supported, the total $86,300,000 budget was divided by $250,000, which equals 334 projects. The interest value of $47,152 then was added to the NPV of the 334 public facilities closest to achieving a positive NPV. Many other projects would have been successful if the CREBs budget had been greater.

4.3.5.1.2 Renewable Energy Production Incentive

The U.S. Department of Energy manages the Renewable Energy Production Incentive, designed to provide incentives to the generation and distribution of renewable energy by new projects at public facilities. The project team assumed a production incentive of $0.02 per kWh (escalated for inflation from 1993 dollars) for the first 10 years of a project's operation. In 2007, Congress appropriated $4,900,000 to REPI. Using the same assumption, that wind projects would get half of the incentive budget, the REPI budget was assumed to be $2,450,000, available to all public facilities. The NPV of the REPI production incentive per project then was added to the NPVs of projects closest to feasibility. The incentive was applied to each project until the $2,450,000 budget was reached. The REPI incentive was applied to 247 projects.

Although the REPI program is subject to annual congressional appropriations funding and projects can be partially funded if there is a shortfall in the budget, the project team assumed that production incentive payments would be paid in full and that full appropriations funding would be provided. Further, the REPI amount allocated to a project was calculated based on turbine size. Therefore eight average annual kWh figures, corresponding to the eight turbines available, were used to assess the incentive amount. To maximize the number of projects funded, the project team gave priority to those that achieved feasibility using the least amount of incentive money, thus maximizing the impact of the REPI budget.

4.3.5.1.3 U.S. Department of Agriculture 9006 Grants

The U.S. Department of Agriculture (USDA) Section 9006 grant program supports farmers, ranchers, and rural small businesses (USDA 2007). The USDA follows the Small Business Administration's (SBA) definition of a small business, which is based on business size or number of employees and then matched to a NAICS code. Of the customer types considered in the study, the project team assumed that commercial and industrial customers that had fewer than 1,000 employees would be eligible for the grant program. The number of employees chosen was based on a review of the SBA's Table of Small Business Size Standards Matched to NAICS code. In fiscal years 2003 to 2007, Congress funded the USDA's Section 9006 competitive grant program at $23,000,000 per year. In fiscal year 2008, the program received $15,800,000 for competitive grants. (For this analysis, the project team assumed that in future years the grant program will be funded at the historically greater amount of $23,000,000, and that wind projects will receive half of the grants.) Grants ranged from $2,500 to $500,000 and could not exceed 25% of total eligible project costs. To maximize the number of projects receiving funds, the projects that achieved feasibility using the least amount of grant funding were given priority. (USDA 2007)

4.3.5.2 State Incentives

The project team collected information about budget-capped or otherwise restricted state incentives from DSIRE and conducted follow-up research online and via conversations with government officials and stakeholders. Incentives were cost- , project- , and capacity-based. As with other incentives in the model, if an incentive applied to a majority of the state area (such as to the customers of a specific utility that covered the majority of the state), the analysis applied the incentive statewide.

The project team followed state rules as of June 2008 for each incentive. The team considered the state's current and historical budget for the incentive. If an incentive's budget was ambiguous, then the team contacted staff at the program office for clarification. The analysis assumed that wind power would receive 50% of the program's budget, unless specified otherwise. Funds were allocated across customer types based on the rules and history of each program. Program funds then were apportioned within each customer type to maximize the number of new winners. Priority was given to sites where the hurdle to achieving a positive NPV could be overcome most easily, but only enough funds necessary to achieve a positive NPV were allocated.

For each site considered, the team determined eligibility for the state's various incentives. Taking availability of program funds into consideration, the analysis then examined the site's characteristics to select the package of incentives that would optimize net financial benefit while consuming the fewest incentive dollars. This method avoided "double-dipping" in terms of a program's budget and the number of incentives that one site could receive, and maximized the incentive budget. All customer types except community wind, for example, are eligible for California's "feed-in" tariff, a production incentive. The tariff stipulates that sites only can participate if they do not receive other forms of state funding. For each site considered, the capped analysis compared the positive impact of the feed-in tariff on NPV to the positive impact of other incentives and assigned priority to the project that used the fewest incentive dollars. For many sites, the analysis determined that the "feed-in" tariff was the best incentive package to optimize NPV. Appendix B contains a complete list of included state-government incentives.

4.4 Results and Analysis

The study found that, out of the 3,611,655 sites that were analyzed for economic viability, 59,708 yielded a positive NPV under current market conditions and policies (excluding incentives with budget caps). The "capped" analysis, which addressed capped federal and state incentives, produced another 2,792 winners in addition to the 59,708 winners from the uncapped analysis, yielding a total of 62,490 winners overall. The project team also considered the impact of state and federal incentives with budget caps at current levels for 10 years into the future; another 4,601 commercial, industrial and public facility customers would have eligible projects along with 9 for community wind. This would yield a total of 67,100 distributed wind projects across the 4 customer categories over 10 years. These numbers were obtained by running the automated capped incentive analysis 9 more times with current state and federal incentive budgets. Each successive year of capped funding produced fewer winners because those projects closest to profitability were funded first and, in subsequent years, the same budget amounts had to be spread across fewer projects—each requiring greater incentives to reach NPV break-even. Table 12 totals and compares winners by customer type and analysis performed. Figure 12 through Figure 14 illustrate the geographic distribution of winners by combinations of customer type and analysis performed. See Appendix C for tables that describe the kW potential of each state by customer class.

Table 12. Winners by Customer Type and Analysis Performed

	Commercial, Industrial, and Public Facility	Community Wind
Sites/raster cells screened	21,901,124	2,840,165
Sites/raster cells that survived preliminary screening (*see* Table 11)	2,343,310	1,265,176
Financially successful sites/cells ("winners" of the "uncapped" analysis)	56,529	3,169
Additional financially successful sites/cells with 1 year of capped state/federal incentives ("winners" of the "capped" analysis)	2,791	1
Additional financially successful sites/cells assuming that today's incentives remain static over 9 more years	4,601	9
Total "winners"	**63,921**	**3,179**

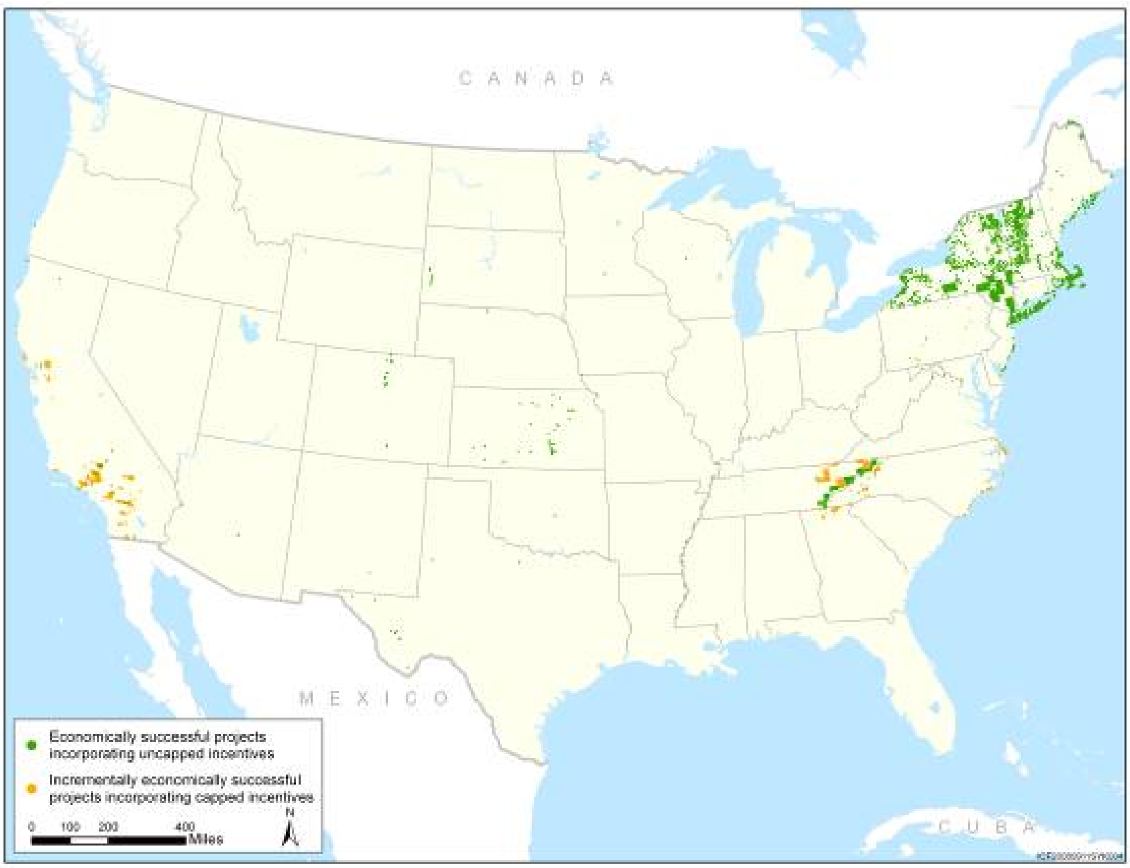

Figure 12. Commercial, industrial, and public facility winners (ICF International 2008)

Figure 13. Western community wind winners (ICF International 2008)

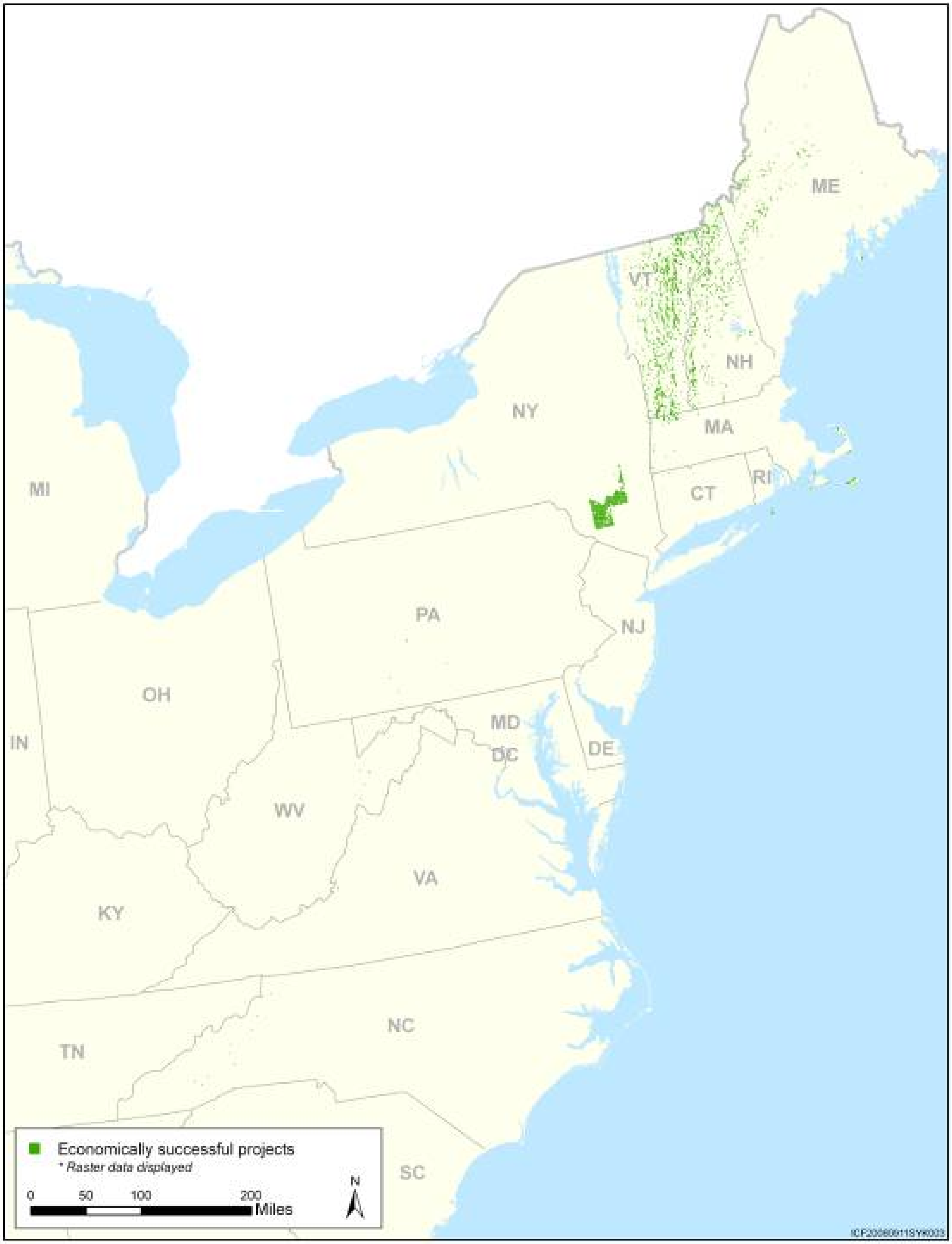

Figure 14. Eastern community wind winners (ICF International 2008)

4.4.1 Discussion

The project team analyzed the "winning" results for each customer class and the factors that had the greatest impact in determining whether surviving sites generated a positive NPV. The project team totaled the amount of "winning" kilowatts per state by customer class. These calculations, provided in Appendix C, demonstrate enormous potential for distributed wind. These results are unlikely to be attained in reality, however, because several of the assumptions used are likely to be more favorable than the real-world circumstances experienced. The discount rates used are on the low end of the range seen in reality, and the escalation rate for electricity prices reflects the significant electricity price inflation of recent years, which might not continue unabated although carbon costs remain a significant uncertainty. Furthermore, a number of constraints that would operate in the real world and would reduce the number of winners were not included in this analysis. For community wind, the analysis was not constrained with respect to connectivity to the electric grid and, in reality, many sites could not support the injection of 5 MW of generation. For all customer segments, population density was used as a rough proxy for parcel availability. It should be noted, however, that the vast majority of winning megawatts were in the 1,000 kW, 2,000 kW, and 5,000 kW project sizes. Projects of this range need parcels of from 35 acres to more than 120 acres, which are likely to be scarcer than the analysis indicates.

