STATE OF NEW JERSEY
Board of Public Utilities
www.nj.gov/bpu

Jon S. Corzine
Governor

Kristi Izzo
Board Secretary

NOTICE[1]

The Board's April 27, 2007 Order, Docket Number EO07030203, In the Matter of the Comprehensive Energy Efficiency and Renewable Energy Resource Analysis (CRA) for 2009 – 2012 Clean Energy Program – Order Establishing Procedural Schedule set forth the following schedule for hearings on this proceeding for 2009 – 2012 program funding and funding allocation.

TAKE NOTICE THAT pursuant to N.J.S.A 48:3-60, the New Jersey Board of Public Utilities (Board) has scheduled a public hearing wherein interested parties may present comments for the record concerning proposed funding levels for the Clean Energy Program for the years 2009 through 2012.

The Electric Discount and Energy Competition Act (EDECA or the Act) directed the Board to initiate a proceeding and cause to be undertaken a comprehensive resource analysis (CRA) of energy programs, such proceeding to be commenced within four months of the effective date of the Act and every four years thereafter. After notice, opportunity for public comment and public hearing, and after consultation with the New Jersey Department of Environmental Protection (NJDEP), the Board would determine, within eight months of initiating the proceeding, the appropriate level of funding for energy efficiency and Class I renewable energy programs (now called New Jersey's Clean Energy Program) that provide environmental benefits above and beyond those provided by standard offer or similar programs in effect as of February 9, 1999.

As required by the Act, in 1999 the Board initiated its first comprehensive energy efficiency and renewable energy resource analysis proceeding. At the conclusion of this proceeding, the Board issued its initial comprehensive resource analysis order, dated March 9, 2001, Docket Nos. EX99050347 et al. (hereinafter referred to as the March 9th Order). The March 9th Order set funding levels for the years 2001 through 2003, established the programs to be funded and budgets for those programs and determined that the energy efficiency programs and customer-sited renewable energy programs would initially be administered by the State's utilities and that the grid-connected renewable energy programs would be administered by the Board. By Order dated July 27, 2004, Docket Nos. EX03110945 et al., the Board adopted a final 2004 funding level. The Board approved funding levels as set forth in the Table below:

Year	Total ($ million)	Energy Efficiency ($ million)	% of Total	Renewable Energy ($ million)	% of Total
2001	$115	$86.25	75%	$28.75	25%
2002	$119.326	$89.45	75%	$29.83	25%
2003	$124.126	$93.09	75%	$31.03	25%
2004	$124.126	$93.09	75%	$31.03	25%
Total	$482.578	$361.88	75%	$120.64	25%

[1] Not a Paid Legal Advertisement

By Order dated May 7, 2004, Docket Nos. EX03110946 and EX04040276, the Board initiated its second comprehensive energy efficiency and renewable energy resource analysis proceeding (Comprehensive Resource Analysis or CRA) and established a procedural schedule for the determination of the funding levels, allocations and programs for the years 2005 through 2008. By Order dated December 23, 2004, Docket No. EX04040276, the Board concluded its second CRA proceeding, set funding levels for the years 2005 through 2008, and approved 2005 programs and budgets. The Board approved funding levels as set out in the table below:

Year	Total ($ million)	Energy Efficiency ($ million)	% of Total	Renewable Energy ($ million)	% of Total
2005	$140	$103	74%	$37	26%
2006	$165	$113	68%	$52	32%
2007	$205	$123	60%	$82	40%
2008	$235	$133	56%	$102	44%
Total	$745	$472	63%	$273	37%

As set forth at N.J.S.A. 48:3-60(a)(3), the Board is to determine the funding level and allocation, as well as the programs to be funded, taking into consideration the existing market barriers and environmental benefits with the objective of transforming the markets, capturing lost opportunities, making energy services more affordable for low income customers and eliminating subsidies for programs that can be delivered in the marketplace without customer funding.

Hearings are scheduled for:

April 22, 2008 — Hearing on Funding Levels and Allocation for
Clean Energy Programs for the years 2009-2012
10:00 a.m. to 5:00 p.m.
New Jersey Board of Public Utilities Hearing Room
8th floor
Newark, New Jersey 07102

May 6, 2008 — Hearing on Funding Levels and Allocation for
Clean Energy Programs for the years 2009-2012
10:00 a.m. to 5:00 p.m.
Merit Board Hearing Room
1st floor
44 S. Clinton Street
Trenton, New Jersey 08625

Staff's Straw Proposal is published on the website at www.njcleanenergy.com. Comments on the overall 2009-2012 funding level, allocations and programs to be funded will be accepted until May 6, 2008.

All comments/rebuttals should be submitted in pdf format to OCE@bpu.state.nj.us so they can be posted on the website.

Kristi Izzo
Secretary of the Board

Dated: February 14, 2008

MSEIA
MID-ATLANTIC SOLAR ENERGY INDUSTRIES ASSOCIATION

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March 4, 2008

VIA EMAIL—OCE@bpu.state.nj.us

Office of Clean Energy
New Jersey Board of Public Utilities
44 South Clinton Avenue, 7th Fl.
Trenton, NJ 08625

Re: *In the Matter of the Comprehensive Energy Efficiency and Renewable Energy Resource Analysis (CRA) for 2009-2012 Clean Energy Program*

Enclosed please find comments of the MidAtlantic Solar Energy Industries Association (MSEIA) related to the above matter. We understand that the Office of Clean Energy (OCE) is accepting "informal" comments in an effort to inform the process prior to articulating a publishing a revised straw proposal on or about March 24, 2008, and public hearings on April 22 and May 6, 2008.

MSEIA looks forward to participating in the CRA process and to working with the OCE Staff to identify appropriate levels of funding for energy efficiency, renewable and particularly solar energy programs.

Very truly yours,

Susan P. LeGros

cc: Noreen Giblin
Lance Miller
Mike Winka
MSEIA ExCom

The Case for Maintaining the Small Solar Market Segment

Submitted as Comments to Docket No. EO07030203, In the Matter of the Comprehensive Energy Efficiency and Renewable Energy Resource Analysis for 2009 to 2012 Clean Energy Program

Submitted March 4, 2008 (revised)

Background

In 1999, N.J.S.A. 48:3-49 et seq. (EDECA) authorized the New Jersey Board of Public Utilities (NJBPU) to promulgate New Jersey's first renewable energy program, funded by utility bill societal benefit charges. The law did not assess an additional fee for renewable energy development, opting instead to appropriate 25% of the funds set aside for energy efficiency (demand side management). Additionally, EDECA required that the NJBPU re-assess the program after eight years.

The first phase of the renewable energy program was a cash rebate incentive to customers to spur the installation of renewable energy systems and to spur investment in new renewable energy businesses. This program, called the Customer On-site Renewable Energy Program (CORE) was created and administered by the New Jersey Board of Public Utilities Office of Clean Energy. It has been enormously successful, so much so that the incentive has been oversubscribed. The CORE program has been responsible for making New Jersey the second largest market for solar power in the United States.

New Jersey is second only to California in development of the solar energy industry and in the number of photovoltaic systems installed. New Jersey's CORE program has created an entirely new economic sector of renewable energy within five years. Over 120 solar energy businesses and thousands of high-quality jobs exist today in New Jersey's solar industry. Solar energy in the state is still at an early stage (48 MW installed), but it has already proven to be a powerful small business engine. In addition to creating jobs, solar energy has begun to distribute electric generation and enhance energy security, and is responsible for definitive action to reduce global warming greenhouse gases.

In 2007, the NJBPU initiated a transition away from the CORE program and to a solar renewable energy credit program (SREC) based on production of kWh. The SREC program was proposed by the NJBPU as a result of the oversubscription of the CORE program, concerns about increasing the SBC and its effect on rates, and the NJBPU's projections about the cost of meeting NJ's Renewable Portfolio Standard requirements (N.J.A.C. 14:8-2.1).

This transition has disproportionate effect on the small and medium-sized solar energy businesses that were created in response to demand and are now established in New Jersey. The proposed SREC system is much more complex than a direct cash rebate. It is very difficult to finance residential and small commercial projects based on the SREC production credits alone. Small projects, and the small businesses who serve them, have not been able to obtain SREC contracts of sufficient term and value to make projects financeable. Economies of scale and federal incentives further reward large photovoltaic installations only. For example, the federal investment tax credit for commercial photovoltaic installations provides a 30% tax credit as well as accelerated depreciation. Residential solar power systems, by contrast, cannot take a deduction for depreciation, and have a tax credit that is capped at $2,000. For a typical residential system, the federal tax credit is only about 4% to 5% of the cost of the system.

Add to these systemic disincentives the fact that the SREC program created by the NJ CEP will involve a complex commodity trading system that will result in an increased administrative burden, particularly for those who are dealing in smaller quantities of SRECs. In fact, it is likely that small system SRECs will reach system owners at a significantly lower value due to the fact that they generally will reach them through aggregators. The addition of the administrative burden, intermediary, and additional complexity will clearly result in new obstacles and make it increasingly difficult for solar businesses that supply and install small PV systems.

The Role of Small Systems in Recent Years

In the last three years, ≤10 kW PV systems accounted for about 20% to 30% of the overall growth of solar power in New Jersey, but have resulted in the majority of PV installations in the state (NJCEP CORE data). The small system PV market has resulted in the majority of the new solar energy businesses established in the State, and likely account for the majority of solar industry jobs created in New Jersey over the past few years. On location experience by solar installers has shown that more jobs/kilowatt (kW) are created by the installation of small PV systems than by larger ones. In a typical 10 kW installation, 3-4 installers are hired; in a 100 kW system, 8-12 installers; and in a 500 kW system, 15 installers are hired.

These solar businesses and their employees are alarmed about the economic disadvantage facing them when a SREC only incentive system is instituted. It appears they will have to close their businesses permanently and that residential installations and other small installations, e.g. for houses of worship and other non-profits, will not occur in the future. In fact, many solar installation businesses already have closed their doors; resulting in lost jobs & stagnating businesses

If residential PV systems are more expensive than large ones, why should they be supported? Here are a few reasons:

1. Equity among rate classes

The CORE rebate program is supported by the Societal Benefits Charge (SBC), a small charge (<.005 cents) per kilowatt-hour that appears on every New Jersey electric ratepayer's bill. Every New Jersey ratepayer benefits *indirectly* from the renewable energy that is built using these funds. These indirect benefits include moving toward greater domestic and global energy security, a less stressed and therefore more reliable electric grid, lower summertime peak demand (resulting in a lowering of electric prices), and of course, the environmental benefits of producing clean power without greenhouse gas emissions. But ratepayers who use the Clean Energy Program to put solar power systems on their own roofs or properties also benefit by participating *directly* in the economic benefits these systems provide. ***The more widely these direct economic benefits are distributed, the greater the equity that is created.***

The residential sector accounts for 39.5% of total electric power revenues in the State, and 36.4% of kilowatt-hour sales, according to the latest (2006) figures from the U.S. Energy Information Administration. Thus, even at the historic levels at which the CORE program has supported small projects – 20% to 30% - homeowners are contributing much more to the SBC fund than they are getting back out in terms of direct participation. If the CORE program for small systems is cut while large systems are encouraged to grow rapidly, a serious inequity would be created between the rate classes.

2. The residential and small system sector represents voters

Public incentives for renewable energy, and in particular for solar energy, enjoy strong support among the public, as has been shown in numerous national and state public opinion polls. This support cuts across ideological, political, and economic lines. Keeping this public support strong is a key to success in moving our society toward a sustainable energy future and reducing global warming emissions as rapidly as possible.

Homeowners, non-profit organizations, houses of worship, and small commercial building owners who put PV on their roofs are universally very excited about their decision, and about the rebate support they've received from the state. These individuals and organizational leaders become enthusiastic renewable energy ambassadors throughout numerous sectors in New Jersey. Consequently, distributing the benefits of New Jersey's Clean Energy Program to include "the man on the street" reinforces the political and public support for solar energy and its funding.

3. "Green collar" jobs and new clean tech businesses create economic growth

The small PV project sector resulted in the creation of over 100 new, small businesses in the state, and many hundreds of high-quality green collar jobs. Small PV projects are almost always completed by small businesses headquartered within the state of New Jersey, and they are labor-intensive. If a total of 50 MW of additional CORE rebates from small PV systems were to continue from FY 2009 -2012, this would result in approximately 2,000 additional solar installation positions paying high-quality trade wages.

The solar share of New Jersey's Renewable Portfolio Standard is expected to generate approximately $10 billion in direct, new economic activity (total construction) over the next 12 years, with additional indirect economic activity resulting. It is vitally important that an investment of this magnitude be as efficient as possible in creating jobs, new businesses, and economic growth.

4. Small systems maximize the benefits of distributed generation

The benefits of distributed electric generation have been well-studied and are a goal of both the NJ BPU and the NJ DEP. Solar energy is a distributed technology, lending itself to small systems spread throughout the electric grid infrastructure. Installed as they are on the downstream end of the transmission and distribution system, PV systems take pressure off of this infrastructure and can relieve over-stressed lines in congested areas.

Low voltage is a common problem in suburban and semi-rural areas of New Jersey. As they become more widespread, small distributed PV systems can help lower the throughput of the distribution system in these areas, and thus help support power quality for the grid.

Smaller solar power systems are inherently more widely distributed than larger systems, and consequently result in improved energy security A healthy mix of small systems in New Jersey's build-out of solar power will help to maximize the benefits of distributed generation and energy security, and must be seriously considered in order for the state to meet these goals.

Proposal to Preserve the Small PV Market Segment

1. MSEIA's proposal for CORE rebate budgets during the 2009 to 2012 period constitutes a substantial <u>reduction</u> in the small PV market segment as a percentage of the total PV market (although in terms of absolute volume it allows for a modest increase). MSEIA's proposal for a cut in the percentage of the PV market occupied by the small project segment is, however, much less severe than the cuts proposed in the OCE Staff straw proposal. In the MSEIA proposal, the share of the PV market occupied by systems under 10 kilowatts would be reduced from 22% (2007) to <u>14%</u> of the total market in 2009 and thereafter. The OCE Staff proposal, on the other hand, would reduce the small system share to about half MSEIA's proposal; that is, the less than 10 KW segment can be expected to be reduced from 22% (2007) to about <u>7%</u> in 2009.

2. MSEIA's proposed budgets assume that the current federal tax environment remains unchanged; that is, residential systems receive a 30% federal investment tax credit with a $2,000 cap.

3. The total for small projects under 40 KW should constitute 20% of the RPS goals during the years 2009 to 2012. Since CORE budgets often carry over from year to year, or support projects that are built in a subsequent year, and since SRECs will have a two-

year trading life, MSEIA has based its proposed budget for small systems on 20% of a levelized total PV market of 63 MW per year, or 12.6 MW per year.

4. The 12.6 MW for small systems should be divided into 9.0 MW for systems under 10 KW and 3.6 MW for systems between 10 KW and 40 KW.

5. The proposed rebate levels, after discounts resulting from an Expected Performance-Based Rebate formula, begin in 2009 at an average of $2.65 per watt for systems under 10 KW, and a tiered rebate equal to an average blended rebate of $2.00 per watt for systems between 10 KW and 40 KW. Rebate levels would then ramp down to $2.00 per watt for systems under 10 KW and $1.00 per watt for systems between 10 KW and 40 KW.

6. Different and lower rebate levels should be established for small commercial projects able to take advantage of the current federal investment tax credits and accelerated depreciation. The average rebate levels in Table 1 reflect this assumption.

7. The proposed budget assumes that the current federal tax environment remains unchanged; that is, residential systems receive a 30% federal investment tax credit with a $2,000 cap. If the federal tax environment improves for residential PV systems, MSEIA proposes that the CORE rebate budget be reduced appropriately, based on reduced rebate levels. The rebate levels and resulting budget should be designed based on the particulars of any such new federal tax credit, to preserve a vibrant small systems market. An example of how the CORE rebate budget might be reduced in response to a federal residential tax credit is shown in Table 2.

TABLE 1 – Proposed CORE Rebate Budget, 2009-2012

Year	2009	2010	2011	2012	Total
Systems <10KW	9.0 MW	9.0 MW	9.0 MW	9.0 MW	36.0 MW
Systems 10 to 40 KW	3.6 MW	3.6 MW	3.6 MW	3.6 MW	14.4 MW
Rebate, <10 KW	$2.75/watt	$2.50/watt	$2.25/watt	$2.00/watt	
Blended ave. rebate, 10 to 40 KW	$2.00/watt	$1.75/watt	$1.25/watt	$1.00/watt	
CORE rebate budget, $MM	32.0	28.8	24.8	21.6	107.1

TABLE 2 – Revised CORE Rebate Budget if Federal Residential Tax Credit Is Increased (example)

Year	2009	2010	2011	2012	Total
Systems <10KW	9.0 MW	9.0 MW	9.0 MW	9.0 MW	36.0 MW
Systems 10 to 40 KW	3.6 MW	3.6 MW	3.6 MW	3.6 MW	14.4 MW
Rebate, <10 KW	$2.00/watt	$1.75/watt	$1.5/watt	$1.25/watt	
Blended ave. rebate, 10 to 40 KW	$1.00/watt	$0.85/watt	$0.70/watt	$0.55/watt	
CORE rebate budget, $MM	21.6	18.8	16.0	13.2	69.7

8. MSEIA proposes that the OCE begin accepting applications for the 2009 rebate program in August, 2008 for projects to be installed and requesting rebates starting January 1, 2009. This will be of great help in ensuring the continuity of the many

businesses that depend on the small project market segment. Assuming that such applications are approved by the beginning of September, those projects will have four months to permit projects, order PV modules, deliver product, and install the systems by January 1.

9. The rebate program should continue support for low-income PV projects through the HMFA SUNLIT program. The above budget figures assume that the the set-aside for the SUNLIT program is included.

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February 27, 2008

Michael Winka Director
NJBPU- Office of Clean Energy
609 777 3335; 609 777 3330 (fax)
Michael.Winka@bpu.state.nj.us

Re: Staff Straw Proposal for the NJCEP 2009 through 2012 funding levels

Dear Mr. Winka,

Please find this letter as response to the above referenced Staff Straw Proposal. Our firm is a leader in the design of public and private facilities, promoting sustainable design in every project. We have had great success to date in educating our Public School clients and promoting NJCEP's programs such as the CORE Rebate program. Our clients are beginning to understand that educating today's staff and students about the benefits of sustainable design will reap great rewards in the future. In addition, the enormous positive benefit of saving energy and thus reducing monies appropriated for utility costs is undeniable.

Our educational efforts have translated into over 6.3 megawatts or $42 million dollars in construction of proposed solar renewable energy at school buildings throughout more than 20 of our Districts. School buildings have the added benefit of large roof areas for PV arrays and less restrictive zoning approval processes for construction on their properties, perhaps a prime opportunity for Small Wind energy production in addition.

However, our clients are reading about the uncertain future of the CORE program as well as the instability of the SREC trading market. School Districts have difficulty including the upfront capital costs in school budgets that are already severely limited by various State requirements and an annual growth cap. Equipment costs have not fallen as was earlier expected, making financing such a project a costlier and longer-term proposition. In reaction, Districts have sought long-term financing approval via public referenda and NJ Department of Education debt service aid, which ultimately has an impact through a different channel: homeowner property taxes in lieu of ratepayer utility cost increases.

While it is understood that the current rebate structure cannot maintain the necessary growth to achieve the future EMP goals, consideration should be given to the above discussion regarding schools as a building type where we think the rebates have made a great impact and are largely the tipping point for a Public School Board deciding to go forward with a referendum and public approval of long term debt to fund the balance of the project.

Therefore, we suggest the initial first cost incentive for public entities such as schools remain a part of the CORE program. Clearly, installing PV on public buildings, especially our public schools, has the most wide spread reach in terms of tax reduction, education, and community involvement of any project type. As our school buildings become used more and more by the community for adult

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education, recreational programs, and community group meetings, the cost to operate and maintain these facilities rises along with electric rates.

Lastly, we understand the proposed funding level for public schools for 2008 to range between $16 and $20 million based on historical trends of K-12 rebates. However, the proposed funding level for public schools in the 2009 to 2012 funding cycle has been removed entirely from the budget, with the exception of the SREC program of course, which is open to all but market dependent on values of SRECs to deterimine an uncertain payback period. Since the only PV first cost incentive funding available would be for small systems, defined as 20 kW or smaller in the Straw proposal, project progress, market penetration and potential future approvals from school boards may have been effectively eliminated by this approach. Public Schools have just begun to understand the benefits and negotiate the State requirements through the Department of Education, referendum process, and NJCEP requirements to make a significant number of projects happen in 2008, based on the stability of the incentives and SREC value.

This approach of eliminating the first cost incentives for the K-12 market now, at a time when the market has just begun because of these incentives, does not seem to recognize the efforts and diligence required of a school board to solicit and get approval from the public for long term debt to fund large projects such as photovoltaics or wind or the additional significant benefits derived from projects on public buildings. Therefore, we suggest that the same 2008 funding levels allocated for public school projects be included in the funding budget 2009 through 2012 at a minimum, if not increased to accurately reflect the real reach and value of including PV in our public schools. Our children are our future.

Respectfully Submitted on behalf of the Spiezle Architectural Group,

Sincerely,

Jason Kliwinski, AIA, LEEDap
Director of Sustainable Design

AIA-NJ COTE Chair & First Vice President

Cc: Scott Spiezle, CEO; Larry Uher, Principal; Thomas Perrino, Principal; Scott Downie, Principal; Jeanne M. Fox, President NJBPU; Frederick F. Butler, Commissioner NJBPU; Joseph L. Fiordaliso, Commissioner, NJBPU; Christine V. Bator, Commissioner NJBPU; New Jersey Association of School Business Officials

COMMENTS ON STRAW PROPOSAL for the CRA: 2009-2012 funding years

Bruce A. MacLeod
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1. **Maintain or increase the proposed funding for wind as outlined in the Straw Proposal**.

RENEWABLE ENERGY (RE): this is open to all energy consumers, but is restricted by investment cost and environmental impact. The reach of solar is more widespread because of availability both to purchase and install. Projects can be in almost any size or capacity. Less obtrusive, and if installed on a rooftop takes no land mass. Wind energy is a more costly investment and presents greater environmental concerns as well as neighborhood impact. Biomass is limited to commercial or governmental operators.

Current Incentives: rebates, srec(s) & wrec(s), and tax credits

Funded: Societal benefit charge (SBC), State of NJ

The level of funding and incentives should not be decreased during the next CRA period. The solar program appears to have been successful reaching a point where the quantity of rebate applications exceeded the State's ability to process and approve them. This bottleneck delayed the installation of new alternative energy resources. The public opinion is favorable, and it is the program with the most far reaching potential on a property-to-property basis (residential or C&I) for installation. Now is not the time to take incentives away. Rather, the State should be promoting this success story.

Renewable wind energy should be promoted to the C&I and government sector. Government facilities, schools, corporate and industrial centers form the group of largest consumers of energy. Also, this group can initiate investments in wind energy, which in most cases is probably beyond the reach of the residential energy consumer. The government sector can be a willing partner in wind energy. Financing is costly, and will be paid through tax dollars. Municipalities are able to bond capital cost and repay the debt over a number of years. To accelerate the participation of municipal government into wind energy other incentives besides rebates and wrec(s) should be considered such as:

- Adopt statutes to waive down payments on bond ordinances for alternative energy
- Create a fund for "no or low" interest loans
- Provide assistance for professional technology services
- Make the permitting process less strenuous

- No permit fees as an incentive
- Create opportunities to incorporate education and monitoring of wind turbines on school properties

Getting alternative energy resources installed and operating is the only win-win. An allocation of 25 million for wind energy per year is not enough. A single wind turbine depending on size will cost between $700,000.00 and $3,000,000.00. An initial 20% rebate on the less expensive wind turbines would produce 178.5 installed units. At the end of three years that would still be less than one unit per municipality in the State of New Jersey, and does not count any school districts. The opportunity to create alternative energy feeding any public facility is a savings to the taxpayer of the State of New Jersey. In addition, the reduced impact on greenhouse gas should be significant because the new alternative energy will be supplying some of the largest municipal or public buildings (libraries, courts, town halls, schools) and other facilities such as water and sewer plants.

Michael R. Edelstein, Co-Director, Institute for Environmental Studies, Ramapo College of New Jersey.

Here are some thoughts for additions to a well thought-through straw proposal.

The challenge presented in the proposal is how to create a sharper increase in renewable adoptions than can be sustained by incentives and recs. The answer suggested is to bring the price of renewable adoptions lower in the market place.

Without denconstructing this formulation, it should be noted that a drop in price requires that manufacturers provide PV and other renewable components at lower rates than currently found. If New Jersey were to purchase components at batch prices or assist renewable businesses to buy as coops in bulk, substantial savings might be found. Furthermore, New Jersey might also provide funding or tax incentives for renewable component manufacture in the state in exchange for in-state special pricing and priorities.

The market also has to be enhanced in order to facilitate drops in the cost of design and installation by firms that set rates that offset current inefficiencies. If a firm is not certain that its rate of business can be sustained at a given level, it may aim lower. Yet, sufficient capacity of skilled service-providers is needed to meet surges in the market.

One way to address this issue is for the state to develop projects for state buildings that will allow the state to practice what it is preaching, offer a means to drop the costs of components through bulk purchase, and provide a context for service-providers to work during periods when the market is soft. In this way, the state can benefit from the energy and cost-savings benefits in its own operations while supporting the development of a skilled service segment that can attract and support increased consumer demand.

An enhancement in the market is needed, in any case, to achieve the state’s goals. How can the market be enhanced without relying on incentives, recs and reduced costs or by maximizing the effects of these stimuli? What is required is to change the expectations and perception of appropriate models for new construction, building renovation and building-systems replacement. There follows several propositions:

1. Homeowners (and some other building owners) about to make serious investments in their homes are more likely to adopt renewable technologies or other approaches that aid in achieving New Jersey’s greenhouse gas reduction goals if they are educated about the context for making such appropriate decisions (the climate crisis, peak oil, energy independence, changing valuation in homes, the importance of decentralizing the grid, environmental impact issues and payback/lifecycle cost savings).

2. These building owners will be responsive if there is a change in culture and social support that recognizes conservation and renewable activities as intelligent steps for the building owner and also as community service. The point is to build up community support and social opinion in favor of these activities. Conspicuous consumption is replaced by green consumption.

3. Building owners will only act, however, if they are aware of the alternative options, are assured that options are sufficiently tested to not be risky investments, if they have a means of comparison shopping, if they know that installation and service companies are available and have a comparative basis for selecting contractors, and if these decisions can be viewed as mainstream rather than fringe.

4. The ability to see new technologies in use is a major means of reassuring consumers.

Concept for Community Outreach in Renewables and Conservation

Ramapo College is opening its new Sustainability Education Center in September 2008. Facilities such as this, located in distinct geographic regions of New Jersey, can serve to further the current concept in several ways.

1. First, there is the potential to demonstrate and show concepts to community visitors drawn by special events or advertised demonstration opportunities.
2. Second, there is the potential to educate the public about the context for making decisions that bear on adoption of renewables and other green choices.
3. Third, there is the potential to network regional service companies to make sure that a sufficient mass of service options is recognizable, to help form cooperatives for buying components, and to create opportunities to reach the public.
4. Fourth, the learning environment can be utilized for training, certificate courses, attracting students to fill niches that are understaffed, etc.
5. Fifth, these centers can serve to help coordinate the involvement of regional contractors in state building renewable and conservation projects.

As part of its current project funded by BPU with DOE monies, Ramapo College offered a conference and expo, Green Meets Green, in November/December 2007 that demonstrated the potential for such events to attract wide segments of the audience. We estimate that some 1,500 people participated in this event in some form. A full day conference provided multiple audiences with the opportunity to communicate and to hear leading experts. A two-day EXPO attracted a good representation of the green business community, including providers of renewable and conservation services. It also attracted a steady stream of public visitors who toured the EXPO. An event called KIDSPO was created for children in order to attract families. And a LEED training workshop coincided with the program. By all accounts, the event was successful, particularly for a new offering. Repeated, it has the potential to become a regional means for disseminating innovations and information to consumers. If integrated into future offerings, such events are a means to collect information, as well and to network key constituencies.

In sum, the Straw Proposal offered by BPU for 2009-2012 needs to account for a substantial growth in green consumerism that extends beyond the available incentives and is not narrowly cost-driven. We need to have means for growing the consumer audience as green consumers and showcasing the services that they need. And we have to have a mechanism for recognizing and addressing mismatches between consumer demand and the ability to satisfy it.

NJNG comments on capturing "whole community" gains

As mentioned at last week's meeting, it is important to try to capture the gains that are being made under the "whole community" approach. Not all conservation and energy efficiency improvements made by the homeowner as a result of outreach by the state, the utilities or at general community would be captured under the current system. Obviously, it would capture savings for homeowners as a direct participants in some programs but it would not capture many others. Examples include customers who take the Home Energy Analyzer and implement the recommendations on their own, customers who may have the HPES audit done but choose to implement the recommendations on their own, customers who install or make better use of existing programmable thermostats, etc. These types of improvements are extremely hard to quantify but are still important to try to analyze because as public awareness and actions regarding climate change continue to grow, they could account for a significant portion of NJ's efforts to achieve the EMP goals. Due to the difficulty in measuring, we would suggest that an annual process to collect anticipated normalized usage at the residential customer level be reported to the BPU and evaluated to see if there are sustained improvements that reflect activity above and beyond the savings captured by NJCEP. For the straw proposal, there obviously isn't anything to quantify at this point but referencing the intention to track and potentially capture such progress might be a good addition to the straw proposal.

Average pricing/usage level feedback from all gas utilities

The residential gas heating and pricing data used to estimate the impact (page 14 of the straw proposal) did not look accurate. Each of the gas utilities provided updated normalized data for the average residential heating customer and current prices. We collectively show a significantly higher average usage and a lower average unit cost. This is based on a straight-line average on utility data. If you want a more precise calculation, we can revise the calculation to reflect a weighted average based upon customer count. The weighted average would show an even higher average usage level due to the number of natural gas customers served by PSE&G.

Refine OCE assumptions for Straw Proposal

Gas

	therms	**$/therm**	**cust charge**	**Total Annual bill**
Current OCE 2009 assumptions	912	$1.7980		
Etown	1,034	$1.3894	$7.55	$1,527.24
NJNG	1,069	$1.4416	$6.60	$1,620.27
PSE&G	1,210	$1.3748	$5.84	$1,733.54
SJG	914	$1.4572	$7.75	$1,424.88
Avg	**1,057**	**$1.4157**	**$6.94**	**$1,576.48**

Comments on Straw Proposal by Michael Mercurio

To all,

- The definition of Community Wind has many different semantics' from region to region and from State to State. The reason for this divergence is because of the divergence in Local or State net metering laws and interconnecting laws. Also Country's, States have different agreements between Utility's laws and their customer's. Some states also leave these laws up to the local utility on policy. The following is a good overall general definition written by Trudy Forsyth from NREL wind technology program under the DOE.

- **"Small-scale" community wind":** Using wind turbines to power large, grid-connected loads such as schools, public lighting, government buildings, and municipal services. Turbines can range in size from very small, several-kW turbines to small clusters of utility-scale multi-megawatt turbines.

- **"Group Net Metering"** is different then "Community" projects and should be address as such. Group Net Metering is where a group of different legal ententes group together to accomplish one common renewable power source. One meter accounts for the group and sub-meters that follow. Just as some Town Associations enjoy a common Street, entrance or driveways on one shared common property.

- **"Small Wind Funding Levels"** should have a larger share of the budget then other renewable systems because of policies in this area are just starting to be changed and address. This industry is in the pioneering stage of development in the State of New Jersey while other forms of renewable energy have not had so much controversy. Plus most of the Wind development in this area will be in the area local Government, schools and Commercial enterprises.

- **Strategy** for obtaining 200 MW of on shore/terrestrial wind should be concentrated on selling Wind generation with the Municipalities, Schools and Municipal owned Utilities where the better wind resource exists behind the meter. Local pilot projects in Towns should be started as a first step. The reason for this is that when it demonstrates success for the town, others such as commercial, industrial and residential will follow in their foot steps. A good example of this is the Ocean Gate Wind Project with the success of causing a stabilizing effect to tax payer's costs in the town. Because of this, other towns have now gotten on the band wagon. This is causing a trickle down effect for wind development in the State. Another example of this trickle down effect has also come from the ACUA project. Mayors that have visited this project have learned that they now can do this on a smaller scale in their towns.

- **On Shore Wind** is any wind project in from the coastline i**nland** including tidal bay areas, not marsh lands. If the tidal bay areas are used in some areas we can exceed the goal of 200 MW's easily. See the NREL 30 Meter wind resource areas.

- **Offshore Wind:** The DEP is now conducting environmental impact studies for offshore wind and has defined offshore wind as, from the coastline out to 20 miles from the coastline of New Jersey. Offshore Wind has the greatest potential in this State with the possibility of exceeding 4,000 megawatts in the next 20 years depending on the Policy that is formed by MMS. It will revile the gas industry and produce desalinization and hydrogen plants. See Attached "Framework for Offshore Wind Development in the USA".