4.4.1.1 Commercial, Industrial, and Public Facilities Analysis Details

As noted above, each of the 2,343,310 CIP sites evaluated for financial viability was tested for each of the 8 different turbines available to the CIP group. Overall, in both the capped and uncapped analysis, there were 63,921 financially successful sites with at least 1 of the 8 turbines tested. Of these, some were successful with only 1 turbine while others were successful with 2 or more turbines. In all, 110,476 projects at 56,529 unique sites in the uncapped analysis were financially successful (*see* Table 13); this suggests that the typical site has the choice more than one turbine, any of which would be a "winner". An additional 7,392 successful sites in the capped analysis and a total of 7,412 successful projects (*see* Table 14) suggest that capped "winners" only win with 1 specific turbine.

Table 13. Total Uncapped Winning Turbines by Turbine Size

10 kW	50 kW	100 kW	250 kW	500 kW	750 kW	1,000 kW	2,000 kW
12	6,583	195	2,403	8,004	15,390	27,031	50,858

Table 14. Total Capped Winning Turbines by Turbine Size

10 kW	50 kW	250 kW
2,726	**3,350**	**1,156**

The project team deemed it unlikely that a commercial, industrial, or public facility would install more than one distributed wind turbine on a property; space availability would be one obvious consideration. Additionally, the fraction of electricity production used onsite would be reduced if two or more turbines were operating at a single site—which could make all turbines unprofitable.

To complete the analysis, for those sites which had more than one winning turbine the project team had to choose which turbine to "count." For the uncapped analysis, the team selected the turbine with the highest NPV because it produced the greatest economic value. Thus the 56,529 sites moved into the counting process with only 1 winning turbine apiece, and that turbine was the one that produced the greatest NPV for that site. For the capped analysis, the team selected the project that used the least incentive dollars to become financially feasible. Thus the 7,392 sites counted for the capped analysis were those that "won" with the fewest incentive dollars, effectively maximizing the state or federal budget to be applied to other projects.

4.4.1.2 Commercial, Industrial, and Public Facilities Results

As shown in Appendix D, Table D-1, 47,256 (84%) of the 56,529 uncapped winners were located in Massachusetts, New York, and Vermont. These states are characterized by high retail electric rates and high REC values. For locations with lower electric rates, some combination of large project size and strong wind resource is necessary for success. The 2 x 1,000 kW turbine package had the most winners with 50,419 (89%) successful uncapped sites. The economy of scale for these large projects is the main factor that caused these projects to win. It is doubtful that, in the real world, all 50,000 projects would be built, because a site size of more than 50 acres is standard for an installation of this size.

As shown in Appendix D, Table D-2, an additional 7,392 CIP sites became financially feasible for distributed wind with the application of capped state and federal incentives, and 94% are in California and Tennessee. California's incentives alone created 5,730 of these new winners, either via the new feed-in tariff announced in early 2008, the Emerging Renewables Program, or the Self-Generation Incentive Program (CPUC 2008). Note that the project team followed all state rules, therefore the California feed-in tariff incentive was not combined with the other available incentives. The Tennessee winners occurred because the team maximized winners based on lowest incentive cost across states. The Tennessee Valley Authority provides a generous uncapped incentive which brought many Tennessee projects close to a positive NPV. These projects therefore were first in line to receive federal USDA incentives during the capped analysis. Delaware had an additional 246 winners as a result of its Green Energy Program incentives; the program provides a grant of up to 50% of a project's cost with a limit of $100,000. Georgia offers a Clean Energy Tax Credit for commercial and industrial customers only, providing a 35% tax credit over 5 years up to a maximum of $500,000. This tax credit brought 65 projects to success. North Carolina had an additional 122 winners as a result of its Green Business Fund which offers grants in amounts up to $100,000. Pennsylvania had 15 additional winners due to its Energy Harvest Grant Program, which offers a grant of 50% of a project's cost up to a limit of $500,000. This Pennsylvania grant program is open to public facilities only.

Although there are other significant incentive programs that CIP projects are eligible for, such as in Oregon and New York, these state incentive budgets were exhausted by the project team's parallel analysis of residential turbines. A discussion of the residential customer type is not included in this document; however, the residential analysis had a significant impact on allocation of statewide project incentives for the CIP customer type. Residential turbine costs are less than those for commercial, industrial, public facility, and community wind, therefore a lesser incentive dollar amount typically is required to bring residential turbines to financial feasibility. The implications of this incentive allocation method are that—in states with overlapping incentives for CIP and residential—the residential customer type receives the majority of available incentive dollars.

4.4.2 Community Wind

Community wind projects were assumed to export all of their power, therefore their economic success is dependent on only a few factors: The prices offered by the wholesale power market; REC prices; and wind resources. As shown in Table 11 and Appendix D, Table D-3, there exist 3,179 raster cells that successfully could support the installation of a community wind farm.[26] Four of the 13 wholesale power pools produced no winners: Florida Reliability Coordinating Council (FRCC), Mid-America Interconnected Network (MAIN), Mid-Continent Area Power Pool (MCPP), and Southwest Power Pool (SPP). These power pools are characterized by low prices (MAIN, MCPP, SPP), poor wind resources (FRCC), or low REC values (all four). It is worth noting, however, that the lowest-priced power pool (NWPP) had winners and the highest-priced power pool (FRCC) did not. Figure 7 shows that, in any given year, the difference between the lowest- and highest-priced power pools typically is $0.04 to $0.05 per kWh.

Wind resources and REC values were the other important influences on the success of community wind. The New England Power Pool (NEPOOL) is characterized by the highest REC prices in the country, which enabled community wind to be successful with wind resources as low as WPC 2. In every other region the minimum WPC necessary for success was 5 and, in many cases, it was 6 or 7.

4.4.3 Model Limitations

As with any modeling project, the model experienced some limitations which, if possible, should be addressed and resolved for future studies. Many of these limitations stemmed from the tight budget and schedule under which the project operated.

4.4.3.1 Applying Utility-Level Factors Statewide

To maintain a controllable amount of data, the model applied utility- and regional-level factors such as net metering rules, utility-specific incentives, and wholesale power prices statewide. This simplification obscured some of the heterogeneity in the data, but was unavoidable at the level of resources with which the project operated.

4.4.3.2 Sensitivity Analysis

The project did not have sufficient time or resources to conduct sensitivity analyses. Although 7,777,770 scenarios represent a considerable range of possible situations, several other sensitivities should be explored. As with any long-term financial analysis, for example, the selection of discount, interest, and inflation rates is critical. Developers and owners could be interviewed in detail about these factors and the models could be run again, using greater or lesser rates, if warranted. There also exists a number of emerging policy instruments that could favor renewable energy generally, such as a national RPS, a carbon cap-and-trade program, or a carbon tax. The impact of such policies on project economics should be evaluated.

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[26] Unlike commercial, industrial, and public facilities sites, community wind was relatively unaffected by capped state and federal incentives. Of the 3,179 successful community wind sites, only 10 were winners as a result of these incentives.

4.4.3.3 Debt Service Coverage Ratio
The model should—but does not—constrain positive NPV to only those scenarios with a minimum debt service coverage ratio (DSCR). Adding a DSCR constraint would make the model more realistic.

4.4.4 Data Limitations and Areas of Uncertainty
In addition to the limitations of the model, the accuracy of the study's results was adversely affected by the limitations of the publicly available data which the study employed. Nearly 1,000,000 (995,361) of the 21,900,000 sites screened in the GIS analysis were eliminated from consideration due to data errors. The project team sampled this data set and found that 86% of the records had no NAICS code and 75% of the records included no employees. These independent factors prevented the sites in question from being assigned an energy consumption per employee factor. Without this information the analysis could not calculate electricity consumption and thus had to exclude the sites from further consideration.

Based on these factors, the project team determined that there was a very slim chance that these sites would be feasible candidates for distributed wind. The lack of a NAICS code precluded the team from calculating site electricity consumption or from obtaining the site's retail electric rate. The lack of an employee count also prevented calculation of a site electricity load and further suggested that any load would be small. The project team concluded that although these entries could be associated with real organizations they might not have a physical location or energy consumption and, as such, would not be candidates for this study.

4.4.5 Technology Implications
The GIS analysis and preparation of real-world data eliminated the majority of all the CIP sites and raster cells considered before the process ever tested them for financial viability. Although the economics of the remaining sites and raster cells that survived these screens could be improved through policy measures, consideration also should be given to whether technological improvements and other changes could make distributed wind generation possible for some sites that were eliminated in the screening process. The analysis incorporated two NREL "virtual" turbines as an initial effort in this direction as described in the next section.

4.5 New Technology Opportunities
Utility-scale wind turbines steadily have improved in productivity in recent years and continued improvements are anticipated. Gains were achieved through increasing rotor diameters and by increasing tower heights, all for turbines of a given rated power. Aerodynamic efficiencies also have been improved through optimized design with the maximum power coefficients ($C_{p,\,max}$) now approaching or exceeding 0.5. Significant potential exists to reduce miscellaneous losses through developments such as reduced blade soiling, improved turbine controls, and reduced downtime due to improved turbine reliability. Application of these technology improvements to mid-scale wind turbines has the potential to increase economic viability and to create larger markets for distributed wind.

To assess this potential, two virtual wind turbines—the NREL 250 and NREL 500 (250 kW and 500 kW, respectively)—were included in this study. These turbines were assumed to utilize technology improvements realized to date in the utility-scale market as well as improvements resulting from R&D. A wind turbine design, cost, and scaling model developed by NREL was used to estimate turbine performance (NREL 2006). Table 15 and Table 16 below compare the key parameters used for the NREL 250 and NREL 500 to those of the conventional, existing turbines of the same size that were used in this study.

Table 15. NREL 250 Compared

Parameter	Fuhrländer FL250	NREL 250
Rotor diameter (m)	29.5	32.5
Tower height (m)	42	50
Maximum C_p	0.47	0.50
Miscellaneous losses	12%	6%

Table 16. NREL 500 Compared

Parameter	Vestas V39	NREL 500
Rotor diameter (m)	39	43
Tower height, m	50	65
Maximum C_p	0.47	0.50
Miscellaneous losses	12%	6%

In addition to increased energy capture, cost reductions also are possible for 250 kW and 500 kW turbines. Today's wind turbine market is characterized by high prices driven by inadequate supply and by uncertainties in federal policy for wind power (*see* section 3.)

Industry participants predict that up to $380 per kW in cost reductions could be achieved through the market certainty that corresponds to a 10-year extension of the PTC (Wiser et al. 2007). These cost reductions primarily would come from new industry investments and labor efficiencies, and from private R&D expenditures. This cost reduction has been assumed for both the NREL 250 and 500 wind turbines. Partially offsetting this, the estimated cost reduction for the NREL 500 wind turbine was reduced by a $143 per kW cost increase due to the larger rotor and taller tower. This increase was estimated using the NREL design, cost, and scaling model noted above. This model does not have an adequate range of applicability be used to estimate costs for the NREL 250 wind turbine. Consequently, the cost reduction noted above was applied only to the NREL 500 turbine.

4.5.1 Assumptions

In the CIP analysis, the project team analyzed the NREL turbines using uncapped incentives only. Based on the information provided in Table 17 through Table 19, which describe the annual energy production, cost, and expenses assumed by the project team, the team estimated the NPVs for the two virtual turbines. Table 20 through Table 23 compare the two NREL turbines to the Fuhrländer 250 (250 kW) and the Vestas V39 (500 kW) to illustrate the technology differences between the NREL turbines and the existing technologies used in the analysis.

Table 17. Net Annual Electricity Production (kWh) in the First Year of Operation by WPC and by Project Size for NREL Turbines

	Project Size	
NREL WPC	NREL 250	NREL 500
2	575,000	1,163,000
3	718,000	1,445,000
4	823,000	1,654,000
5	912,000	1,831,000

	Project Size	
NREL WPC	NREL 250	NREL 500
6	1,018,000	2,039,000
7	1,156,000	2,292,000

Table 18. Installed NREL Turbine Costs in Relation to Turbine and Project Sizes

Project Size (kW)	Number of Turbines in Project	Example Turbine	Installed Cost per Turbine	Installed Cost of Project	Installed Cost per Kilowatt
250	1	NREL 250	$705,000	$800,000	$2,820
500	1	NREL 500	$1,285,000	$1,400,000	$2,570

Table 19. Annual NREL Turbine Ongoing Expenses

	Unit	Commercial, Industrial, and Public Facilities
Operations and maintenance	$/kWh	$0.010/kWh
Operations and maintenance contingency fund	$/kWh	$0.003/kWh
Insurance	$/kW	$8.00/kW
Property tax	$/kW	$6.00/kW
Administrative/financial/legal management	$/kW	$1.00/kW
Production tax expense	$/kWh	$0.00
Warranty expense	$/kW	$13.00/kW
Decommissioning fund pre-warranty expiration	$/kW	$0.00
Decommissioning fund post-warranty expiration	$/kW	$1.00/kW
Other expenses	$/kW	$2.00/kW

Table 20. NREL Turbine Cost Comparison

Turbine	Installed Cost	Installed Cost per kW
Fuhrländer FL-250	$800,000	$3,200
NREL 250	$705,000	$2,820
Cost reduction	$95,000	$380
Percent reduction	12%	12%
Vestas V39	$1,400,000	$2,800
NREL 500	$1,285,000	$2,570
Cost reduction	$115,000	$230
Percent reduction	8%	8%

Table 21. NREL Turbine Annual kWh—First Year Comparison

Annual kWh—First Year				
NREL Class	Fuhrländer FL-250	NREL 250	Vestas V39	NREL 500
2	384,076	575,000	728,579	1,163,000
3	493,223	718,000	955,680	1,445,000
4	580,166	823,000	1,135,119	1,654,000
5	658,003	912,000	1,294,107	1,831,000
6	756,259	1,018,000	1,491,512	2,039,000
7	1,015,119	1,156,000	1,987,834	2,309,000

Table 22. NREL Turbine Capacity Factor Comparison

Capacity Factor				
NREL Class	Fuhrländer FL-250	NREL 250	Vestas V39	NREL 500
2	17.5%	26.3%	16.6%	26.5%
3	22.5%	32.8%	21.8%	33%
4	26.5%	37.6%	25.9%	37.8%
5	30.0%	41.7%	29.5%	41.8%
6	34.5%	46.5%	34.1%	46.6%
7	46.4%	52.8%	45.4%	52.7%

Table 23. Change in Capacity Factors

NREL Class	250 kW % Increase	500 kW % Increase
2	50%	59%
3	46%	51%
4	42%	46%
5	39%	41%
6	35%	37%
7	14%	16%

4.5.2 Discussion

Similar to the main CIP analysis, it is possible for a site to have more than one NREL "winning" turbine. The NREL 250 and NREL 500, for example, both could have positive NPVs at one unique site. In total, there were 204,677 unique sites in 34 states where at least one NREL turbine was economically successful. (For more details *see* Appendix D, Table D-4, and Figure 16.) This compares with 2,403 and 8,004 uncapped winners with the existing 250 kW and 500 kW turbines, respectively. Table 24 lists the number of NREL turbines that were successful overall. Figure 16 demonstrates the additional successful NREL turbines when compared to uncapped CIP winners.