- ***Michael A Mercurio***

Adopting and Adapting Community Wind in New Jersey – Key Facts

1 Widely promoted by European governments and accepted by European public
   - In early 2004, EU had nearly three-quarters of the world's installed wind power capacity
   - Community Wind – roughly 80% of all capacity in Germany, Denmark, Sweden, and the UK

2 Enablers in Europe provide lessons and templates for implementation in the US
   - General EU commitment to efficiency, conservation, and renewable energy
   - Growing EU commitment to energy independence – ahead of public commitment
   - "Feed-in tariffs" – requirements that utilities pay for surplus power – German model
   - Strong awareness and leadership at senior government levels – often ahead of public opinion
   - Broad public acceptance of national, regional (European), and local solutions, in that order
   - More utilities with aggregated metering processes and supporting technologies
   - Relative weakness of coal and oil industry influence on energy policy compared to US
   - National competitiveness strategies
   - Familiar business models
     - Community "co-operatives" – Sweden, UK, Denmark – in fact, partnerships
     - General partnerships – all countries
     - Limited Liability Corporations (LLCs) – Germany
     - Industrial and Provident Society (IPS) model in UK – analogous to a Public Benefit Corporation

3 Constraints in Europe are outweighed by Enablers, provide lessons for New Jersey
   - Replacement of feed-in tariffs by market supports – Danish and Swedish models
   - Lack of urgency in public opinion – energy dependency fears don't loom as large in Europe

4 Minnesota, Iowa, Wisconsin, and Illinois are proving community wind can help supplement and stabilize farmer income, and thereby contribute to the preservation of farming communities and the rural landscapes and values they sustain.
   - Minnesota has best wind resources, sited near rural populations, policy infrastructure to encourage community wind
   - All are tackling policy and technology issues that New Jersey would have to address

5 Large-scale wind farms in densely populated states, e.g. New Jersey
   - require more infrastructure re-engineering to tie into the existing grid
   - requires utility-grade winds – scarce in New Jersey, except perhaps along and off the coast
   - require long-term public awareness and acceptance campaigns
   - require long, complex ownership planning cycles
   - have higher transmission losses than community wind sited at or near points of use

6 Community wind in New Jersey
   - can be based on multiple public, private, and public-private ownership models
   - can tie more easily into the existing grid
   - can use lower-grade winds than are required for large-scale wind farms
   - is less likely to arouse aesthetic and wildlife protection issues
   - costs less to maintain
   - can be sited where large-scale wind cannot
     - Any exposed flat building roof over 30 feet add (for PV), e.g. schools, hospitals, strip malls
     - Any parcel of land that can support a single or multiple community wind system, but not a much larger multiple unit wind farm installation
   - can be combined with solar power in single, integrated installations
   - allows for the cost of the renewable energy system to be divided among a group, so more people are able to utilize renewable energy at a reduced cost

Prepared by Roger Dixon and Robert Benjamin for the NJSWWG meeting 1/30/08

Renewable Energy Aggregated Net Metering in NJ

The purpose of aggregated net metering would be to allow an entity (municipality, school system, farm, etc.) to aggregate all of their electrical meter billing under a master bill and install a renewable energy system to offset up to the total amount of kilowatts used at all meters. Even though the renewable energy production may be more than a particular location can use, that RE production could then be netted out against the overall master bill, allowing for the best physical location for an RE system on any property on which any of those meters are located. This would be beneficial for all parties in the following ways:

- Allows a choice of the best possible physical location owned by that entity for a particular RE system. This will maximize the resource, sun or wind.
- Supports more cost-effective capital planning (government, commercial, and non-profit) on an enterprise-wide basis rather than on an isolated location basis
- For municipal governments facing serious pressures to cut their operating costs, including energy costs, or to raise local taxes, this represents a significant opportunity to reduce monthly energy bills and/or to prevent or temper future tax increases.
- By enabling unused or underutilized parts of existing commercial properties, e.g. open spaces, flat roofs (for PV), etc. to become energy production sites, it increases their value as tax ratables.
- Encourages in-migration of small businesses dependent on reliable, efficient energy supply.
- Reduces dependence of vital services (police, fire, EMS) on conventional bulk power.
- Allows some choice of placement for a RE system, which can help to avoid many of the NIMBY siting issues. A tower is more apt to be less controversial at the municipal landfill, water treatment plant or ball field than in the parking lot of the town hall or fire station.
- Aggregated net metering requires no breakthrough technologies for its adoption by utility companies. Information technologies that have existed for over two decades provide a strong foundation for aggregated net metering.
- Use of an electronic sub-metering system will allow automatic data uploads from each meter to a central source. For a fee, that source will forward the data to each utility in a comprehensive and organized fashion for billing by them. This frees up some existing personnel requirements for those accounts. It could also be sent directly to the utility and with a bit of software manipulation it would integrate right into the utility's existing billing program. The cost for the equipment and monthly service fee would be born by the entity that installs the RE system.
- The most consistent, factually-supported argument that utilities offer against aggregate net metering is that it would require redesign and reengineering of customer accounting systems. Since this would result in more efficient, effective, and adaptable customer accounting processes, utilities would benefit from such a redesign and reengineering effort with or without aggregate net metering as a driver. Some utilities have already undertaken and benefited from these kinds of initiatives.
- Utilities can be paid for use of their franchise and equipment (transmission wires & poles, etc.). This is already in place as a delivery charge on current electric bills. The same calculation of this fee could be used or amended to compute the electric generated at one meter and transferred to offset electric used at another meter.
- Group Net Metering should be encouraged because it can increase rates of participation in renewable energy systems.

Prepared by Roger Dixon and Robert Benjamin for the NJSWWG meeting 1/30/08

Biopower Technical Working Group.
CRA 2009-2012 Straw
Comments

Joe Summer
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Ridge Clean Energy & Fuel, LLC is a NJ based developer of waste to energy projects. Ridge applies a clean, closed loop gasification technology to transform a variety of biomass and other feedstocks into electricity or liquid fuel, typically low sulfur # 2 diesel.

Feedstocks can be wood, manure, Municipal Solid Waste (MSW), sludge, medical waste, tires, and waste coal. The system we use exceeds all EPA air standards and is in use at several locations in southern California. Ridge Clean Energy & Fuel is in the planning stages for 3-5 projects in the Northeast, with two in NJ. Our projects run between $40-$60 million and can be in production in 18 months to 24 months. When we produce electricity, a 15-25 MW plant costs about $.05 per Kwh.

When planning, we have a choice between ouputs, and find that the $.035 wholesale rate offered by the utilities makes electricity production not economical. We can find a large user as a buyer, but that creates client risk. Thus we are currently planning to produce diesel, which is easier to sell and generates profits. If we could sell electricity for closer to retail rates, than we would invest in generating electricity. We need also need help with seed funding during the early planning stages for siting, engineering, permitting, legal, and other up front costs that are incurred before we go to our project finance lenders.

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To bring new generation online this can take years and would need to be strategically placed close to the feedstock source but also at a location in the grid were pricing is high. I think to focus on existing plants already connected to the PJM grid located in high pricing pockets would be more economical for meeting short term goals. Typical testing and permitting for existing generation to burn biodiesel can take up to a year and our plant has already begun the process. Utilizing existing generation would get you MWs sooner so that you can meet your current goals.

Peaking plants such as ours would never run on biodiesel unless the fuel pricing became more competitive with natural gas and the REC pricing higher. However, we can determine the $/MWhr we would need to run in order to make a profit so getting a subsidy for the difference in price between the biodiesel and natural gas might be a solution. Our Bayonne plant is 165 MWs and would only be able to put out about 154 MWs on chicken fat. I am not sure how many hours we will be permitted to run on Biodiesel.

Availability of feedstock is an important factor. Pricing of the biodiesel is not competitive with natural gas. Suppliers need to work on lowering their prices. If the pricing of one biodiesel feedstock becomes more attractive it is not easy to switchover to another biodiesel fuel. This is why we would like to see:

The ruling on the Air Permit Modification should allow for the burning of biodiesel from any feedstock as long as it meets the ASTM Standard D6751. Since biodiesel is not classified as Class 1 we would need to get a Sustainability Determination in order to get RECs. A Sustainability Determination needs to be performed for each different feedstock you use, looking both at the feedstock source and at the emissions data. Therefore, if one fuel becomes more attractive than another because of pricing then we would have to test that fuel and request a new sustainability determination. The testing to get the emissions data can be costly. Currently there is no funding for the testing and RECs can not be rewarded until the sustainability determination has been approved.

RECs should be rewarded for the testing or there should be some subsidy for the R&D. Since testing can be expensive, I would recommend that some funding can go towards Rutgers, Princeton, etc. to test the varies biodiesel feedstocks for emissions data so that testing at each plant does not need to be performed therefore the only information needed to be evaluated for the sustainability determination is the feedstock source.

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PPL Renewable Energy develops renewable energy projects including solar, wind, hydro, biomass and biogas. PPL has landfill gas to energy projects in the size range of 1 to 5MW, with two projects in NJ. There are very few landfills left in NJ for development. PPL has studied wood waste conversion projects in the 3 to 20MW size range and found the costs to be about $3000 to $4000 per kW or about 15 to 20 cents per kWh depending on capital costs, fuel costs and operating costs.

Due to more stringent air permitting requirements, smaller scale landfill gas and wastewater treatment projects need about 10 to 20% buydown on costs. Wood biomass projects can need anywhere from 25 to 50% buydown depending on the factors involved which may include operating costs, fuel costs, permitting requirements and capital costs.

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Biomass encompasses a wide range of generation possibilities each of which presents a different set of opportunities and considerations. This is in contrast to wind projects which, while they may differ in size and specific details, are more uniform in general concept and in fuel characteristics. The same is true with solar.

1) All solar and wind projects need to be built. But whereas some biomass projects need to be designed and built, it is also possible to use existing facilities to produce energy with biomass, perhaps with some minor capital investment. Many (or possibly most) existing generating facilities that are currently burning oil or that are dual fuel (oil and natural gas) can burn biofuel. Using existing facilities has two advantages which go a long way toward meeting the goal of 900 mw of biomass and also toward the mwh goals set for New Jersey.

a) Biopower can be produced with a very short lead time. Permits must be obtained, fuel storage must be prepared, etc., but this can be done in a lot less time than developing a new project.
b) Biopower can be produced in large quantities. Rather than a large number of small projects measured in kw, a few large facilities can provide most of the 900 mw of biomass set as a goal.

Therefore, with the right incentives, biomass generation could provide a large number of mwhs of renewable energy in a very short time.

2) Unlike wind and solar which are intermittent and require a “use or lose” approach, biofuel can be stored. Stored fuel will be used when it is most economically efficient. Why burn fuel for $30/mwh when it can be held and burned for $90/mwh? Therefore, if revenue comes exclusively from the energy markets, projects will most likely choose to bid into the wholesale market at a higher price, thus providing peaking energy rather than base load energy. Increased mwhs would require incentives that would allow biomass generators to bid into the wholesale markets at a lower price and therefore to be dispatched more frequently. It would take a high $ incentive to produce a base load generator.

3) Many biomass burning plants have the unique characteristic among renewable energy generators of being able to choose between competing fuels. If a generator can buy natural gas at a cost that equals $20/mwh, why would they consider burning biofuel at a cost of $120/mwh if the price of a mwh is the same? Biomass generators would require a $ incentive high enough to make biofuel a financially more attractive alternative to natural gas and/or oil.

A REC price in the $20 range would not be enough to incentivize generators to burn biofuel. The higher cost of biofuel and the lower heat value would simply not make biofuel attractive to a generator that has an alternative fuel.

A possible suggestion: a price guarantee that sets a floor that is higher than what a generator could expect from the market alone. For example, rather than a specific amount of money per mwh, guarantee a mwh price, for example $100. If the energy price for a given period (hour) was $70, an addition $30 would come from the subsidy; however, if the energy price was at $120, no subsidy would be required. This would do 2 things: first, it would provide price support for the generator who would then have a financial incentive for using renewable fuel; secondly it would benefit the rate payer, who would pay for renewable energy only when energy prices were low. If the rate payer was already paying a high price for energy, there would be no need for additional payments to be made for renewable energy. Since energy prices are expected to go higher (price of gas and oil, additional carbon costs of RGGI), the subsidy required would be lower. At this higher guaranteed price, a generator would be able to run for more hours than energy price alone would determine.

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More Comprehensive. Unlike solar or wind, the bio-energy business has many more process components that must be integrated, and more marketable by-products that can be sold to various purchasers—not just electricity, but also natural gas, and further processed waste products for additional recycling and reuse. If properly managed and maintained, bio-energy projects can provide many more benefits at a much lower cost than the wind turbine or solar energy conversion business. What's more, most of the income and the income multipliers will stay in NJ instead of going to other nearby states (CT and NY are working on similar incentive packages for renewable energy) or Overseas.

More Feedstock Flexible. As pointed out in the Rutgers Bio-Mass Assessment, NJ has substantial bio-energy resources for the anaerobic digester business, including: dairy waste; agricultural waste; process food waste; processed oil waste; and bio-energy crops, to name only a few. These waste products also have significant waste water issues associated with their current "burial" strategy. These waste streams can provide material amounts of electricity on a wholesale basis, and support a reliable base load electrical service.

Site Specific Opportunities. Developers of bio-energy look for site specific opportunities where (a) feedstock is available on a long term basis in volumes and at prices (including logistics management) that make it economic to fuel a conversion process; (b) specific conversion processes (whether anaerobic digesters to process waste streams into gas or electric, or fuel for boilers or generator sets); (c) capital and operating costs of specific equipment needed to process the feedstock's, (d) stable markets for sale of processes products and long term purchase agreements with buyers in these markets, (e) financing viability, including up front risk capital to support pre-development costs (feasibility, engineering assessment, permitting, legal contract management, etc) as well as sources of construction and long term project financing, (f) a host of other operating and management issues surrounding the operations and potential improvements that can be brought to the projects over time, and (g) government incentives (tax credits or deferrals, rebates, direct grants, etc) that would support the whole process.

Distributed Generation vs. Central Plants. Bio-energy offers the opportunities for planners and developers to consider where distributed energy resources or central plants might be most appropriate. In recent years, developers and small independent power producers (IPP's) have increasingly established multiple distributed generation strategies for all sorts of commercial, industrial and institutional applications. Bio-energy is readily suited for projects that can be as small as 200KW up to multi- MW sites. IPP's probably top out at 20MW or so depending on feedstock availability. Utilities might be looking at larger projects, say up to 200MW, but such plants require feedstock stability over the long term that may be difficult to reach with existing bio-energy feedstock resources.

Better Global Warming Impact. Bio-energy projects capture methane (which is 20 times more destructive in terms of Heat Trapping Gases) as opposed to being environmentally neutral; so they are better contributors to the solution to the global warming problem.

Better Utilization of Process Waste Streams for Additional Recycled Products. The waste streams from bio-energy projects AFTER the extraction of methane--the "digestate"--is still a BTU rich product that can be utilized as a myriad of renewable energy sources for boilers gasifiers steam generators etc. These provide additional products that can be re-cycled and get much closer to utilizing 80 to 90 percent of their available BTU's as opposed to the 20 to 30 percent we get now.

Better Economic Development Opportunities for NJ. They provide another income stream for major NJ Industries and Institutions. For example, were we in five years to be able to capture and utilize waste streams from any University in New Jersey would be a bonanza.

How the OCE Can Help Kick Start a Viable Bio-Energy Market.

Support the Start-Up of Viable Markets for Bio-Energy Products. Any commodity market to be successful has to have a number of buyers and sellers. There has to be market volume to create effective price competition. The issue is really a chicken and egg problem.

(a) Market Development. To develop an efficient market for what, one hopes, will be an efficient market, you need (i) a legal market structure with appropriate regulations so that each product can be fairly identified and it's energy value independently certified, (ii) you need easy access to buyers and sellers via some market for exchange, (iii) prices have to be relatively transparent and transaction costs need to be low, (iv) you need a floor below the commodity product (probably based on BTU value) to encourage the market to develop. All of these will require some form of government support. There are also other commodity markets that have structurally required "market rules" that can be duplicated – PJM ISO is an excellent example.

(b) Development Timing and Off take Product Support. Because building a plant can take up to two years currently, we would need to encourage the building of plants by guaranteeing or underwriting the initial price of the product (on a BTU basis factoring in the environmental profile) in the market for several years. No one wants to build a waste to energy plant unless they have confidence that they can sell their output(s) profitably. However, in order to effectively utilize the renewable energy "pellets", the customer must install a very expensive device(s) to consume our product. They will never undertake that proposition unless they know that there is a reliable, cost efficient consumable.

(c) Price Supports to Stimulate Supply. We need to stimulate the supply of the product so that it is available when demand catches up. With $4 fuel and $1.75 per therm natural gas, the demand for alternatives, particularly green alternatives will spike up. Providing a floor for the sales price of the digestate “pellets” will allow developers to utilize this and other revenue streams to make various development deals bankable. This sort of support is much more effective than providing front end rebates or subsidies in that it provides more bang for the buck. And this is analogous to the direction that NJ is going with the Solar Business – subsidize performance, not initial sizing.

The Need for Incentives. Without an sound economic strategy that can be financed at commercial rates, no project developers will plant a bio-energy tree or build a digester plant unless they are fairly confident that they can sell their off take products at a price that supports the financing investments. No business or consumer or institution will buy a gasifier, engine generator set or solid fuel boiler unless they know that they have a fairly priced reliable product to utilize in their operation.

First Step, Model the Comparative Economics. Because bio-energy projects are so diverse and more complicated than other renewable energy alternatives, any government incentives for specific projects must be based on an economic model that compares and evaluates the particular inputs, outputs, processes, and “pain points” of the desired project. The Bio-Power Working Group therefore recommends that a detailed economic model be built to perform for Bio-Energy projects a type of economic analysis demonstrated by the “well to wheel” models used by the petroleum industry. Bio-energy projects must be viewed from the perspective of the project developer, looking at all the issues from feedstock availability and security, technology conversion processes and capital costs, life cycle operating expenses, associated logistics and material handling, multiple process output products and recycling opportunities, markets available for sale of these products and prices applicable (wholesale, retail, subsidized), and where government incentives can support these markets to encourage developers to take on the risk of undertaking the projects themselves. Armed with such a comparative model, the OCE would be able to more appropriately target the development of specific incentive mechanisms which make it more likely that sufficient bio-energy projects would be undertaken in NJ to meet the 900MW objectives.

Comparison with Wind.
Wind is intermittent. It can't be counted as a base load. It is not reliable when it is needed most in mid summer afternoons. The value of wind as an electrical source goes up exponentially with wind speed. Twice the wind speed four times the energy – three times the wind speed eight times the energy. There are no good areas in NJ (anything above a Class 3) except well Off- Shore.

Off-Shore projects are so big they stand or fall on their own – and it’s the financing rate, not less than 5% of the gross cost rebate. No one has figured out yet how to service wind turbines that are in the Ocean. Do you send the Helicopter whenever they need to be repaired? And not just any helicopter - it has to be able to handle inclement weather and put an electrician / maintenance man (who also happens to be a Navy Seal in a past life) down on a wind swept point in the Ocean. And what happens if the repair takes a long time?

All the good wind turbines have two year product lead times for delivery. The turbines are 300 feet high; some believe they are eye sore blights on the landscape and will be difficult to permit.
If you opted for older, being taken out of service wind turbines, because they are only 100 to 150 feet high and they are available – one is essentially subsidizing 20 year old equipment that would have been scrapped otherwise.

The manufacturers, who also finance a lot of the larger projects, understand the value of the project finance strategy and because supply is constrained they raise their sale's prices to extract most if not all of the free cash flow. By offering rebates to wind turbine projects, you are merely further enriching the rapacious (non New Jersey based) firms.

We appreciate that there is a strong and persuasive lobbying group behind the Wind Turbine Industry, but these same Professionals could provide so much more value to the State of New Jersey if they focused just a small amount of their time on the waste streams that are available to power New Jersey's green energy future.

Re-furbishing of old used wind turbines (to avoid the new permitting problem, seems like a waste of subsidy dollars for old inefficient equipment that otherwise would have been scrapped.

Wind is more land-intensive than other sources. To build a single wind turbine or even two or three or a wind farm is just not going to happen on land in New Jersey. If it does, it will be the financing subsidies not a front end rebate that will cause the installation to be completed - with just the same efficiency and intermittent operation.

Babu Metgud
President
Innovation Technology and Enterprise Development Center
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I am expressing my opinion and am requesting you to add my comments to straw proposal to BPU as follows:

1. Project Fundamentals are a " MUST" for all SUCCESSFUL Power Plants :- For every project, raw material must be assured from the suppliers, the finished product and its take-off must be guaranteed by the customers, and in between the conversion performance must be guaranteed by EPC and O&M contractors.

Unless, these three fundamentals are met, financial closing will never take place. Only these three factors will create full confidence in the minds of equity investors and debt financing bankers. So, in our New Jersey scenario, the weakest component among all the three is a lack of assurance of the available raw material which is bio mass feedstock. Currently available landfill material including wood waste, lumber waste etc, would not give enough material to support 900 MWs. Bio power plants. The remaining two factors – demand for power and technology for power production are available. So, we the citizens must concentrate our focus and attention on enhancement of production of bio mass material in the State of New Jersey.

2. Biomass Feedstock for Production of Bio Power:-
Current Biomass Feedstock consists of some wood waste in the New jersey forest waste in the lumber yards, waste produced by consumers in their yards and landfills. Out of this material a certain portion is used to produce mulch depending upon the market conditions. The balance feedstock remained is very limited. Further, this feedstock is distributed over the entire state proportionate to the population density. In North Jersey, consumer generated Biomass is more and in South Jersey, wood waste is more. To run a biomass power plant, the transportation cost is enormously high. Hence, a new way of producing a biomass which is rich in protein and high in calorific value is a must. Otherwise, the cost of producing power will go up enormously. So, it is very essential that new ways of producing enriched biomass in reliable and sustainable quantities is a must.

3. R & D for Reliable and Sustainable Feedstock Development is a MUST:-
As discussed in the earlier paragraphs, currently available feedstock is not enough to produce 900 MW Bio power. New ways of production of new biomaterials have to be implemented. Fortunately, the science and technological tools are nearing maturity and need to be sharpened a bit and brought to fruition on an expedited basis. So, a rapid deployment of state-of-the-art technologies must be encouraged. In my judgment and opinion, the state must be encouraged to invest about $75 million per year for the next four years, so that new biomass materials are produced in the state. Further, a new R&D must be encouraged in the development of new equipment suitable for bio power such as, Biomass Gasifier, Specialized Burners and Boilers, Fly Ash Arrestors, Carbon Capture devices, etc.

4. Biopower must be a base load power plant:-
Wind and Solar Power can be produced on a small scale and gradually scaled up for utility size. However, their contributions to the total requirement will be very small due to limited availability of sun and wind. Biomass material is bulky, voluminous, and heavy. It can produce a large amount of power in the tune of 100 to 500 or even 900 MW, which also can run around the clock and produce billions of units of power. The bio-power plant cannot be started on and off based on the peaks and valleys of the demand. Further, it must run 24/7. So, it must be a base load plant. Hence, for 900 MW, at a rate of $3.3 Million per MW amounts to $3 Billion. For any banks to finance this huge capital, they do need a guarantee of supply of raw material.

5. Special Seed Capital for Bio Power Projects
The magnitude of the capital requirement is substantially large and to commit this amount of money by any developer would require serious feasibility study. Understanding the risk and the plan to mitigating the risk involves a substantial study. These kind of studies would very easily cost somewhere in the range of $3 to $5 Million per project per study. For technology companies, it is essential that government support must be provided. So, up front investment in the form of a grant by the state government to the developers to conduct the feasibility study, must be provided. So, it is my recommendation that, at least, about $25 Million per year be provided in the budget for the next 4 years.

6. Investment by the State Government
It is my comment and recommendation that the State of New Jersey make an investment of $75 Million/yr for R&D and $25 Million/yr for feasibility studies and the total

combined investment of $100 million/yr for the next four years. This kind commitment and investment by the state government will make the Biopower possible in the state of New Jersey. Further, this kind of initial commitment by the state government will improve power availability at an affordable cost and make environmental quality desirable for many decades to come.

I hope the above comments meet your expectations. Should there be a need for any additional information or supporting documentation, I will be happy to make a presentation to the BPU or and other bodies you may wish. Looking forward to working with you and hearing from you.

Concerned in Camden

To our minds, there is no question. Support for Bio-mass should win out over wind. Wind efforts are separate, individual projects; Bio-mass is an industry that eventually will affect every household and every business in New Jersey.

Wind – you build it and occasionally come by and repair it.

It makes power whenever the wind blows sufficiently (but not too sufficiently) whether its night time, weekends or whenever.

It can’t be counted on during heat waves or electrical emergencies.

It can’t be counted on as a base load.

It tends to not operate when most needed – hot stagnant summer afternoons during system peak demand events.

It can’t be counted on for ancillary power or grid support.

It’s a high priced source of un-reliable supply

Almost all the money for Wind projects is in the Equipment – a one-time shot and it goes overseas to the low cost manufacturing site in the Far East. And the manufacturers merely increase the price of their product to reflect the new rebates – there selling them as fast as they can build them – to places where they have so much more value – where the wind profiles create exponentially more power per wind turbine because of the superior average wind speeds.

There are no downstream economic multipliers. Nobody has to collect the wind, or separate it, or transport it, for refine it into different value added end products. There is no industry except for the occasional repair man.

And Jersey is lousy for wind projects – there are no class 4 sites in New Jersey – landowners hate them – the new ones are 300 feet high for gosh sakes – and with Home Rule good luck getting anything permitted that reduces a tax payers perceived property value.

Bio-Mass does what bio-mass does.

Today bio-mass is mostly thought of negatively—a waste product that must be controlled. The potential for a serious accident – or vagary of nature for example, a series of major rain storms that cause the water table to be fouled

What that same organic waste stream can be, WITH THE RIGHT SHORT TERM SUPPORT FROM THE STATE OF NEW JERSEY can be a series of vibrant local industries with both excellent economic multipliers and positive externalities.

For example, here's one of many "supply chains for bio-mass. Assume we are at a Jersey Dairy Farm – What is currently a waste stream that needs to be managed as it is disposed can become a source of power providing, revenue generating, waste recyclying economic development opportunities.

The animal waste (all 100 pounds plus per day per cow) can be separated into useful products at the farm – the farmer doesn't have to pay to dispose of his waste – he actually now has products that displace bedding and fertilizer that he would have to otherwise purchase.

The processed "animal waste" that no longer smells could be utilized at the farm to create clean energy or transported to a central site where it is converted into pipeline quality natural gas or renewable electricity for the New Jersey Rate Payers.

And then where one of many additional bi-products of the manufacturing process is very cost attractive fuel sources for the home or the office or the factory – let's call them bio-mass pellets.

Unfortunately there are not currently many boilers or burners or generator plants that can combust solid fuel sources. That has to (and will over time) change.

In Northern Europe – 25% of new boilers sold are solid fuel boilers – 25%. Many of those have the dual role of making electricity (by adding a generator) and providing building or process heat. In New Jersey the average family buys a new or upgraded boiler every eight years. The re-build re-purchase decision is made by Industry every ten years.

Imagine an industry where all the revenues, all the "Value Added", all the collection, transportation, manufacturing, growing and harvesting, processing, and final sales accrue to LOCAL SOURCES - built around a product that provides clean renewable energy in an environmentally responsible fashion from what are now Environmental Problems. A vibrant Industry with so much more benefits for the State and Rate Payers.

We strongly suggest that the OCE and State should support all renewable energy initiatives – you have to by Law and it's the right thing to do. Just please allocate more of the People's Money where it will do more good for the New Jersey Community—in bio-mass projects that can help us better utilize our natural resources and develop new economic opportunities for us right here and now.

Michael A. Dimino, P.E.
Executive Director
Western Monmouth Utilities Authority
103 Pension Road
Manalapan, NJ 07726

Below expresses my chief concern for the BPU BioPower program as it relates to the wastewater industry. Please feel free to enter this comment where you see appropriate in the overall regulatory process.

In defining the scope of a project for anaerobic sludge digester BioPower, there are two broad components, the digester itself and the add on power generation equipment (i.e., fuel cell, microturbine, gas driven generator). It has been my understanding that the BPU will only honor the power generation equipment for the purpose of a rebate. Often, upgrading the digesters with better gas mixing equipment and digester cleaning will result in an increase 20% or more digester gas production. Therefore, I am proposing that the digester improvements qualify for the rebate program as well as long as the improvements are made along with the addition of the power generation equipment. By requiring the combination of these efforts the BPU will be assured that they would not be funding plant maintenance costs without the benefit of produced renewable power.

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CRA Biopower Working Group Committee Member Comment:

The most practical, readily available and economical solution to reducing GHG emissions from existing coal-fired boilers is to encourage co-firing of eligible biomass fuels.

As a precursor to aggregation and supply outlined above, a biomass fuel market must be cultivated including initial customer base. Cultivating a customer entails the marriage between a quantifiable biomass supply with a committed purchaser having appropriate conversion technology. The developer of, for example, a stand-alone biomass direct-combustion power generator will not obtain project financing if he cannot contract a dedicated fuel supply (and or power offtake). Given this chicken-egg scenario, biopower program funds would be useful to establishing the connection between would-be biomass supplier and real customer(s).

Since, at present, no real market for biomass fuel exists in New Jersey, it may be necessary for some interim period to encourage cofiring of biomass in the state's existing solid-fuel boilers as a means to short-circuit the "project finance" part of the equation. Cofiring with reliable fossil fuel (consumption of which is occurring anyway) enables economic protection in the event of short-term interruptions of biomass flow in an emerging marketplace.

Given the extremely (relative) low capital cost of cofiring, BPU funding of biopower would get the most return on invested capital. Funds should be made available to solid-fuel boiler operators to offset their front-end costs as a means to persuade these companies to undertake the necessary modifications to begin blending small percentages of biomass. The main advantage is that capital modifications are minor and impacts on combustion and emissions at low percentage blends will be minimial. US DOE biomass program has conducted extensive analysis of various cofiring methods and fuel types therefore providing important technical input to support owner (and regulator) decision-making on fuel selection, ratio, control methods, etc.

The cofiring approach creates many attractive opportunities. First, it encourages operators of coal-fired facilities to blend carbon neutral biomass fuel and thus burn less coal. Cofiring, rather than a development of a “greenfield” biomass fired generator, will create a relatively immediate demand which will stimulate the flow of biomass so that a channelized supply market can emerge.

Far less complicated to simply move material as opposed to modifying an existing power plant equipment (and air permit). Engineering, test firing, and permitting could consume $1M or more for a given project.

Once the power plant owner gets the go-ahead on his permit modification and commences the engineering & procurement of capital upgrades, implementation of the biomass co-op is then initiated. For co-op's capital expenses, land and equipment (tub grinders) are what is needed and quickly set up within matter of months. Material flow cannot begin until the power plant customer is near ready to begin test firing.

The capital cost economics of cofiring will give us the most bang-for-program-buck.

Using the estimated capital cost of cofiring of $200-400 $/kW, if the biopower program allocation of $15M per year is deployed in covering 100% of the capital costs to existing unit operators, this yields a potential of between 50 to 100 MW of biomass power. Highly realistically kWh production can be achieved by fiscal year 2009. Considering roughly 2500 MW of coal fired power boilers either active or inactive in the state, 50-100 MW this equates to 2-4 percent cofiring percentage with proportional, commensurate reduction in SO_2 and CO_2 emissions.

For comparison—and excluding LFG power applications—the next most cost-effective biomass power option would be stand-alone direct combustion ($2250-3260/kW capital cost). However, at this cost, the $15M biopower program funds would only yield 4.8 to 6.6 MW. Moreover, siting, permitting and construction of the project (assuming it is financeable) can realistically be expected to take between 3 to 5 years. Siting and approvals of this type of development will be frought with development risk, thus, the potential risk to the biopower program is that it may take years if ever to realize any biomass derived energy.

***

I would like to recommend that the biopower program earmark between $500k and $1M for 2008 to fund an RFP to solicit projects from each and every owner/operator of a solid fuel boiler in the state (here again, blending woody biomass into a coal boiler is technically feasible at low percentage, with sufficient political will the air permit modification should be straightforward). Selection of winning projects would be announced before year-end 2008 and projects would be eligible for funding beginning in 2009.

I recommend that highest possible percentage of $15M annual program funding be directed toward funding of cofiring projects—defraying permit variance and capital equipment modifications at existing coal-fired boilers that are willing to blend biomass feedstock and coal. 2 to 4 percent biomass cofiring in the state’s coal fired boilers can result in 50-100 MW of capacity and reliable biomass energy reaching the grid within a timeframe of 6 to 18 months. If the biopower program funds the capital costs to incentivize owners, and assuming cofiring is approved as Class-I renewable energy, then revenue from REC's will enable boiler operators to justify the technical and operational risks of the new fuel mix.

Cofiring a small fraction of total Btu input will result no significant risk to an existing operation but will begin the flow of biomass as fuel. Once the flow of material starts, then stand-alone development can gain confidence in a visible supply system. Fuel supply reliability for biomass plants has plagued this sector since it first began. Wood-fired plants in the forests in the northwest often run out of feedstock. Pulp and paper manufacture is also a delicate, often cyclical source.

Alternatively, if biopower program monies are only targeted toward stand-alone biopower projects, then BPU will be taking a bet on viability of one or more development projects, together with associated development risks and perils and ascribed probability of a successful conclusion.

After-the-fact award of matching funds may not be a sufficiently attractive inducement to owners of existing units. It may be necessary to contribute funds during the development stage as means to share the very real risks during this stage of any modification project (including probability of money at risk if development is unsuccessful for reasons beyond the developer's ability to control or manage). If contributing toward development expenses, some level of built-in loss is to be expected, diminishing return for program dollars. Thus, alignment of ratepayer and developer risks and rewards must be carefully balanced.

Accordingly, coal-biomass cofiring is perhaps the lowest risk profile given the environmental up-side of diminished coal consumption and reduced emissions of pollutants like SO_2, avoidance of fuel supply risk (compared to biomass only), minimal capital costs, and minimal incremental operational cost and risk to an existing operational facility.

Comments on Straw Proposal Years 2009-2012

Wind energy has a much more difficult path to acceptance and completion of a project than most forms of renewable energy. Correct siting is probably the most important factor, followed by financial incentives to offset the up-front costs. Lack of local municipal zoning regulations that are wind electric friendly are a huge detriment to the process. After a few years of funding being in place, we are now just starting to see some interest and movement. The time line for approval and installation is also an elongated process as compared to other RE programs, due to those same zoning and variance hearing processes.

Siting plays a critical part in the overall cost of the installation. The coastline has the best wind resource, but also has sandy soil, which requires a large footing. The northern ridge top areas have 100’ trees, necessitating taller towers than usual. Taller towers are not stock items and must be custom made. This increases the installation cost. Taller towers also require larger footings and bigger structural components, due to the moment, or force, that tries to uproot the tower. The taller the tower, the more force acting against it.

Municipalities are a prime candidate for wind electric. They have enough electrical load to use units from 50kW up to 2MW and more, if current regulations are altered to allow aggregated net metering and also community wind (see attachments). Both of these alterations to the current regulations are critical to drive the municipal and commercial business wind electric markets in NJ. I am currently aware of five municipalities that would be swayed to a more proactive stance if both of these concepts were adopted. One is looking at a 2MW installation to share with neighboring townships and perhaps a Coast Guard Station. The others would benefit from aggregated net metering. Municipalities are anxious to benefit from reduced electrical costs, which can at least help to stabilize local tax rates, if not reduce them.

Schools would be other ideal candidates for wind electric. I cannot think of a better example than to have wind electric installations at schools. The students will see them every day, remote digital informational bulletin boards could be installed in the cafeteria or science classrooms where real time data, such as wind speed and power production, can be monitored. Schools are large users of electric and the reduction in electricity costs would be welcomed by any school board that has concerns regarding their budget. Municipalities and schools will be the drivers on the local level for residential wind as well. It will naturally follow as a trickle down effect, once the example is set allowing for easier zoning, permitting and installation processes to be adopted. The US DOE (Department of Energy) in conjunction with NREL (National Renewable Energy Laboratory) has developed a model program called Wind for Schools as a part of their Wind Powering America program (see two attached files.) More information can be found at http://www.eere.energy.gov/windandhydro/windpoweringamerica/schools.asp.

I am also working with a consortium of seafood distributors that own large businesses and contiguous properties who would be more proactive if a Community Wind Model, eligible for state grant money, was allowed in NJ. I am sure they are not the only businessmen in NJ that have an interest in wind electric who are faced with similar circumstances.

All of the examples cited above are also contending with the current 2MW limit on grid connected net metering. This level, although on the large end of the United States net metering scale, needs to be increased to allow for larger community wind installations to be net metered and qualify for funding money.

In looking at the NREL 30 meter map (attached), any area that is not white is a candidate for small wind. The immediate coastline from Bayonne south around Cape May and back up to the Salem Nuclear Plant, as well as some of the ridge top areas in northern and north western NJ have enough wind to support larger installations. This is roughly 40-45% of the state. Out of the 566 municipalities in NJ if we assume 40% of that number (to match our map) we have about 225-250 municipalities. If we presume 40% penetration of that group, we now have 90-100 municipalities that could install wind electric. Assume the size of the installations would run from 50kW to 2MW, with an average of 1MW. There is now 100MW of terrestrially installed wind potential. Additionally, using the same numeric scenario, if school systems, of which there are 616 school districts in NJ, were to install half of that amount, we have now attained 150MW of installed capacity. Add to that the commercial application potential of another 50MW-100MW and we have surpassed the 200MW target outlined in the Navigant Report. This does not consider residential-sized 10-20kW installations. If we assumed only 5000-10,000 installations over the next twelve years, the overall capacity increases a bit more. Although residential installations will never reach a critical mass that will address 200MW of onshore wind, they will add to the overall installed capacity and acceptance of wind electric in NJ.

Essentially, we have three different sectors that would benefit from segmented funding:

- residential and small commercial from 5kW-100kW
- municipalities from 50kW to 2-3MW (with aggregated metering and community wind models)
- larger commercial applications from 500kW to 2-3MW (with aggregated metering and community wind models)

The Navigant Report target for offshore wind is 1000 MW by 2020. There is currently a solicitation for 350 MW being addressed. NJ has a few prime areas offshore that have Class 7 wind speeds and a good area from Manasquan Inlet to Cape May that has Class 6 wind speeds. If the 350MW project proceeds and is completed this will add one third of the offshore capacity addressed in The Navigant Report. In order to achieve this goal, the project needs to move forward. Additional capacity may be added at a later date and other offshore locations can be investigated as well. These projects will not be cheap.

According to AWEA, The American Wind Energy Association, utility scale wind is currently being installed for $1800-$2000 per kW, while small scale wind is being installed for $3000-$5000 per kW. Using the projected numbers noted above, the installation of 200MW of onshore wind will cost between $360,000,000 and $1,000,000,000, depending on how much of the mix is small wind vs. how much is utility scale wind. This does not address the cost of offshore wind. According to AWEA, the installed cost of offshore wind is in the neighborhood of $3500-$4000 per kW. (These numbers were provided by Elizabeth Salerno at AWEA.)

Municipalities need to float bonds to provide the additional funding above and beyond the available grant money. Commercial businesses must go to the bank for loans. Most home owners will need to either borrow through a home equity loan or dip into savings if possible. Each of these scenarios drives up the final cost of the project due to the capital cost of funding.

To reallocate wind electric funding and grant money toward more solar installations will effectively stifle any substantial growth in the wind electric market. To not adequately fund for projected growth of wind electric will lead to large backlogs of projects and subsequent disinterest. If anything, we should be increasing the funding levels as the years go by to keep pace with what could and should be a very rapidly growing facet of the NJ renewable energy program. There is a long educational process and learning curve associated with the installation of wind electric systems. We have yet to see the results of our labor.

Roger Dixon, President
Skylands Renewable Energy, LLC
3 Thads Hill Road
Hampton, NJ 08827

Community Wind

Community wind projects are locally owned by farmers, investors, businesses, schools, utilities, or other public or private entities and they optimize local benefits. The key feature is that local community members have a significant, direct financial stake in the project beyond land lease payments and tax revenue.

Why Community Wind?

Wind energy development is expanding rapidly, creating many opportunities for communities to participate in wind development. Windy acreage, once cursed for losing top soil, is now seen as a potential goldmine. Many farmers and landowners are clamoring to get in on the action. Wind energy offers many financial, environmental, and social benefits to the communities and individuals who choose to get involved with its development.

The concept of community wind is simple and flexible. Projects can be any size – one turbine or one hundred, usually commercial-scale and greater than 100 kW, connected on either side of the meter. Community wind includes both on-site wind turbines used to offset the customer's load and wholesale wind generation sold to an unrelated third party. Community wind projects are in the planning stages in nearly every state with wind development, and the concept is continually being re-defined as new community groups and models for ownership emerge. The key element is local ownership and local benefits.

In the United States, community wind projects are owned by farmers, schools, colleges, tribal governments, municipal utilities, local businesses, and rural electric cooperatives, to name a few. These projects have come together through hard work, local innovation, and public policies that support locally owned projects, local champions, and the need for new economic opportunities in rural America.

The rapid expansion of wind energy can be attributed to improving economics and effective public policies. When wind is developed locally, the economic, social, and environmental advantages accrue to local farmers, landowners, and other members of the community. As a potential community wind developer, it is important that you understand both the benefits and challenges of wind energy so you can explain to others in your community how the project will help keep their power costs down and accurately answer their basic question: "Why wind?"

Revitalizes Rural Economies. Locally-owned and locally controlled wind development can diversify the economy of rural communities, substantially broadening the tax base. Wind turbines provide a new source of property taxes in rural areas that otherwise have a hard time attracting new industry.

Stimulates the Local Economy. Community wind projects have higher multiplier effects and greater local returns in creating new jobs, growing business opportunities, and bringing new investment into the community than outside development, keeping energy dollars local.

Stabilizes Energy Prices. Wind as a fuel for electrical generation has zero cost and does not need to be mined or transported, removing two expensive and fluctuating aspects from long-term energy costs. Fixed-price wind projects can help hedge against fossil fuel price spikes.

Promotes Cost-Effective Generation. The cost of windgenerated electricity has fallen from nearly 40¢/kWh in the early 1980s to 2.5-5¢/kWh today depending on wind speed and project size.

Creates Jobs. Wind energy projects create new short and long term jobs. Related employment ranges from meteorologists and surveyors to structural engineers, assembly workers, lawyers, bankers, and technicians. According a study by the New York State Energy Research and Development Authority, wind energy creates 27% more jobs than a coal plant and 66% more than a natural gas combined-cycle plant per unit of energy generated.

Social Benefits of Community Wind

Promotes Energy Independence and National Security. Local wind generation diversifies our energy portfolio and reduces our dependence on imported fossil fuels. Distributed community wind generation adds reliability to the nations electrical grid by decentralizing generation.

Creates a New Crop. Community wind is a new revenue source for farmers and rural landowners, diversifying their income. It is compatible with agricultural use of the land as wind turbines can be installed amid cropland with minimal affect on people, livestock, or agricultural production.

Promotes Local Ownership. Small clusters of turbines or even single turbines operated by local landowners and small businesses increase local control of energy production, making a significant contribution to the regional energy mix.

Galvanizes Support and Neutralizes Opposition. Increased local benefits broaden support for wind energy, engage rural and economic development interests, and build a larger constituency with a direct stake in the industry's success. Local investment in wind can reduce local opposition to new wind farms and will cultivate local advocates.

Environmental Benefits of Community Wind

Produces Clean Electricity. Widespread community wind development addresses climate change by providing a nonpolluting source of energy that reduces greenhouse gas emissions.

Keeps Water Sources Clean. Turbines produce no particulate emissions that contribute to mercury contamination in our lakes and streams. Wind energy also conserves water resources.

Protects Natural Resources. Harvesting the wind preserves natural resources as there is no need for destructive resource mining or fuel transportation to a processing facility.

Preserves Land. Wind farms are spaced over a large geographic area, but their actual footprint covers only a small portion of land resulting in a minimum impact on crop production or livestock grazing. Wind farms preserve open space, preventing residential sprawl.

Conclusion

Wind energy is rapidly expanding across the U.S., but much more needs to be done so that community wind can reach its full potential. Wind energy offers many significant benefits to the communities that choose to get involved in project development. Developing wind energy can be a complicated process requiring substantial time and effort, but it can also be very rewarding, both financially and on a personal level. Windustry's Toolbox will help guide you through the process of wholesale community wind development and put you on the path toward becoming a community wind farmer!

(Taken from Community Wind Toolbox: Chapter 1, Windustry website, http://www.windustry.com/your-wind-project/community-wind/community-wind-toolbox/chapter-1-introduction/community-wind-toolbo).

U.S. Department of Energy - Energy Efficiency and Renewable Energy

Wind and Hydropower Technologies Program - Wind Powering America

Wind for Schools: Developing a Model for School Wind Energy

Wind Powering America (WPA) is developing a replicable model for schools to use to install a wind turbine that will help defray their energy costs and/or provide education. To begin this process, Wind Powering America and the National Renewable Energy Laboratory (NREL) embarked on a pilot project in its home state of Colorado. This is how the development of the "Wind for Schools" model is progressing:

Key Elements of a Successful Project

Champion

Key elements of a successful project.

A local project champion is needed. A project cannot succeed without a local individual or group who can keep the key players in the community that need to be involved in the project informed, cooperating, and moving toward project goals. This is important because the stages of learning, carrying out agreements for finances, power purchase agreements, permitting, obtaining equipment, construction, and operations and maintenance can be lengthy and time consuming. Issues of local politics, personalities, and public opinion are always involved.

Wind Resource

One of the reasons that WPA/NREL chose Colorado for the pilot project is the excellent wind resource on the eastern plains. In addition, these rural Colorado areas could also benefit from economic development. Therefore, NREL contacted 17 school districts (indicated on the map with stars) that are in or near areas of good wind resources. This enabled NREL to analyze the wind resource at or near the school. NREL also looked at the school utility bills and discussed the economic viability of projects.

Community Support: Different Project Models

NREL staff discussed three basic project models with the communities, and many permutations of the models, depending on local situations and preferences. Each required different wind resource, financial arrangements, and partnerships.

1. Behind the meter — a wind turbine sized to less than the school load, to be used to decrease energy bills.
2. A community-scale turbine
3. Piggybacking — i.e., the school or community develops a financial agreement with a large-scale wind farm nearby.

A Colorado wind map shows the location of the 17 schools that were contacted to participate in the pilot project.

Viewing Options
Larger Jpeg: Click Map
Printable: (PDF 4.9 MB)
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Partners

WPA/NREL offered school districts and their communities the assistance of a team of professionals who understand wind technology and projects.

NREL

NREL assembled the partners to work with the schools and their communities. For interested schools, NREL staff analyzed their wind resource and utility bills to advise them on the practical issues of system performance and potential cost savings. Working with the partners, NREL has put together a "base system" to offer the schools. NREL provides technical assistance on project planning, selecting a site, installing a system, and connecting it to the grid. NREL has also provided training for Colorado science teachers who are ready to include wind in their curricula.

Tom Potter, Consultant
Colorado's Field Advocate for Sustainability. Tom has worked with communities in eastern Colorado, particularly with farm organizations and economic development specialists, to help communities understand renewable energy project options and their impacts.

Southwest Windpower
An international manufacturer of small wind systems. Southwest offers a discounted wind turbine, guyed tower, grid interconnect hardware, and display unit for the "base system."

Community Energy
A national company that develops wind farms and sells renewable energy certificates, commonly known as "Green Tags." For this project, Community Energy is providing much of the cost of the "base system." They market Colorado Rural Green Tags from the Lamar Light & Power wind farm throughout the state and hope to use proceeds from the sale of green tags to support more wind turbines at schools.

Western Resource Advocates (WRA)
A regional conservation law and policy organization that encourages the use of renewable energy and energy efficiency in the Interior West. WRA has worked with utilities throughout the region to develop and implement green power programs, including Xcel Energy's Windsource program. Susan Innis, Green Power Marketing Director, sells Colorado Rural Green Tags to businesses and households on the Front Range and in rural Colorado.

The School and Community
It is very important that the community is a full partner in designing the project and in paying for much of it. All key players such as the school, the local utility, local funding partners, and others need to be included during the life of the project.

Economics
The NREL team discussed financing options with each school district. The school district often has access to low-cost loans for facilities enhancement or improvement. Local and state grant monies may be available. It is not unusual to find private or community donors willing to participate.

A net metering arrangement is necessary for a small wind turbine. This arrangement delineates how a school will be credited on its utility bill for the electricity it generates. For larger turbines, the sale of excess electricity to the local utility through a Power Purchase Agreement (PPA) is critical. The limits, arrangements, and amount the utility will pay for the electricity in both of these cases vary from utility to utility and must be discussed on a case-by-case basis.

Green Tags, or Renewable Energy Certificates, represent the environmental benefits of generating electricity using wind (or other renewable energy) systems. There is a growing market for Green Tags, and they add a revenue stream to the project.

Policy
A variety of policies at the state or local level can impact a school wind policy. These should be reviewed, as they will impact the feasibility and nature of the project.

- Renewable Portfolio Standards
- Buy-down programs or tax benefits
- Net metering policies
- Permitting and zoning
- Environmental policies

WPA/NREL Presented Results to Local Wind Development Committees

For the school districts that chose to participate, WPA/NREL staff presented the results of their analysis to local wind development committees. These are groups of community members that are interested in a school wind application that benefits their community. It is important that all interested parties understand what must occur for a school wind project to succeed and the role that each of them has in the success of the endeavor.

- School board members
- City government
- Local utility
- Economic development interests
- Other interested parties (energy service companies (ESCOs), farmers, agriculture extension agents)

Characteristics of Rural School Wind Energy Projects

During this process, WPA/NREL staff found that rural school wind energy projects have certain characteristics:

- The school is often the largest load in the community
- The community supports the school
- Low-cost grants and loans may be available
- The project generates local interest in wind energy
- Curricula/science projects are a natural parallel focus
- Several application/ownership options exist
- The project focuses the community on its energy future
- Local ownership means local economic development benefits for community projects

Lessons Learned

- School stakeholders like the "Wind for Schools" concept
- There is a long learning curve/education process
- The project represents a substantial change/effort over multiple years; it can't be successful without a champion
- Wind energy development is complex; and there is an appearance of financial risk
- Rural schools are often connected to a renewable energy co-op
    - Low avoided cost
    - Net metering not welcomed

- A demand charge tariff can be a disincentive
- Favorable policies make a big difference
- Public and private grant funding is available
- Organizing a school wind project represents a melting pot of community activity and opinions
- Science teachers are interested in wind curricula

Technical Characteristics of a Sample Small School System

The NREL team will provide the "base system," and the community must provide the trenching, foundation, costs to interconnect with the local utility, and operations and maintenance (O&M) costs. O&M costs for a small wind turbine are low, but annual maintenance should be part of the plan and budget. The community will install the turbine, with assistance from NREL.

Often the community desires a configuration beyond the "base systems" outlined below. Examples of modifications might be: a larger turbine, a free-standing tower (as opposed to the guyed tower), fencing around the system, or a special display unit. NREL will help the community evaluate options, but the costs of such upgrades are the community's responsibility.

The "Base System"

- Southwest Windpower "Whisper 100" (produces 900 W of power at a wind speed of 28 mph, and about 100 kWh per month in a Class 4 wind area).
- 62-foot guyed tower
- Grid-tie connection (hardware)
- Display unit
- Batteries
- Inverter

Other Necessary Components (to Be Provided by the Community)

- Foundation
- Trenching
- Cabling
- Raising the turbine on its tower
- Interconnection agreement with the utility
- O&M fund

Frequently Asked Questions for Pilot Project Participants

Q. Can I change the "base package?"

A. You are free to design a project to meet your needs, and the partners will help you determine the project cost and the energy that will be produced using a particular turbine at a given location. However, the partners cannot provide extra funding to cover the cost of customizations.

Q. Why is the turbine in the "base package" so small?

A. This package is what we were able to negotiate. There are large economies of scale on a wind project, but the up-front capital costs are large and the complexity of finding funds and negotiating an acceptable arrangement with the utility also grow as the project grows. A small turbine will not generate large cost reductions on your energy bills, but it is useful for educational purposes.

Q. How much money can the school save on its electricity bills?

A. That depends on how much electricity the school wind turbine generates and how much the utility will pay for excess electricity generated. This is an agreement between the school and the utility. Under current Colorado practices, the savings will be much more if the school is billed one rate for usage. However, the practice of charging a low usage rate and a higher demand charge is not advantageous for small wind generators because the turbine will seldom drop the peak demand noticeably.

Q. Is financial help available?

A. Yes. Local foundations will usually help provide some grant funding for a school project. There are state grant funds. The school is eligible for some U.S. Department of Agriculture funds. Xcel Energy has a Renewable Energy Trust that provides funding for renewable energy projects. Most schools have access to low-interest loans.

If it is available, the local funding is usually the most straightforward process to pursue. The project definition and application process for the other funding sources can be time consuming.

In addition, it may be advantageous for a foundation or some other legal entity to own the turbine at first to gain access to some types of funding.

Q. Are there legal issues?

A. Yes. There may be issues of permitting and zoning. The agreement with the utility is a legal contract. And there is a debate as to whether a wind turbine can be owned by a school to sell electricity. There is no debate as to whether the turbine can be purchased for educational purposes.

Q. What if there is no good site on school grounds for a wind turbine (poor wind resource or too close to people)?

A. If you still want to pursue a school wind project, look for windy land nearby and negotiate with the landowners to put the machine on their land. Consider some form of joint ownership. And you must negotiate with the utility to "wheel" the electricity to the school or to buy it and credit the benefit to the school's energy bill.

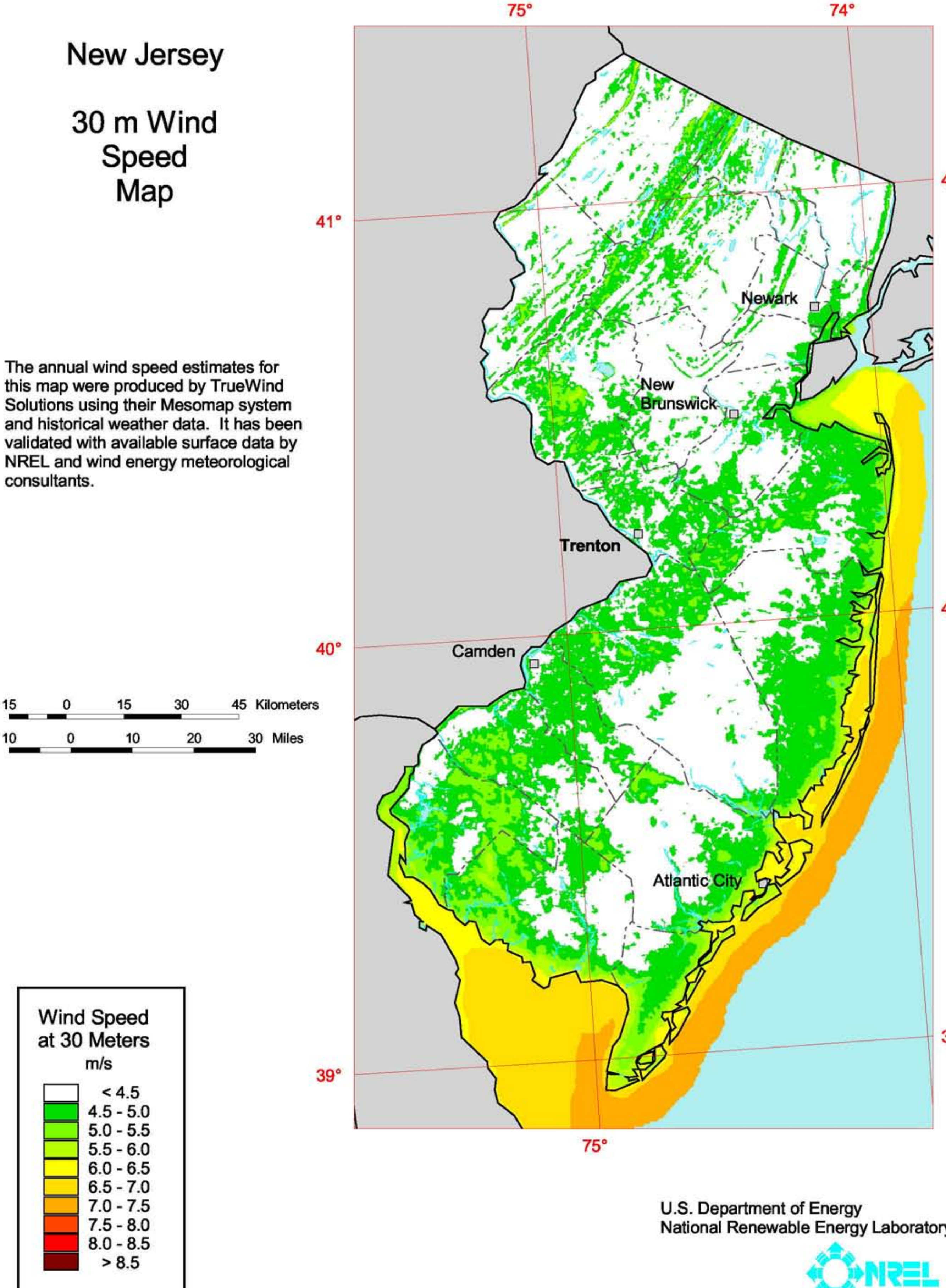
Q. Why do other states such as Iowa and Minnesota have school wind turbines and Colorado doesn't?

A. Those states developed favorable policies to encourage wind for schools, such as requiring the utilities to buy the power produced according to certain rules. They also made grants and low-cost loans available to the schools for wind projects. Finally, these schools often have a one-part tariff (instead of separate demand and usage charges), which increases the savings possible from a wind turbine.

New Jersey

30 m Wind Speed Map

The annual wind speed estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.



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National Renewable Energy Laboratory

10-JAN-2003 1.1.8

NREL

Wind for Schools

WIND POWERING AMERICA

Larry Flowers

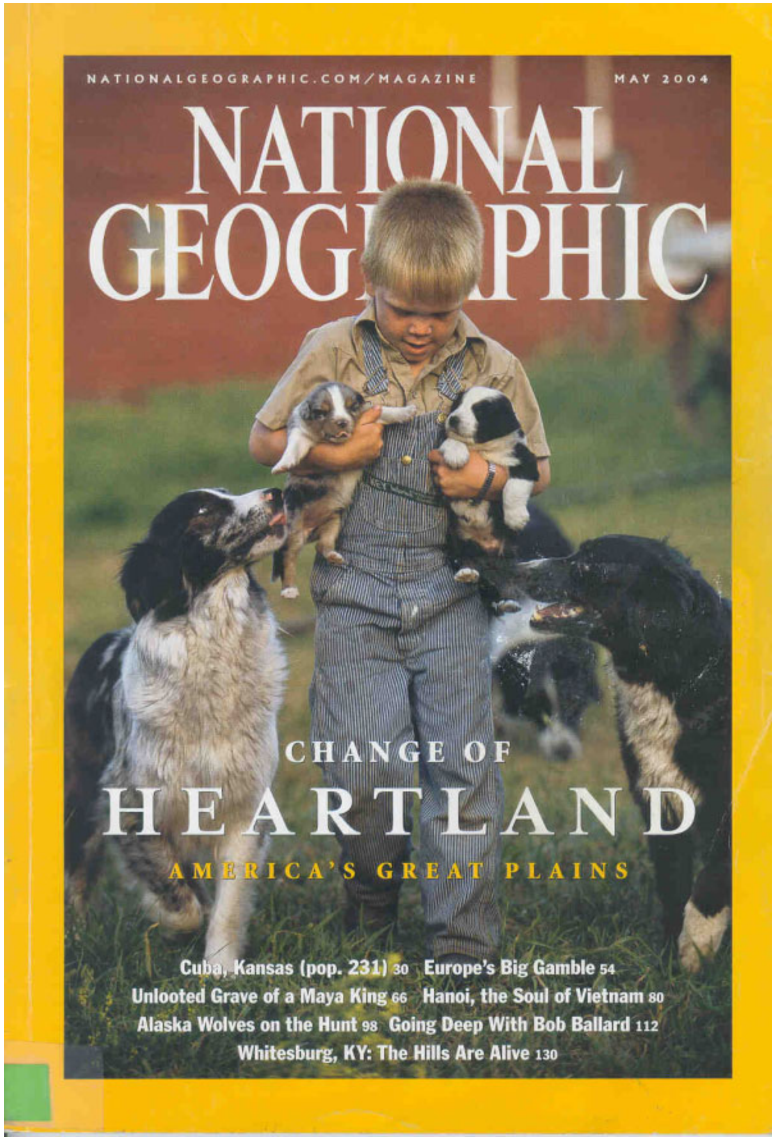
National Renewable Energy Laboratory

National Green Power Marketing Conference

October 25, 2005

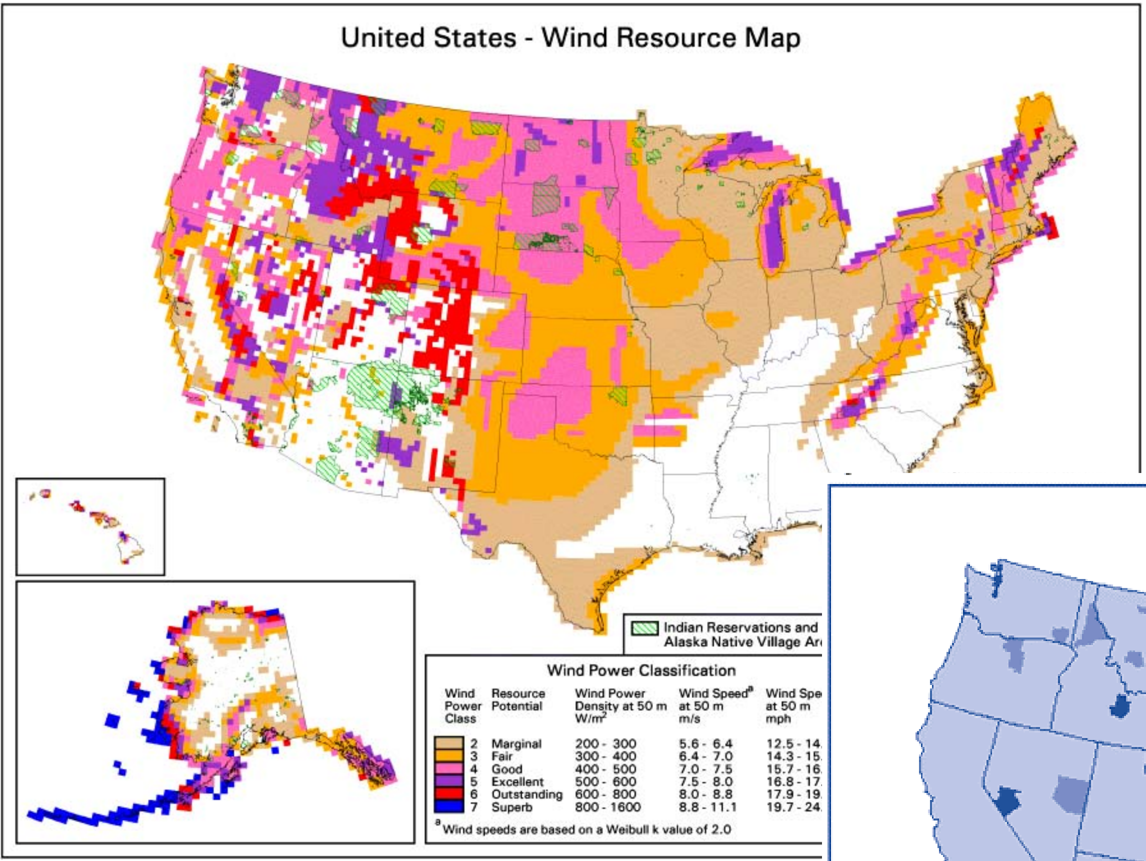
Austin, Texas

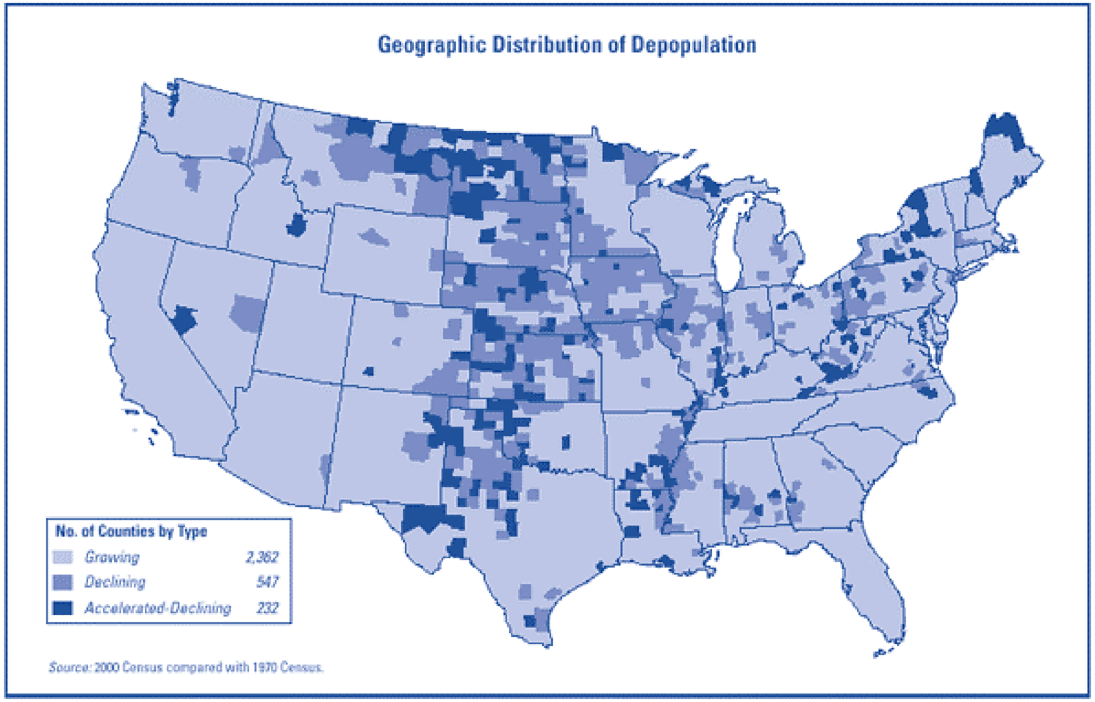
The Depopulation of the Great Plains



"When you lose the school," said a retired teacher, "you've lost the town."