Table 24. Total Winners by NREL Turbine

NREL 250	NREL 500
68,931	204,663

Six states (Connecticut, Massachusetts, Maine, New York, Rhode Island, Texas) account for 91.5% of the NREL turbine winners. New York had the most winners overall with 112,414, which represents 55% of the total. All of these states (with the exception of Texas) have some of the greatest REC rates in the country.

Analysis shows that the NREL turbines are dramatically more successful than existing turbines of the same size classes. For both the 250 kW and 500 kW classes, the number of winners increased by a factor of 25 or more. The combination of lower first cost and higher productivity (especially at lower wind speeds) provides substantial economic benefits. For example, at WPC 3 the NREL 250 produces almost 225,000 additional kWh of energy each year as compared to the Fuhrländer 250. At $0.10 per kWh (whether retail or wholesale), this additional production is worth $22,500 per year or a NPV of $238,000 over 20 years at a 7% discount rate. This is comparable to one third of the installed cost of the NREL 250 turbine. This incremental revenue dramatically improves the lifecycle economics of the NREL turbines.

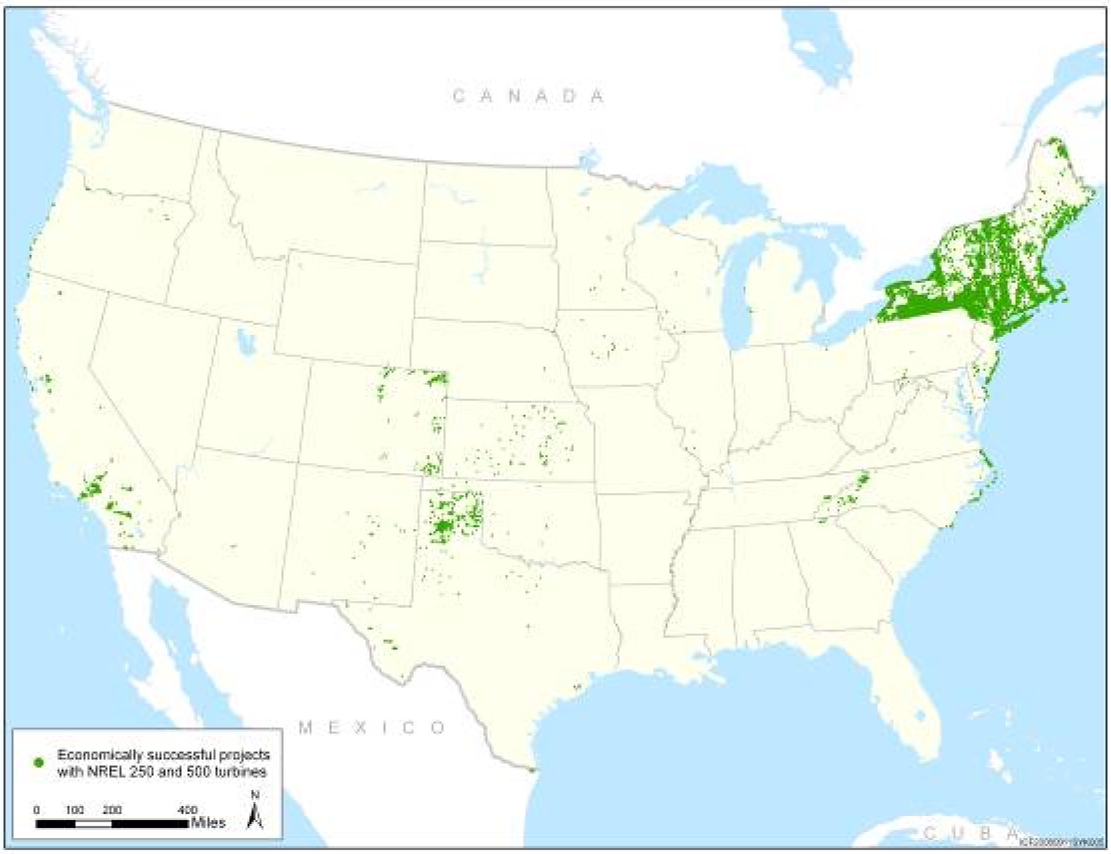

Figure 15. NREL turbine winners (ICF International 2008)

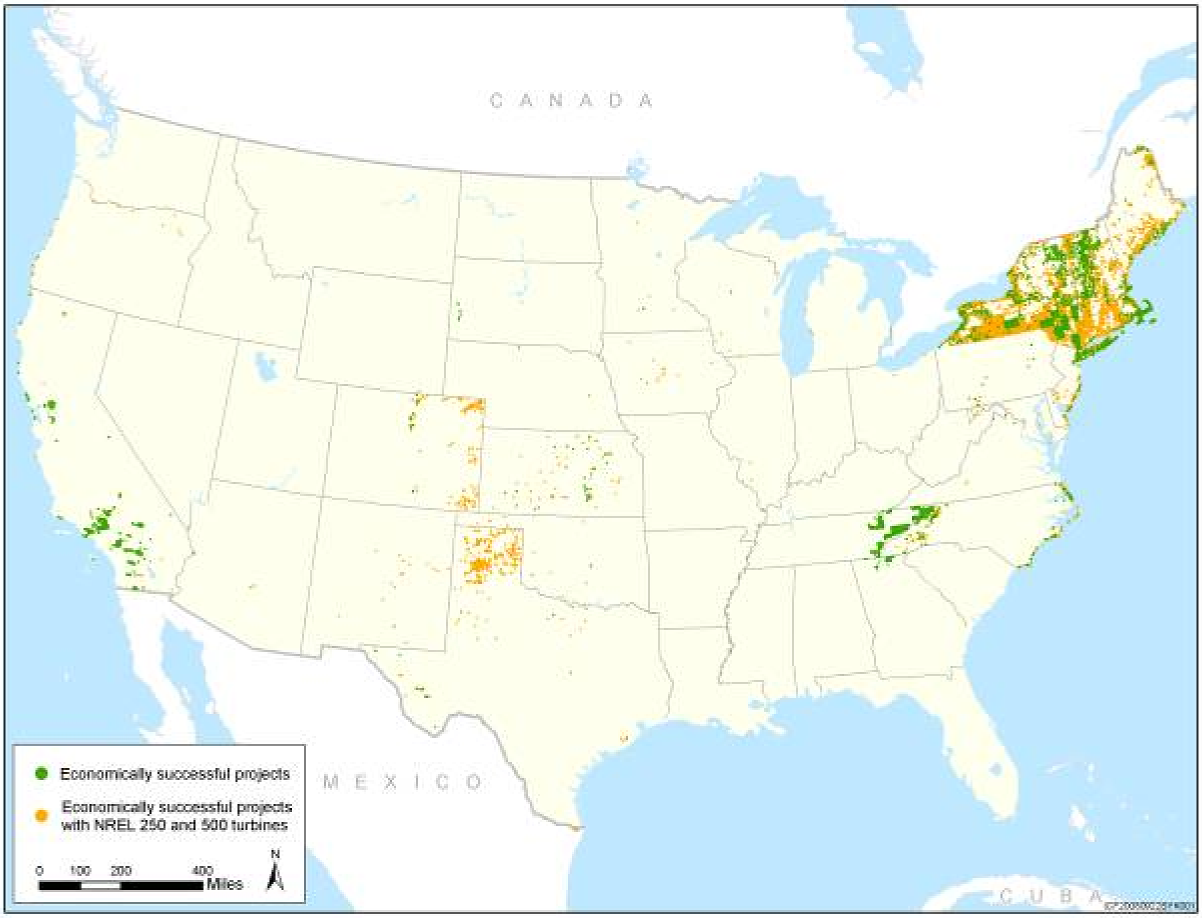

Figure 16. NREL turbine winners compared to current commercial, industrial, and public facility winners (ICF International 2008)

4.6 Conclusions and Implications

Wind technology offers clean, renewable electricity with additional benefits in the form of local employment and economic development. In an era of rising concern about energy security, global warming, and energy costs, wind technology is receiving significant interest from the public and from policy makers, and the private sector has seen fit to invest billions of dollars in recent years to build large, central-station wind farms.

Distributed wind technology, however, has not benefited from the boom in wind projects and (as discussed elsewhere in this report) even might have suffered for it. Distributed wind offers some incremental advantages over central-station wind (e.g., production close to the point of consumption; avoidance of high retail electric rates; no requirement to consider transmission interconnection), but it also suffers from some distinct comparative disadvantages (e.g., greater capital costs per rated kW; reduced conversion efficiency; no economy of scale in installation and maintenance).

Currently, successful distributed wind projects require some combination of good wind resources, sufficient retail and wholesale electric prices, increased REC prices, and supportive incentive policies. The review of "capped" state and federal incentives demonstrated that these programs—which either buy down the first cost of distributed wind or augment the revenue flow—have significant potential to increase the penetration of distributed wind beyond its current level, particularly in the commercial, industrial, and public facility segments.[27] Several developments are needed for distributed wind to achieve greater penetration.

- **Improvements in the technology**. The distributed wind turbines of 2008, technologically speaking, are the same turbines that were used for central-station projects in the early 1990s. Increasing the productivity of mid-scale wind turbines would increase the attractiveness of the technology. Analysis of the NREL virtual turbines further underscores this point.
- **Reduction in cost**. The capital cost of distributed wind turbines (on a $/kW basis) can be several multiples of the capital cost of utility-scale turbines. Any reduction in capital cost would improve project economics.
- **Greater policy support**. All energy technologies in the United States enjoy policy support in some fashion, including production credits, tax benefits for exploration, insurance backstopping, and favorable royalty rules. Renewable energy technologies have benefited in recent years from the introduction of the PTC, state RPSs, the rise of voluntary REC markets, and various other more limited incentives that are capped by budget. Rising concern about global warming is likely to be the most important stimulus for future renewable energy incentives. These incentives could take the form of a carbon tax, a carbon cap-and-trade program, a national RPS, or other policy approaches. Although most of the policy interventions under discussion favor renewable energy (and wind) generally, it is not clear to what extent distributed wind specifically would benefit compared with central-station wind. Policy makers need to consider the incremental virtues of distributed resources—local ownership, local benefits, reduced demand on the electrical grid—to target additional support to distributed wind.

5 References

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[27] See section 4.3.5 for more information about capped incentives. The state incentive allocation method directed incentive money to residential customers first, leaving smaller budget available for CIP customers.

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Appendix A. State and Utility Net-Metering Rules and Programs[28]

Table A-1. Utility Net-Metering Rules and Programs by State

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
AR	Arkansas	25 kW for residential systems; 300 kW for commercial systems	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, fuel cells, microturbines	None	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	All utilities
AZ	Salt River Project	10 kW	Residential	Photovoltaics	None	Purchased monthly by utility at average monthly market price minus a price adjustment of $0.00017/kWh	Utility guidelines	Salt River Project
AZ	Tucson Electric Power	10 kW	Commercial, residential	Photovoltaics, wind	500 kW peak aggregate	Credited at retail rate to customer's next bill; granted to utility after each January billing cycle	Utility guidelines	Tucson Electric Power
CA	California	1 MW; 10 MW for as many as 3 biogas digesters	Commercial, industrial, residential	Photovoltaics, landfill gas, wind, fuel cells (renewable fuels), anaerobic digestion	2.5% of a utility's peak demand; statewide limit of 50 MW for biogas digesters	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	All utilities for PV and wind; IOUs also must offer net metering for fuel cells and biomass
CO	Colorado	2 MW	Commercial, industrial, residential	Solar, landfill gas, wind, biomass, anaerobic digestion, small hydro, fuel cells (renewable fuels)	None	Credited at retail rate to customer's next bill; at end of each calendar year, customer reimbursed for NEG at utility's average hourly incremental cost for the prior 12-month period	Yes	Colorado utilities serving 40,000 or more customers (municipal and co-ops can opt out if the majority of customers agrees)

[28] This table was updated in May 2007. For more updated information about system limit size by state, please see Table 10. The project team used the more updated system limits listed in Table 10 to inform the market analysis.

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
CO	Delta Montrose Electric Association	Customer's maximum measured demand for previous 12 months	Commercial, residential	Photovoltaics, wind, biomass, hydro	1 MW	No credit is offered to the customer for NEG	Yes	Delta-Montrose Electric Association
CO	Empire Electric Association	10 kW	Commercial, residential, nonprofit, schools, agricultural, institutional	Photovoltaics, wind	50 customers	Utility pays customer at a rate equal to the average cost of power from the utility's wholesale supplier for that year, excluding wholesale power sold to loads billed under the utility's SCS tariffs	Yes	Empire Electric Association
CO	Fort Collins Utilities	10 kW	Residential	Photovoltaics, wind	25 customers	Credited to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	Fort Collins Utilities
CO	Gunnison County Electric	10 kW	Commercial, residential	Photovoltaics, wind	50 customers	Purchased by utility at wholesale rate	Yes	Gunnison County Electric
CO	Holy Cross Energy	25 kW	Commercial, industrial, residential	Photovoltaics, wind, biomass, hydro, geothermal	None	Credited to customer's next bill at retail rate; purchased by utility at avoided-cost rate at end of calendar year	Yes	Holy Cross Energy
CO	La Plata Electric Association	25 kW	Commercial, residential	Photovoltaics, wind	1% of utility's aggregate customer peak demand	Credited to customer's next bill at avoided-cost rate; utility pays customer for any unused NEG at beginning of each calendar year	Yes	La Plata Electric Association
CT	Connecticut	100 kW for renewable technologies; 50 kW for fossil technologies	Commercial, residential	Solar, landfill gas, wind, biomass, fuel cells, municipal solid waste, small hydro, tidal energy, wave energy, ocean thermal	None	Purchased monthly by utility at spot-market energy rate	Yes	Investor-owned utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
DE	Delaware	25 kW	Commercial, residential	Photovoltaics, wind, biomass, hydro	None	Varies by utility	Yes	All utilities (applies to municipal utilities only if they opt to compete outside their municipal limits)
DC	District of Columbia	100 kW	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, fuel cells, chp, anaerobic digestion, tidal energy, microturbines	None	Credited to customer's next bill at retail rate	Yes	All utilities
FL	Florida Keys Electric Cooperative	10 kW	Residential	Photovoltaics	None	Credited at retail rate and carried over to customers next bill; purchased by utility at end of 12-month period	Yes	Florida Keys Electric Cooperative
FL	JEA	10 kW	Residential	Photovoltaics, wind	None	Credited to customer's next bill at retail rate	Utility guidelines	JEA
FL	Lakeland Electric	10 kW for residential, 500 kW for commercial	Commercial, residential	Photovoltaics	None	Credited to customer's next bill at retail rate; indefinite carryover	Yes	Lakeland Electric
FL	New Smyrna Beach Utilities	10 kW	Residential	Photovoltaics	None	Credited to customer's next bill at retail rate	Utility guidelines	New Smyrna Beach Utilities
GA	Georgia	10 kW for residential, 100 kW for commercial	Commercial, industrial, residential	Photovoltaics, wind, fuel cells	0.2% of a utility's annual peak demand	Credited to customer's next bill at retail rate; granted to utility at end of 12-month billing cycle	Yes	All utilities
HI	Hawaii	50 kW (increase under consideration)	Commercial, residential, government	Photovoltaics, wind, biomass, hydro	0.5% of a utility's annual peak demand	Credited to customer's next bill at retail rate; granted to utility at end of 12-month billing cycle	Yes	All utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
IA	Iowa	500 kW	Commercial, industrial, residential	Photovoltaics, wind, biomass, hydro, municipal solid waste	None	Credited at retail rate to customer's next bill	No	Investor-owned utilities
ID	Idaho Power	25 kW for residential and small commercial; 100 kW for large commercial and agricultural	Commercial, residential, agricultural	Solar, wind, biomass, hydro, fuel cells	2.9 MW (0.1% of utility's 2,000 peak demand in Idaho)	Credited to customer's next bill at retail rate for residential and small commercial customers; credited at 85% of utility's avoided-cost rate for large commercial and agricultural customers	Utility guidelines	Idaho Power
ID	Rocky Mountain Power	25 kW for residential and small commercial; 100 kW for all other customers	Commercial, residential, nonprofit, schools, government, agricultural, institutional	Solar, wind, biomass, hydro, fuel cells	714 kW (0.1% of utility's 2002 retail peak demand in Idaho)	Credited to customer's next bill at retail rate for residential and small commercial customers; credited at 85% of utility's avoided-cost rate for large commercial and agricultural customers	Utility guidelines	Rocky Mountain Power
IL	ComEd Wind and PV Generation Program	40 kW	All retail customers	Photovoltaics, wind	0.1% of utility's annual peak demand	Purchased monthly by utility at avoided-cost rate; customer also receives an annual production incentive at a rate equal to the difference between the average avoided cost and the average retail rate. This production incentive is capped at the total amount of power the customer purchased from ComEd over the year	Yes	Commonwealth Edison
IN	Indiana	10 kW	Residential, schools	Photovoltaics, wind, small hydro	0.1% of a utility's most recent peak summer load	Credited at retail rate to customer's next bill	Yes	Investor-owned utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
KY	Kentucky	15 kW	Commercial, residential, nonprofit, schools, government, agricultural, institutional	Photovoltaics	0.1% of a utility's single-hour peak load during the previous year	Credited at retail rate to customer's next bill indefinitely	Yes	Investor-owned utilities, cooperatives
LA	City of New Orleans	25 kW for residential; 100 kW for commercial	Commercial, residential	Photovoltaics, wind, biomass, geothermal, hydro, fuel cells (renewable fuels), microturbines	None	Credited at retail rate to customer's next bill indefinitely	Yes	Entergy New Orleans and any other jurisdictional utilities
LA	Louisiana	25 kW for residential; 100 kW for commercial and agricultural	Commercial, residential, agricultural	Photovoltaics, wind, biomass, geothermal, hydro, fuel cells (renewable fuels), microturbines	None	Credited at retail rate to customer's next bill indefinitely	Yes	All utilities
MA	Massachusetts	60 kW	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, fuel cells, municipal solid waste, chp	None	Credited at average monthly market rate to customer's next bill	Yes	Investor-owned utilities
MD	Maryland	2 MW	Commercial, residential, schools, government	Photovoltaics, wind, biomass, anaerobic digestion	1,500 MW	Credited at retail rate to customer's next bill; granted to utility at end of 12-month period	Yes	All utilities
ME	Maine	100 kW	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, fuel cells, municipal solid waste, chp, tidal energy	None	Credited to customer's next bill at retail rate; granted to utility at end of 12-month billing cycle	No	All utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
MI	Michigan	30 kW	Commercial, industrial, residential, nonprofit, schools, government, agricultural, institutional	Solar, landfill gas, wind, biomass, hydro, geothermal, municipal solid waste	0.1% of a utility's peak load or 100 kW (whichever is greater)	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	Various (voluntary participation)
MN	Minnesota	40 kW	Commercial, industrial, residential	Photovoltaics, wind, biomass, hydro, municipal solid waste, chp	None	Customer receives a check for NEG at the end of each month, calculated at utility's average retail rate	Yes	All utilities
MT	Montana	50 kW	Commercial, industrial, residential	Photovoltaics, wind, hydro	None	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	Investor-owned utilities
MT	Montana Electric Cooperatives	10 kW	Commercial, residential	Photovoltaics, wind, geothermal, fuel cells, small hydro	None	Granted to the utility	Yes	Most of MECA's 26 members
NC	North Carolina	20 kW for residential; 100 kW for non-residential	Commercial, industrial, residential	Photovoltaics, landfill gas, wind, biomass, anaerobic digestion, small hydro	0.2% of each utility's North Carolina retail peak load for the previous year	Credited at retail rate to customer's next bill at retail rate; granted to utility (annually) at beginning of each summer season	Yes	Investor-owned utilities
ND	North Dakota	100 kW	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, municipal solid waste, chp	None	Purchased by utility at avoided-cost rate	No	Investor-owned utilities
NH	New Hampshire	25 kW	Commercial, industrial, residential	Photovoltaics, wind, hydro	0.05% of a utility's peak demand	Credited at retail rate to customer's next bill	Yes	All utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technolo-gies	Limit on Total Capa-city	Treatment of Net Excess Generation (NEG)	Intercon-nect Stan-dards for Net Metering	Utilities Involved
NJ	New Jersey	2 MW	Commer-cial, residential	Solar, landfill gas, wind, biomass, hydro, geothermal, anaerobic digestion, tidal energy, wave energy, fuel cells (renewable fuels)	None	Credited at retail rate to customer's next bill; purchased by utility at avoided-cost rate at end of 12-month billing cycle	Yes	Electric distribution companies (does not apply to municipal utilities or electric co-ops)
NM	New Mexico	80 MW	Commer-cial, industrial, residential	Solar, landfill gas, wind, biomass, hydro, geothermal, fuel cells, municipal solid waste, combined heat and power, micro-turbines	None	Credited to customer's next bill at utility's avoided-cost rate or purchased monthly by utility at avoided-cost rate	Yes (revisions in progress)	Investor-owned utilities and co-ops
NV	Nevada	150 kW	Commer-cial, industrial, residential	Solar, wind, biomass, hydro, geothermal	1% of utility's peak capacity	Carried over to customer's next bill indefinitely as a kWh credit for systems < 30 kW; carried over indefinitely as a dollar value or kWh credit for systems >30 kW	Yes	Investor-owned utilities
NY	New York	10 kW for solar; 25 kW for residen-tial wind; 125 kW for farm-based wind; 400 kW for farm-based biogas	Residential, agricultural	Photo-voltaics, wind, biomass	0.1% of IOU's 1996 demand for solar; 0.2% of IOU's 2003 demand for wind; 0.4% of IOU's 1996 demand or farm-based biogas	Credited at retail rate to customer's next bill, except NEG from wind systems over 10 kW, which is credited to customer's next bill at the utility's avoided-cost rate; all NEG purchased by utility at avoided-cost rate at end of 12-month billing cycle	Yes	All utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
OH	Ohio	No limit specified (system must be sized to match some or all of customer's load)	Commercial, industrial, residential	Solar, landfill gas, wind, biomass, hydro, fuel cells, microturbines	1% of a utility's peak demand	Credited at utility's unbundled generation rate to customer's next bill; customer can request refund of NEG credits accumulated over a 12-month period	Yes	All electric distribution utilities and competitive retail electric service providers
OH	Yellow Springs Utilities	25 kW	Commercial, residential	Photovoltaics, wind	None	Not addressed	Utility guidelines	Yellow Springs Utilities
OK	Oklahoma	100 kW or 25,000 kWh per year (whichever is less)	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, municipal solid waste, combined heat and power	None	Granted to utility monthly or credited to customer's next bill (varies by utility)	No	Investor-owned utilities, co-ops
OR	Oregon	25 kW	Commercial, industrial, residential	Solar, landfill gas, wind, biomass, hydro, fuel cells, anaerobic digestion	A limit of 0.5% of a utility's historic single-hour peak load can be set	Purchased at utility's avoided cost or credited to customer's next bill at retail rate; at the end of an annual period, any unused NEG credit is granted to the electric utility	Yes	All utilities
OR	Ashland Electric	None	Commercial, residential	Photovoltaics, wind	None	Purchased by utility monthly at retail rate (1,000 kWh/month maximum)	Utility guidelines	Ashland Electric
PA	Pennsylvania	50 kW for residential systems; 1 MW for nonresidential systems; 2 MW for systems connected to micro-grids or available for emergencies	Commercial, industrial, residential, nonprofit, schools, government, agricultural, institutional	Solar, landfill gas, wind, biomass, hydro, fuel cells, municipal solid waste, chp, waste coal, coal-mine methane, anaerobic digestion, other distributed generation	None	Customer compensated monthly at utility's avoided-cost rate	Yes	Investor-owned utilities

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
RI	Rhode Island	25 kW	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, fuel cells, municipal solid waste, chp	1 MW (Narragansett Electric)	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	No (informal utility guidelines)	Narragansett Electric (National Grid)
TX	Texas	50 kW for renewables; 10 kW for qualifying facilities	Commercial, industrial, residential	Solar, landfill gas, wind, biomass, hydro, geothermal, tidal energy, wave energy, ocean thermal	None	Customer compensated monthly at utility's avoided-cost rate	Yes	Integrated investor-owned utilities (El Paso Electric Company, Entergy Texas, Southwestern Electric Power Company, Xcel Energy)
TX	Austin Energy	20 kW	Commercial, residential	Solar, landfill gas, wind, biomass, hydro, geothermal, municipal solid waste, anaerobic digestion	Tariff re-evaluated after 1% of utility's load is served by distributed renewables	Credited at retail rate to customer's next bill; after 12-month billing cycle, customer is compensated for any remaining NEG credits at the avoided-cost rate	Yes	Austin Energy
UT	Utah	25 kW	Commercial, industrial, residential	Solar, wind, hydro, fuel cells	0.1% of a utility's peak demand in 2001	Credited to customer's next bill at utility's avoided-cost rate; granted to utility at end of calendar year	Yes	Investor-owned utilities, co-ops
UT	City of St. George	10 kW	Commercial, residential	Photovoltaics, wind	None	Credited to customer's next bill at utility's avoided-cost rate; indefinite carryover	Yes	City of St. George
UT	Murray City Power	10 kW	Commercial, residential	Photovoltaics, wind, small hydro	None	Credited to customer's next bill at utility's retail rate; granted to utility each April	Yes	Murray City Power

State	Program	System Size Limit	Customer Classes Eligible	Eligible Technologies	Limit on Total Capacity	Treatment of Net Excess Generation (NEG)	Interconnect Standards for Net Metering	Utilities Involved
VA	Virginia	10 kW residential; 500 kW nonresidential	Commercial, residential, nonprofit, schools, government, institutional	Solar, wind, biomass, hydro, geothermal, municipal solid waste, tidal energy, wave energy	1% of each utility's adjusted Virginia peak-load forecast for the previous year	Credited at retail rate to customer's next bill; either granted to utility annually or credited to following month	Yes	Investor-owned utilities, co-ops
VT	Vermont	15 kW for commercial, residential, all others; 150 kW for agricultural	Commercial, residential, nonprofit, schools, government, agricultural, institutional	Solar, landfill gas, wind, biomass, hydro, anaerobic digestion, fuel cells (renewable fuels)	1% of 1996 peak demand or peak demand during most recent calendar year (whichever is greater)	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	All utilities
WA	Washington	100 kW	Commercial, industrial, residential	Solar, wind, hydro, fuel cells, chp	0.25% of a utility's 1996 peak demand	Credited at retail rate to customer's next bill; granted to utility at end of 12-month billing cycle	Yes	All utilities
WA	Grays Harbor PUD	25 kW	Commercial, industrial, residential	Solar, wind, hydroelectric, fuel cells	0.1% of 1996 peak load	Rolled over as a kWh credit on a monthly basis, and purchased by utility at 50% of retail rate at the end of each calendar year	Yes	Grays Harbor PUD
WI	Wisconsin	20 kW; up to 100 kW for wind energy systems in We Energies territory	Commercial, industrial, residential	Solar, wind, biomass, hydro, geothermal, municipal solid waste, chp, other distributed generation	None	Purchased by utility at retail rate (renewables) or avoided-cost rate (non-renewables); NEG credit is carried over to the customer's next bill until it exceeds $25, at which point the utility must issue a check for the amount payable to the customer	Yes	Investor-owned utilities, municipal utilities
WY	Wyoming	25 kW	Commercial, industrial, residential	Photovoltaics, wind, biomass, hydro	None	Credited at retail rate to customer's next bill; purchased by utility at avoided-cost rate at end of 12-month billing cycle	Yes	Investor-owned utilities, co-ops

Source: DSIRE 2007.