Windy Rural Areas Need Economic Development

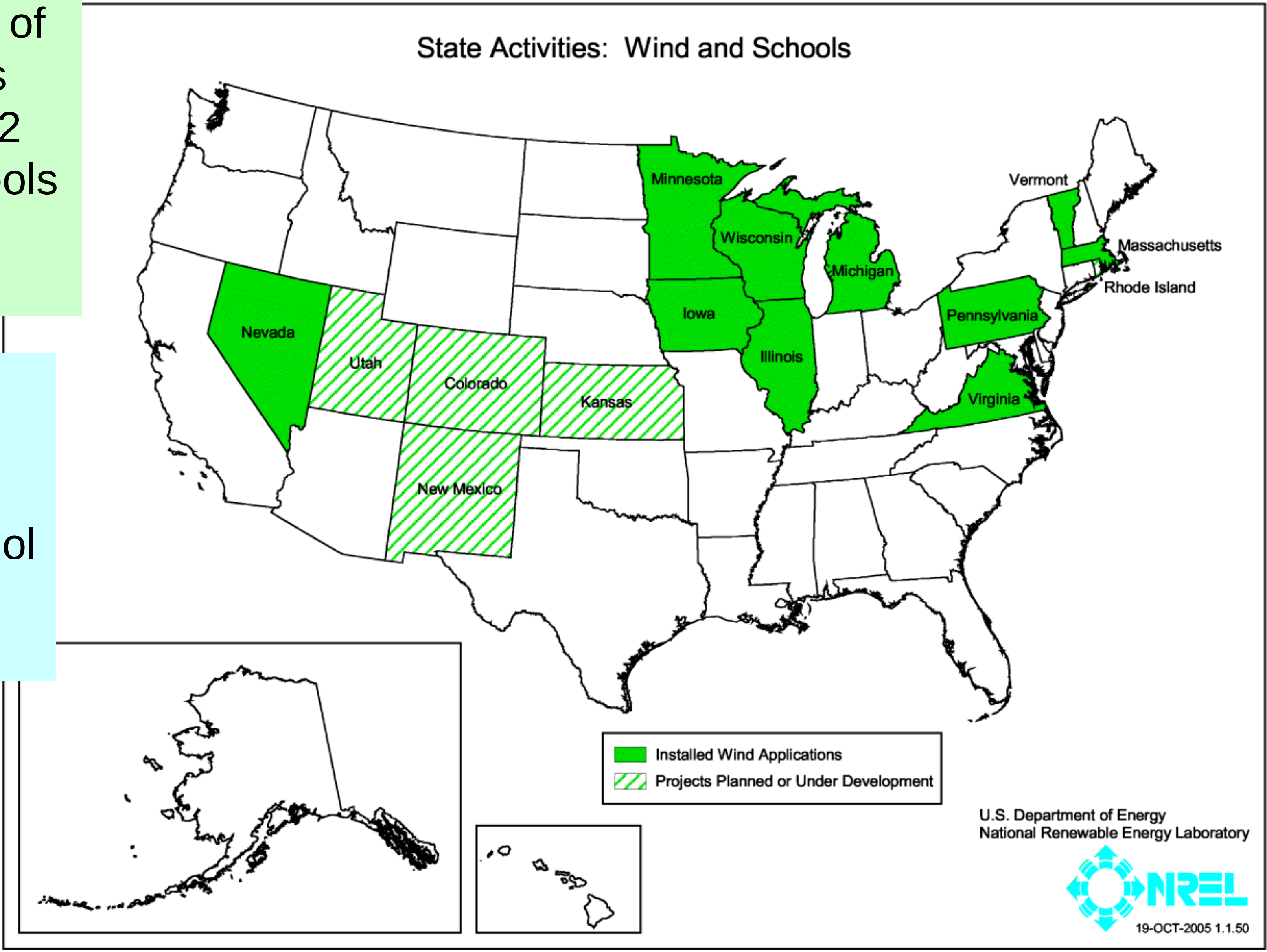




Wind for Rural Schools

About 30% of the nation's 94,000 K-12 public schools are rural.

They serve 27% of the 47M K-12 public school students

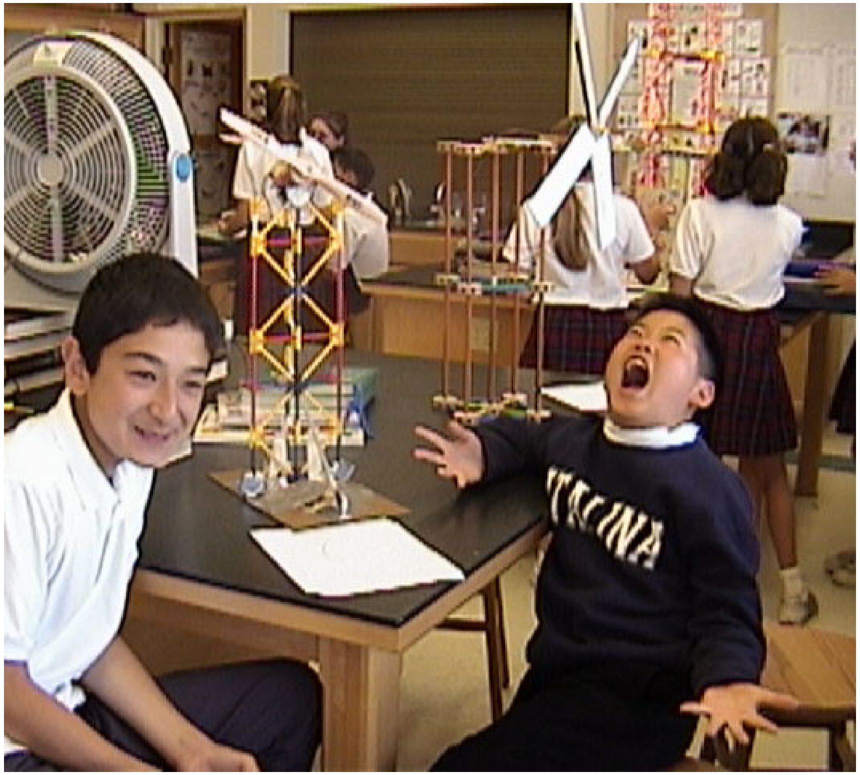


Source: National Center for Education Statistics

Rural School and Community Wind Energy Project Drivers

Rural School Wind Energy Projects

- School is often the largest load in the community
- Community support
- Low cost grants and loans
- Generates local interest in Wind Energy
- Curricula/ science projects
- Several application/ownership options
- Focus on the energy future



Community Wind Energy projects

- Local ownership means local economic development benefits

School Wind Projects across the U.S.

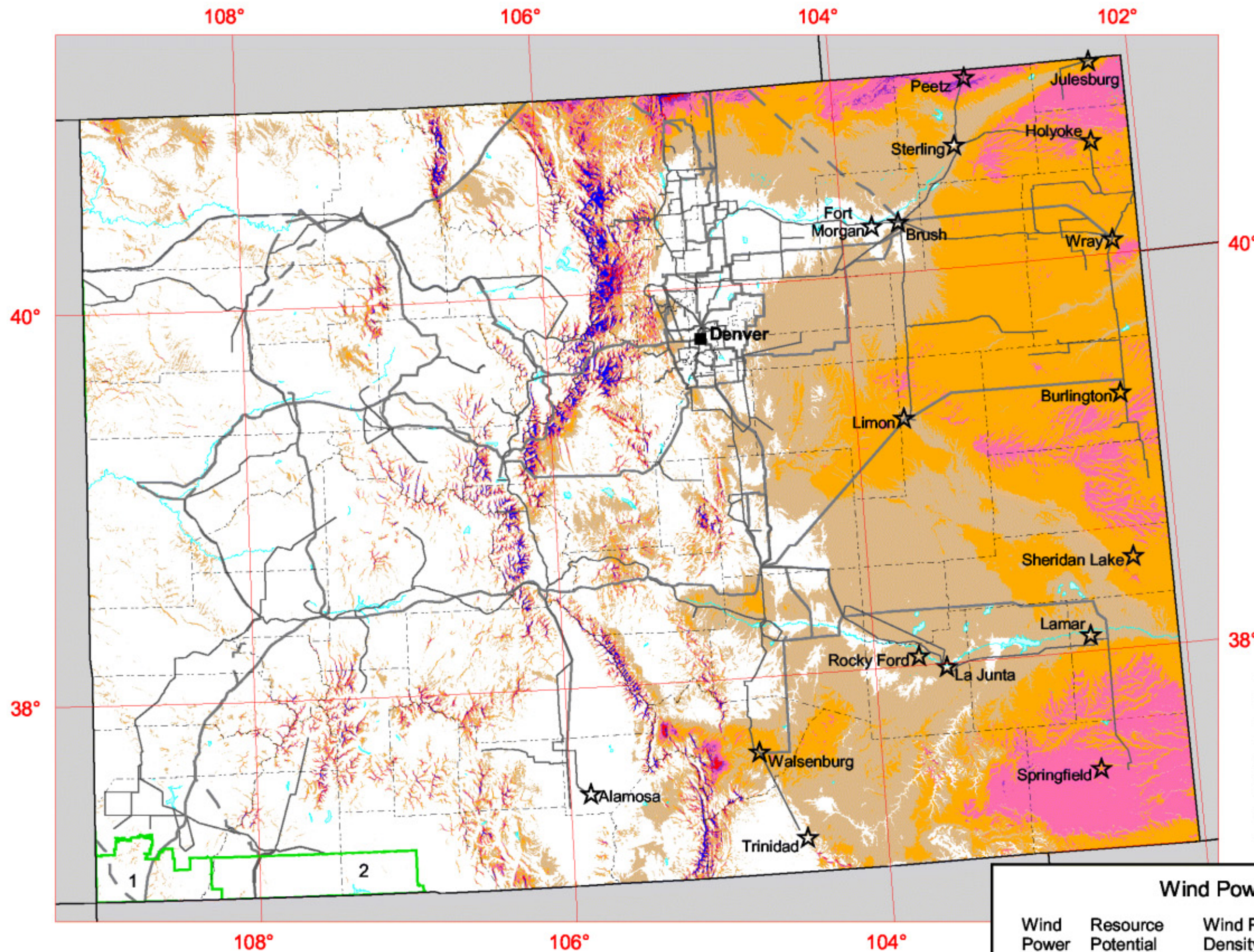
Spirit Lake, IA

Holland, MI

Beverly, MA

Eldora, IA

Colorado Wind and Schools



Transmission Line*
Voltage (kV)
115 - 161
230
345

* Source: POWERmap,©2003 Platts, a Division of the McGraw-Hill Companies

The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ^{2}	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.9	0.0 - 13.2
2	Marginal	200 - 300	5.9 - 6.7	13.2 - 15.0
3	Fair	300 - 400	6.7 - 7.4	15.0 - 16.6
4	Good	400 - 500	7.4 - 7.9	16.6 - 17.7
5	Excellent	500 - 600	7.9 - 8.4	17.7 - 18.8
6	Outstanding	600 - 800	8.4 - 9.3	18.8 - 20.8
7	Superb	> 800	> 9.3	> 20.8

[a] Wind speeds are based on a Weibull k of 2.0 at 1500 m elevation.

50 0 50 100 150 200 Kilometers

50 0 50 100 Miles

Indian Reservation

1 Ute Mountain

2 Southern Ute

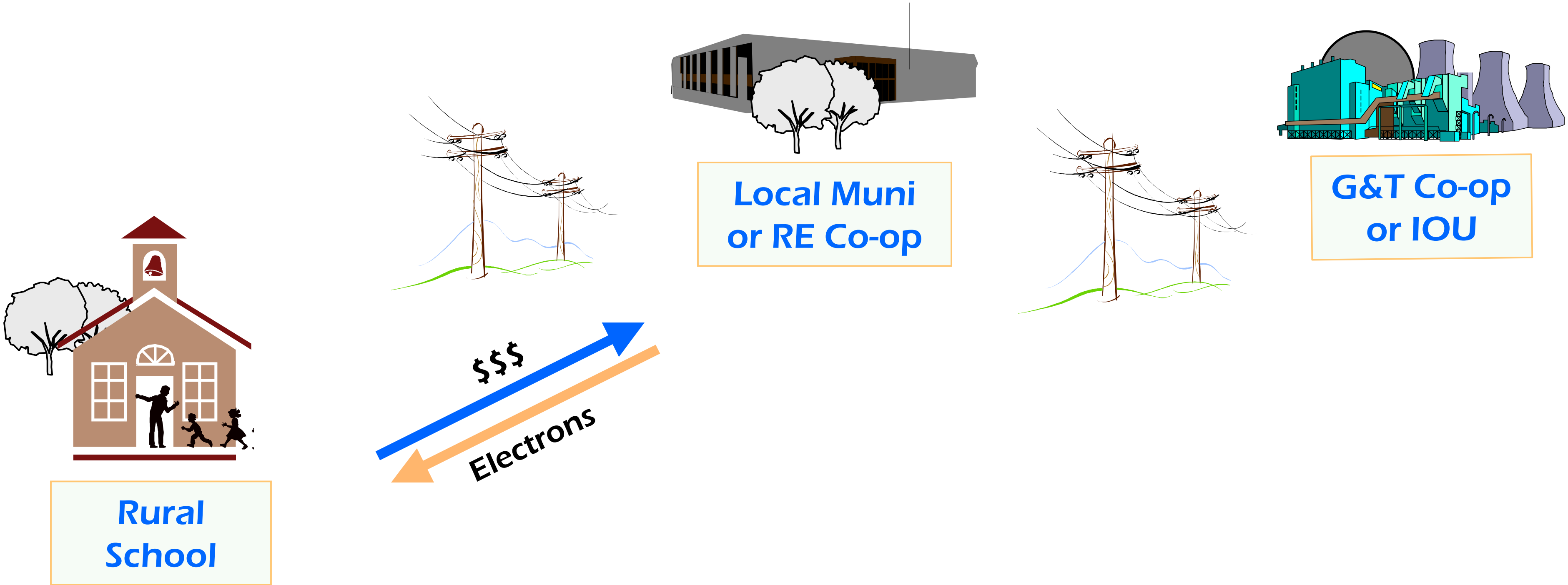
U.S. Department of Energy
National Renewable Energy Laboratory

Colorado Governor's Office of Energy Management and Conservation

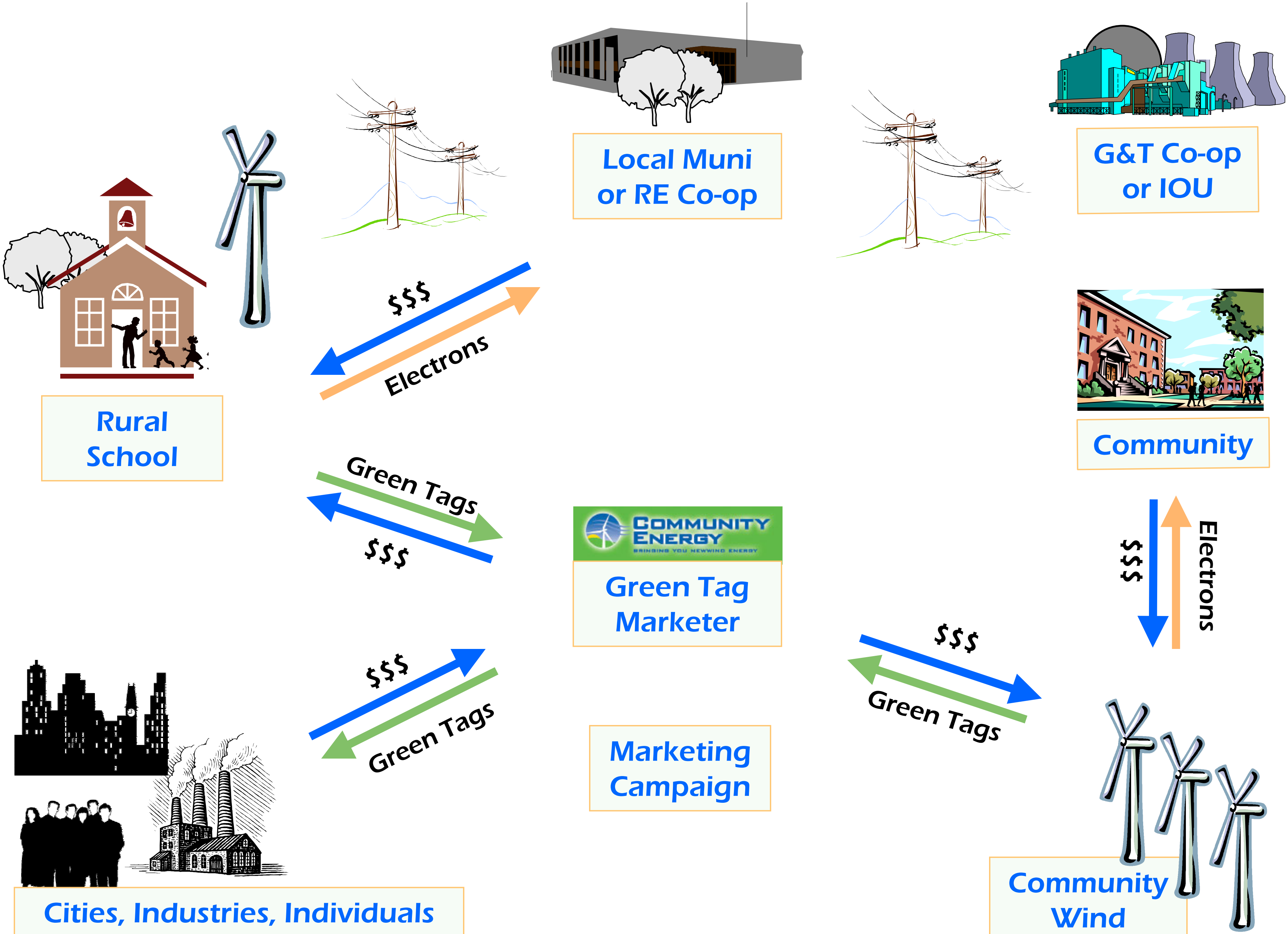
17-OCT-2005 2.1.7

Wind for Schools Pilot Project

- Contacted 17 schools on the eastern plains of Colorado
- Reviewed utility bills
- Performed initial financial analysis
- Presented results to local wind development committees
  - School board
  - City government
  - Local utility
  - Economic development interests
  - Other interested parties (ESCOs, farmers, Ag Extension agents)



Local Muni
or RE Co-op
G&T Co-op
or IOU
$$$
Electrons
Rural
School

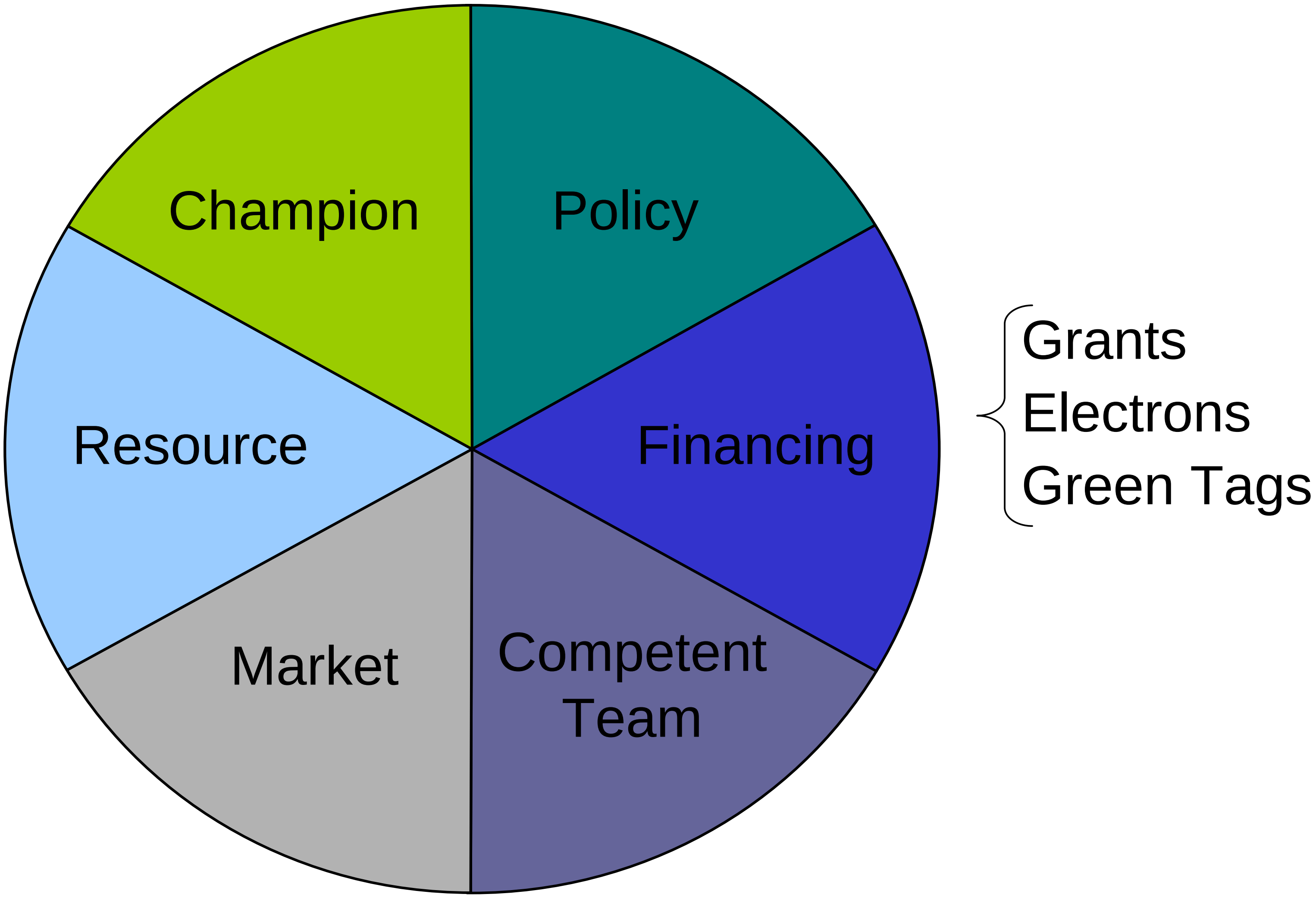


Local Muni or RE Co-op
G&T Co-op or IOU
Rural School
$$$
Electrons
Community
Green Tags
$$$
Community Energy
Bringing You NewWind Energy
Green Tag Marketer
$$$
Electrons
$$$
Green Tags
$$$
Green Tags
Marketing Campaign
Cities, Industries, Individuals
Community Wind

Lessons Learned

- Schools like the "Wind for Schools" concept
- There is a long learning curve/education process
- The project represents a substantial change/effort over multiple years; it can't be successful without a champion
- Wind energy development is complex: appearance of financial risk
- Rural schools are often connected to a RE Co-op
  - low avoided cost
  - Net metering not welcomed
- Demand charge tariff can be a disincentive
- Favorable policies make a big difference
- Public and private grant funding is available
- Organizing a school wind project represents a melting pot of community activity and opinions
- Science teachers are interested in wind curricula

Keys to Success



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Office of Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

Distributed Wind Market Applications

T. Forsyth and I. Baring-Gould

Technical Report
NREL/TP-500-39851
November 2007

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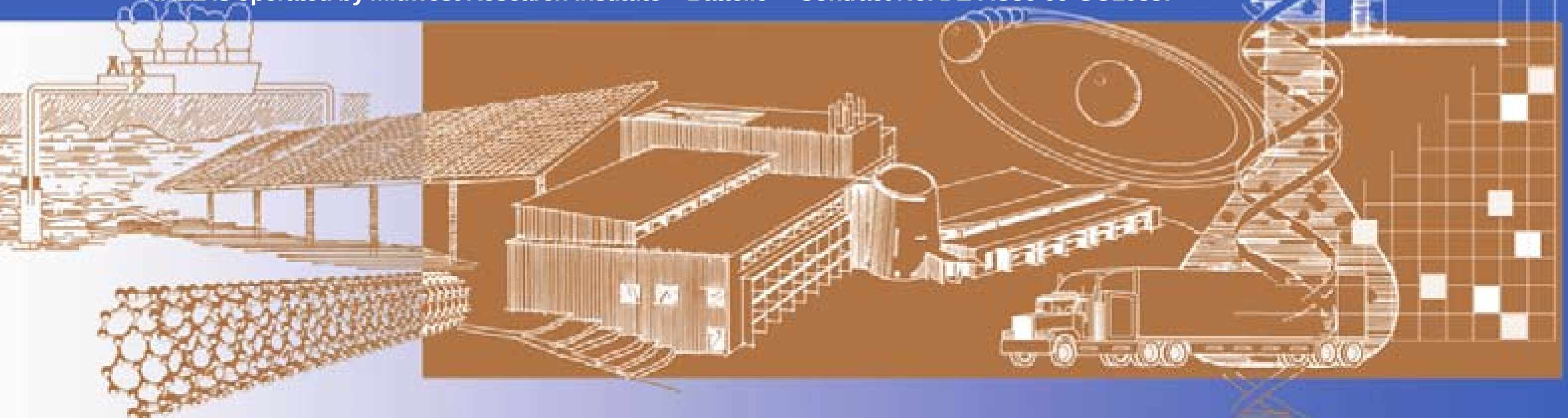

Distributed Wind Market Applications

Technical Report
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Chapter 1. Executive Summary

The Executive Summary will discuss the distributed wind market potential from a domestic and international perspective with greater confidence in the number of units installed for the domestic market. The market potential discussion will be followed by a summary of information provided in each chapter, including regions of market interest for both the domestic and international market, key market and technical barriers, time-critical issues for market development, technology adoption timeframe, and recommended areas of concentration.

Distributed wind energy systems provide clean, renewable power for on-site use and help relieve pressure on the power grid while providing jobs and contributing to energy security for homes, farms, schools, factories, private and public facilities, distribution utilities, and remote locations. America pioneered small wind technology in the 1920s, and it is the only renewable energy industry segment that the United States still dominates in technology, manufacturing, and world market share.

The series of analyses covered by this report were conducted to assess some of the most likely ways that advanced wind turbines could be utilized as an option to large, central station power systems. Each chapter represents a final report on specific market segments written by leading experts in each sector. As such, this document does not speak with one voice but rather a compendium of different perspectives from the U.S. distributed wind field.

For this analysis, the U.S. Department of Energy (DOE) Wind and Hydropower Technologies Program and the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) defined distributed applications as wind turbines of any size that are installed remotely or connected to the grid but at a distribution-level voltage.

Distributed wind systems generally provide electricity on the retail side of the electric meter without need of transmission lines, offering a strong, low-cost alternative to photovoltaic (PV) power systems that are increasingly used in urban communities. Small-scale distributed wind turbines also produce electricity at lower wind speeds than large, utility-grade turbines, greatly expanding the availability of land with a harvestable wind resource. These factors, combined with increasingly high retail energy prices and demand for on-site power generation, have resulted in strong market pull for the distributed wind industry, which is poised for rapid market expansion.

Seven market segments were identified for initial investigation. These market segments, documented in this report, include small-scale remote or off-grid power; residential or on-grid power; farm, business, and small industrial wind applications; and "small-scale" community wind. A summary of the market for remote wind-diesel applications is also included in this summary, although a full report was never completed. The remaining two market segments, water pumping for large-scale irrigation and water desalination, are currently being assessed as part of other program activities and are not included at this time. While some of these market applications have existed for some time, others are just beginning to emerge as part of distributed wind power. A short introduction to each of these assessments is provided below.

- **Small-scale remote or off-grid power (residential or village):** Supplying energy to rural, off-grid applications in the developed and developing world. This market encompasses either individual homes or small community applications and is usually integrated with other components, such as storage and power converters and PV systems.

- **Residential or on-grid power:** Small wind turbines used in residential settings that are installed on the house side of the home electrical meter using net metering to supply energy directly to the home. Excess energy is sold back to the supplying utility.
- **Farm, business, and small industrial wind applications:** Supplying farms, businesses, and small industrial applications with low-cost electric power. The loads represented by this sector are larger than most residential applications, and payback must be equivalent to similar expenditures (4 to 7 years). In many cases, businesses are not eligible for net metering applications; thus the commercial loads must use most of the power from the turbine.
- **"Small-scale" community wind:** Using wind turbines to power large, grid-connected loads such as schools, public lighting, government buildings, and municipal services. Turbines can range in size from very small, several-kW turbines to small clusters of utility-scale multi-megawatt turbines. The key, defining factor is that these systems are owned by or for the community.
- **Wind/diesel power systems:** Providing power to rural communities currently supplied through diesel technology in an effort to reduce the amount of diesel fuel consumed. The rising cost of diesel fuel and increased environmental concerns regarding diesel fuel, transportation, and storage have made project economics more sensible.
- **Irrigation water pumping:** Using wind turbines to supply energy for agricultural applications. Current applications are powered by grid electricity, diesel, gasoline, propane, and particularly natural gas. Wind or hybrid systems allow farmers to offset use of high-priced fossil fuels.
- **Water desalination:** Using wind energy to directly or indirectly desalinate sea or brackish water using reverse osmosis, electrodialysis, or other desalination technologies. The economic and technical performance of wind-powered desalination depends on the configuration and placement of wind resource with regard to the impaired water and existing energy resources. Water desalination works well with the wind resource found in coastal or desert environments.

In these analyses, the DOE Wind and Hydropower Technology Program is assessing two new segments that have not historically been classified under the distributed wind banner: farm/ commercial and the "small-scale" community wind market. Both of these markets struggle to find commercial turbines to meet their needs, demonstrating opportunity for the development of U.S. turbines.

These two emergent market segments combined with the existing small wind market result in three conglomerated turbine capacities. The first is the residential and smaller business sector at roughly 0 kilowatt (kW) to 100 kW capacity. The second sector is the farm/commercial market sector that includes farm, industrial, and wind/diesel from 100 kW to 500 kW. The last market sector for distributed wind is the "small-scale" community wind sector, which has been estimated to be 500 kW to 1 megawatt (MW). Although not covered specifically within this analysis, there is also likely a need to develop methodologies to lower the cost of power from large, multi-megawatt turbines that are installed in distributed community applications. Further hardware development in all of these sectors would help meet the desires of Americans to provide their own electricity, whether for a residence, farm, or business in rural America where zoning challenges are minimized.

This study identifies and describes how the distributed wind industry can overcome long-standing barriers and play an important role (in the United States and the international arena) in supplying power near the point of end use or behind the meter.

I. Summary of Market Potential

Authors were asked to conservatively assess the potential market size for the five market segments in terms of the number of units expected to be installed in 5-year increments through 2020. Additionally, authors were asked to recommend the expected turbine size that would be most applicable to meet the proposed markets. Figure E.1 shows an overview of the different market segments, the kilowatt capacity of the turbines for each market segment, and the existing turbines available within each distributed market segment.

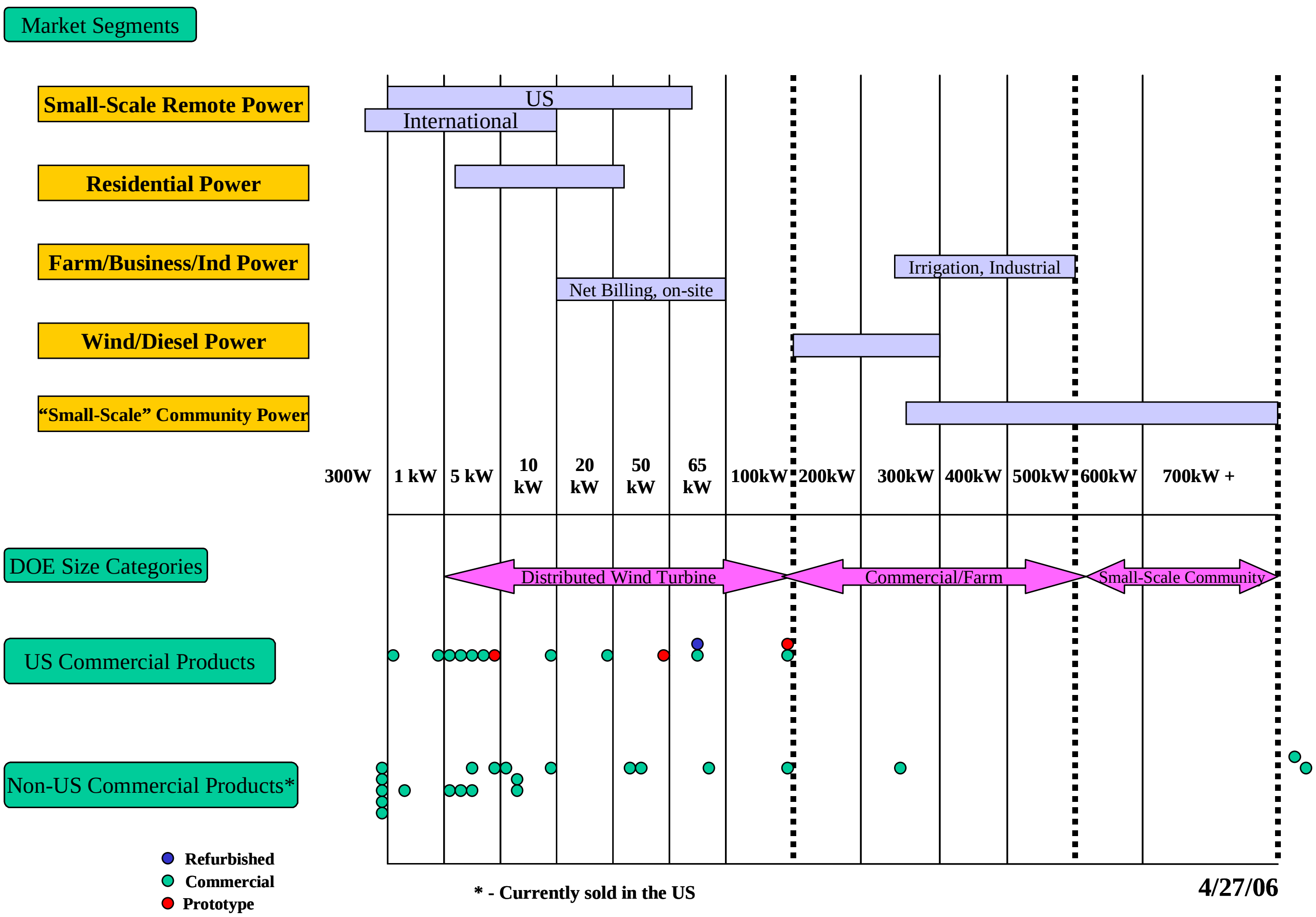

Figure E.1. Overview of market segments and commercial wind turbines

From a manufacturing perspective, the strongest market segment is turbines smaller than 10 kW in size, with 20 domestic or internationally manufactured turbines to choose from. The number of turbine choices between 20 kW and 100 kW is quite limited, and turbines between 100 kW to 1 MW are practically nonexistent.