Appendix B. State Incentives Tables and Assumptions

Table B-1. Capacity Incentives by State and Customer Type

State & Cus-tomer Type[29]	Capacity Incentive Name	Eligible Turbine Size[30]	$/kW per Project	Max % Cost Reduction per Project	Max Cost Reduction per Project	Max kW Eligible for Incentive per Project	Relation-ship Between Project Limits	Incentive Annual Budget	State Owns the RECs
CA-C/I	Self-Generation Incentive Program	100 kW–2,000 kW	$1,500/kW			1,000 kW	kW only	$41,500,000	
CA-C/I	Emerging Renewables Program	10 kW–50 kW	$1,750/kW–$2,250/kW			30 kW	kW only	$5,300,000	
CA-CW	Self-Generation Incentive Program	5,000 kW	$1,500/kW			1,000 kW	kW only	$41,500,000	
CA-P	Self-Generation Incentive Program	10 kW–2,000 kW	$1,500/kW			1,000 kW	kW only	$41,500,000	
CA-R	Emerging Renewables Program	2 kW–10 kW	$2,250/kW–$2,500/kW			7.5 kW–30 kW	kW only	$5,300,000	
CT-C/I	CCEF—On-Site Renewable DG Program	10 kW–2,000 kW	$3,600/kW		$4,000,000		$/kW or $, whichever is less	$6,624,000	
CT-CW	CCEF—On-Site Renewable DG Program	5,000 kW	$3,600/kW		$4,000,000		$/kW or $, whichever is less	$6,624,000	
CT-P	CCEF—On-Site Renewable DG Program	10 kW–2,000 kW	$3,600/kW		$4,000,000		$/kW or $, whichever is less	$6,624,000	
CT-R	DPUC—Capital Grants for Customer-Side Distributed Resources	2 kW–10 kW	$450/kW			65,000 kW	kW only		
IN-C/I	Alternative Power & Energy Grant Program	10 kW–2,000 kW	$2,500/kW		$25,000	10 kW	kW or $, whichever is less	$150,000	
IN-CW	Alternative Power & Energy Grant Program	5,000 kW	$2,500/kW		$25,000	10 kW	kW or $, whichever is less	$150,000	
IN-P	Alternative Power & Energy Grant Program	10 kW–2,000 kW	$2,500/kW		$25,000	10 kW	kW or $, whichever is less	$150,000	

[29] Commercial/industrial, C/I; community wind, CW; public facility, P; residential, R.
[30] For the residential customer class, the project team analyzed turbines with a minimum size of 2 kW. For this reason, all eligible residential turbine sizes are listed in state tables as 2 kW or greater. In some cases these residential incentives might apply to turbines smaller than 2 kW.

State & Cus-tomer Type[29]	Capacity Incentive Name	Eligible Turbine Size[30]	$/kW per Project	Max % Cost Reduction per Project	Max Cost Reduction per Project	Max kW Eligible for Incentive per Project	Relation-ship Between Project Limits	Incentive Annual Budget	State Owns the RECs
MA-R	Small Renewables Initiative (SRI) Rebates	2 kW–10 kW	$2,250/kW		$50,000		$/kW or $, whichever is less	$1,800,000	
MT-C/I	NorthWestern Energy—USB Renewable Energy Fund	10 kW–2,000 kW	$2,000/kW		$10,000		$/kW or $, whichever is less	$300,000	
MT-CW	NorthWestern Energy—USB Renewable Energy Fund	5,000 kW	$2,000/kW		$10,000		$/kW or $, whichever is less	$300,000	
MT-R	NorthWestern Energy—USB Renewable Energy Fund	2 kW–10 kW	$2,000/kW		$10,000		$/kW or $, whichever is less	$300,000	
OH-C/I	ODOD—Advanced Energy Program Grants—Distributed Energy and Renewable Energy	10 kW–2,000 kW	$2,500/kW	50%	$150,000		% or $, whichever is less	$90,000	
OH-CW	ODOD—Advanced Energy Program Grants—Distributed Energy and Renewable Energy	5,000 kW	$2,500/kW	50%	$150,000		% or $, whichever is less	$90,000	
OH-P	ODOD—Advanced Energy Program Grants—Distributed Energy and Renewable Energy	10 kW–2,000 kW	$2,500/kW	50%	$150,000		% or $, whichever is less	$90,000	
OR-C/I	Energy Trust—Small Wind Incentive Program	10 kW–50 kW	$4,000/kW		$60,000		$/kW or $, whichever is less	$1,400,000	Yes
OR-P	Energy Trust—Small Wind Incentive Program	10 kW–50 kW	$4,000/kW		$60,000		$/kW or $, whichever is less	$1,400,000	Yes
OR-R	Energy Trust—Small Wind Incentive Program	2 kW–10 kW	$4,500/kW		$35,000		$/kW or $, whichever is less	$1,400,000	Yes
VT-C/I	Solar & Small Wind Incentive Program	10 kW–2,000 kW	$2,500/kW		$12,500		$ only	$375,000	
VT-CW	Solar & Small Wind Incentive Program	5,000 kW	$4,500/kW	50%	$20,000		% or $, whichever is less	$375,000	
VT-P	Solar & Small Wind Incentive Program	10 kW–2,000 kW	$4,500/kW	50%	$20,000		% or $, whichever is less	$375,000	
VT-R	Solar & Small Wind Incentive Program	2 kW–10 kW	$2,500/kW		$12,500		$ only	$375,000	

Table B-2. Cost Incentives by State and Customer Type

State & Customer type	Cost Incentive Name	Eligible Turbine Size	Max % Cost Reduction per Project	Max Cost Reduction per Project	Relationship Between Project Limits	Incentive Annual Budget	If Tax Credit, Can It be Carried Forward? (Years)
AZ-C/I	Non-Residential Solar & Wind Tax Credit	10 kW–2,000 kW	10%	$50,000	% or $, whichever is less	$500,000	5
AZ-CW	Non-Residential Solar & Wind Tax Credit	5,000 kW	10%	$50,000	% or $, whichever is less	$500,000	5
AZ-P	Non-Residential Solar & Wind Tax Credit	10 kW–2,000 kW	10%	$50,000	% or $, whichever is less	$500,000	5
AZ-R	Residential Solar and Wind Energy Systems Tax Credit	2 kW–10 kW	25%	$1,000	% or $, whichever is less		5
CT-C/I	CCEF—Project 150 Initiative	1,000 kW–2,000 kW		$50,000	$ only, but min not max	12,500 kW	
CT-CW	CCEF—Project 150 Initiative	5,000 kW		$50,000	$ only, but min not max	12,500 kW	
DC-C/I	Renewable Energy Demonstration Project (REDP)	10 kW–100 kW	50%	$163,000	% or $, whichever is less	$225,000	
DC-PF	Renewable Energy Demonstration Project (REDP)	10 kW–100 kW	50%	$163,000	% or $, whichever is less	$225,000	
DC-R	Renewable Energy Demonstration Project (REDP)	2 kW–10 kW	50%	$163,000	% or $, whichever is less	$225,000	
DE-C/I	Green Energy Program Incentives	10 kW–2,000 kW	50%	$100,000	% or $, whichever is less	$741,000	
DE-CW	Green Energy Program Incentives	5,000 kW	50%	$100,000	% or $, whichever is less	$741,000	
DE-PF	Green Energy Program Incentives	10 kW–2,000 kW	50%	$100,000	% or $, whichever is less	$741,000	
DE-R	Green Energy Program Incentives	2 kW–10 kW	50%	$22,500	% or $, whichever is less	$494,000	
GA-C/I	Clean Energy Tax Credit	10 kW–2,000 kW	35%	$500,000	% or $, whichever is less	$1,250,000	5
GA-CW	Clean Energy Tax Credit	5,000 kW	35%	$500,000	% or $, whichever is less	$1,250,000	5
GA-R	Clean Energy Tax Credit	2 kW–10 kW	35%	$10,500	% or $, whichever is less	$1,250,000	5
ID-R	Residential Alternative Energy Tax Deduction	2 kW–10 kW		$10,736–$15,211	$ only		5
IL-C/I	Wind Energy Production Development Program	500 kW–2,000 kW		$25,000	$ only	$562,500	
IL-CW	Illinois Clean Energy Community Foundation Grants	5,000 kW	25%		% only	$2,000,000	
IL-CW	Wind Energy Production Development Program	5,000 kW		$25,000	$ only	$562,500	
IL-P	Illinois Clean Energy Community Foundation Grants	10 kW–2,000 kW	25%		% only	$2,000,000	
IL-P	Wind Energy Production Development Program	500 kW–2,000 kW		$25,000	$ only	$562,500	
KY-C/I	Tax Credit for Renewable Energy Facilities	1,000 kW–2,000 kW	50%		% only		25

State & Cus-tomer type	Cost Incentive Name	Eligible Turbine Size	Max % Cost Reduction per Project	Max Cost Reduction per Project	Relation-ship Between Project Limits	Incentive Annual Budget	If Tax Credit, Can It be Carried Forward? (Years)
KY-C/I	Renewable Energy Tax Credit	10 kW–750 kW	30%	$1,000	% or $, whichever is less		1
KY-CW	Tax Credit for Renewable Energy Facilities	5,000 kW	50%		% only		25
KY-R	Renewable Energy Tax Credit	2 kW–10 kW	30%	$500	% or $, whichever is less		1
LA-R	Tax Credit for Solar and Wind Energy Systems on Residential Property (Corporate)	2 kW–10 kW	50%	$12,500	% or $, whichever is less		0
MA-C/I	MTC—Large Onsite Renewables Initiative (LORI) Grants	50 kW–2,000 kW	75%	$400,000	% or $, whichever is less	$3750,000	
MA-P	MTC—Large Onsite Renewables Initiative (LORI) Grants	50 kW–2,000 kW	75%	$400,000	% or $, whichever is less	$3,750,000	
MA-R	Residential Renewable Energy Income Tax Credit	2 kW–10 kW	15%	$1,000	% or $, whichever is less		3
ME-C/I	Solar and Wind Energy Rebate Program	10 kW–100 kW	35%	$10,500	% or $, whichever is less	$250,000	
ME-CW	Voluntary Renewable Resources Grant	5,000 kW	50%	$50,000	% or $, whichever is less	$150,000	
ME-P	Voluntary Renewable Resources Grant	10 kW–2,000 kW	50%	$50,000	% or $, whichever is less	$150,000	
ME-R	Solar and Wind Energy Rebate Program	2 kW–10 kW	30%	$2,500	% or $, whichever is less	$250,000	
MI-P	Community Energy Project Grant	10 kW–2,000 kW		$6,000	$ only	$45,000	
MT-R	Residential Alternative Energy System Tax Credit	2 kW–10 kW	100%	$500	% or $, whichever is less		4
NC-C/I	North Carolina Green Business Fund	10 kW–2,000 kW		$100,000	$ only	$475,000	
NC-CW	Renewable Energy Tax Credit	5,000 kW	35%	$2,500,000	% or $, whichever is less		4
NC-CW	North Carolina Green Business Fund	10 kW–2,000 kW		$100,000	$ only	$475,000	
NC-P	North Carolina Green Business Fund	10 kW–2,000 kW		$100,000	$ only	$475,000	
NC-R	Renewable Energy Tax Credit	2 kW–10 kW	35%	$10,500	% or $, whichever is less		5
ND-C/I	Renewable Energy Tax Credit	10 kW–2,000 kW	15%		% only		5
ND-C/I	Renewable Energy Tax Credit	10 kW–2,000 kW	15%		% only		5
ND-CW	Renewable Energy Tax Credit	5,000 kW	15%		% only		5
ND-R	Renewable Energy Tax Credit	2 kW–10 kW	15%		% only		5
NH-C/I	New Hampshire Electric Co-Op—Solar and Wind Energy Rebate Program	10 kW–100 kW	25%	$5,000	% or $, whichever is less		
NH-P	New Hampshire Electric Co-Op—Solar and Wind Energy Rebate Program	10 kW–100 kW	25%	$5,000	% or $, whichever is less		
NH-R	New Hampshire Electric Co-Op—Solar and Wind Energy Rebate Program	2 kW–10 kW	25%	$5,000	% or $, whichever is less		
NY-C/I	NYSERDA—On-Site Small Wind Incentive Program	10 kW–250 kW		$24,000–$118,000	$ only	$1,500,000	