It should be noted that the re-powering of wind farms in Europe and the United States has made available re-manufactured turbines that are being used to supply many current distributed applications. Although generally inexpensive compared to existing new turbine models, most of these are based on significantly outdated technology. Turbine design, reliability, and energy capture have been improved over the intervening time, resulting in current projects with reduced energy capture than would be expected from projects with turbines incorporating current technology and design practices.

II. Summary of Domestic Markets for Distributed Wind Technologies

Teams of technical experts with knowledge of their market segments provided the market projections summarized below. Each of these experts was asked to provide a conservative estimate to ensure the report validity in retrospect. It should be noted that NREL did not attempt to validate the expected market data from these market summary reports.

The benefits from distributed wind projects are minimized when quantified using total megawatts of installed capacity, especially for the smaller distributed turbines. However, the use of a simple number of units produced reduces the visibility of the mid-size turbines used in the farm/commercial, wind/diesel, and "small-scale" community wind segments. For this reason, the summary results are presented in terms of both the number of units and total installed capacity. It should be noted that the estimates of the number of units and thus the total installed megawatts are very rough and should only be considered in relative terms. The DOE Wind and Hydropower Program is in the process of conducting more detailed market assessments for the segments that show the most promise.

Table E.1 summarizes the cumulative number of expected domestic turbine sales over the five market segments. Note that the table also presents the turbine size for each market segment. Currently the largest sector in terms of the number of installed units is the small-scale remote or off-grid power market segment. The majority of these off-grid units have a lower capacity, with a typical turbine size in the range of a few kilowatts or less. All market segments combine to a potential total of 680,000 installed units by the end of 2020.

There are several market niches within the domestic off-grid segment, specifically in Alaska and Native American communities. An example is the Navajo Nation—approximately one-third of the 250,000 people on the reservation lack electricity.

The estimated market growth across 15 years to 2020 is 11% per year for the small-scale remote or off-grid market segment; 22% per year for the residential or on-grid segment; 48% across the farm, business, and small industrial segment; 26% per year for the wind/diesel segment; and 23% per year for the "small-scale" community segment.

Table E.1. Market Projections of Domestically Installed Units

	Off-grid	Residential	Farm, Industrial & Business	" Small Scale" Community	Wind/Diesel
Turbine size	300 W - 60 kW	1 - 25 kW	Large: 250-400 kW Net Bill: 10-60kW	100 - 1000 kW	100 - 300 kW
2005	125,700	1,800	20	150	65
2010	219,450	6,250	1,270	360	565
2015	455,450	14,000	4,270	1,010	1,565
2020	631,450	36,500	7,395	3,235	2,190

These data are shown graphically in Figure E.2. The off-grid market segment is excluded due to its dominance of the graph, which reduces the reader's ability to see the effects of other market segments. With the off-grid data removed, the residential market segments show that on a unit-production basis, residential leads the distributed market segment. From a manufacturing standpoint, in which high volume can reduce cost, the high number of units should be attractive.

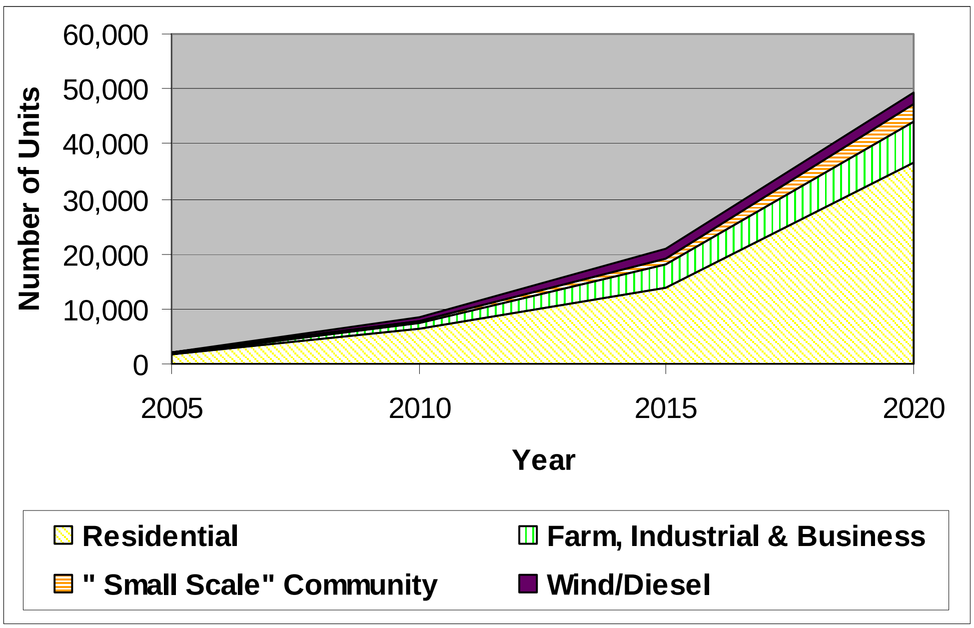

Figure E-2. Market projections using number of units installed in the United States

Table E.2 and Figure E.3 show these same data based on the expected cumulative installed domestic capacity of the turbines in these market segments. This figure provides a different view of the markets in that although fewer turbines will be installed in either the farm or community wind markets, their capacity (in terms of rated kilowatts) is much larger than the cumulative sum of the smaller residential and off-grid market segments.

It should also be understood that the "small-scale" community wind market was arbitrarily capped at a maximum turbine size of 1 MW. It is quite clear that a vibrant community wind market exists that uses turbines greater than 1 MW in size, with multiple installations reaching up to 20-MW sites. Further DOE market assessment activities will likely extend this size range of turbines to be considered to include turbines up to 1.5 MW in size.

Table E.2. Projected Domestic Installed Capacity (MW) by Sector through 2020

Year	Off-grid	Residential	Farm, Industrial & Business	" Small Scale" Community	Wind/Diesel
Turbine size	1 kW	12.5 kW	Large: 325 kW Net Bill: 30 kW	750 kW	200 kW
	Cumulative installed capacity (MW)				
2005	126	23	4	113	13
2010	219	78	260	270	113
2015	455	175	875	758	313
2020	631	456	1,516	2,426	438

Table E.2 shows the market segment with the largest installed capacity as “small-scale” community wind, followed by the farm, business, and small industrial market segment. Note that the farm, business, and small industrial market segment shares the same size turbine capacity as the wind/diesel market segment. Technological solutions would likely address both market segments. And combining the total projected market capacity of the farm, business, and small industrial segments results in approximately the same total as the “small-scale” community segment.

To date, approximately 270 MW of community wind projects are installed in the United States, representing $250 million in investment in rural communities. Of those, 110 MW would meet the “small-scale” community wind definition of 1 MW or less. At least 440 MW of new community-owned wind projects are in the advanced planning states in the United States; however, project developers expect to utilize turbines larger than 1 MW for nearly all of this future capacity (due to their better economics and availability).

Figure E.3 shows the total of all five market segments, resulting in 5.4 gigawatts (GW) of projected capacity by the end of 2020.

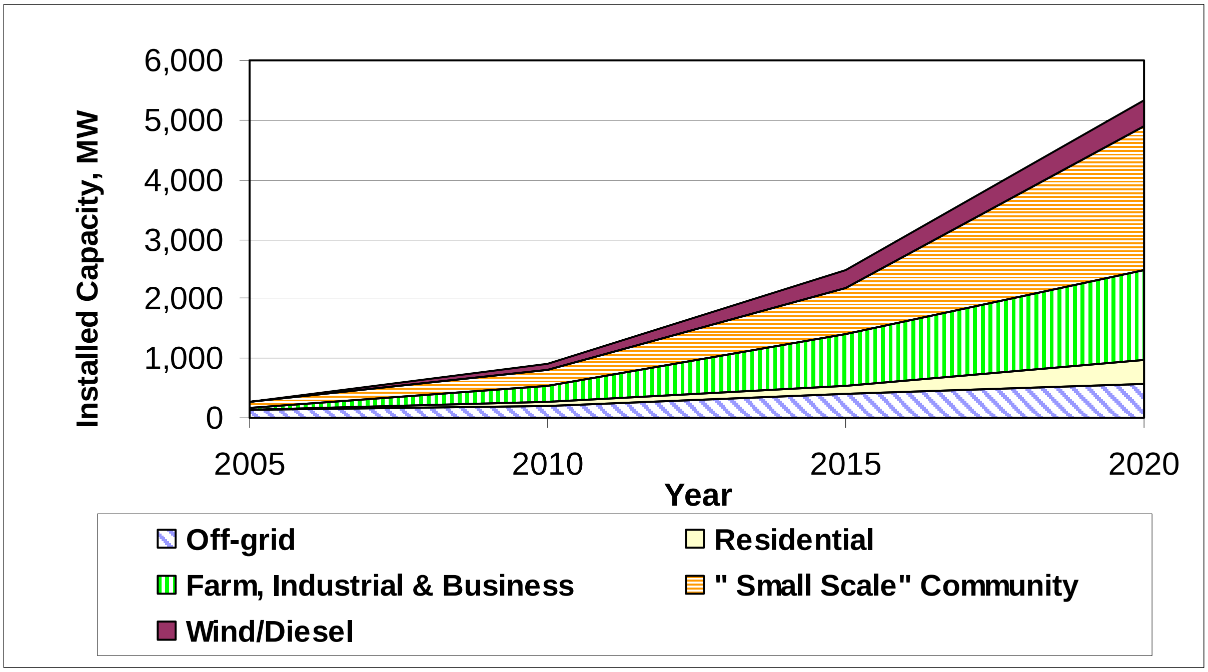

Figure E.3. Incremental domestic installed capacity by sector through 2020

A number of capacities were presented for each market segment, as shown in Tables E.1 and E.2. Each market segment chapter provides a range of market potential for 2010, 2015, and 2020 (found in each chapter's Summary Information Table). Based on those data, we evaluated the total market potential assuming *minimum* values of capacity and market potential, *likely* values of capacity and market potential (as shown in the above tables and figures), and the *maximum* value of capacity and market potential. Figure E.4 shows the bars, which represent the *likely* value of installed capacity in megawatts. The lines for each bar show the minimum and maximum for future years.

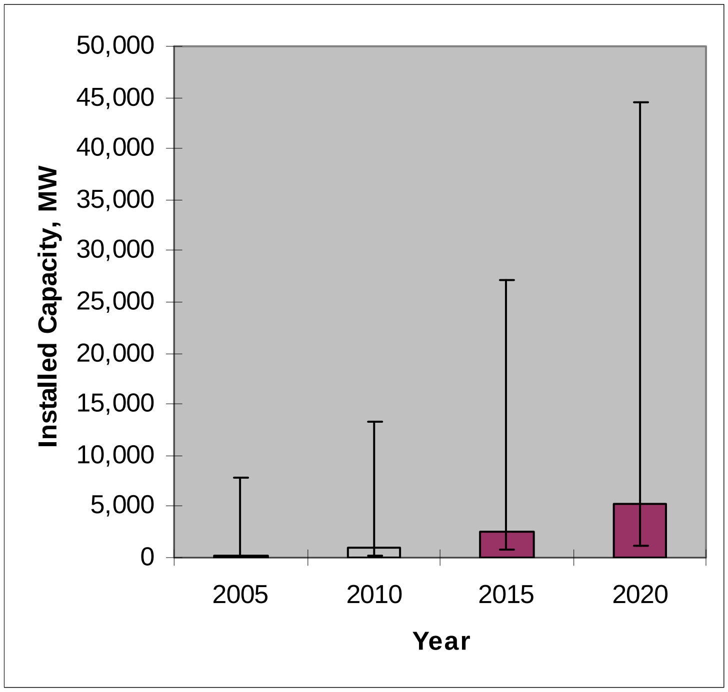

Figure E.4. Potential capacity variation for all domestic market segments

A large variation exists between the minimum and maximum value for the year 2020. This is due to several factors, including uncertainty about the optimum turbine size for each market segment, uncertainty in the removal of market barriers that are needed to propel the market forward, and uncertainty in the technology cost and the competitiveness of new products in the marketplace.

III. Summary of International Market for Distributed Wind Technologies

Although not the focus of this work, each of the market segment authors was asked to estimate the international market for distributed applications. It should be noted that international market information is notoriously difficult to measure, and the scope of these documents only allowed a cursory investigation.

The international market is of special interest because unlike the market for large wind turbines, U.S. small wind turbine manufactures currently hold a dominant market share. U.S. manufacturers of small and distributed wind turbines represent the most diverse and internationally recognized industry in this technology area.

Table E.3 provides a summary of the international market potential as identified in the market segment reports. Note that the table also presents the turbine size for each market segment. The largest sector in terms of installed megawatts is the community wind market segment. Historically, the European Union has been the leader in community wind, with about 80% of all the installed wind turbines considered community applications. This market is currently estimated to be 8.2 GW of installed units under 1 MW.

In comparison to the domestic market, three international market items stand out. First, "small-scale" community wind becomes a more dominant player in the world wind market, replacing the substantially increased off-grid market. Second, wind/diesel applications become a stronger market element. Finally, residential wind diminishes in importance. The off-grid market, although not as large as "small-scale" community wind, still offers a huge potential. Although most of this market potential is outside the developed world, China has a current installed capacity of 170,000 mini wind turbines (60 to 200 W).

Table E.3. Cumulative Installed International Capacity in MW by Sector through 2020

Year	Off-grid	Residential	Farm/Industrial/Bus	Community	Wind/Diesel
Turbine size	5 kW	12.5 kW	Large: 325 kW Net Bill: 30 kW	750 kW	200 kW
2005	2,361	14	0	8,250	10
2010	3,118	36	154	17,250	310
2015	6,275	99	410	40,125	1,810
2020	10,693	286	666	95,625	3,810

Table E.3 summarizes the cumulative capacity of expected international turbine sales over the five market segments. Note that the table also presents the turbine size for each market segment while Figure E.5 shows the expected number of installed units of each market segment, excluding the off-grid or small-system segment, which is expected to grow at more than 150,000 units per year in 2020, and distorts the impact of the other market segments. The largest sector in terms of the number of installed units is the off-grid or small-scale remote power market segment; however, the majority of these off-grid units will have a lower capacity, with a typical turbine size in the range of a few kilowatts or less. All market segments combine to a potential total of almost 1,500,000 installed units by the end of 2020. The total year-over-year international market grown is estimated at about 20%. It should be noted that due to the limited data available to support these estimates, the range between *minimum, likely,* and *maximum* values of capacity is quite large (Figure E.6).

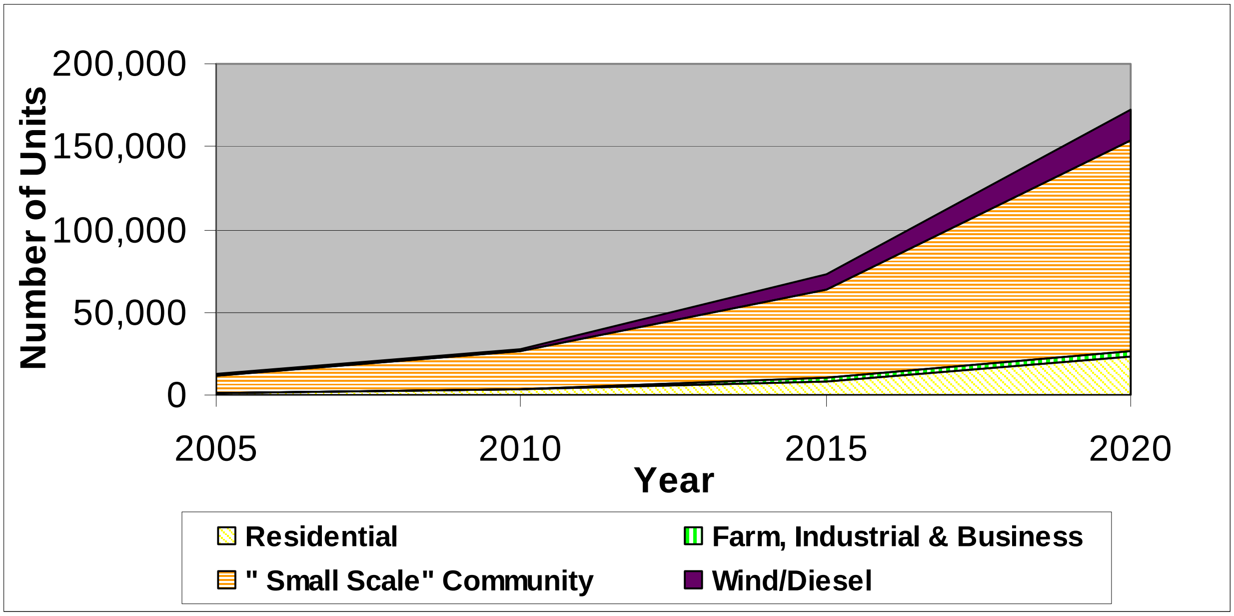

Figure E.5. Incremental international installed capacity by sector through 2020 without data for off-grid or small-system segment (which is too large to show graphically)

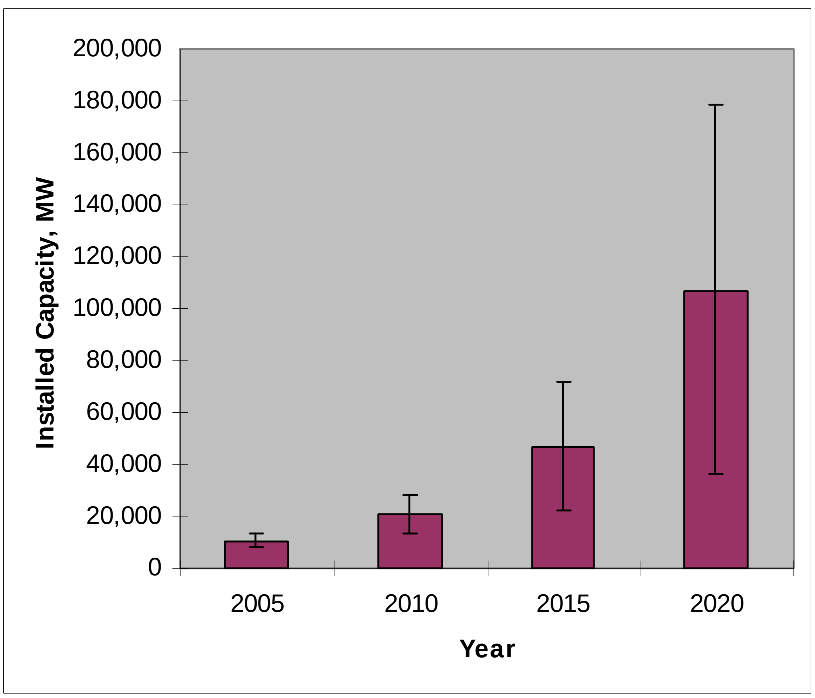

Figure E.6. Potential capacity variation for all international market segments

A robust market potential is estimated for the farm, business, and small industrial segment due to strong economic policy (for example, the German "feed in" tariffs, in which high economic value is given to the production of kilowatt-hours based in part on higher electricity rates). China also has aggressive renewable energy goals, and there is already proven use of mini turbines.

IV. Market-Based Barriers to the Distributed Wind Market

Through this market analysis, several market-based barriers were identified that hinder the development of the distributed wind applications market. Unless otherwise noted, many of the barriers, which are described in basic rank order of importance, were found to be casual factors in multiple market segments.

- **Technology not quite cost competitive:** Although markets exist in which incentive programs can be combined to give consumers 50% cost-sharing of their turbines, further cost decreases through volume manufacturing will be needed to allow appropriate payback periods for most American consumers. (Markets in which distributed wind technologies are cost effective exist in Class 3 to 4 wind resource areas and locations with high electricity costs, such as remote diesel stations.)
- **Turbine availability:** In the current market, turbines sized between 100 kW and 1 MW to serve farm, business, small industrial, wind/diesel, and small-scale community loads are not produced. There is also a shortage of turbines sized greater than 1 MW because of pre-purchases by wind developers using the Production Tax Credit. There are also opportunities for turbine development in the 5-kW to 15-kW range to meet needs in the residential market segment.
- **Zoning/permitting restrictions or complications:** Zoning remains a large issue for distributed applications, specifically for individual home or business owners seeking to install a small wind turbine on their properties in suburban America. The permitting costs and zoning requirements can greatly increase the overall cost, lead time, and complexity of installing even the smallest wind turbine. In most locations across rural America, zoning and permitting are not an issue for smaller turbines, but those locations don't typically have the incentives in place to compel the purchase of a distributed wind turbine. Model zoning ordinances for mid-size turbines currently do not exist, and there is a need for them. These ordinances should consider proper setback for sound levels and safety, as well as avian and other wildlife issues.
- **Interconnection to the grid, including standards and defined requirements:** Turbine grid interconnection is a complex issue that varies from state to state and generally from utility service provider to service provider. This creates a number of complexities, both from a technology perspective and an information outreach perspective. With such a wide range of requirements, it's almost impossible for the industry and other supporting organizations to provide informative assistance to interested homeowners.
- **Lack of consistent incentive policies across markets:** The lack of clear, consistent, and economically motivating incentives complicates and distorts markets for small wind systems. More systematic market incentives, such as "feed in" tariffs, a national investment tax credit for distributed wind applications, and state-based rebates for all distributed applications would expand the technology adoption.
- **Poor image due to past small wind experiences:** The historical performance of some distributed wind turbines has resulted in a somewhat persistent belief that small wind turbines are noisy, unsafe, and unreliable. Outreach activities addressing previous market issues and some of the largest preconceived notions of modern small wind turbines are needed.

V. Technical Barriers to the Distributed Wind Market

In addition to market barriers, technical barriers were also identified. A summary of these barriers, all of which are discussed in greater length in each of the chapters, is provided.

- **Product reliability and performance:** Turbine and system reliability, especially in distributed applications where service personal are less readily available, hinder the adoption of wind systems. Performance is typically over-predicted (usually due to a poor understanding of the wind resource, the micrositing of the turbine system, and insufficient tower heights).
- **Limited size choices using older designs:** The limited number of commercial turbines 50 kW and greater, combined with non-optimized turbine efficiency and design, result in missed market share. Many technological advances have been made on residential turbine designs and multi-megawatt turbine designs, and these technological advances could be applied to distributed turbines.
- **Availability of maintenance support:** By definition, distributed applications will not be installed in organized wind farms where field support is readily available. The lack of or additional cost of field support undermines technology acceptance.
- **Lack of performance standards, testing, and ratings:** The lack of industry-accepted standards undermines the credibility of performance estimates for wind turbines. In many cases, incentive organizations are unsure of which products to endorse and incent, limiting the available product with good economic value.
- **Technologies for low-wind regimes:** Most mid-size wind turbines used in the distributed market were designed before recent advances in low-wind-speed technology. However, a large number of sites where distributed applications will be applied are not in high-wind-speed regimes and would receive the most advantage of low-wind-speed designs.
- **Turbine noise:** Although distributed turbines are becoming quieter with each successive generation, some are still considered too noisy to be used in residential settings. Further technical advances to reduce noise will allow turbines to operate in a wider variety of settings.
- **Lightning susceptibility and grounding:** The susceptibility of distributed wind turbines to lightning and the cost of lightning protection increase the cost and technical complexity of wind systems.
- **Grid interconnection and integration:** The technical complexity and cost of interconnection of small wind systems to the electric distribution grid require further advancement, standardization, and testing. Distributing turbines through the use of more sophisticated remote-monitored controllers can allow the turbine to support the weak rural distribution systems, providing grid stability.
- **Tower options for larger wind systems:** Most towers are currently designed around wind turbines for central station wind farms. To allow for more cost-effective installation and maintenance, distributed wind turbines must be developed with towers and systems specifically designed for the distributed wind market, such as self-erecting towers or lightweight, tall towers for small turbines in rural low-wind-speed applications.
- **Energy storage for remote power systems:** Remote, non-grid-connected power and water irrigation applications require some form of energy storage to supply consistent, grid-quality electrical service. Energy storage is currently the highest life-cycle cost

component of a remote power system. Improving the cost and technical performance of energy storage will increase the applicability of wind-driven remote power systems.

VI. Acknowledgements

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The farm, business, and small industry report was written by Ken Starcher and Vaughn Nelson from West Texas A&M University – Alternative Energy Institute and Robert Foster and Luis Estrada from New Mexico State University – Southwest Technology Development Institute.

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All of these teams have significant experience dealing with the market sector that they reported on and have provided potential market growth estimates based on their experiences. Their reports include a description of the market today, current market and technical barriers, their associated time frames, and projected market growth for the domestic and international markets.

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VII. Conclusion

Distributed wind technologies provide an avenue for Americans and people from across the globe to economically take part in the determination of the world's energy future. Until recently, most of the world's population was dependent on outside forces to provide energy services, primarily through large central-station power generation. Although individuals with adequate financial resources have been able to rely on personal energy sources, such as photovoltaic panels or small fossil-fueled generators, these personal energy sources have been out of reach for many. The dramatic reduction in the cost and availability of distributed wind technologies, combined with new policy incentives in many parts of the world, has started to change this dynamic. This report documents a substantial market for distributed wind applications and, although some technical and market-based barriers exist, none of them are insurmountable. The report also indicates that there is much to be understood about this market and that further analysis will be required in areas of specific interest. As the nation moves toward a posture of energy independence using more environmentally friendly energy technologies and away from large, central-station power generation and the large transmission lines that these will require, distributed wind applications—from residential wind turbines connected to our homes to large distributed wind and wind/diesel applications—can play a greater and significant role in our energy portfolio.

Chapter 2. Small-Scale Remote or Off-Grid Power

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I. Executive Summary

This section evaluates the key market and technical barriers faced by wind energy technology for the small-scale remote or off-grid power (residential and village) market sector. Market and technical questions posed by the National Renewable Energy Laboratory (NREL) are discussed to identify promising priority areas for U.S. Department of Energy (DOE) wind program research and development activities.

Small-scale wind energy systems employing renewable energy offer an attractive and practical approach to meet electrical power needs for individual households and rural communities around the globe. Small wind turbines are a distributed energy source with good potential for rapid growth in the next 20 years. The key to long-term success for any small-scale wind energy system is to install a well-designed energy system while keeping in mind the institutional framework and structure needed to provide long-term operation and maintenance for the system.

The small wind turbine industry is already a sustainable market around the globe. With about 1.7 billion people without electric grid power, the village electrification market is estimated to be at least 26 GW [1]. Remote village power can be designed as a complete system with options of wind, photovoltaics (PV), batteries, and diesel generators. The major challenges are system costs, sizing system components, and establishing high-volume production of systems with a corresponding price reduction.

II. Application Background

Small wind energy systems come in many sizes to fit the need for energy and the resources available to the end users. This market encompasses single-home or small-community applications by supplying electricity to rural, off-grid applications in the developed and developing world. Sizes range from simple home-sized systems (60 W and up) to larger, village-scale systems with hundreds of kilowatts of wind added to the generation mix. In the United States, most consumers want to use wind energy to meet their energy needs at remote sites away from the grid or to make themselves energy self-sufficient. Developing countries desire small wind energy systems to supply energy for remote homes and villages without increased infrastructure demands on the limited resources of the central governments.

Wind power can provide significant amounts of energy to rural households and communities currently supplied through diesel technology and reduce consumption of diesel fuel. Small wind offers capabilities for individual loads or a collection of loads to be met.

In some villages, positive exposure to the first small wind energy systems predictably has led to an overall increase of energy use. Load management needs to be considered for each wind system installation because system designers cannot plan for unlimited growth in their initial system designs. Enforcing payments from the energy users seems one way to curb the exponential growth in system load, but it is feasible only if the costs are kept low so that energy value remains affordable.

High penetration for wind/diesel is defined as the wind providing at least 75% of the current load. For high-penetration, wind/diesel power systems without energy storage, there are three operating stages: (1) diesel only, (2) wind/diesel, and (3) wind only. The transition between these three separate operation stages is the most difficult part of system control. Both the wind and the load will fluctuate over short time periods.

III. Current Status of Small-Scale Wind

Small wind energy systems have been around for many decades and are a mature technology, initially gaining popularity in the early 20th century for small farms and ranches in the Midwest. Most of these farms and ranches were already accustomed to using wind-powered mechanical water pumping systems. Before the large U.S. rural electrification programs, many rural farms installed small wind electric systems to supply energy (e.g., Jacobs units). However, small wind popularity waned as the large rural grid-electrification programs were initiated during the Depression and after World War II. But the small wind industry has once again gained popularity in recent years as more people move to rural, off-grid areas and most states offer net metering. Net metering allows utility customers to use their wind generation to offset their power consumption over an entire billing period.

The small wind turbine industry is consistently growing, but not as rapidly as the large wind turbine industry. To date, more than 430,000 small wind units are installed worldwide, representing about 110 MW of installed capacity. The most successful turbines for the small-scale industry are the smaller units, usually only a few hundreds Watts in size. The largest market for these small turbines is overseas, in places such as China and Mongolia. The turbines are most often used to power individual households. There are also about 150 wind-hybrid power systems installed around the globe, using larger wind turbines (typically ranging from 1 kW to 50 kW). For these larger hybrid systems, institutional management issues are key to their long-term success. Likewise, a similar number of telecommunication systems around the world use small wind technologies to help power microwave repeater stations, etc.

The leading U.S. and world manufacturer of small wind turbines is Southwest Windpower (SWWP) in Flagstaff, Arizona, which has sold nearly 100,000 units to date. SWWP has roughly half of the world market share for small wind turbines, with 40% sold domestically and 60% overseas. The market that includes turbines for sailboats is shrinking and represents 15% of SWWP's sales. In 2006 (SWWP's best sales year to date), sales sometimes surpassed 1,000 units per month and, at the time of this writing, were expected to be about 12,000 for the year. High-volume production has allowed SWWP to sell a competitive-priced unit [2]. Other key manufacturers are Marlec from the UK (more than 50,000 90-W units produced) and Bergey Windpower in Oklahoma (more than 4,800 units produced, both 1-kW and 10-kW units).

IV. Market Barriers Issues and Assessment

Expected United States Market

In the United States today, there are an estimated 35,000+ kW of installed small wind turbines, representing more than 90,000 total units in the 90-Watt to 25,000-Watt size range. The U.S. small wind market is growing at about 15% to 20% per year, and it roughly doubles every 5 years.

There is a growing interest in small wind systems in the United States, especially for rural households. The implementation of net metering in most states is allowing the small wind industry to grow. Also, since the U.S. rural electric grids were never set up with the intent of meeting all of the electrical services for today's modern households with their many electrical appliances (big-screen TVs, satellite dishes, microwave ovens, computers, etc.), small wind systems could play a role in strengthening the rural electric grids.

There are several U.S. wind niche markets. For instance, some rural U.S. villages are not electrified (most notably in Alaska). Approximately 75,000 people live in 175 rural communities throughout Alaska [3]. Of these, 42,000-plus people in 91 communities have a high potential for wind/diesel systems. Most of these are Native American communities.

The largest Indian reservation in the United States is the Navajo Nation, and approximately one-third of the 250,000 people on the reservation lack electricity. The households are typically scattered and will never be electrified by the grid or a village system. The Navajo Tribal Utility Authority has already installed hundreds of individual PV systems for some of these rural households (typically about 300 Wp each). Small wind generators can help augment battery charging for these existing and new systems.

Another significant, often overlooked U.S. niche market is the sailboat market. Small wind turbines (e.g., Air Marine) are very popular with boaters. This market was one of the first to help launch Southwest Windpower to success.

Expected International Market

Predicting the future overseas market for the small-scale, remote power distributed wind applications market is not a simple process. Many political, technical, and fuel price variables will have a direct impact on future market growth. Energy demand for overseas markets will continue to rapidly grow in the near term (decade), but most will be supplied by conventional generation. Likewise, as oil prices continue to increase over the next decade, the economics of small wind systems improve. There will also be greater interest in using wind energy technologies as a clean energy technology to help offset CO_2 and other global warming emissions. The use of wind energy will become more desirable to operate remote diesel mini-grid systems as diesel fuel costs continue to increase. Small wind turbines (1 kW to 50 kW) can be shipped in containers and assembled and installed in areas with little or moderate infrastructure. The operation will be modular in that two to ten units can be added as needed. The prognosis is excellent for increased growth for small wind in the international markets for years to come.

China. China has been a leader in adopting small wind technologies. More than 70 million people in rural areas are still not connected to the national electricity grid. China has nearly 125,000 villages with 8.89 million households without electrical power. About one-third could be powered by renewable energy [4], as grid expansion is too slow and expensive. The province of Inner Mongolia has implemented a U.S.$30 million fund per year for 5 years for rural electrification. The United Nations recently completed a survey of Chinese village power and found that there are about 45 wind/solar or hybrid village power systems, with an installed capacity of 1,363 kW.