State & Customer type	Cost Incentive Name	Eligible Turbine Size	Max % Cost Reduction per Project	Max Cost Reduction per Project	Relationship Between Project Limits	Incentive Annual Budget	If Tax Credit, Can It be Carried Forward? (Years)
NY-P	NYSERDA—On-Site Small Wind Incentive Program	10 kW–250 kW		$28,800–$141,600	$ only	$1,500,000	
NY-R	NYSERDA—On-Site Small Wind Incentive Program	2 kW–10 kW		$7,200–$24,000	$ only	$1,500,000	
OR-C/I	Business Energy Tax Credit	10 kW–2,000 kW	50%	$10,000,000	% or $, whichever is less		8
OR-CW	Business Energy Tax Credit	5,000 kW	50%	$10,000,000	% or $, whichever is less		8
OR-P	Business Energy Tax Credit	10 kW–2,000 kW	50%	$10,000,000	% or $, whichever is less		8
PA-P	Pennsylvania Energy Harvest Grant Program	10 kW–2,000 kW	50%	$500,000	% or $, whichever is less	$2,500,000	
RI-R	Residential Renewable Energy Tax Credit	2 kW–10 kW	25%	$3,750	% or $, whichever is less		no
TN-R	TVA—Green Power Switch Generation Partners Program	2 kW–10 kW		$500	$ only	75 kW	
TX-C/I	Solar and Wind Energy Device Franchise Tax Deduction	10 kW–2,000 kW	100%		% only		Indefinite
TX-CW	Solar and Wind Energy Device Franchise Tax Deduction	5,000 kW	100%		% only		Indefinite
UT-C/I	Renewable Energy Systems Tax Credit	10 kW–500 kW	10%	$50,000	% or $, whichever is less		0
UT-R	Renewable Energy Systems Tax Credit	2 kW–10 kW	25%	$2,000	% or $, whichever is less		4
VT-C/I	Clean Energy Development Fund (CEDF) Grant Program	10 kW–2,000 kW	50%	$60,000–$250,000	% or $, whichever is less	$1,741,200	
VT-CW	Clean Energy Development Fund (CEDF) Grant Program	5,000 kW	50%	$250,000	% or $, whichever is less	$1,741,200	
VT-P	Clean Energy Development Fund (CEDF) Grant Program	10 kW–2,000 kW	50%	$250,000	% or $, whichever is less	$1,741,200	
VT-R	Clean Energy Development Fund (CEDF) Grant Program	2 kW–10 kW	50%	$60,000	% or $, whichever is less	$1,741,200	

Table B-3. Production Incentives by State and Customer Type

State & Customer Type	Production Incentive Name	Eligible Turbine Size	$/kWh per Project	Max Years Eligible	Max Money per Project Each Year	Incentive Annual Budget	State Owns the RECs	If Tax Credit, Can It be Carried Forward? (Years)
CA-C/I	Feed-in Tariff	10 kW–2,000 kW	$0.1000/kWh	20		114,224 kW	Yes	
CA-CW	Feed-in Tariff	5,000 kW	$0.1000/kWh	20		114,224 kW	Yes	
CA-P	Feed-in Tariff	10 kW–2,000 kW	$0.1000/kWh	20		114,224 kW	Yes	
CA-R	Feed-in Tariff	2 kW–10 kW	$0.1000/kWh	20		114,224 kW	Yes	
CT-C/I	CCEF—Project 150 Initiative	1,000 kW–2,000 kW	$0.0550/kWh	15		1,250 kW	Yes	
CT-CW	CCEF—Project 150 Initiative	5,000 kW	$0.0550/kWh	15		1,250 kW	Yes	

State & Customer Type	Production Incentive Name	Eligible Turbine Size	$/kWh per Project	Max Years Eligible	Max Money per Project Each Year	Incentive Annual Budget	State Owns the RECs	If Tax Credit, Can It be Carried Forward? (Years)
FL-CW	Renewable Energy Production Tax Credit	5,000 kW	$0.01/kWh	3		$2,500,000		5
IA-C/I	Renewable Energy Production Tax Credits (Corporate)	2,000 kW	$0.0100/kWh	10		225,000 kW		
IA-CW	Renewable Energy Production Tax Credits (Corporate)	5,000 kW	$0.0100/kWh	10		225,000 kW		
IA-P	Renewable Energy Production Tax Credits (Corporate)	2,000 kW	$0.0100/kWh	10		225,000 kW		
MD-C/I	Clean Energy Production Tax Credit (Corporate)	10 kW–2,000 kW	$0.0085/kWh	5	$2,500,000	$12,500,000		10
MD-CW	Clean Energy Production Tax Credit (Corporate)	5,000 kW	$0.0085/kWh	5	$2,500,000	$12,500,000		10
MD-R	Clean Energy Production Tax Credit (Corporate)	2 kW–10 kW	$0.0085/kWh	5	$2,500,000	$12,500,000		10
NJ-C/I	New Jersey Clean Energy Rebate Program	10 kW–500 kW	$0.50-3.20/kWh	1	$32,102–$361,489	$25,000,000		
NJ-P	New Jersey Clean Energy Rebate Program	10 kW–500 kW	$0.50-3.20/kWh	1	$32,102–$361,489	$25,000,000		
NJ-R	New Jersey Clean Energy Rebate Program	2 kW–10 kW	$3.2000/kWh	1	$16,639–$32,102	$25,000,000		
NM-C/I	Renewable Energy Production Tax Credit	1,000 kW–2,000 kW	$0.0100/kWh	10	$4,000,000	$10,000,000		
NM-CW	Renewable Energy Production Tax Credit	5,000 kW	$0.0100/kWh	10	$4,000,000	$10,000,000		
OK-C/I	Zero-Emission Facilities Production Tax Credit	1,000 kW–2,000 kW	$0.0050/kWh	10				10
OK-CW	Zero-Emission Facilities Production Tax Credit	5,000 kW	$0.0050/kWh	10				10
OK-P	Zero-Emission Facilities Production Tax Credit	1,000 kW–2,000 kW	$0.0050/kWh	10				10
OR-R	Residential Energy Tax Credit	2 kW–10 kW	$2.0000/kWh	1	$6,000		No	5
TN-R	TVA—Green Power Switch Generation Partners Program	2 kW–10 kW	$0.1500/kWh	10			Yes	
UT-C/I	Renewable Energy Systems Tax Credit	750 kW–2,000 kW	$0.0035/kWh	4				0
UT-CW	Renewable Energy Systems Tax Credit	5,000 kW	$0.0035/kWh	4				0
WA-C/I	Washington Renewable Energy Production Incentive	10 kW–2,000 kW	$0.1200/kWh	6	$2,000		No	
WA-CW	Washington Renewable Energy Production Incentive	5,000 kW	$0.1200/kWh	6	$2,000		No	
WA-P	Washington Renewable Energy Production Incentive	10 kW–2,000 kW	$0.1200/kWh	6	$2,000		No	
WA-R	Washington Renewable Energy Production Incentive	2 kW–10 kW	$0.1200/kWh	6	$2,000		No	

Table B-4. Property Tax Incentives by State and Customer Type

State & Customer Type	Property Tax Incentive Name	Eligible Turbine Size	% Reduc tion	Number of Years Exempt	Max Cost Reduc-tion Per Project
CT-C/I	Property Tax Exemption for Renewable Energy Systems	10 kW–2,000 kW		Indefinite	
CT-CW	Property Tax Exemption for Renewable Energy Systems	5,000 kW		Indefinite	
CT-R	Property Tax Exemption for Renewable Energy Systems	2 kW–10 kW		Indefinite	
IA-C/I	Property Tax Exemption for Renewable Energy Systems	10 kW–2,000 kW	100%	5	
IA-CW	Property Tax Exemption for Renewable Energy Systems	5,000 kW	100%	5	
IA-R	Property Tax Exemption for Renewable Energy Systems	2 kW–10 kW	100%	5	

State & Customer Type	Property Tax Incentive Name	Eligible Turbine Size	% Reduc tion	Number of Years Exempt	Max Cost Reduc- tion Per Project
ID-C/I	Property Tax Exemption for Wind and Geothermal Energy	10 kW–2,000 kW	100%	Indefinite	
ID-CW	Property Tax Exemption for Wind and Geothermal Energy	5,000 kW	100%	Indefinite	
IN-C/I	Renewable Energy Property Tax Exemption	10 kW–2,000 kW	100%	Indefinite	
IN-CW	Renewable Energy Property Tax Exemption	5,000 kW	100%	Indefinite	
IN-R	Renewable Energy Property Tax Exemption	2 kW–10 kW	100%	Indefinite	
KS-C/I	Renewable Energy Property Tax Exemption	10 kW–2,000 kW	100%	Indefinite	
KS-CW	Renewable Energy Property Tax Exemption	5,000 kW	100%	Indefinite	
KS-R	Renewable Energy Property Tax Exemption	2 kW–10 kW	100%	Indefinite	
MA-C/I	Renewable Energy Property Tax Exemption	10 kW–2,000 kW	100%	20	
MA-CW	Renewable Energy Property Tax Exemption	5,000 kW	100%	20	
MA-R	Renewable Energy Property Tax Exemption	2 kW–10 kW	100%	20	
MN-C/I	Wind and Solar-Electric (PV) Systems Exemption	10 kW–100 kW	100%	Indefinite	
MN-R	Wind and Solar-Electric (PV) Systems Exemption	2 kW–10 kW	100%	Indefinite	
MT-C/I	New or Expanding Industries Property Tax Abatement	1,000 kW–2,000 kW	83%	9	
MT-C/I	Renewable Energy Systems Exemption	10 kW–750 kW	100%	5	$100,000
MT-CW	New or Expanding Industries Property Tax Abatement		83%	9	
MT-R	Renewable Energy Systems Exemption	2 kW–10 kW	100%	10	$20,000
ND-C/I	Large Wind Property Tax Reduction	100 kW–2,000 kW	70%	Indefinite	
ND-C/I	Geothermal, Solar, and Wind Property Exemption	10 kW–50 kW	100%	5	
ND-CW	Large Wind Property Tax Reduction	5,000 kW	70%	Indefinite	
ND-R	Geothermal, Solar, and Wind Property Exemption	2 kW–10 kW	100%	5	
NV-C/I	Renewable Energy Systems Property Tax Exemption	10 kW–2,000 kW	100%	Indefinite	
NV-CW	Renewable Energy Systems Property Tax Exemption	5,000 kW	100%	Indefinite	
NV-R	Renewable Energy Systems Property Tax Exemption	2 kW–10 kW	100%	Indefinite	
NY-C/I	Solar, Wind, and Biomass Energy Systems Exemption	10 kW–2,000 kW	100%	15	
NY-CW	Solar, Wind, and Biomass Energy Systems Exemption	5,000 kW	100%	15	
NY-R	Solar, Wind, and Biomass Energy Systems Exemption	2 kW–10 kW	100%	15	
OH-C/I	Energy Conversion Facilities Property Tax Exemption	10 kW–2,000 kW	100%	Indefinite	
OH-CW	Energy Conversion Facilities Property Tax Exemption	5,000 kW	100%	Indefinite	
OR-C/I	Renewable Energy Systems Exemption	10 kW–2,000 kW	100%	Indefinite	
OR-CW	Renewable Energy Systems Exemption	5,000 kW	100%	Indefinite	
OR-P	Renewable Energy Systems Exemption	10 kW–2,000 kW	100%	Indefinite	
OR-R	Renewable Energy Systems Exemption	2 kW–10 kW	100%	Indefinite	
PA-C/I	Wind-Energy System Exemption	10 kW–2,000 kW	100%	Indefinite	
PA-CW	Wind-Energy System Exemption	5,000 kW	100%	Indefinite	
PA-R	Wind-Energy System Exemption	2 kW–10 kW	100%	Indefinite	
SD-C/I	Renewable Energy Systems Exemption	10 kW–2,000 kW	50%	5	
SD-R	Renewable Energy Systems Exemption	2 kW–10 kW	100%	Indefinite	
TN-C/I	Wind Energy Systems Exemption	10 kW–2,000 kW	67%	Indefinite	
TN-CW	Wind Energy Systems Exemption	5,000 kW	67%	Indefinite	
TX-C/I	Renewable Energy Systems Property Tax Exemption	10 kW–2,000 kW	100%	Indefinite	
TX-R	Renewable Energy Systems Property Tax Exemption	2 kW–10 kW	100%	Indefinite	

State & Customer Type	Property Tax Incentive Name	Eligible Turbine Size	% Reduc tion	Number of Years Exempt	Max Cost Reduc-tion Per Project
WI-C/I	Solar and Wind Energy Equipment Exemption	10 kW–2,000 kW	100%	Indefinite	
WI-CW	Solar and Wind Energy Equipment Exemption	5,000 kW	100%	Indefinite	
WI-R	Solar and Wind Energy Equipment Exemption	2 kW–10 kW	100%	Indefinite	

Table B-5. Sales Tax Incentives by State and Customer Type

State & Cus-tomer Type	Sales Tax Exemption	Eligible Turbine Size	Scope of Exemption (Equipment, Installation, Both)
AZ-C/I	Solar and Wind Equipment Sales Tax Exemption	10 kW–2,000 kW	Both
AZ-CW	Solar and Wind Equipment Sales Tax Exemption	5,000 kW	Both
AZ-R	Solar and Wind Equipment Sales Tax Exemption	2 kW–10 kW	Both
IA-C/I	Wind and Solar Wind and Solar Energy Equipment Exemption	10 kW–2,000 kW	Both
IA-CW	Wind and Solar Wind and Solar Energy Equipment Exemption	5,000 kW	Both
IA-R	Wind and Solar Wind and Solar Energy Equipment Exemption	2 kW–10 kW	Both
ID-C/I	Renewable Energy Equipment Sales Tax Refund	50 kW–2,000 kW	Both
ID-CW	Renewable Energy Equipment Sales Tax Refund	5,000 kW	Both
KY-C/I	Tax Credit for Renewable Energy Facilities	1,000 kW–2,000 kW	Both
KY-CW	Tax Credit for Renewable Energy Facilities	5,000 kW	Both
MA-R	Renewable Energy Equipment Sales Tax Exemption	2 kW–10 kW	Equipment
MN-C/I	Wind Sales Tax Exemption	10 kW–2,000 kW	Both
MN-CW	Wind Sales Tax Exemption	5,000 kW	Both
MN-R	Wind Sales Tax Exemption	2 kW–10 kW	Both
NJ-C/I	Solar and Wind Energy Systems Exemption	10 kW–2,000 kW	Equipment
NJ-CW	Solar and Wind Energy Systems Exemption	5,000 kW	Equipment
NJ-R	Solar and Wind Energy Systems Exemption	2 kW–10 kW	Equipment
OH-C/I	Energy Conversion Facilities Sales Tax Exemption	10 kW–2,000 kW	Equipment
OH-CW	Energy Conversion Facilities Sales Tax Exemption	5,000 kW	Equipment
RI-C/I	Renewable Energy Sales Tax Exemption	10 kW–2,000 kW	Equipment
RI-CW	Renewable Energy Sales Tax Exemption	5,000 kW	Equipment
RI-R	Renewable Energy Sales Tax Exemption	2 kW–10 kW	Equipment
UT-C/I	Renewable Energy Sales Tax Exemption	50 kW–2,000 kW	Equipment
UT-CW	Renewable Energy Sales Tax Exemption	5,000 kW	Equipment
VT-C/I	Sales Tax Exemption	10 kW–250 kW	Equipment
VT-R	Sales Tax Exemption	2 kW–10 kW	Equipment
WA-C/I	Sales and Use Tax Exemption	10 kW–2,000 kW	Equipment
WA-CW	Sales and Use Tax Exemption	5,000 kW	Equipment
WA-R	Sales and Use Tax Exemption	2 kW–10 kW	Equipment
WY-C/I	Renewable Energy Sales Tax Exemption	10 kW–2,000 kW	Equipment
WY-CW	Renewable Energy Sales Tax Exemption	5,000 kW	Equipment
WY-P	Renewable Energy Sales Tax Exemption	10 kW–2,000 kW	Equipment
WY-R	Renewable Energy Sales Tax Exemption	2 kW–10 kW	Equipment