More than 170,000 mini wind turbines (60 to 200 Watts) operate in China, of which more than 110,000 are located in Inner Mongolia. An additional 12,000 units are installed in Mongolia. The annual production of mini wind turbines exceeds 21,000 units in the region. The Chinese government estimates that the total installed capacity of mini wind turbines was about 30 MW in 2000 and will be about 140 MW in 2020, with total energy generation of 90 and 450 GW-hours, respectively.

India. As per projections by the Indian Ministry of Non-Conventional Energy Sources, 10% of the 24,000 megawatts of the anticipated installed capacity requirement by the year 2012 will come from renewables. Half of this capacity (12,000 MW) may come from wind power. India has gained a wealth of technical and operational experience for mid-size to large wind turbines. It is anticipated that as the larger wind turbines become more popular, this will also have a positive effect on smaller wind turbine usage in rural areas and with hybrid systems. There are more than 24,000 remote village sites across all 23 states of India, many of which are located in good wind regimes.

Latin America. Mexico, Brazil, and the Caribbean represent the largest potential small wind markets in the Americas. More than 5 million people in Mexico in more than 70,000 small communities are without power. In 2006, the United Nations Development Program studied the use of distributed small wind systems for productive use applications in rural Mexico. The UN intends to help finance 15 MW of rural wind projects before the end of the decade. Likewise, Brazil has more than 25 million people without power in hundreds of thousands of dispersed small communities. Other areas, such as Central America and the Southern Cone, also have significant potential for hybrid systems development, with more than 10 million people without electric service.

Europe. Europe has an extensive electric grid, so there is little need for off-grid wind energy systems. However, there is some potential for small on-grid wind energy systems, which many Europeans would find attractive. Likewise, the European Union members are examining ways to successfully develop and market hybrid wind systems for developing countries, as well as supply high-penetration systems for existing diesel-powered micro grids. A survey from monitoring programs in France states that there were 276 renewable projects in the European Union, with only 24 projects that could be classed as hybrid or autonomous wind systems [5].

Spain has an increased interest in hybrid systems because of the recent success of the utility-scale wind farms in Tenerife [Spain]. In the Canary Islands, two research groups (ITC and ITER) are active in testing these types of systems. Federal funds are funneled to the CIEMAT test facility in Soria, Spain, to develop components and whole systems for autonomous hybrid systems.

Africa. Africa has seen relatively little use and development of small wind technology to date. South Africa, the most developed country on the continent, is only now seriously examining hybrid systems for village electrification. There are a few small pilot wind hybrid projects, including a 1-kW PV, 6-kW genset, 1-kW wind system by Peninsula Teknicon in Port Elizabeth, which is used to power a local radio station. There is a 500-W PV, 4-kW genset powering a remote area school north of Durban in Kwa Zulu, Natal Province. Finally, there are three 150- to 250-kW PV/wind/diesel hybrid systems powering the Hluleka Nature Reserve on the Wild Coast in the Eastern Cape Province, as well as two other villages in the same area.

Global. A good indicator of potential market size for small- and village wind hybrid systems is the need for electrification around the globe. Approximately 1.7 billion people around the world are without electrical service. The largest unserved electrical markets are in Asia and Africa. Table 2-1 provides relative comparisons among unserved electrical markets around the globe.

Technology Adoption Timeframe

While further innovations are needed for supporting technologies such as energy storage, the timeframe for technology adoption is not dependent on these. Generally, any site with a Class 2 or better wind resource, such as much of the Midwest, is good enough to justify the investment for a small wind turbine. Economics for small wind systems are very good in Class 3 or better wind sites. There is already a robust small wind energy manufacturing industry in China, the United States, and the United Kingdom.

One of the key drivers will be energy prices, especially as compared to conventional energy and the likely continued escalation of diesel fuels and electricity costs. There will be an eventual tipping point at which diesel mini-grids, which can already cost U.S.$.50/kWh or more to operate, become so expensive to operate that wind hybrid systems could become the system of choice for many regions. As other energy prices increase over the next 10 to 20 years, the market for small wind systems will rapidly open (especially grid-connected, the way it has recently opened for PV).

As the rest of the world becomes electrified, wind will be selected as a better option over extending the grid for many places. If the grid can be easily extended to a location, chances are good that it's already there. The remaining areas to electrify are often difficult to get to and located farthest from existing infrastructure.

Small wind technology and know-how exist already. We have experience with more than 150 pilot wind hybrid systems around the world. The small wind technology can be rather quickly adopted and implemented. Additional capacity building will be needed, especially overseas, to help hasten the pace of adoption.

Table 2-1. Electrical Access in Developing Countries by Region (Year 2000)

	Total Population Year 2000 (estimate)	Electrical Access With Access		Electrical Access Unserved	
	Millions	Millions	%	Millions	%
Total	5,060.0	3,391.7	67.0	1,668.3	29.2
Europe & Central Asia	477.1	472.4	99.0	4.7	1.0
Latin America & Caribbean	507.8	441.4	86.9	66.4	11.5
East Asia & Pacific	1,798.7	1,582.6	88.0	216.1	11.0
Middle East & North Africa	292.4	256.0	87.6	36.4	10.4
South Asia	1,343.5	529.5	39.4	813.9	52.2
Sub-Saharan Africa	640.5	109.7	17.1	530.8	66.7

Source: World Bank, 2001. Prepared from country-level estimates using best available data.

Non-Technical Barriers for Technology Adoption

Current small wind technology has not been as widely successful as small solar electric systems, even though solar is a more expensive technology. Issues regarding interconnection, cost, safety, and net metering for small wind systems impede market development. Some of the key non-technical barriers are as follows:

Cost. A key driver for all renewable energy technologies is the installed cost. The adage that "wind energy is free – but it's not cheap" is a problem, especially for the smaller wind turbines. The cost is particularly high for village systems. Many of these systems are initially subsidized by the government, but then there are no funds available for the long-term operation of the system.

Education. Education of people at all levels, including the general public, is a barrier to widespread wind technology adoption. Local maintenance personnel and installers need to be trained to reduce dependence on foreign knowledge and expertise. Utility and government planners should be trained so they can understand how wind can be a viable, economic, and reliable source of energy that can be employed without dependence on foreign assets. Information that is understandable to local users needs to be disseminated (workshops) during system planning. Information for the general public about wise energy use will go a long way in reducing the village power micro-grid loads during the initial operation.

Regional infrastructure. There is a critical mass of systems required in any region to develop and retain sufficient technical expertise to properly maintain systems. With enough systems installed in a region, regional utilities obtain economies of scale for administration, operation, and maintenance. Using a minimum of half local materials/construction methods would reduce overall system costs and involve the locals at the onset of a project. Keeping the size of projects manageable for the anticipated grid size is a method of keeping maintenance costs down. Systems can be worked on without significant outside involvement of tools and materials for unexpected repairs. Increasing in-country training of systems developers, installers, and operators would allow for quicker response to system errors, making more people available system-wide to notice discrepancies or poor system performance. Suppliers need to offer a minimum 2-year warranty on parts, labor, and travel. If conventional generation is included, the units should be supplied in country, which would reduce dependence of small countries on developed countries.

Developing industry in the host country can pay off in the long run for U.S. manufacturers. Reducing shipping costs and down time by having materials readily available will make local government more apt to choose them over a competitor. Showing that the technology can be turned over to properly trained in-country representatives and letting them "work the territory," instead of U.S. representatives coming in as outsiders, should pay handsome dividends, as well as taking advantage of favorable exchange rates in managing company payrolls.

Image. The small wind industry sometimes suffers from a poor image in some sectors. This is in part due to a number of installed substandard small wind turbines that were not very reliable. Overseas, the image is even worse, as almost any garage shop can make a perfunctory wind turbine out of a car alternator and fan blades. These homemade units do not have the same reliability as well-engineered production units.

Safety concerns also exist for installing and operating units, as well as for living in proximity to an operating unit. When a wind turbine that is designed to feather its blades is operated in high winds, it sounds like a Formula One racecar, and neighbors become concerned that the unit is about to self-destruct. Likewise, turbines have been known to throw blades, etc. So decisions to install a wind turbine next to highly populated areas, such as a school, may require extra thought and preparation. The industry should self-police itself and develop minimal safety requirements for turbines.

When prototypes of first system installations are made, manufacturers should make a concerted effort to support viable projects and not just make the sale. Ten village hybrid projects installed in Mexico in the 1990s left the industry with a poor image after most failed within a few years and essentially resulted in a national hold on this kind of development.

Developers and manufacturers need to take a long-view approach when working in a country for the first time. It may be more advantageous to design the correct system instead of selling the system requested that may not fit the bill. Even if a problem has nothing to do with the wind turbine (e.g., inverter failure), the wind industry image is still tarnished. One of the ingredients for SWWP's success is good customer service (even though SWWP had its fair share of turbine problems as the technology developed). Pilot and demonstration projects, especially for village hybrids, require at least 2 years of manufacturer support to ensure that everything works beyond the project inauguration day.

Institutional. Especially for village hybrid projects, institutional issues are key to the long-term project success. Too often hybrid projects involve complex technology that the local villagers cannot possibly operate and maintain. The community has to be involved in the planning process to determine goals and expectations. The implementation process requires sufficient political will, duration, good administration, and follow-up to be successful. Unrestrained load growth on a wind-hybrid village system cannot be supported. The industry must overcome the obstacle of villagers thinking that energy is free and no one at the local level has ownership in the system. Minimal payment for energy has to be implemented at the local level. It is important for the small wind industry to work with local partners on maintenance, tariff design, development coordination, planning tools, and delivery. The ultimate goal of such pilot projects is a standardized design for commercial replication. Project planning parameters that should be taken into account include performance, proven technology, loads, diesel retrofits, monitoring, buy-down, and bundling multiple projects.

Time-Critical Issues

Time critical issues are most often a factor of the project scale: the larger and more complicated a project, the more that time is an issue. A small individual wind generator of a few hundred Watts does not face significant time-critical issues for technology selection. The availability of small wind turbines is generally good in the United States, although such availability may vary regionally.

Larger village hybrid systems with perhaps hundreds of kilowatts of wind turbines face more time-critical issues, from possible new technology development (e.g., controllers) to the time and cost for transport and packaging of units (especially to remote villages). Also, often there are significant timelines for obtaining project financing for larger projects such as village hybrids.

Incentive Markets

In the domestic market, some states (and federal programs) provide wind energy subsidies and incentives. These include grant programs such as those offered by the USDA, net metering, and the production tax credit. Net metering is the only incentive that is really helpful for small on-grid systems. However, there are no relevant domestic incentives for small-scale, off-grid wind energy systems.

International markets have a variety of subsidies that are country dependent. Europe has feed-in tariffs that are beneficial for on-grid wind systems. Unfortunately, like the United States, European countries do not offer many incentives for off-grid wind systems.

Developing countries have even fewer incentives for small-scale, distributed wind energy development. In less-developed countries, rural users typically have limited financial means and usually do not even pay taxes. So the only possible subsidy of interest would be a direct subsidy for technology buy-down, and some international development programs will do this (e.g., the USAID/Winrock Dominican Republic small wind project in the late 1990s). The United Nations Development Program (UNDP) is already supporting small-scale wind development projects in China and Mexico.

Utility Industry Perspectives

For the most part, the utility industry (which includes rural cooperatives, investor-owned utilities, and municipal utilities) is not significantly impacted by the use of small wind turbines, either on or off the grid. Utilities can take advantage of small wind systems to limit their infrastructure investments. The utility did not build the hardware, so it does not have to maintain the wind energy systems. Individual small wind energy systems that are connected to the electric grid have essentially no impact on the grid and make the utility essentially indifferent to their application.

In developing countries, small wind systems can be an attractive option for utilities in lieu of extending the conventional grid to remote communities over difficult geographical hurdles. Some utilities operate independent diesel mini-grids that can use small wind turbines (given the appropriate resource) as a complementary fuel source that can help reduce diesel fuel expenditures and transportation.

V. Technical Barriers Issues and Assessment

Barriers for Small-Scale Turbines

There are many reliable and rugged wind turbines on the market for small wind systems. Small wind turbine technology has been around for some time, particularly for off-grid applications. The growth of small wind turbines providing grid-connected electricity is a relatively new market application, but it represents significant growth opportunities, some of which have already been realized. DC systems have an advantage of being more readily understood in remote areas due to exposure to automotive battery systems; however, AC power is more readily transported, and AC appliances are more available. Some of the key technology barriers for the further development and expanded implementation of small turbine technology are as follows:

Energy storage. One of the largest barriers to widespread small wind technology acceptance is energy storage, which is expensive. Most wind turbines use lead-acid battery storage, which is an old battery storage technology. Batteries currently offer the best method of energy storage for wind systems and help to reduce the on/off cycles of gensets when used at low wind/limited sunlight times of the day. The greatest fuel savings occur when the gensets are shut down; even a small amount of storage would aid in those periods when renewable energy flow is just meeting or slightly under the load needs.

Operation and maintenance (O&M). Wind turbines are rotating machinery, and thus they require maintenance. Long-term O&M is a problem, especially for installations in remote areas where there is little maintenance infrastructure. Lack of observation, diagnosis, and repair can take months or longer if there are no locally trained operators. O&M issues are of greatest concern in severe environments, such as corrosive coastal or severe arctic environments. Initial village installations need to be kept relatively small so that maintenance requirements are manageable. Inverters are expensive and generally not repairable at the local level.

Electrical grounding. Damaging lightning strikes are always an issue for the wind energy industry, big or small. Wind turbines in the West and Southeast often face significant problems from and can be shut down due to lightning events. Structural performance, sensitivity to electromagnetic effects, and grounding techniques make a difference as to wind system survivability.

Long-term reliability of blade coatings. Little research has been conducted on blade surface technology development and long-term life of coatings. Surface performance, soiling degradation, and aging are factors that are not currently monitored.

Controls. Power electronic and controls offer enhanced function. The most improvement in terms of system reliability and ruggedness can be made to the microprocessor or computer controller. Power monitoring of the grid is also an expensive item, yet a necessary component of any grid-tied system to keep the voltage/frequency levels suitable for good power transmission and to maintain suitable power quality. High-speed power switches can be made more rugged and able to energize on zero crossing of AC-voltage levels to minimize surges and unwanted harmonics in the microgrid.

Hybrid systems. There is a lack of high-quality, well-documented information of the true performance and costs of hybrid systems. Through detailed monitoring and evaluation of pilot systems, a large discrepancy was found between the power produced by small wind turbines and energy production estimates based on the wind resource and the turbine power curve. The reasons for this discrepancy vary but can result in as much as a 75% reduction in turbine output. Partial solutions include the wider use of discretionary loads and improved system control. System design impact should be considered, and computer models need to be evaluated to accurately assess this problem [6].

To avoid failure, village hybrid systems must include realistic system sizing and proper institutional controls from the onset. Planners must allow for anticipated load growth, a realistic tariff structure, and a means to meet future maintenance requirements. Allowable ranges of frequency fluctuation can be higher in microgrid applications than in conventional utility grid systems; a 3% variation is probably acceptable. This allows for simpler controllers and less stringent efforts on the part of the system controller to maintain frequency levels. Village power microgrids will often be the first exposure to utility power for many of the users, and they will not be disappointed with this level of variation over a day when compared with no power availability.

For wind hybrid systems to be a viable and sustainable energy solution for remote village applications, an adequate and manageable institutional structure must accompany the technology intervention. The need for accurate meters installed at each point of service is required to empower local leaders to establish a use-based tariff that is equitable and manageable. Villagers need to be trained on how to operate an equitable tariff system. Key lessons learned from village wind hybrid system experience around the world are as follows [6]:

- Maintenance is critical for long-term system survival.
- System ownership and responsibilities need to be established early.
- Metering is key for successful operation of village hybrid systems.
- Local village support and training are crucial for a successful hybrid system.
- Long-term planning is needed for all village hybrids.
- Corrosion-proof hardware for coastal locations is required.
- Battery charging from the generator is needed to enhance system efficiency and battery life.

Complexity of technical barriers. Maintaining a database of systems to determine what has worked and failed in other locales would help developers and designers pick components and controllers with a proven field record and avoid those that need more design or manufacturing improvements.

Diesel grids need to be retrofitted with hydrogen storage/peak shaving systems, a storable fuel cell, or heat engines to completely displace non-renewable fuels.

Design tools are helpful to plan or project the savings from hybrid operation; they must be readily available, user-friendly, and reliable. Simulating the mix of renewables with existing or planned conventional energy will help developers see the benefits of renewables when they are, in fact, economically viable. There are several good models to model complex systems, including the Hybrid Power System Simulation Model (Hybrid 2), the Hybrid Optimization Model for Electric Renewables (HOMER), ViPOR, and RETScreen International.

Optimal turbine size. For small household systems, optimal turbine sizes vary from about 0.3 kW to 3 kW. For hybrid systems, optimal turbine size is from 5 kW to 50 kW. This size range is considered the optimal village size, easiest to match with existing components and not too large to install in remote, undeveloped areas. Turbines are not readily available in size ranges for modular hybrid systems because there is not enough production volume to keep costs low, and the sizes currently in production make load matching difficult.

Cost of energy. System costs have been a stumbling block to the sales of small wind systems, especially for wind-hybrid systems. The key competitors for the small wind industry are diesel gensets, followed by the PV industry.

A small 1-kW wind system will cost approximately $3,200 to install. In a good wind regime, assuming a 20% capacity factor, such a unit might produce about 880 kWh/year. The most inexpensive wind turbines will cost about U.S.$1,000 to $1,200 to install, including all balance-of-system costs. This translates to a cost of energy of about $0.15 to 0.18/kWh for small wind turbines in a good wind regime and with little follow-up maintenance. The cost of energy of the wind turbine itself is about half of this amount; however, the final energy cost is due to the entire balance of system (inverters, cables, towers, etc.).

Thus, the small wind systems are already cost-competitive in off-grid applications, where diesel gensets can cost $.40/kWh or more to operate, and off-grid PV systems are almost as much. For on-grid applications, the small wind systems are not yet economically competitive with retail grid costs of $0.06 to .10/kWh. Some industry members believe that small turbine costs can be halved in the next 5 to 10 years, especially as production volumes increase [2]. Thus, in another decade or two, interconnected small wind turbines should prove competitive with an increasingly expensive grid power. However, for the meantime, subsidies and incentives will be required for small wind to compete against grid power.

For wind hybrids, the lack of a manufacturer with modular systems of the same design is a major problem. If standard-configuration, modular systems were available (instead of a newly engineered prototype or demonstration project), real costs would be reduced. Manufacturers would be able to buy components in bulk, and a single standard design, tweaked to fit the locale, would ultimately lead to commercial success.

Seasonal and intermittency wind resource impacts. For off-grid systems, seasonality is a larger issue. For instance, in the case of the Mexico Xcalak hybrid project, the villagers always suffered through about 2 to 4 weeks of little power during September, the lowest wind month [6]. This was unacceptable to them, and the issue would have been removed if the diesel generator were able to charge the battery bank. For other applications, the seasonality also can play a role, such as for water pumping (i.e., does the wind blow in the summer when the water is most needed?).

Some utilities (e.g., Xcel Energy, Idaho Power, Kansas co-ops) have installed off-grid solar energy systems to pump water so that extensive rural lines do not have to be maintained for small loads. It is conceivable that utilities could also be sold on the same concept for small wind systems (although in the Midwest there is a tendency for less wind in the summer when water pumping is of highest priority).

Interface. For small wind hybrid systems, 120- to 240-volt AC single-phase and 240- to 480-volt 3-phase microgrids are the two most common system voltage/configurations. Single-phase systems are most commonly selected for lighting and residential use, while the 3-phase is selected to handle industrial loads and to take advantage of the cheaper 3-phase gensets available. There are also many small off-grid wind systems used for battery charging, normally at 12 or 24 V.

Some components are incompatible when a wind turbine is combined with controllers, batteries, and PV or diesel gensets. While the individual components can be obtained from current manufacturers, it is often the designer's problem to size and integrate components to provide the best overall system. The integration of mismatched components will yield a working system, but not one that gives the best energy value over the life of the system. For off-grid systems, component mismatch is larger since there are more components than for grid-tied AC systems.

VI. Recommended Areas of Technical Concentration

Technical Challenges

Technical challenges focus on systems integration but also include innovative designs of controller/inverter integration or simply modifying current wind turbines to allow battery charging or autonomous operation. Some of the key areas for future technical research are as follows:

Energy storage. Small wind can be used in combination with other generation or with energy storage capability alone to meet small to medium loads. Adding some storage can improve fuel savings by reducing diesel start/stops and by reducing idling. Idling units consume 30% of full-load fuel rates. This also requires a reliable starting mechanism for each independent genset. But the battery bank comes at a high initial cost, and battery maintenance is an additional system operating expense. There may be other, newer energy storage technologies, such as NiMH batteries or fuel cells that can be used to replace more traditional lead-acid battery technology. Additional research should be performed on short-term battery storage to reduce diesel cycles during low/medium wind conditions when lightly loaded gensets are least efficient.

Controllers. Controls and metering need to be assessed for differing applications. Controllers and the control strategy that will simplify the coordination and connection of many manufacturers' units into a seamless system are a top research priority. The highest priority should be given to controllers, which determine the operational stages and integration with the conventional diesel gensets. Testing of the controllers near system limits of stability for extended periods of time is imperative. However, efforts also need to be placed on a standard methodology and a robust and reliable control plan. While some fluctuations are allowed, overall power quality will not be compromised. The operating stages are diesel, hybrid, and renewable power. Adding variable-sized diesels with complex controllers is a second method to better match loads to resource; starting a 30-kW diesel instead of a 100-kW diesel for a 20-kW load is preferable over the long term. There are limited developers and suppliers of controllers that are compact and rugged enough to last in field conditions for the life of the system. This limited availability results in high initial costs and a lack of opportunity to develop a standard controller for general applications rather than a specific high-cost controller for each system as it is specified.

Technology improvement. Optimizing rotor/controls for small wind turbines, along with optimizing the overall system layouts/controls should be completed. Among the prime targets are:

- New blade designs for light wind regimes
- Low Reynolds Number airfoils
- Axial permanent magnet generators
- Switched reluctance generators
- Passive yaw/passive power regulation
- Energy storage.

Hybrid village systems. Research has to be directed at reducing cost and improving performance and reliability. Many of these problems are intertwined with institutional issues at the local and regional level. Even though standardization and modular components would help reduce costs, the main problem is to have the standard, modular components in an integrated working hybrid system that is robust and has high availability. Economies of scale are needed to reduce costs for remote villages.

A standard design with modular components must be developed for village hybrid systems. This would allow resources to be added as the load grows within the original design. A new design for each village power system is a waste of engineering effort and cannot reduce costs. Low-maintenance and easy-to-maintain and easy-to-operate systems must be developed.

Computer models need to be validated against village hybrid systems at three stages: planning/design, installation, and after at least 2 years of operation. A simplified spreadsheet tool of expected performance and costs, with graphics output, for planners who are not technical experts must be readily available.

A database on problems of village systems at the following three stages must be developed: planning/design, installation (first 3 months of operation), and after at least 2 years of operation. Unless a database of component failures is available, it is difficult to determine where research emphasis should be placed. The current NREL village power database should be extended to include this information.

Targets to improve the amount of operating time in hybrid mode are:

- Reduce wind speed cut-in of turbines by increased rotor area
- Use as high a penetration of turbines as can be economically afforded to increase the wind band percentage time
- Increase the reliability of system controller to supply synchronous capacitance to maintain grid frequency with no diesel operation
- Rugged dump loads to shed unneeded power into useful storage at times of high wind/low village load.

Water desalination (salt or brackish water). Many areas with fresh water limitations have brackish or saline water availability in differing aquifers. This is especially true of coastal regions where there is also a good wind resource, as well as many desert regions. Wind energy could be applied to desalination techniques that could prove to be a huge industry. Likewise, fresh water can be stored fairly inexpensively. Technical challenges include assessing direct (high-efficiency) desalination opportunities and integration with wind turbines. This could be a particularly interesting market sector for off-grid small wind.

Table 2-2. Summary Information Table: Small-Scale Remote Power (Residential or Village)

Domestic Market Off-Grid Only	**Regions of Specific Interest**
(Specify units – MW potential, # of units)	*(not year-dependent)*
2010 16,000 turbines/yr, 11 MW	1. Western states (ranches, etc.)
2015 40,000 turbines/yr, 28 MW	2. Tribal lands (Alaska, Navajo)
2020 85,000 turbines/yr, 60 MW	3. Islands, sailboats (New England, Washington)
International Market Off-Grid Only	**Countries of Specific International Interest**
(Specify units – MW, # of units)	*Off-Grid*
2010 24,000 turbines/yr, 17 MW	1. China
2015 60,000 turbines/yr, 42 MW	2. India
2020 150,000 turbines/yr, 105 MW	3. Caribbean
Key Technical Barriers	
1. Energy storage 2. Reliability/BOS lifetime 3. Undersized/underdesigned 4. Maintenance availability	
Key Market Barriers	
1. Cost 2. Lack of market investment incentives 3. Training/education 4. Image (noise, safety, reliability concerns)	
Expected Turbine Size Range	
0.3 kW to 60 kW United States 0.1 kW to 10 kW International	
Expected Turbine Coupling	
Mechanical (High speed:__; Low speed:__; proposed nominal speed:_____) Electrical (Voltage: 12 to 48 DC, a few hybrids at 240/480 V AC; 1- or 3-phase) Thermal (Temperature: _____) Other: ____________	

VII. Conclusions

The known problems have not changed much over the past few years. The major problems involve cost, low performance and reliability, and institutional problems. Also the maintenance should be allocated so that the villagers do not feel that the new power source is simply a right or gift from a benevolent government but is their responsibility to operate and upkeep. Charging even a pittance to ensure that the benefactors of the power are also the ones supporting its operation would make each one responsive to the real costs and value of this energy. This could also curb the unlimited growth in power use as more and more villagers become used to the advantages and benefits of reliable electricity. Village systems that were designed for 10% load growth over 5 years and experienced increases of 20% to 30% in a single year can quickly be overtaxed and fail prematurely.

Some key barriers facing the small wind industry for widespread adoption of small wind systems (both off-grid) include the following:

- Deployment challenges
- Untrained dealer network and high dealer pricing
- Questionable (unverified) wind resources
- Lack of available towers
- Lack of market investment incentives.

Planners should develop regional utility systems or cooperatives for village power systems for administration and maintenance. The hybrid system is still operated at the local village. There must be enough systems in a region or a state for a viable infrastructure. The main recommendations for further development of the use of distributed wind power in isolated power systems are as follows:

- Develop the use of wind power in isolated systems as concerted actions in national and international programs rather than as individual projects.
- Join forces in development of international standards for decentralized power systems with renewable energies.
- Develop best practice guidelines as dynamic documents with common references and based on updated experience from recent projects.
- Promote wind power in small- to medium-size systems following simple and proven approaches; e.g., by repeating and/or downscaling pilot and demonstration systems with positive track records.
- Filter down from the large-scale systems any technological achievements adaptable to smaller systems.
- Invest research and development in small systems to support development of rugged technology applicable for remote communities.
- Use modeling assumptions from the hardware reality for the types of systems that will be applied.
- Install experimental systems only at test benches prepared to serve as experimental facilities.

- Encourage the industry to offer medium-scale wind turbines (10 kW to 300 kW) for hybrid system applications; large wind turbine manufacturers need to give priority to allocation of production line capacity for smaller machines.

In summary, the technical capacity to design, build, and operate isolated power systems with high penetration of wind power exists, but the mature product and the market have not met. Interesting markets, such as water desalination, have not been significantly explored. The above recommendations are seen as moves that would lead to development of the use of wind power in distributed power systems, but as in any technological development process, financing is needed.

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Chapter 3. Residential Power

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I. Executive Summary

The distributed wind industry is poised for rapid market growth in response to continuing energy price hikes and increased demand for on-site power generation. However, in order for distributed wind to reach its mainstream market potential, the industry must overcome several hurdles, primarily in system costs, interconnection, and installation restrictions.

This study provides a preliminary assessment of the grid-connected residential wind market, with an emphasis on potential market size and critical technical and market barriers. It recommends high-priority research, policy, and outreach efforts to address these obstacles. This study is designed to assist the U.S. Department of Energy (DOE) Wind and Hydropower Technologies Program and NREL in their consideration of future technical and other programmatic investments.

The study confirms substantial and growing market potential in this sector; the dominant role of the United States distributed wind turbine (DWT) industry in domestic and international markets; and compelling reasons to continue research, development, and dissemination efforts to foster continued market expansion. Findings are based on surveys and interviews with key industry participants, a review of published and unpublished articles and studies, and the industry familiarity and expertise of the team members who conducted this study.

The small wind turbine and distributed generation markets are emergent in nature, with approximately 2,900 residential grid-connected turbines totaling 14.5 MW installed worldwide as of 2005. United States turbine manufacturers provide an aggressive outlook for the DWT market, forecasting approximately 32% annual growth in grid-connected residential sales. Historically, the residential grid-connected sector has comprised less than 5% of total small turbine sales (up to 100 kW). However, manufacturers expect that portion to grow to more than 20% by 2020. As a mid-point forecast between lower and upper bound estimates, this study projects that this sector of the DWT market will grow to about 78,000 units totaling 830 MW worldwide by 2020.

Currently, United States manufacturers dominate the world market, but new turbines from China, India, and Europe will provide stiff competition for U.S. products in overseas markets and

potentially in the U.S. market as well. China and United Kingdom provide examples of strong government support for DWT product development and market incentives.

Historically the most significant barrier to residential market growth has been high total installed costs, which essentially reflects the cost of energy generated. The economics of residential DWT are highly variable, with an average cost of energy in the range of $0.08-0.12/kWh required to be competitive with conventional generation sources. The most common alternative to residential DWT, solar photovoltaics (PV), currently has total installed costs of about $7-10/W or around $0.20-0.35/kWh without incentives, compared to $4-7/W or $0.12-0.15/kW for grid-connected DWT. In order to achieve significant market expansion in the U.S. grid-connected market, reductions in DWT total installed costs to $2-3/W are needed. This can be achieved through technology improvements along with policy support. Drivers of market growth include financial incentives, favorable net metering, standardized interconnection policies, and high retail electricity rates. Key technical challenges include the lack of performance standards and ratings, product reliability, low-wind-regime technologies, and quiet operation.

Oversight of performance certification and compliance testing is urgently needed to address critical reliability and credibility issues in order to support major expected growth in the grid-connected residential wind market. A third party familiar with the issues of both inverter and turbine manufacturers is in the best position to bridge the gap and provide innovative system solutions. These are important roles for an independent national testing laboratory to fill.

With large wind turbine and PV manufacturers scrambling to keep up with demand, this study describes how the distributed wind industry can overcome long-standing stumbling blocks and play an important role both in the United States and internationally in supplying power at the point of end use. Efforts to enhance the viability of the DWT industry will have major global benefits in securing future energy supplies and meeting increased demand for decentralized, affordable clean power.

II. Application Background

Residential distributed wind generation, for the purpose of this study, is defined as small wind turbine systems, typically 1 to25 kW, connected to the utility grid on the customer side of the meter to supply electricity for residential applications, also referred to as grid-tied or grid-connected residential DWT.

Small wind energy systems provide clean, renewable power for on-site use and help relieve pressure on the nation’s power grid, while providing domestic jobs and contributing to energy reliability and security. The United States pioneered this technology in the 1920s, and it is the one renewable energy technology that the United States still dominates. American companies lead in both technology and world market share. In contrast to utility-scale wind turbines that no longer have a strong U.S. manufacturing base, more than 90% of small wind turbines installed in the United States are still manufactured in the United States.

Based on industry statistics, the 1- to 10-kW segment of the residential DWT market currently has the widest product coverage, with numerous market newcomers expected in various sizes [1]. Growing current and potential markets for these turbines are found in industrialized as well as developing countries.

Small wind turbine systems are typically procured by property owners. Manufacturers market their systems through distributors, dealers, and directly to customers. Local dealers or installers typically install grid-connected systems, although some customers install their own systems with inspections conducted by certified electricians. The wind resource, turbine size and model, micro-siting, and installation requirements such as tower height and foundation are site-specific. Many states, counties, and utilities are promoting distributed wind generation for its clean energy benefits and contribution to renewable portfolio standards, energy reliability, and energy independence.

Widespread deployment of small wind turbines can increase the public's familiarity with wind turbine visual impacts, attract mainstream media coverage, and pave the way for local community support for larger wind developments. Small turbines, in particular installations at schools and other high-visibility locations, can become an important asset in reducing fears about unfamiliar technology, which in turn can help reduce the expense and unpredictable nature of siting and permitting large wind developments. Small turbines can be installed in selected neighborhoods to increase public awareness of residential wind options and provide an additional benefit by educating students on how electricity is made and the benefits of wind power. Neighborhood DWT installations can also help utilities increase customer interest and participation in voluntary green power programs and provide local "advertisements" of utilities' involvement in renewable energy.

III. Current Status of Grid-Connected Residential Distributed Generation

The Future

Residential DWT installed capacity has historically comprised less than 5% of total sales of small wind turbines (up to 100 kW) [worldwide]. However, manufacturers expect that portion to grow to more than 20% by 2020 [2]. The U.S. Department of Energy Renewable Energy Plant Information System (REPiS) has documented nearly 1,200 small wind turbines (up to 100 kW) totaling 16 MW as of 2005 in 45 states. Approximately 70% of the DWT systems and 40% of the DWT capacity documented in the REPiS database are estimated to be grid-connected residential applications [3].