Incentives Omitted

- All pilot incentives purely for demonstration projects (e.g., R&D). These included the Tennessee Bonneville Environmental Foundation and Pennsylvania Energy Development Authority Grants.
- The local option property-tax exemptions in Vermont and Colorado did not have evidence of widespread use.
- The Montana Alternative Energy Corporate Tax Credit, because it only came out of income tax from projects and was difficult to include in the modeling.
- The Minnesota Production Tax Credit and the South Dakota capacity incentive, because they actually are a production taxes.
- The Connecticut Capital Grants for Customer-Side Distributed Resources, because the grant program is funded through federally mandated congestion charges which are based on periods of peak demand. The cap was difficult to determine and no historical data could be found. Including this incentive as an uncapped incentive would have given all Connecticut projects unrealistic NPVs.

General Assumptions

- In cases where wind had been added as an eligible technology to a solar incentive program, but specific wind incentives limits had not been set, the project team assumed that wind projects would get the same level of incentive as solar PV or solar thermal, depending on the incentive program rules.
- The project team considered commercial, industrial, and public facility projects ineligible for Florida's Renewable Energy Production Tax Credit, because the credit only applied to kWh sold.
- For the Energy Trust of Oregon Small Wind Incentive, the project team assumed that the Trust kept all the RECs for the entire span of the project.
- Pennsylvania Harvest grants have varied grant awards. The project team used the new $500,000 maximum award and assumed a maximum reduction of 50% of total project costs based on historical awards.
- The project team assumed reauthorization of all incentives as they currently stand, unless the project team received information which strongly suggested otherwise.

Application Rules for Incentives

- For Kentucky commercial, industrial, and community wind projects, the cost and sales incentives combined cannot exceed 50% of capital costs.
- In California, only one incentive can be used per project and no federal incentives can be combined with the state incentive. Further, non–tax credit incentives received from sources other than the Emerging Renewables Program, such as utility-based incentives, reduce the amount of the Emerging Renewables Program rebate by no less than 5% to prevent total incentives from exceeding total system costs.
- For Iowa commercial, industrial, and community wind projects, the production tax credit cannot be combined with the sales- and property-tax incentives.

Simplifying Assumptions

The project team reassigned the Washington Renewable Energy Production Incentive as a one-time cash grant for all customer sectors and turbine packages. The project team calculated that all scenarios would exceed the cap each year, and thus calculated the NPV of a one-time grant.

Appendix C. Kilowatt Potential Tables by State

Table C-1. Total Kilowatts per State, Community Wind Customer Class*

State	Total (Capped and Uncapped)
AZ	45,000
CA	1,510,000
CO	350,000
CT	50,000
MA	575,000
MD	10,000
ME	1,195,000
NC	50,000
NH	2,695,000
NM	480,000
NV	165,000
NY	2,860,000
OR	35,000
PA	30,000
RI	40,000
VA	15,000
VT	5,755,000
WV	35,000
Grand Total	15,895,000

*All sites use 5,000 kW turbines.

Table C-2. Total Kilowatts per State, CIP Customer Class

kW size	10	50	50	250	250	500	750	1,000	2,000	
State	**Capped**	**Capped**	**Uncapped**	**Capped**	**Un-capped**	**Un-capped**	**Un-capped**	**Uncapped**	**Uncapped**	**Total**
AZ									4,000	4,000
CA	23,550	113,450		276,500				2,000	2,266,000	2,681,500
CO									122,000	122,000
DE	2,460									2,460
CT							1,500		992,000	993,500
GA		1,500		8,750					2,000	12,250
KS			950		1,000	1,000	3,000	9,000	34,000	48,950
MA									26,994,000	26,994,000
ME			50						3,746,000	3,746,050
MN									4,000	4,000
NC	1,220								76,000	77,220
NE			200							200
NH									586,000	586,000
NJ									228,000	228,000
OK					500		750	1,000		2,250
OR									2,000	2,000
PA				3,750					6,000	9,750
RI									636,000	636,000
SD									62,000	62,000
TN		1,500	239,350							240,850
TX							750		88,000	88,750
VA									2,000	2,000
VT									2,766,000	2,766,000
WI			100		250		750			1,100
WV									2,000	2,000
Total	27,230	16,450	254,300	289,000	41,000	75,000	277,500	340,000	100,838,000	102,258,480

Table C-3. Total Kilowatts per State, NREL Turbines

State	Turbine Size (kW) 250	500	Total
AZ		2,500	2,500
CA		1,928,500	1,928,500
CO		206,500	206,500
CT		4,792,500	4,792,500
DE		49,000	49,000
GA		4,000	4,000
IA		7,000	7,000
IL		1,500	1,500
KS	5,500	48,500	54,000
MA		19,275,000	19,275,000
MD	250	14,000	14,250
ME		5,123,500	5,123,500
MI		14,500	14,500
MN		4,500	4,500
NC		1,112,000	1,112,000
NE		1,500	1,500
NH		1,597,500	1,597,500
NJ		514,000	514,000
NM		49,000	49,000
NV		2,000	2,000
NY	146,750	55,913,500	56,060,250
OH		1,000	1,000
OK	2,500	8,500	11,000
OR		218,000	218,000
PA		9,000	9,000
RI		3,572,500	3,572,500
SD		500	500
TN		616,000	616,000
TX		4,742,000	4,742,000
VA		4,000	4,000
VT		2,191,000	2,191,000
WI	250	3,500	3,750
WV		500	500
WY		500	500
Grand Total	155,250	102,028,000	102,183,250

Appendix D. Economically Successful Projects Incorporating Uncapped Incentives

Table D-1. Economically Successful Commercial, Industrial, and Public Facility Projects Incorporating Uncapped Incentives

Retail Rate[1] and Turbine Size[2] (horizontal) State and WPC[3] (vertical)	0.1		0.1 Total	0.15			0.15 Total	0.2						0.2 Total	0.25		0.25 Total	0.3				0.3 Total	0.4						0.4 Total	Grand Total
	50	2K		750	1K	2K		50	250	500	750	1K	2K		50	2K		50	250	750	2K		50	250	500	750	1K	2K		
AZ	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
6	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
CA	--	8	8	--	2	1,125	1,127	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,135
3	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
4	--	1	1	--	1	68	69	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	70
5	--	7	7	--	--	607	607	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	614
6	--	--	--	--	--	406	406	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	406
7	--	--	--	--	--	44	44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	44
CO	--	60	60	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	61
4	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
5	--	13	13	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14
6	--	43	43	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	43
7	--	3	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
CT	--	1	1	--	--	482	482	--	--	--	2	--	3	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	488
2	--	--	--	--	--	4	4	--	--	--	2	--	3	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9
3	--	1	1	--	--	478	478	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	479
GA	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
4	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
KS	--	--	--	--	--	5	5	4	--	--	2	5	10	21	4	--	4	1	--	--	--	1	10	4	2	2	4	2	24	55
3	--	--	--	--	--	--	--	1	--	--	--	4	3	8	--	--	--	1	--	--	--	1	8	3	2	2	4	1	20	29
4	--	--	--	--	--	5	5	3	--	--	2	1	7	13	4	--	4	--	--	--	--	--	2	1	--	--	--	1	4	26
MA	--	725	725	--	--	12,754	12,754	--	--	--	--	--	18	18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13,497
2	--	--	--	--	--	110	110	--	--	--	--	--	9	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	119
3	--	312	312	--	--	9,770	9,770	--	--	--	--	--	8	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10,090
4	--	376	376	--	--	2,373	2,373	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,749
5	--	36	36	--	--	352	352	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	388
6	--	1	1	--	--	149	149	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	150
7	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
ME	--	1,029	1,029	--	--	764	764	--	--	--	--	--	--	--	--	56	56	1	--	--	18	19	--	--	--	--	--	6	6	1,874
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--	1
3	--	824	824	--	--	145	145	--	--	--	--	--	--	--	--	42	42	--	--	--	15	15	--	--	--	--	--	--	--	1,026
4	--	205	205	--	--	619	619	--	--	--	--	--	--	--	--	14	14	--	--	--	3	3	--	--	--	--	--	6	6	847
MN	--	--	--	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
4	--	--	--	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
NC	--	38	38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	38
4	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
5	--	29	29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29
6	--	7	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7
7	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
NE	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--	--	--	--	--	4	4
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--	--	--	--	--	4	4
NH	--	112	112	--	--	181	181	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	293
2	--	--	--	--	--	17	17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17
3	--	66	66	--	--	109	109	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	175
4	--	21	21	--	--	22	22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	43
5	--	13	13	--	--	10	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23
6	--	9	9	--	--	9	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	18
7	--	3	3	--	--	14	14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17
NJ	--	--	--	--	--	114	114	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	114
3	--	--	--	--	--	31	31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31
4	--	--	--	--	--	83	83	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	83
NM	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
6	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
NY	--	1,194	1,194	--	--	17,610	17,610	273	157	148	361	328	12,305	13,572	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32,376
2	--	--	--	--	--	--	--	--	--	79	205	167	752	1,203	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,203
3	--	--	--	--	--	65	65	273	157	69	156	161	455	1,271	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,336
4	--	1,124	1,124	--	--	11,329	11,329	--	--	--	--	--	11,098	11,098	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23,551
5	--	70	70	--	--	6,215	6,215	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,285
6	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1

Retail Rate[1] and Turbine Size[2] (horizontal) State and WPC[3] (vertical)	0.1		0.1 Total	0.15			0.15 Total	0.2						0.2 Total	0.25		0.25 Total	0.3				0.3 Total	0.4						0.4 Total	Grand Total
	50	2K		750	1K	2K		50	250	500	750	1K	2K		50	2K		50	250	750	2K		50	250	500	750	1K	2K		
OK	--	--	--	--	--	--	--	--	2	--	1	1	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4
3	--	--	--	--	--	--	--	--	2	--	1	1	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4
OR	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
4	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
PA	--	3	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
5	--	3	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
RI	--	--	--	--	--	185	185	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	133	133	318
2	--	--	--	--	--	11	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11
3	--	--	--	--	--	169	169	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	169
4	--	--	--	--	--	3	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	123	123	126
5	--	--	--	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	10	12
SD	--	31	31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31
7	--	31	31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31
TN	4,787	--	4,787	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,787
4	2,880	--	2,880	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,880
5	678	--	678	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	678
6	1,229	--	1,229	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,229
TX	--	38	38	1	--	2	3	--	--	--	--	--	4	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	45
3	--	--	--	1	--	2	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
5	--	38	38	--	--	--	--	--	--	--	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40
6	--	--	--	--	--	--	--	--	--	--	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
VA	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
6	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
VT	--	170	170	--	--	946	946	--	--	--	--	--	267	267	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,383
2	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
3	--	108	108	--	--	381	381	--	--	--	--	--	69	69	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	558
4	--	18	18	--	--	287	287	--	--	--	--	--	63	63	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	368
5	--	25	25	--	--	155	155	--	--	--	--	--	17	17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	197
6	--	13	13	--	--	100	100	--	--	--	--	--	85	85	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	198
7	--	6	6	--	--	22	22	--	--	--	--	--	33	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	61
WI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	1	--	4	--	--	--	--	--	--	--	4
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	1	--	4	--	--	--	--	--	--	--	4
WV	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
6	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
Grand Total	4,787	3,416	8,203	1	2	34,181	34,184	277	159	148	366	334	12,607	13,891	4	56	60	4	1	1	18	24	14	4	2	2	4	141	167	56,529

Table D-1 Notes

1. Retail rate expressed in cents per kilowatt hour (¢/kWh). To condense the presentation, rates are grouped in $0.05 intervals. For example, the column headed by 0.2 represents retail electric rates from $0.16 to $0.20 per kWh.
2. Turbine size is expressed in kilowatts (kW).
3. Wind Power Class (WPC).

Analysis considered turbine sizes 10 kW, 50 kW, 100 kW, 250 kW, 500 kW, 750 kW, 1,000 kW, and 2,000 kW.

Table D-2. Economically Successful Commercial, Industrial, and Public Facility Projects Incorporating Capped Incentives

Retail Rate[1] and Turbine Size[2]	0.075			0.075 Total	0.1			0.1 Total	0.125			0.125 Total	0.15			0.15 Total	0.175		0.175 Total	Grand Total
	10	50	250		10	50	250		10	50	250		10	50	250		10	50		
State and WPC[3]																				
CA						3	2	5		76	108	184	2,311	2,170	996	5,477	44	20	64	5,730
2															1	1	41		41	42
3						3	2	5		76	108	184	2,311	2,170	995	5,476	3	20	23	5,688
DE									222			222	24			24				246
2									222			222	24			24				246
GA						30	35	65												65
4						30	35	65												65
NC	25			25	97			97												122
2	24			24	96			96												120
3	1			1	1			1												2
PA			1	1			14	14												15
3			1	1			14	14												15
TN		224		224		990		990												1,214
3		221		221		990		990												1,211
4		3		3																3
Grand Total	25	224	1	250	97	1,023	51	1,171	222	76	108	406	2,335	2,170	996	5,501	44	20	64	7,392

Table D-2 Notes

1. Retail rate expressed in cents per kilowatt hour (¢/kWh). To condense the presentation, rates are grouped in $0.05 intervals. For example, the column headed by 0.2 represents retail electric rates from $0.16 to $0.20 per kWh.
2. Turbine size is expressed in kilowatts (kW).
3. Wind Power Class (WPC).