Based on a review of available market data, this study estimates that approximately 700 wind turbines totaling 3.5 MW were sold worldwide for residential grid-connected applications during 2005, with 500 of these totaling 2.5 MW sold in the United States. This study estimates that the cumulative grid-connected residential installed capacity was 2,900 units totaling 14.5 MW worldwide as of 2005, with 1,800 of these units totaling 9 MW installed in the United States.

Market challenges. Because economics are a significant barrier to market adoption and growth of grid-connected DWT, it is important to examine factors contributing to turbine system costs. Key determining factors include turbine size (rotor diameter, rated capacity), average wind speed at hub height, power output control/limitation technology, and applied grid control technology. External factors include infrastructure and transport logistics costs, permitting costs and time, and other location-specific conditions.

From the perspectives of power generation potential (kWh/kW), return on investment, and cost of energy (cents/kWh), current small turbine designs are at a disadvantage compared with much larger utility-scale wind turbines. Small turbines are relatively more expensive to manufacture (both materials and labor) and their limited hub heights (because of cost, setback requirements, aesthetics, etc.) result in comparatively less energy production. In addition, their low volume currently manufactured impede cost reductions with series-scale production [4]. The lack of performance standards, independent testing and consistent ratings for DWT contribute to product reliability concerns in the market. Complex interconnection standards and the reluctance of utilities to adopt net metering and DWT incentive programs further constrain the market and hinder market efficiencies. Dealers and installers increasingly report that the insurance industry is requiring additional insurance coverage for DWT owners. Finally, small wind turbines are not consistently addressed in state renewable portfolio standards (RPS), incentive policies, and consumer education campaigns.

In the United Kingdom, the most commonly perceived barriers to residential distributed generation are permitting, expensive metering, lack of installation targets and incentives, high cost, and low consumer awareness. As in the United States, the United Kingdom experiences a high correlation between incentives and installations [5].

Utility acceptance. The market for grid-connected residential wind is primarily rural homeowners and small businesses. Many domestic residential sites appropriate for wind power are served by rural electric co-ops (RECs), which typically view net metering and distributed generation as cross-subsidies and inconsistent with co-op principles that members share equally in the investment, risk, and benefits of the co-operative [6]. The official position of the National Rural Electric Co-operative Association (NRECA) is that net metering results in reduced co-op revenue while the fixed costs remain the same and that the co-op’s other consumers ultimately subsidize the self-generating consumer [7]. While RECs do hold a large territory, many other utilities in more populated areas do not oppose net metering. However, most utilities still require significant education, softening of interconnection requirements, and generally an improved understanding of the benefits of capturing consumer investments in DWT.

Potential new market segments. While the rural residential market has been the primary target for United States grid-connected small wind systems, new initiatives are exploring the urban and suburban markets. Among others, a U.S. manufacturer is aggressively pursuing small wind for the suburban residential market with new turbine technology and shorter towers. It can be anticipated that at least 1 year of market experience will be required to determine if this is a viable market segment for DWT and to identify the key technical and market barriers for this market segment, as well as the best practices for suburban residential market penetration.

Several efforts are underway internationally to develop roof-top mounted [8] and building-integrated DWT designs [9], but so far none have proven commercially viable. It is premature to anticipate the feasibility of such designs, especially until extensive testing establishes that they pose no potential threat to the integrity of the structures on which they are mounted. The concepts are mentioned simply as examples of enabling technologies that may have the potential to significantly augment the distributed generation market in the future.

IV. Market Barriers Issues and Assessment

Expected United States Market

Market targets. Historically, rural properties have been the primary market for residential-scale wind distributed generation systems. The industry is increasingly focused on the rural residential market, with new attention on the large-lot suburban residential market. As shown below in

Figure 3-1, a 2004 survey of readers of Home Power Magazine (3,573 respondents) indicated that 38% intended to utilize renewable energy in a rural home, 27% in a suburban home, and 16% in an urban home, with more than 40% of respondents planning to install wind turbines [10].

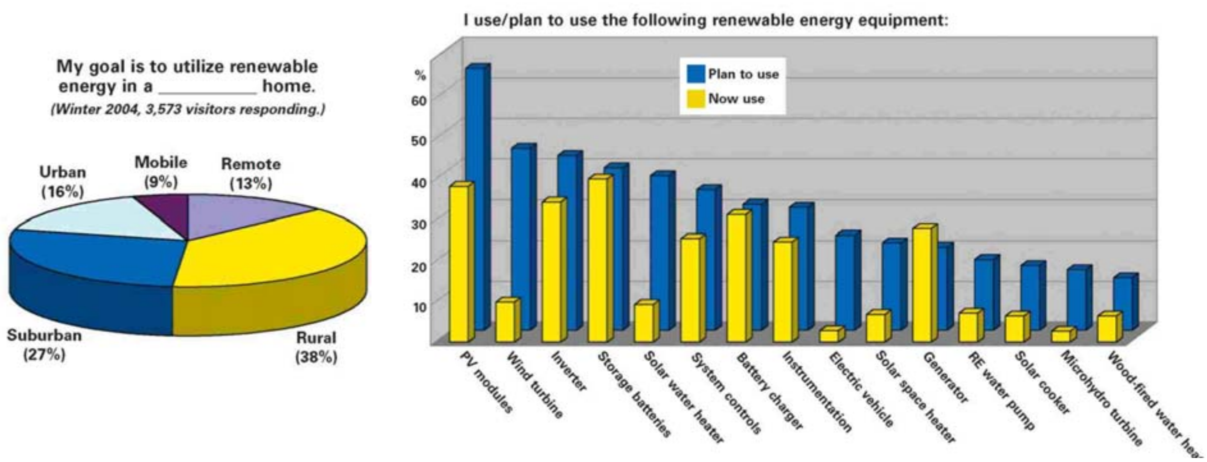

Figure 3-1. Renewable energy system end-use information from *Home Power* readers' survey

Market potential. The growth potential of the U.S. residential DWT market presents a unique, timely opportunity. Moreover, trends show that growth may occur at significantly increased rates if critical market barriers are overcome. A new market survey of the grid-connected residential wind market was conducted for this study in January 2006[1]. This most recent survey found that the leading U.S. DWT manufacturers are projecting an average annual growth rate of 32% for the U.S. grid-connected market through 2020, with their potential domestic market share as high as 9,500 units totaling 26 MW in 2010, 21,000 units totaling 70 MW in 2015, and 41,000 units totaling 130 MW in 2020. These projections provide an aggressive outlook for the DWT market and signify that manufacturers are confident that the market is poised for strong growth.

It is important to note that predictions about the percentage of future DWT market growth vary greatly and often depend heavily on the degree of expected state and federal support for DWT. The DWT market study conducted by the American Wind Energy Association (AWEA) in the spring of 2005 [11] found that in ideal market conditions (i.e., with sufficient policy support), annual U.S. sales of DWT could reach $55M by 2010. The same study forecasts a slow growth scenario based on scaled-back projections from only the established industry players, estimating annual U.S. sales at $27M in 2010 if the key barriers are not addressed. These estimates represent higher and lower bound average annual growth rates of 24% and 9%, respectively; however, some industry members believe that these projections are too conservative. With increased monitoring of these market trends, it is becoming increasingly evident that the DWT industry has the potential to become one of the leading renewable energy distributed system industries for residential homes in the United States.

[1] See the Acknowledgements section for a list of survey participants.

In 2002, AWEA set a bold industry goal of installing 50,000 MW of total DWT capacity (3% of domestic electricity demand) by 2020 based on census data for appropriately sized lots and acreages, and put the total potential domestic market at 15.1 million homes[2]. The AWEA report estimated that more than 80% of the United States DWT market will be grid-connected residential systems with an average turbine size of 7.5 kW. Reaching 50,000 MW by 2020 would require average annual growth of around 60% over the next 15 years. Although this is an ambitious goal, given the recent annual market growth of 40% [12], it may be obtainable with adequate incentives, research and development (R&D) funding, and other policy support at state and federal levels.

In consideration of these studies and familiarity with current industry trends, this study conservatively estimates that cumulative U.S. on-grid residential wind turbine installations in 2010 will have a lower bound of 5,100 units totaling 29 MW and an upper bound of 7,400 units totaling 44 MW, with average annual growth rates of 9% and 28%, respectively. An increase in the average turbine size for this sector from 5 kW in 2005 to 9 kW in 2020 is projected as a result of the availability of new products. As shown in the Summary Information Table (Table 3-5), assuming the same growth rates in the number of units, this study's lower and upper bound United States estimates are 10,000-26,000 units totaling 72-211 MW in 2015 and 18,000-92,000 units totaling 170-1,000 MW in 2020, resulting in a midpoint forecast for the United States grid-connected residential market sector of 55,000 units totaling 590 MW in 2020.

One of the conclusions of this study is that the residential wind industry would benefit from a new, detailed potential market analysis. An in-depth market study focused on consumer motivations would provide valuable information to inform research, product development, marketing, and policy decisions.

Regions of interest. The criteria for states in the United States with strong residential DWT markets include high residential electricity rates and/or loads, adequate wind resources, financial incentives, clear and reasonable permitting requirements, positive public perception of small turbines, state or utility public education and awareness campaigns, and simplified interconnection processes.

Taking into consideration relevant economic variables, a 2004 study by Lawrence Berkeley National Laboratory calculated simple payback for DWT break-even turnkey costs in the United States [13]. The top ten states for DWT simple payback at $2.50/W were reported to be California, New York, New Jersey, Rhode Island, Vermont, Hawaii, Montana, Maine, Alaska, and Illinois.[3] Since then, California and Illinois rebate funding levels have declined, and Massachusetts and Washington have introduced significant DWT incentive programs. Fifteen states have renewable energy funds with $3.5 billion in aggregate for renewable energy from 1998 to 2010: California, Connecticut, Delaware, Illinois, Maine, Massachusetts, Minnesota, Missouri, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, and Wisconsin [14]. However, so far only a few of these have established funding mechanisms for DWT.

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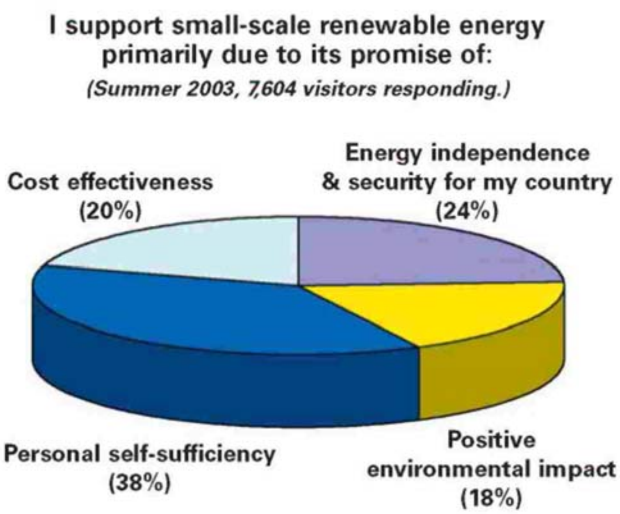
[2] The 2002 AWEA Roadmap estimated that by 2020 there will be 43.2 million homes with more than 0.50 acre of land and that 35% of these homes will have a sufficient wind resource to generate electricity from DWT.

[3] The model assumed a 10-kW system, 25-year system lifetime, 8% IRR on investment, operating and maintenance at 1.5¢/kWh, cash payment, and wind production valued at full average residential electricity rate.

Responses to the survey conducted for this study confirm that the states of specific interest for the grid-connected residential market fall into three primary regions:

- West Coast (California and Washington State)
- Northeast and Mid-Atlantic (New York, Massachusetts, Pennsylvania, Vermont)
- Midwest/Central (Texas, Ohio, Minnesota, Iowa, Wisconsin, Colorado).

Correlations to residential PV. Considerable market information is available for the residential PV industry that could be useful to the DWT industry. Examples include trends in grid-connected PV installations and forecasts,[4] cost of energy, consumer demographics, purchase criteria, effectiveness of incentives and market drivers, and potential applications and market size for hybrid wind/PV systems. This insight can help inform marketing and technology decisions for the potentially large suburban residential market that some small wind turbine manufacturers are beginning to target.



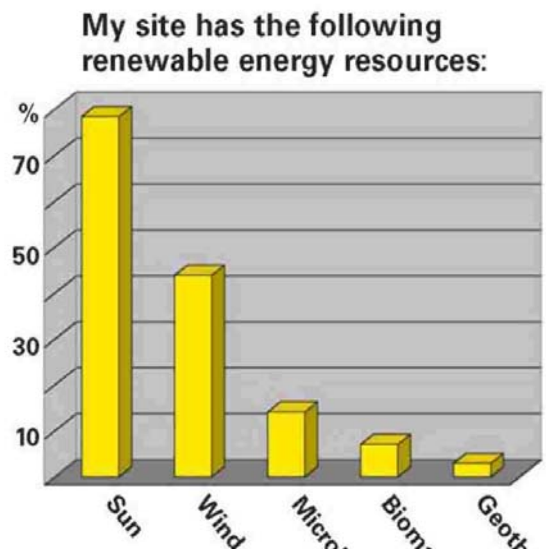


Figure 3-2. Renewable energy end-user information from *Home Power* readers survey

[4] The U.S. Department of Energy's Energy Information Administration (EIA) forecasts residential grid-connected PV to be 127 MW of installed capacity in 2010, 141 MW in 2015, and 157 MW in 2020. The calculations are based on 2-kW residential systems.

It is also important to note that the PV industry has significant public support and resources to advance policy incentives, obtain research funding, and conduct public education and awareness campaigns. Coordination between the DWT and PV industries based on similar interconnection technologies and overlapping target markets could prove effective for developing recommendations beneficial to both industries. Customer motivations and resource information, such as that collected by Home Power Magazine in a 2003 reader's survey (Figure 3-2) can provide important insights for marketing both PV and DWT.

Expected International Market

U.S. DWT manufacturers are in an excellent position to take advantage of the international DWT market. AWEA estimates that more than 40% of U.S.-manufactured DWT are exported [15]. Currently, two U.S. manufacturers, Bergey Windpower and Southwest Windpower, are both recognized as the world's dominant market leaders in terms of sales volume [16]. A recent study conducted by Marbek for the Canadian Wind Energy Association indicated that 96% of reported sales in Canada are attributed to three U.S. manufacturers: Bergey Windpower, Southwest Windpower, and Aeromax [17]. The international export market, therefore, presents a considerable economic opportunity for U.S. manufacturers, both for grid-connected residential DWT as well as off-grid, remote applications.

The 2006 market survey conducted for this study confirms a robust international export growth outlook. The leading U.S. DWT manufacturers are projecting an average annual growth rate of 34% for the non-U.S. grid-connected market through 2020, indicating a potential U.S. export market of 3,200 units totaling 11 MW in 2010, 10,000 units totaling 31 MW in 2015, and 22,000 units totaling 66 MW in 2020.

Other estimates of the international DWT market come from AWEA's 2005 DWT market study and a 2002 study by Garrad Hassan Consulting. The AWEA study estimates that the international small wind market is roughly the size of the total domestic market and that 40% of DWT manufactured in the United States are exported. A 2002 article in REFOCUS magazine by United Kingdom-based Garrad Hassan Consulting projects a five-fold increase from 2002 for global small wind sales. This estimate equates to 150 MW/year, or 150,000 turbines/year assuming $5/W total installed costs and an average turbine size of 1 kW [18].

A number of countries have shown considerable interest in DWT technologies. In 2005, Canada and the United Kingdom published studies about their potential markets for small wind. A 2005 United Kingdom study on "microgeneration" anticipates up to 5 GWh of energy from residential wind by 2030 (1.5-kW systems), with a doubling by 2050 and with small wind supplying 4% of United Kingdom's electricity requirement [19]. The study, commissioned by the UK Department of Trade and Industry, estimates an upper bound of nearly 120 MW and a lower bound of 20 MW of installed DWT capacity by 2020, depending on the amount of government support.

The Canadian study reports a total potential of 120,000 units for grid-connected residential, 3-kW average capacity, and total capacity of 360,000 kW. The study references U.S. programs and market adoption rates and concludes that the Canadian DWT market requires incentives in four areas: market development (federal rebate and provincial incentives), policy development (net metering and streamlined environmental processes), technology development (standardized testing and demonstration programs), and education and awareness-raising (model interconnection agreements and installation guidelines for siting, zoning, permitting, and interconnection) [20].

Lawrence Berkeley National Lab reports that China manufactured 12,000 small wind turbines in 2000 and that the Chinese market has been strongly supported by government policies and incentives [21]. In February 2005, China passed a groundbreaking law to promote renewable energy. However, while China has a great potential for wind, as in much of the world, its primary market is off-grid rural electrification [22].

In consideration of these studies, the large DWT market share held by U.S. manufacturers, and familiarity with current industry trends, this study conservatively estimates lower and upper bound international annual growth rates of 11% and 28%, respectively. These rates are slightly higher than those estimated for the domestic residential DWT market as a result of the likelihood that new international residential markets will continue to emerge and expand. As with the U.S. market, the average international turbine size for this sector is expected to increase from 5 kW in 2005 to about 9 kW in 2020 as a result of the availability of new products.

As shown in the Summary Information Table (Table 3-5), using these estimated growth rates for the number of units, cumulative international on-grid residential wind turbine installations in 2010 are estimated to have a lower bound of 2,500 units totaling 14 MW and an upper bound of 3,300 units totaling 19 MW. Lower and upper bound international grid-connected residential wind installation estimates are 4,800-11,000 units totaling 34-86 MW in 2015 and 8,700-37,000 units totaling 82-410 MW in 2020, resulting in an international mid-point forecast for this sector of 23,000 units totaling 250 MW in 2020.

Regions of interest. Responses to the survey conducted for this study indicate that the major international markets for grid-connected residential wind fall in these three regions:

- Asia (Japan, China, India)
- Europe (United Kingdom, Spain, Italy, Germany, Netherlands, Greece)
- Central and South America.

Technology Adoption Time Frame

There are some technologies on the horizon that could stymie the implementation of worldwide residential DWT. Fuel cells are often cited as a potential future example. However, commercially available fuel cells that do not rely on ever-tighter supplies of natural gas will not be available for several decades. By contrast, the recent United Kingdom “microgeneration” study forecasts mass-commercialization of DWT in 2015, with electricity prices the most important market change for small wind [23].

A much more immediately available technology, and one that “competes” with small wind in various applications today, is PV. Given the current public benefits programs, PV is more competitive than wind in the 1- to 3-kW category. In addition, currently PV systems can be ordered, permitted, and installed in a fraction of the time that is required to install a comparably sized residential wind turbine. However, in areas that do not have incentives for PV, residential wind is cost-competitive and easily installed for those facing reasonable zoning, permitting, and interconnection requirements. While PV is often viewed as a competitor, market growth can be anticipated in hybrid wind/PV systems.

That said, there are still pressing hurdles that the DWT industry needs to overcome to reduce consumer hesitation with the technology, specifically in regard to reliability and timeframe for installation. In addition, the limited availability of cost-effective, state-of-the-art, synchronous inverters is a constraint to 3-kW (and larger) grid-connected variable-speed turbine types. While the manufacturers of these inverters also manufacture products for the grid-tied PV market, the inverter itself controls DWT generators differently than PV systems. When a small wind turbine manufacturer develops a new turbine model, inverter manufacturers may find it risky to invest in a new product line without the prospect of selling substantial numbers. Inverters and system electronics continue to be the least reliable component of small wind technology, which in turn has stalled innovation [24]. Some companies, such as SMA of Germany and Magnetek of the United States, have designed inverters for a number of residential wind turbines.

Development of new small wind turbines that do not require an inverter for grid-intertie applications is another direction being pursued by a few designers. This would bypass the above-mentioned dilemma. However, current development on these concepts has been greatly slowed by lack of R&D funding. Multiple paths for inverterless small wind turbines should be employed to seek the best solution to connecting DWT to the grid in a timely manner, including direct-drive induction generators and gear-driven systems.

Another significant time-sensitive barrier to current small wind turbine designers is the lack of effective computer modeling covering all components of a small wind turbine, in a variety of wind conditions including furling wind speeds. Quickly addressing this need could expedite crucial design improvements to help meet required cost targets during this critical window of opportunity to maintain U.S. dominance in this sector.

Towers are one of the greatest challenges for DWT. Towers for large wind turbines are generally less than 20% of the hardware cost. For small wind turbines, towers often comprise 40%-80% of the hardware cost. A concerted effort to develop more cost-effective designs with composites or other materials should be explored.

Non-Technical Barriers for Technology Adoption

The January 2006 survey (Table 3-1) conducted for this study indicates that economics, lack of incentives, zoning, public perception challenges, and interconnection issues are the most significant barriers to residential DWT market adoption. Up-front costs also are rated as the key decision-making factor in a recent Canadian DWT market study [25].

Economics

Most consumers carefully weigh the economics of DWT systems, taking into consideration total installed costs, out-of-pocket costs, perception of value and return on investment. Factors contributing to DWT system costs are listed above in the market challenges section. Reductions in total residential DWT installed costs from the current range of $4-7/W to $2-3/W after incentives will be necessary for significant market expansion in the U.S. grid-connected market [26]. This estimate is based on an analysis of PV module shipments vs. price (Figure 3-3) and an assumption that since PV and small wind are competitors in the grid-connected market, small wind must be priced competitively with PV.

Lengthy and costly permitting processes, requirements to access state incentive funds (environmental analyses, site assessments, installation inspections, lengthy applications), and other site-related processes also drive up total installed costs because dealers and installers typically assist consumers with these steps. Inconsistent “rated output” turbine model designations may be an additional factor in reducing consumer confidence and perceived value.

Table 3-1. 2006 Survey Responses on Grid-Connected Residential Wind Market Barriers

Residential Wind Market Barriers	Not an Issue	Moderately Low	Medium	Moderately High	Biggest Barrier	Response Average
Economics / out-of-pocket costs (total installed cost)	0% (0)	2% (1)	26% (11)	**55% (23)**	17% (7)	**3.86**
Economics/perception of value (cost of energy, return on investment)	0% (0)	10% (4)	26% (11)	**43% (18)**	21% (9)	**3.76**
Lack of incentives (rebates, buy-downs, loans)	2% (1)	22% (9)	17% (7)	**49% (20)**	10% (4)	**3.41**
Restrictive zoning	10% (4)	18% (7)	**28% (11)**	**28% (11)**	18% (7)	**3.25**
Connecting to the grid (rural electric co-op)	5% (2)	22% (9)	29% (12)	**34% (14)**	10% (4)	**3.22**
Visual impacts/neighbor concerns	0% (0)	**34% (14)**	24% (10)	27% (11)	15% (6)	**3.22**
Inadequate net metering/net billing	10% (4)	20% (8)	**34% (14)**	24% (10)	12% (5)	**3.10**
End User convenience/complexity (siting, installation, maintenance)	7% (3)	22% (9)	**39% (16)**	24% (10)	7% (3)	**3.02**
Wind myths (reliability, sound, aesthetics, safety, avian impact)	7% (3)	27% (11)	24% (10)	**41% (17)**	0% (0)	**3.00**
Lack of utility-sponsored programs and marketing for wind	7% (3)	24% (10)	**34% (14)**	29% (12)	5% (2)	**3.00**
Permitting costs and time	7% (3)	27% (11)	**37% (15)**	20% (8)	10% (4)	**2.98**
Low public awareness/support	10% (4)	22% (9)	32% (13)	**34% (14)**	2% (1)	**2.98**
Lack of tax incentives (sales, property)	10% (4)	24% (10)	**34% (14)**	27% (11)	5% (2)	**2.93**
Connecting to the grid (investor-owned utility)	10% (4)	30% (12)	**33% (13)**	25% (10)	3% (1)	**2.80**
Lack of consumer access to wind resource information/maps	22% (9)	32% (13)	**41% (17)**	5% (2)	0% (0)	**2.29**

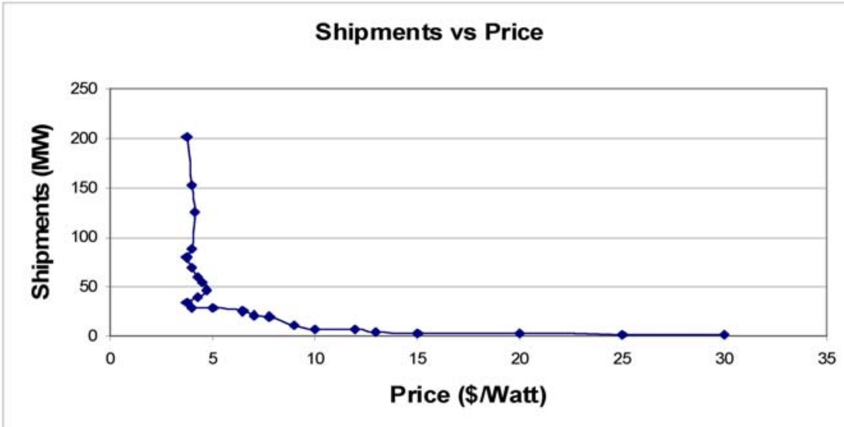


Figure 3-3. Constructing a demand curve for DWT – experience from PV [27]

Lack of Incentives

Federal, state, and local governments have a role in establishing policies and incentives that affect market adoption of residential distributed generation. Both the small wind and PV markets have seen growth surges following the introduction of state financial and policy incentives and extensive public education campaigns. The most recent federal tax credit for small wind turbines was 1985; 2005 federal legislation did not include small wind in a residential tax credit for PV. At the local level, industry participants consistently report that the work required to remove or reduce DWT permitting barriers is time consuming and cost-intensive. However, actively engaging federal, state, and local governments in addressing the key economic, permitting, and public education barriers can ensure the realization of the energy security, self-sufficiency, and reliability that DWT promises.

Zoning, permitting, neighbor perception, and public awareness. Restrictive zoning (tower height, setbacks) and environmental requirements (state environmental assessments) contribute to the complexity, time, and costs required to install residential grid-connected systems. Model zoning ordinances and standardized data on sound, safety, reliability, rated output, setback requirements, and biological impact should be developed to streamline the zoning, permitting, and incentive application processes.

The industry would benefit from a national public education campaign to promote awareness among consumers and public policy makers and to create market demand. These campaigns would promote the benefits of DWT and address concerns about wind energy in general (reliability, acoustics, aesthetics, safety, avian impact). A separate campaign targeted at utilities could provide education on the topics listed above and promote economic and customer satisfaction benefits for utilities. DWT system cost and payback calculators, wind resource maps, and consumer guidebooks, such as those on the Wind Powering America Web site [28], need to be maintained and enhanced to aid consumers with residential DWT purchase decisions.

Connecting to the grid. Interconnection standards are important to streamline installations and reduce up-front costs for consumers. Increased awareness and support among investor-owned utilities (IOUs) and RECs will be necessary for small wind to be included in utility marketing efforts. As most preferred residential wind turbine sites are rural and fall in REC service territories, the unwillingness of many RECs to interconnect distributed generation is a significant market barrier for residential wind. New business models for both private and public utilities such as turbine leasing, sales, installation, maintenance, and turn-key "green energy" programs can be advanced as incentives for utilities to promote small wind. A marketing and public awareness campaign for RECs could assist in resolving grid balance and cross-subsidy issues.

Overcoming barriers. The majority of the barriers listed above are consistent with the 2002 U.S. Small Wind Turbine Industry Roadmap [29] that identified the following key market and policy barriers:

- Market: Lack of effective standards, low visibility of the industry and technology, misconceptions about the wind resources, insufficient capitalization, complicated financial impact, lack of multilateral bank funding for export markets.
- Policy: Lack of federal incentives, restrictive zoning, NIMBY (not in my backyard) and environmental concerns, excessive interconnection requirements and unequal billing policies, undervaluation of green energy, disincentives in the tax code, lack of state-based and national incentives, interconnection standards, and national models for net metering and zoning rules.

Since the publication of the 2002 Roadmap, the industry has made progress on addressing many of the challenges identified, in developing turbine standards, promoting small wind applications, contributing to state and national policy discussions, and developing zoning models. A leading industry member predicts that innovative turbine designs significantly reducing the cost of energy will lead to tremendous success for the small wind industry [30].

Time-critical nature of small wind technology. Residential-scale wind technology is driven by a range of customer needs and desires. These include customer requirements for reliable sources of electric power, the desire to reduce utility bills by self-generation, and customer interest in owning and running wind turbines. On-site electric power can be reliably provided by a number of other technologies, including fossil- and renewable-fueled generators, PV, fuel cells, batteries, and small hydro generators. These technologies can also serve to reduce utility bills. Other efficiency and conservation methods include solar hot water, solar and geothermal heat collectors and cooling, and building designs that include passive solar features, such as solar lighting strategies. Therefore, several alternatives are competitively available for nearly all customer motivations.

The main market drivers that impact customers' choices among technologies are the cost and perceived value of wind turbines available, effective incentive programs, the strength of provider firms' marketing and customer response capabilities, zoning and interconnection policies, and high fuel prices. Most of these issues lead to broad-scale patterns characterized by gradual shifts in market demand, rather than immediate or crisis-mode response. However, spikes in fuel prices can motivate customer decisions to investigate and invest in alternatives that reduce customer costs and risks, so it is important that advances in DWT technology are made in a timely manner to address the adoption timeframe issues discussed previously in this report.

Subsidy Market for Residential Wind Distributed Generation

Market drivers. The most significant drivers of residential DWT market growth in the United States are state incentives (buy-down programs, production incentives, tax credits or exemptions, favorable financing), favorable policies (net metering, standardized interconnection), and high retail electricity rates [31]. The DWT market has seen growth surges following the introduction of state financial incentives and extensive public education campaigns. Policy actions, such as state renewable portfolio standards, can increase interest and sale of renewable energy systems. Green marketing programs such as green tags, renewable energy credits, and utility green rates will have increasing impact on DWT market dynamics in the near future. These programs also serve as a metric for consumers' willingness to pay more for green energy products.

Several states and utilities have some form of incentives or enhanced buy-back rates for distributed generation, but in many cases these programs are not available for DWT or are not significant enough to move the market. One example of DWT's exclusion is the $0.15 premium paid to net-metered PV systems by WE Energies in southeastern Wisconsin. In 2005, the state of Washington introduced a feed-in law to pay up to $2,000/year for both solar and wind generation at $0.15/kWh; however, implementation of the program has been stalled. Massachusetts and New Mexico have enacted similar production-based incentives directed toward PV. Market experience in California and New York has shown that up-front financial incentives of approximately 50% are required to accelerate residential DWT market adoption. Annualized net metering can also be a market stimulus in areas with high retail rates.

Currently there are no federal incentives targeting small wind. However, Congressional and industry support is increasing for a federal investment tax credit following the passage of the 30% investment tax credit for PV in the 2005 Federal Energy Policy Act as an opportunity to "level the playing field." Although residential wind is eligible for the USDA Farm Bill Section 9006 grants, the grants are only available for agricultural producers and much of the scoring weight of applications is placed on the cost of energy, therefore limiting the applicability of this program to residential wind projects. [Editorial note: The USDA 9006 grants are available to rural homeowners and businesses, not just agricultural producers. Although the cost of energy alternatives is one of the many criteria, it is not a majority portion of the scoring weight.] Typically, Renewable Portfolio Standard rules do not effectively address small wind, although states and advocates are showing increased interest in including set-asides or extra credit for PV in RPS policies. Table 3-2 provides a summary of U.S. state small wind programs as of January 2006 [32].

Utility Industry Impact of Residential Distributed Generation

Investor-owned utilities. An increase in the number of residential wind turbines would likely have minimal impact on the IOU industry because the grid penetration on any particular feeder line is not likely to be very high. Therefore, the electrical impact and revenue loss for the local utility will be minimal from residential wind turbines. It should be noted that utilities are somewhat skeptical of DWT, in part a result of the common concerns about wind safety, interconnection, and reliability.

Rural electric co-ops. As stated earlier, although some RECs support residential-scale renewable energy systems, most view distributed generation as a cross-subsidy and inconsistent with co-op principles that members share equally in the investment, risk, and benefits of the co-op. Many RECs also perceive safety and reliability issues with distributed generation.

Co-ops in many areas of the country have grid capacity that could serve to aggregate and export distributed generation. Some minor technical modifications may be required at the utility substation to enable it to handle bi-directional power, but there are no technical reasons that the rural distribution system cannot act like a collector system for gathering distributed wind power and delivering it to the substation and higher voltage transmission system. Using the rural electric distribution system would provide economic diversification and fair-policy benefits for co-ops, economic returns for co-op members, and benefits to augment the national grid system.

Utilizing utilities to create market demand. There is a business opportunity for RECs and IOUs to provide DWT sales, lease, installation, and maintenance services as a new revenue source and customer service option. Offering turnkey systems to green-energy program customers, similar to programs in place for PV, would benefit both the small wind industry and consumers.