Analysis considered turbine sizes 10 kW, 50 kW, 100 kW, 250 kW, 500 kW, 750 kW, 1,000 kW, and 2,000 kW.

Table D-3. Economically Successful Community Wind Projects Incorporating Capped and Uncapped Incentives

REC[1] Rate[2]	0.004	0.0057	0.00715	0.015	0.042	0.045	
Wholesale Power Pool[3] and WPC[4]							**Grand Total**
CA-ISO			302				302
6			240				240
7			62				62
ECAR		7					7
7		7					7
MAAC	6						6
6	6						6
NEPOOL		2			1,939	123	2,064
2					4		4
3					254		254
4					557	81	638
5					356	22	378
6		2			352	13	367
7					416	7	423
NWPP			7				7
7			7				7
NYISO				572			572
5				568			568
6				2			2
7				2			2
RMPA			208				208
6			171				171
7			37				37
SERC		13					13
6		5					5
7		8					8
Grand Total	6	22	517	572	1,939	123	3,179

Table D-3 Notes

1. Renewable Energy Credit (REC).
2. REC rate expressed in cents per kilowatt hour (¢/kWh).
3. Wholesale abbreviations are:
    - CA ISO—California Independent Systems Operator;
    - ECAR—East Central Area Reliability Council;
    - ERCOT—Electric Reliability Council of Texas;
    - MAAC—Mid-Atlantic Area Council;
    - NEPOOL—New England Power Pool;
    - NWPP—Northwest Power Pool;
    - NYISO—New York Independent System Operator;
    - RMPA—Rocky Mountain Power Area;
    - SERC—Southeast Reliability Council; and
    - WPC—Wind Power Class.

Analysis considered one turbine package only, 5 x 1,000 kW.

Only 10 winners were added due to capped incentives, therefore both capped and uncapped are included in a single table. Total includes all successful projects over a 10-year horizon.

Table D-4. Economically Successful Projects Incorporating Uncapped Incentives—NREL Turbines in Commercial, Industrial, and Public Facility

Retail Rate[1] and Turbine Size[2]	0.10			0.15				0.20				0.25				0.30			0.40			Grand Total
	500	Both[4]	Total	250	500	Both	Total	250	500	Both	Total	250	500	Both	Total	500	Both	Total	250	Both	Total	
State and WPC[3]																						
AZ	**3**	**2**	**5**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**5**
4	3	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
6	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
CA	**47**	**7**	**54**	–	**2,472**	**1,326**	**3,798**	–	**4**	**1**	**5**	–	–	–	–	–	–	–	–	–	–	**3,857**
2	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	1
3	32	–	32	–	768	25	793	–	3	1	4	–	–	–	–	–	–	–	–	–	–	829
4	14	1	15	–	1,704	244	1,948	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,963
5	1	6	7	–	–	607	607	–	–	–	–	–	–	–	–	–	–	–	–	–	–	614
6	–	–	–	–	–	406	406	–	–	–	–	–	–	–	–	–	–	–	–	–	–	406
7	–	–	–	–	–	44	44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	44
CO	**253**	**60**	**313**	–	**98**	**2**	**100**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**413**
2	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
3	1	–	1	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
4	252	1	253	–	97	–	97	–	–	–	–	–	–	–	–	–	–	–	–	–	–	350
5	–	13	13	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14
6	–	43	43	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	43
7	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
CT	**383**	**55**	**438**	–	**8,205**	**852**	**9,057**	–	**74**	**16**	**90**	–	–	–	–	–	–	–	–	–	–	**9,585**
2	383	54	437	–	8,205	364	8,569	–	74	16	90	–	–	–	–	–	–	–	–	–	–	9,096
3	–	1	1	–	–	488	488	–	–	–	–	–	–	–	–	–	–	–	–	–	–	489
DE	**98**	–	**98**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**98**
3	98	–	98	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	98
GA	**6**	**2**	**8**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**8**
4	6	2	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
IA	**14**	–	**14**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**14**
3	12	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
4	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
IL	–	–	–	–	**3**	–	**3**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3**
3	–	–	–	–	3	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
KS	**6**	–	**6**	–	**19**	**18**	**37**	**4**	–	**45**	**49**	**2**	–	**7**	**9**	–	**1**	**1**	**3**	**14**	**17**	**119**
3	3	–	3	–	3	4	7	1	–	19	20	–	–	–	–	–	1	1	2	12	14	45
4	3	–	3	–	16	14	30	3	–	26	29	2	–	7	9	–	–	–	1	2	3	74
MA	**21**	**724**	**745**	–	**22,069**	**15,095**	**37,164**	–	**568**	**73**	**641**	–	–	–	–	–	–	–	–	–	–	**38,550**
2	18	2	20	–	22,069	2,451	24,520	–	568	64	632	–	–	–	–	–	–	–	–	–	–	25,172
3	3	309	312	–	–	9,770	9,770	–	–	8	8	–	–	–	–	–	–	–	–	–	–	10,090
4	–	376	376	–	–	2,373	2,373	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,749
5	–	36	36	–	–	352	352	–	–	–	–	–	–	–	–	–	–	–	–	–	–	388
6	–	1	1	–	–	149	149	–	–	–	–	–	–	–	–	–	–	–	–	–	–	150
7	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	1
MD	**25**	–	**25**	–	–	–	–	**1**	**2**	**1**	**4**	–	–	–	–	–	–	–	–	–	–	**29**
2	–	–	–	–	–	–	–	1	2	1	4	–	–	–	–	–	–	–	–	–	–	4

Retail Rate[1] and Turbine Size[2]	0.10			0.15				0.20				0.25				0.30			0.40			Grand Total
	500	Both[4]	Total	250	500	Both	Total	250	500	Both	Total	250	500	Both	Total	500	Both	Total	250	Both	Total	
State and WPC[3]																						
3	12	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
4	13	–	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13
ME	**3,195**	**1,215**	**4,410**	–	**4,689**	**1,021**	**5,710**	–	–	–	–	–	**35**	**63**	**98**	**4**	**19**	**23**	–	**6**	**6**	**10,247**
2	3,193	184	3,377	–	4,689	257	4,946	–	–	–	–	–	35	7	42	4	1	5	–	–	–	8,370
3	2	826	828	–	–	145	145	–	–	–	–	–	–	42	42	–	15	15	–	–	–	1,030
4	–	205	205	–	–	619	619	–	–	–	–	–	–	14	14	–	3	3	–	6	6	847
MI	**27**	–	**27**	–	**2**	–	**2**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**29**
2	–	–	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
5	27	–	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	27
MN	**1**	**1**	**2**	–	**1**	**6**	**7**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**9**
2	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
3	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
4	1	1	2	–	–	4	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
NC	**1,976**	**185**	**2,161**	–	**62**	**1**	**63**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2,224**
3	1,976	–	1,976	–	62	1	63	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,039
4	–	148	148	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	148
5	–	29	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	29
6	–	7	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
7	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
NE	–	–	–	–	–	**3**	**3**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3**
4	–	–	–	–	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
NH	**467**	**132**	**599**	–	**2,084**	**512**	**2,596**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3,195**
2	467	20	487	–	2,084	348	2,432	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,919
3	–	66	66	–	–	109	109	–	–	–	–	–	–	–	–	–	–	–	–	–	–	175
4	–	21	21	–	–	22	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	43
5	–	13	13	–	–	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	23
6	–	9	9	–	–	9	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	18
7	–	3	3	–	–	14	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17
NJ	–	–	–	–	**64**	**964**	**1,028**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1,028**
2	–	–	–	–	64	–	64	–	–	–	–	–	–	–	–	–	–	–	–	–	–	64
3	–	–	–	–	–	881	881	–	–	–	–	–	–	–	–	–	–	–	–	–	–	881
4	–	–	–	–	–	83	83	–	–	–	–	–	–	–	–	–	–	–	–	–	–	83
NM	**18**	**2**	**20**	–	**67**	**11**	**78**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**98**
3	–	–	–	–	2	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
4	17	–	17	–	65	–	65	–	–	–	–	–	–	–	–	–	–	–	–	–	–	82
5	1	1	2	–	–	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
6	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
NV	**4**	–	**4**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**4**
4	4	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
NY	**5,017**	**1,186**	**6,203**	–	**32,098**	**20,083**	**52,181**	–	**31,639**	**22,391**	**54,030**	–	–	–	–	–	–	–	–	–	–	**112,414**
2	–	–	–	–	735	–	735	–	738	5,684	6,422	–	–	–	–	–	–	–	–	–	–	7,157
3	4,848	93	4,941	–	31,363	2,538	33,901	–	30,901	5,609	36,510	–	–	–	–	–	–	–	–	–	–	75,352
4	169	1,023	1,192	–	–	11,329	11,329	–	–	11,098	11,098	–	–	–	–	–	–	–	–	–	–	23,619

Retail Rate[1] and Turbine Size[2]	0.10			0.15				0.20				0.25				0.30			0.40			Grand Total
	500	Both[4]	Total	250	500	Both	Total	250	500	Both	Total	250	500	Both	Total	500	Both	Total	250	Both	Total	
State and WPC[3]																						
5	–	70	70	–	–	6,215	6,215	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6,285
6	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
OH	–	–	–	–	**1**	**1**	**2**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2**
2	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
4	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
OK	**9**	–	**9**	**2**	**2**	**4**	**8**	**2**	–	**8**	**10**	–	–	–	–	–	–	–	–	–	–	**27**
3	1	–	1	2	1	4	7	2	–	8	10	–	–	–	–	–	–	–	–	–	–	18
4	8	–	8	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
OR	**336**	**100**	**436**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**436**
2	3	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
3	33	21	54	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	54
4	300	12	312	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	312
5	–	67	67	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	67
PA	**15**	**3**	**18**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**18**
4	15	–	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15
5	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
RI	**1**	–	**1**	–	**6,078**	**933**	**7,011**	–	–	–	–	–	–	–	–	–	–	–	–	**133**	**133**	**7,145**
2	1	–	1	–	6,078	759	6,837	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6,838
3	–	–	–	–	–	169	169	–	–	–	–	–	–	–	–	–	–	–	–	–	–	169
4	–	–	–	–	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	123	123	126
5	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	10	10	12
SD	–	–	–	–	–	**1**	**1**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
3	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
TN	**1,232**	–	**1,232**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1,232**
6	1,232	–	1,232	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1,232
TX	**8,576**	**29**	**8,605**	–	**824**	**43**	**867**	–	**8**	**4**	**12**	–	–	–	–	–	–	–	–	–	–	**9,484**
2	–	–	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
3	2	–	2	–	34	35	69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71
4	7,977	5	7,982	–	786	8	794	–	3	–	3	–	–	–	–	–	–	–	–	–	–	8,779
5	597	24	621	–	2	–	2	–	5	2	7	–	–	–	–	–	–	–	–	–	–	630
6	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	2
VA	**7**	–	**7**	–	**1**	–	**1**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**8**
6	7	–	7	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
VT	**738**	**203**	**941**	–	**2,053**	**1,073**	**3,126**	–	**45**	**270**	**315**	–	–	–	–	–	–	–	–	–	–	**4,382**
2	735	35	770	–	2,053	128	2,181	–	45	3	48	–	–	–	–	–	–	–	–	–	–	2,999
3	3	106	109	–	–	381	381	–	–	69	69	–	–	–	–	–	–	–	–	–	–	559
4	–	18	18	–	–	287	287	–	–	63	63	–	–	–	–	–	–	–	–	–	–	368
5	–	25	25	–	–	155	155	–	–	17	17	–	–	–	–	–	–	–	–	–	–	197
6	–	13	13	–	–	100	100	–	–	85	85	–	–	–	–	–	–	–	–	–	–	198
7	–	6	6	–	–	22	22	–	–	33	33	–	–	–	–	–	–	–	–	–	–	61
WI	–	–	–	–	–	**4**	**4**	–	–	–	–	–	–	–	–	–	**4**	**4**	–	–	–	**8**
2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	4	–	–	–	4
3	–	–	–	–	–	4	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4

Retail Rate[1] and Tur-bine Size[2]	0.10			0.15				0.20				0.25				0.30			0.40			Grand Total
	500	Both[4]	Total	250	500	Both	Total	250	500	Both	Total	250	500	Both	Total	500	Both	Total	250	Both	Total	
State and WPC[3]																						
WV	–	**1**	**1**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
6	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
WY	–	**1**	**1**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
6	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Grand Total	**22,475**	**3,908**	**26,383**	**2**	**80,892**	**41,953**	**122,847**	**7**	**32,340**	**22,809**	**55,156**	**2**	**35**	**70**	**107**	**4**	**24**	**28**	**3**	**153**	**156**	**204,677**

Table D-4 Notes

1. Retail rate expressed in cents per kilowatt hour (¢/kWh). To condense the presentation, rates are grouped in $0.05 intervals. For example, the column headed by 0.20 represents retail electric rates from $0.16 to $0.20 per kWh.
2. Turbine size expressed in kilowatts (kW).
3. Wind Power Class (WPC).
4. “Both” means a site would be successful using both the 250 kW turbine and the 500 kW turbine. If a site is listed as “both” within a certain retail rate, it is not also counted in the corresponding 500 kW or 250 kW column.

Analysis considered NREL turbine sizes 250 kW and 500 kW.

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This report examines the status, restrainers, drivers, and estimated development potential of mid-scale (10 kilowatt to 5000 kilowatt) distributed wind energy projects.

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