Table 3-2. Small Wind Programs by State

	POLICIES				RESOURCES			EDUCATION				
	Financial Incentives	Net Metering	REC Net Metering	Zoning/Siting	Working Group	Anemometer Loan	Wind Map	Consumers Guide	Workshops	Ag Workshops with USDA	Other Education Events	Publications
Alabama												
Alaska	P				•	•	•	•	•		•	•
Arizona	•	P	•		•	O	•	•			O	
Arkansas		•	•				O					
California	•	•	•	•	•		•	•	•			
Colorado	P	P	P		•	•	•	•				•
Connecticut		•	NA				•					
Delaware	•	•	•				•	•				
District of Columbia	•	•					•					
Florida	•	P										
Georgia	P	•	•		•							
Hawaii	•	•	•		•		•	•	•			•
Idaho	•	P			•	•	•	•	•	•		•
Illinois	•	P		P	O		•	•	•			•
Indiana	•	P			•		•	•				
Iowa	•	P				O	•	•	•			•
Kansas					•		•	•		O		•
Kentucky		P										
Louisiana		•	•									
Maine		•	•			•	•	•				•
Maryland	•	•	•		•		•	•				
Massachusetts	•	•	•		•	•	•	•	•			•
Michigan		P	•		•	O	•	•				
Minnesota	•	•	•				•	•			•	•
Mississippi	P											
Missouri					•	•	•	•				
Montana	•	P	P		•	•	•	•		•		•
Nebraska					O		•					•
Nevada		P			•	•	•	•		•		•
New Hampshire	•	•	•			O	•	•				
New Jersey	•	•	•		O	•	•	•				•
New Mexico		P	•		•		•	•		•		•
New York	•	•	•	O			•	•	•			•
North Carolina	•	P			•	•	•	•	•	O	•	
North Dakota	•	P			•	•	•	•				
Ohio	•	P			•	•	•	•	•	•	•	•
Oklahoma		•	•		•		•	•				
Oregon	•	•	•		•	•	•	•				•
Pennsylvania	•	P			•	O	•	•			•	•
Rhode Island	•	P					•	•				
South Carolina												
South Dakota						•	•	•				•
Tennessee	•				•	•		•				
Texas		P				•	•		•		•	•
Utah	•	•	•		•	•	•	•	•			•
Vermont	•	•	•			•	•	•				•
Virginia	•	•	•	P	•	•	•	•	•			•
Washington	•	•	•	•	•		•	•				
West Virginia					•		•					
Wisconsin	•	P	P		O		•	•	•		•	•
Wyoming		P			O	•	•		•			•

P = part of state NA = Not Applicable Open circle = under development

V. Technical Barriers Issues and Assessment

Technology Barriers for Distributed Wind Generation

The introduction of new grid-connected small wind generators in recent years along with major market growth demonstrate the public's desire to invest in residential-scale DWT. Economic factors including total installed cost, cost of energy produced, and payback, as noted throughout this study, drive the distributed generation market. While some industry participants are optimistic that DWT technology can reach cost targets to produce energy for approximately $0.05/kWh within the next few years, a more realistic near-term target may be the retail cost of energy. The average U.S. retail rate was $0.09/kWh in 2004 [33]. Technological advances, in addition to improved policy and financial incentives, can help the DWT industry to meet these targets and effectively compete in the residential distributed generation market.

As shown in Table 3-3, the January 2006 survey of key industry participants conducted for this study indicated that the most important technical challenges for the grid-connected residential wind market are consumer credibility and the lack of effective performance standards, testing, and ratings; product reliability, performance, and manufacturer support; the lack of equipment choices for low wind regimes; and quiet operation.

Performance standards, testing, and ratings. Establishing hardware certification, conducting certified field tests, and releasing consumer-friendly standardized ratings for small wind turbine performance and sound levels are urgent priorities for the residential DWT industry in order to assure consumers, zoning authorities, funding agencies, and lenders that small turbines are safe and will perform as expected. This activity is critically important to increase industry credibility and help prevent exaggerated claims and unethical marketing as new incentives become available. In several cases, including Oregon and California, the lack of effective standards and consistent ratings has delayed the implementation and funding of state rebate programs. Without credible, widely used performance and reporting standards for small wind turbines, there is a risk that some inexperienced manufacturers might sell unsafe or poorly performing systems that could damage the reputation of the entire wind-energy industry.

Product reliability, performance, and manufacturer support. Power electronics, the most unreliable element of DWT systems, would benefit from increased robustness, with more attention paid to efficiency and power quality. Integrated monitors could report on long-term system performance and track maintenance issues. Adding capabilities for PV inputs and alternate outputs (such as resistance heat or battery charging) could increase utility confidence. Small grid-tie inverters need to be more tolerant of ground faults and lightning, while also able to load the turbine in absence of the grid to reduce acoustics and rotor loading. Manufacturer support has been difficult because different companies usually build the inverter and the turbine. A fresh look at small direct-drive induction machines is warranted as they offer the promise of eliminating the inverter without introducing reliability problems of gearboxes. Most direct-drive DWT alternators would also benefit from more powerful super-magnets, reduced cogging, and a steeper or exponential output curve. Maximum power point tracker (MPPT) technology could also aid DWT performance.

Technologies for low-wind regimes. The highest percentage of people interested and willing to install small wind turbines do not live in high-wind regimes suitable for large commercial wind farms but in moderate Class 2 and 3 sites. There is a significant need for easily constructed DWT designs that function adequately and reliably in low wind regimes, work in turbulent environments, and produce enough energy to satisfy the needs of these homeowners with an anticipated long service-free life.

Survey respondents recommended R&D efforts for supervisory control systems that coordinate wind turbine operation with load management (discretionary electric loads, heating loads, refrigeration loads, etc.), energy storage to enhance the performance and economics of distributed wind, and improved electronics and integration systems. Several industry players believe that towers need to be much taller because in some cases the doubling of tower height from 20 m to 40 m adds as little as 10% to system cost while increasing energy capture by 35%.

It should be noted, however, that a major industry player believes that a high-performance turbine on a short tower is needed to address zoning restrictions and aesthetic considerations in order to penetrate the potentially large suburban residential market. Regardless, new lighter-weight tower materials and self-erecting capability, when coupled with simpler footing and anchor systems, could reduce costs and enhance aesthetics for all turbine designs.

Reduction of acoustic emissions. As rotors are optimized for Class 2 and 3 wind resources, higher tip speeds during gusts will create greater acoustic challenges as the optimal tip-speed ratio will occur at lower wind speeds. Lower tip-speed ratios and higher blade solidity are worth investigating. Computer models are needed to predict the complex behavior of passive rotor control strategies along with quantifying blade, wind shaft, and tower reactions to help manage rotor speed during governing and in unloaded conditions. Small changes to a blade design (such as the tip or leading edge shape) can greatly aid in reducing acoustic emissions without the need for redesigning the entire system. NREL's initial R&D in this area has made promising advances; however, more research and product development are needed to achieve consistently quiet operation.

Complexity of Technology Barriers

The technology barriers discussed previously are not unique to any single small grid-tie wind turbine manufacturer but are common to all. Addressing these challenges will require considerable time and monetary resources beyond the capabilities of most manufacturers.

Performance certification along with examining reliability issues is the natural role of a single independent national testing laboratory. Standards can be proposed by the industry, but compliance testing must be overseen by an outside source. A third party familiar with the issues of both inverter and turbine manufacturers is in the best position to bridge the gap and provide innovative system solutions.

Many of the reliability improvements outlined in Section V can be applied incrementally in the form of minor detailed design changes or exchanging one component for a more reliable but otherwise equivalent component. Improved alternators, generators, and power electronics can be introduced to a design with relative ease if their basic specifications (such as the torque vs. RPM curve) are not significantly changed.

Table 3-3. 2006 Grid-Connected Survey Responses

Residential Wind Technical Barriers	Not an issue	Moderately Low	Medium	Moderately High	Biggest Immediate Challenge	Response Average
Credibility with consumers/lack of effective performance standards & ratings	6% (2)	17% (6)	28% (10)	**31% (11)**	19% (7)	3.42
Product Reliability	6% (2)	18% (6)	**35% (12)**	26% (9)	15% (5)	3.26
Sound levels/quiet operation	6% (2)	21% (7)	**44% (15)**	26% (9)	3% (1)	3.00
Manufacturer support	6% (2)	29% (10)	26% (9)	**35% (12)**	3% (1)	3.00
Installation	3% (1)	**38% (13)**	29% (10)	21% (7)	9% (3)	2.94
Hardware & shipping costs	9% (3)	**40% (14)**	26% (9)	14% (5)	11% (4)	2.80
Power electronics & software	9% (3)	30% (10)	**42% (14)**	15% (5)	3% (1)	2.73
Maintenance costs	9% (3)	35% (12)	**44% (15)**	12% (4)	0% (0)	2.59
Engineering or reengineering of specific turbine components	16% (4)	**36% (9)**	**36% (9)**	12% (3)	0% (0)	2.44
High cut-in speed/complete turbine redesign	13% (4)	**47% (15)**	28% (9)	9% (3)	3% (1)	2.44
Designing self-erecting capabilities	21% (7)	30% (10)	**33% (11)**	15% (5)	0% (0)	2.42

Some of the improvements may require major system redesigns. Certification may lead to substantial redesign of a system if that system is found to be unsafe. A new airfoil may change the rotor loads and performance so much that the supporting structure and controls would also need to be adjusted. In most cases, the use of a new tower would not require redesign of the turbine, but there may be situations, particularly for larger and/or constant-speed systems, where system changes would be necessary.

While excessive sound levels from wind systems remain a large consumer issue, especially for residential DWT to access the suburban market, for some manufacturers acoustics are farther down the priority list. One possible reason is the complexity of the issue and the necessity of hiring outside expertise largely beyond the manufacturers' resources. In addition, because of its complexity, variable geometry rotors have yet to be modeled satisfactorily. Such modeling would surely benefit all passive controlled machine manufacturers, as well as manufacturers of blade-pitch-governed machines that furl in high winds beyond their rated capacity and during unloaded operation.

A dynamic look at a furling rotor under the influence of wildly varying angles of attack with specific attention paid to acoustic emissions would greatly aid the advancement of small wind technology. Development of such a model is likely beyond the scope of a single small turbine manufacturer, but it would benefit nearly all small turbine designs.

Expected Turbine Size for Residential Distributed Generation

Small wind systems for grid-connected residential applications require turbines in the 1- to 25-kW range. The appropriate turbine size for residential applications is site specific and cannot be generalized. This wide range in turbine size takes into account variations in residential consumptions for different types of homes and energy conservation measures, the wind resource available, seasonal load variations, and economic incentives, such as net metering. This turbine range is also consistent with the wide variation in residential lot sizes and related zoning provisions (e.g., smaller turbines for more densely populated areas).

The January 2006 survey of key industry participants conducted for this study revealed that the most common size for the residential market falls in the 1-kW to 25-kW range (96% of the responses falling within this range) based on the average U.S. residential consumption of 10,900 kWh per year [34]. Currently, turbine models rated at 1, 2.5, 3, 10, and 20 kW are commercially available. Within this range of available turbines, there are notable gaps for 5- and 15-kW systems where development and substantial market growth could be seen if products become available. Turbines at the larger end of this range are expected to see only limited residential use because they have less attractive economics related to high upfront costs, limitations on three-phase service in residential areas, height and setback restrictions on many residential lot sizes, and reduced production where there are height restrictions. Smaller turbines must be highly efficient to offer significant power output and competitive cost per installed kW of capacity.

The DOE's consumer guide for small wind electric systems states that for a typical home with an annual electricity consumption of 10,000 kWh, depending on the wind resource, a 5- to 15-kW wind turbine is required to make a significant contribution to this demand [35]. In the United States, load varies substantially by region and season as well as household size. Table 3-4 provides a breakout of average residential load by state and region [36]. This information further supports the need for various turbine sizes for the residential distributed generation market.

Feedback from dealers and installers reveals that many residential consumers install distributed generation systems to offset electricity costs and benefit the environment; few expect to export significant amounts of electricity to the grid [37]. Small wind residential systems, in the absence of annualized net metering, are generally sized to generate approximately 80% of the residential load to maximize the offset of retail energy.

Table 3-4. Average Customer Load in kWh/year, by State and Segment

Average consumption (kWh/year)			
State	Residential	Commercial: Small/Med	Commercial: Large
Midwest - East North Central			
Illinois	8,711	87,455	7,394,237
Indiana	11,427	86,112	2,344,113
Michigan	7,788	74,755	2,480,151
Ohio	9,826	70,344	70,344
Wisconsin	8,634	65,732	4,673,847
Regional Weighted Average	**9,157**	**76,979**	**3,282,208**
Midwest - West North Central			
Iowa	9,945	49,110	4,050,919
Kansas	10,543	67,023	729,050
Minnesota	9,333	85,583	3,963,724
Missouri	12,246	80,681	1,685,644
Nebraska	11,797	59,104	729,961
North Dakota	11,939	64,680	64,680
South Dakota	10,928	56,212	1,048,383
Regional Weighted Average	**10,830**	**70,492**	**2,148,511**
NorthEast - Middle Atlantic			
New Jersey	7,934	81,329	938,889
New York -1	6,532	65,638	2,472,830
New York -2	6,532	65,638	2,472,830
New York -3	6,532	65,638	2,472,830
Pennsylvania	9,081	54,710	1,384,796
Regional Weighted Average	**7,694**	**64,599**	**1,760,078**
NorthEast - New England			
Connecticut	8,573	92,465	947,327
Maine	7,208	60,283	2,777,927
Massachusetts	7,126	76,125	809,128
New Hampshire	6,934	45,206	754,247
Rhode Island	6,464	77,338	547,171
Vermont	7,028	46,124	46,124
Regional Weighted Average	**7,412**	**72,109**	**970,213**
South - East South Central			
Alabama	14,281	59,196	5,258,472
Kentucky	13,229	59,565	6,186,238
Mississippi	14,222	60,206	3,449,249
Tennessee	15,177	67,016	16,902,980
Regional Weighted Average	**14,312**	**62,111**	**9,128,569**

Average consumption (kWh/year)			
State	Residential	Commercial: Small/Med	Commercial: Large
South - South Atlantic			
Delaware	10,895	90,209	5,872,970
Florida	13,806	81,344	817,951
Georgia	12,716	88,536	3,425,552
Maryland	11,910	115,183	834,362
North Carolina	12,649	71,434	71,434
South Carolina	13,883	68,368	5,889,721
Virginia	13,227	92,524	3,630,781
Washington, DC	8,605	267,426	279,693,635
West Virginia	11,917	56,477	969,271
Regional Weighted Average	**13,053**	**84,136**	**4,596,780**
South - West South Central			
Arkansas	12,702	61,779	663,524
Louisiana	14,140	79,578	1,876,633
Oklahoma	12,984	65,414	65,414
Texas	14,059	77,049	77,049
Regional Weighted Average	**13,818**	**74,664**	**358,665**
West - Mountain			
Arizona	12,891	101,067	1,851,363
Colorado	7,930	72,581	1,383,645
Idaho	12,712	68,638	1,134,733
Montana	9,454	46,956	46,956
Nevada	11,602	57,780	5,887,283
New Mexico	6,824	62,123	3,688,728
Utah	8,671	94,240	857,299
Wyoming	9,557	58,139	58,139
Regional Weighted Average	**10,166**	**74,737**	**2,020,298**
West - Pacific			
Alaska	8,060	59,096	1,188,636
California - 1	6,528	64,240	520,152
California - 2	6,528	64,246	520,167
California - 3	6,528	64,246	520,157
Hawaii	7,473	57,092	5,794,191
Oregon	12,035	70,322	1,061,215
Washington	12,808	83,901	1,062,193
Regional Weighted Average	**8,008**	**67,167**	**791,503**
National Weighted Average	**10,520**	**72,893**	**2,783,283**

1) Source: EIA, US Average Monthly Bill by Sector, Census Division and State, 2001. Assumption made that load per customer remains constant with time.
2) Note 1: The EIA commercial segment data is assumed for small/medium commercial while EIA industrial segment data is assumed for large commercial.
3) Note 2: Weighting is done by number of customers by segment, by state (EIA data, 2001), which is provided in the appendix.

Required Cost of Energy

The survey conducted for this study indicated a range of $0.05-0.19/kWh in the retail cost of energy required for wind systems to compete in the grid-connected residential market without incentives, with most responses between $0.08 and $0.12/kWh. Consumers generally desire a payback period of 8 to 12 years, assuming nominal rate increases. In addition to electric rates, standby demand charges can impact the economics of small residential projects.

Because residential DWT is usually an alternative to grid-connected electricity, its cost must be close to the cost of commercial energy to the end user for the project to be economically competitive. The residential retail electricity rates vary widely across the U.S. (Figure 3-4), with state averages ranging from about $0.06 to $0.18/kWh as of 2004 [38]. This data is useful to calculate the required cost of energy for DWT economic returns and to identify the key states for expected DWT market growth. The most common alternative to residential DWT, PV, currently costs about $7-10/W or around $0.20-0.35/kWh without incentives, compared to $4-7/W or $0.12-0.15/kW for grid-connected DWT sited in adequate wind resources [39].

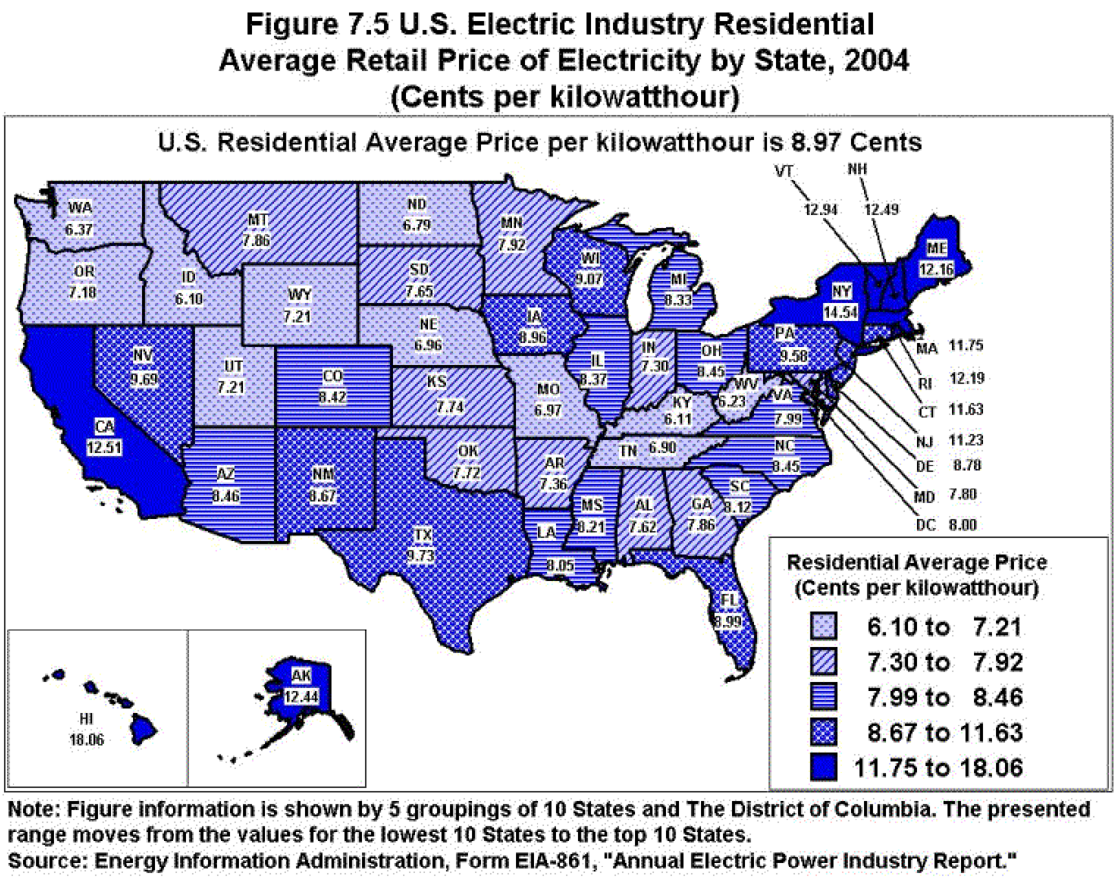


Figure 3-4. United States residential average retail price of electricity by state, 2004 (cents/kWh)

Seasonality and Geographic Nature of Wind Resource

In general, most grid-connected rural residential areas with adequate wind resources are suitable for small wind turbines. However, turbulence resulting from the presence of trees, obstructions, and uneven terrain remains a significant problem for residential wind systems, particularly for the large suburban market and with towers that have less than 10 m clearance above nearby obstacles.

Coastal marine environments can also cause problems for turbine operation over time. Power electronics in unheated spaces suffer from corrosion of connections, relays, and contactors. In warmer climates, serious tower erosion, slip ring corrosion, and shorting of windings can greatly reduce system life.

The structure of net metering laws can have a significant affect on the economics of residential systems. Seasonal wind variations are strong in many regions with the result that a residential turbine may produce more energy than the consumer demands in some months and much less in others. Banking of excess generation on a yearly basis allows customers to accumulate electricity credits in the winter and spring when winds are typically strongest and use them in months when less wind is available. Annual net metering enhances the value of wind energy and reduces the cost and complexity of evaluating a site by eliminating questions regarding seasonal matching of load and wind.

NREL's research conducted to date has greatly aided performance in cold climates and with roughness-tolerant blades and is an example of how federal research and development programs can assist the industry.

Impact of Intermittency on Residential Wind Energy

The intermittency and variable nature of wind generation reduces the value of the electricity generated to some utilities. However, for residential applications, net metering essentially mitigates the intermittency issue because it lets wind turbine owners bank their excess generation with the utility for later use when the wind turbines are not generating enough power to meet site loads. If net metering is not available, intermittency of the wind resource reduces the amount of wind-generated electricity that can be used because any excess cannot be banked and must be granted or sold to the utility at "avoided cost." Therefore, the owner has an incentive to undersize the wind turbine so as to minimize the excess sold back to the utility; because smaller wind turbines typically cost more per kWh, systems become less attractive without net metering.

Wind resources typically are not well correlated with utility load profiles. Therefore, utilities still need to size their systems for peak load. While the cumulative amount of residential distributed generation may be significant, peak load correlation may be promoted as added value with utilities at the local level when there is a peak-coincident wind regime. Improved wind resource maps will be necessary to improve turbine siting and resource matching.

A research and demonstration project for supervisory control systems that coordinate wind turbine operation with load management (discretionary electric loads, heating loads, refrigeration loads, etc.) and/or energy storage to enhance the performance and economics of distributed wind may be helpful to the grid-connected DWT industry.

Interface between Turbine and Wind-Distributed Generation

Typically, the interface of residential wind turbines is 120/240V AC at 60 Hz as this is the standard voltage and frequency of most residential loads. Smaller wind turbines in the range of 1 to 10 kW use permanent magnet alternators that generate AC of variable frequency and voltage level, which must be converted using a power electronic inverter to DC and back to AC at 120/240V at 60 Hz. Most residential loads have single-phase service, limiting the size options available for turbines without significant upgrades to the typical home's electrical service. Larger wind turbines are three-phase because of the simpler, more robust design of induction machines.

Any applications that smaller turbines might power in a residential setting will already have the ability to interface with 120/240 V and 60 Hz AC. The development of more versatile, efficient, reliable, and robust controllers/inverters with higher power quality is needed to improve the interface of small wind systems with residential service.

VI. Recommended Areas of Technical Concentration

The Future

The United States dominates the international small-wind turbine industry, and the major industry participants are small, privately owned companies. Other governments (e.g., United Kingdom, China) are providing technical and market support for their fledgling small turbine manufacturing industries. Federal assistance in the form of R&D, performance standards, testing, and ratings will be required for U.S. manufacturers to continue to dominate and compete in the DWT market.

Recommended areas of technical concentration for the grid-connected residential wind sector fall into four primary areas.

Performance standards, testing, and ratings. In several cases, the lack of effective standards and consistent ratings has delayed the implementation of state rebate programs for small wind systems. The industry must establish hardware certification, conduct certified field tests, and release consumer-friendly standardized ratings for small wind turbine performance and sound levels. If these standards can be established, consumers will have reliable data upon which to base purchase decisions, and industry credibility will be enhanced. The existence of industry standards will also deter exaggerated product claims and unethical marketing. The industry requires federal assistance to develop performance standards, testing, and ratings.

Reliability and performance. Power electronics are the most unreliable element in any wind system. Numerous technical enhancements are needed for increased robustness, reliability, and efficiency: integrated monitors, capabilities for PV inputs and alternate outputs, lightning-tolerant components, acoustic and rotor loading enhancements, and maximum power point tracker technology. Direct-drive turbine alternators would benefit from more powerful super-magnets, reduced cogging, and a steeper or exponential output curve. Addressing reliability problems with gearboxes for direct-drive induction machines without inverters is also warranted.

Low-wind regime technologies. New turbine technologies are required for cost-competitive energy in low-wind regimes, often characteristic of the suburban residential areas, which offer huge potential for distributed generation. Turbines must function reliably in low wind regimes (Class 2 and 3) and turbulent environments resulting from topography, vegetation, or ground structures. R&D investments include supervisory control systems that coordinate turbine operation with load management, improved electronics and integration systems, and lighter-weight towers with self-erecting capability.

Acoustics. Lower tip-speed ratios, higher solidity, and blade design will help reduce acoustic emissions. Computer models to predict the complex behavior of variables to help manage rotor speed are also needed.

Table 3-5. Summary Information Table: Residential Power

Domestic Grid-Connected Residential Wind Market Potential*		
Potential Market Size (cumulative installations)		
2005	9 MW	1,800 Units
2010	29-44 MW	5,100-7,400 Units
2015	72-211 MW	10,000-18,000 Units
2020	170-1,000 MW	18,000-55,000 Units

Regions of Specific Interest

1. West Coast (California and Washington State)
2. Northeast and Mid-Atlantic (New York, Massachusetts, Pennsylvania, Vermont)
3. Midwest/Central (Texas, Ohio, Minnesota, Iowa, Wisconsin, Colorado)

International Grid-Connected Residential Wind Market Potential*		
Potential Market Size (cumulative installations)		
2005	5.5 MW	1,100 Units
2010	14-19 MW	2,500-3,300 Units
2015	34-86 MW	4,800-11,000 Units
2020	82-410 MW	8,700-37,000 Units

Countries of Specific Interest

1. Asia (Japan, China, India)
2. Europe (United Kingdom, Spain, Italy, Germany, Netherlands, Greece)
3. Central and South America

* Grid-connected residential capacity has historically been less than 5% of the total DWT market (up to 100 kW); however, that portion is expected to grow to more than 20% by 2020.

Key Market Barriers

1. Economics (total installed cost, cost of energy generated, payback period)
2. Lack of incentives (financial and policy, state and federal)
3. Zoning, permitting, neighbor perception, and public awareness
4. Connecting to the grid (interconnection standards, IOU, and REC issues)

Key Technical Barriers

1. Lack of performance standards, testing, and ratings
2. Product reliability
3. Technologies for low-wind regimes
4. Sound levels / quiet operation

Expected Turbine Size Range:

1 kW to 25 kW, market void for 5-kW and 15-kW turbines

Expected Turbine Coupling

Voltage: 120V to 240V, 60-Hz AC, the standard electrical service of most residential homes

VII. Conclusions

Small wind energy systems provide clean, renewable power for on-site use and help relieve pressure on the nation's power grid while providing domestic jobs and contributing to energy security. America pioneered this technology in the 1920s, and it is the one renewable energy technology that the United States still dominates. American companies lead in both technology and world market share. In contrast to utility-scale wind turbines that no longer have a strong U.S. manufacturing base, more than 90% of small wind turbines installed in the United States are still manufactured in the United States.

Actively engaging federal, state, and local governments in addressing key economic, policy, permitting, and public education barriers can ensure the realization of the energy security, self-sufficiency, and reliability that DWT promises. The DWT market will be vitally enhanced by cost-competitive and easily obtainable equipment, with production rates keeping up with growing market demand. Technology advances with rotors, towers, and controllers can substantially improve DWT performance, as well as ease installation complexity and maintenance. Industry standards, consistent policy and financial incentives, and public education campaigns will all help enable residential wind turbines to compete vigorously in the distributed generation market. On the other hand, if there are not credible, widely used performance and reporting standards for small wind turbines, there is a risk that some inexperienced manufacturers might sell unsafe or poorly performing systems that could damage the reputation of the entire wind energy industry.

Federal assistance in the form of R&D, support for performance and rating standards development, and testing facilities and expertise will be required for U.S. manufacturers to continue to dominate and compete in the DWT market. A third party familiar with the issues of inverter and turbine manufacturers is in the best position to bridge the gap and provide innovative system solutions. Performance certification along with examining reliability issues is the natural role of a single independent national testing laboratory. Standards can be proposed by the industry, but compliance testing must be overseen by an outside source. Residential distributed wind generation would benefit from technology enhancements and public awareness programs to shift the business paradigm of rural electric co-ops to include support services for members generating wind power as a "cash crop." Co-ops could aggregate wind power from members for sale to outside parties, upgrading their extensive distribution and transmission infrastructure for bi-directional power. Both IOUs and co-ops could offer sales, leasing, installation, and/or maintenance of wind turbines for rural residential members.

The residential wind industry would benefit from a new detailed potential market analysis. With the emergence of more accurate wind resource maps, new low-wind turbine technologies, updated census data, and analysis of economic and social market drivers, a new in-depth market study focused on consumer motivations would provide valuable information to inform research, product development, marketing, and policy decisions.

Widespread deployment of small wind turbines can increase the public's familiarity with wind-energy generation, attract mainstream media coverage, help mitigate concerns about visual and avian impacts, and pave the way for local community support for large wind developments. Small turbines, in particular installations at schools and other high-visibility locations, can become an important asset in reducing fears about unfamiliar technology, which in turn can help reduce the expense and unpredictable nature of siting and permitting large wind developments.

For example, small turbines can be installed in selected neighborhoods to increase public awareness of residential wind options and provide an additional benefit by educating students on how electricity is made and the benefits of wind power. Neighborhood DWT installations can also help utilities increase customer interest and participation in voluntary green power programs and provide local “advertisements” of utilities’ involvement in renewable energy.

The international market, and more importantly the international impact on the growth of the residential DWT market, is much larger than the capacity estimates indicate. The added megawatts of distributed grid-connected electricity can make a huge difference to people around the world. Energy security and grid stability can be greatly improved by spreading distributed generation over a broad area. Efforts to enhance the viability of the DWT industry will have major global benefits in securing future energy supplies and meeting increased demand for decentralized, affordable clean power. Mainstream adoption of DWT can enhance awareness and support for the entire wind-energy industry.

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Chapter 4. Farm, Industry, and Small Business

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I. Executive Summary

Wind energy has proven to be one of the most economical, modular, and readily connected renewable technologies. Its use in agricultural, production plants, and small business/home applications will continue to grow for the next 20 years and beyond.

This report is a summary of the expected growth areas, the growth rates, the necessary turbine style/sizes, and the barriers to sustainable market growth for the farm, industry, and small business wind market sector.

The prime barrier is cost. Too few turbines are currently produced to obtain the economies of scale through volume production. Thus, favorable life-cycle costs will not be realized to sell these mid-size turbines alone. The economic payback has to be on the order of 4 to 7 years to be attractive compared to other similarly sized investments for agribusiness. The cost of energy (COE) is in direct competition to that of utility-provided energy at $10–$15/MWh.

The second barrier is lack of installed infrastructure for the ongoing sales and maintenance of a distributed array of many types of turbines. Enough income must exist within 150 miles of a central service site to support $1 million/year in sales (20-25 turbines/year of 50-kW units). An installed base of 300 turbines is needed for an area to support a maintenance facility fulltime. However, a model of similar scale exists for the large farm implement market, covering the same size area, expected sales per year, and installed repair/re-supply base.

The lack of enough matching turbines to the loads is the third most important barrier to the implementation of wind for the farm and small-business market. A 10-kW unit will meet all small loads. These units are available and easily connected through net billing laws in most states already allowing this size unit. Likewise, 50-kW turbines are in production and can help meet the farm-ranch-small irrigation market. Unfortunately, 100- to 250-kW units for center-pivot irrigation and agri-processing industry are very limited. And the 250- to 500-kW units for large industrial loads are no longer made in any significant quantities.

One way to improve the potential sales is not to focus on turbine sales alone, but to develop the market in combination with demand-side energy management and full service of the turbines after installation. This would reduce owners' worries regarding long-term O&M and also ensure that energy produced was used at the best value to the turbine owner (displacing energy that would have been purchased at retail rates from the utility).

II. Application Background

Wind energy use in the agricultural sector has a history of more than 1,000 years. Transportation of goods from source to market by sailing vessels and the use of wind for food processing and land reclamation in Europe demonstrate that wind power has enjoyed a long, broad-based acceptance as an energy source.

During the past century, the wind has provided water for ranching and transportation requirements of American railways, providing a ready corridor for products to go from the Midwest producers to the populated consumer locations on the coasts. Before rural electrification, electric power was often supplied by small wind chargers with an on-site storage system of batteries. Wind power allowed rural residences to be entertained and informed and provided electric light and the powering of small appliances.

Urban communities were also able to use renewables with the passage of the Public Utility Regulatory Policy Act (PURPA), allowing the interconnection of qualified renewable energy products. The generator size limits have only recently been raised to 20 MW by the Federal government. This should help promote the use of small wind for the farm, industry, and small business market sector.

III. Current Status of Activities for this Application

A 1990 report on the wind market in the Great Plains [1] described an annual market of 10,000, 6,000, and 4,000 units for turbine sizes of 10 kW, 50 kW, and 250 kW, respectively. But this was true only if all production could be valued at retail rates. Using this $10/MWH value resulted in $660 million/year of expected value to the wind turbine owners. That report also stated that wind turbines would start to be fully economic in small business, agribusiness, and industrial-sized applications in 2000 to 2005.

The development of wind turbines for the farm, industry, and small business market has been overshadowed by the development of wind turbines for the utility-scale market. Manufacturers have not emphasized production of the smaller turbines in more than 20 years, allowing the greater profits and market share to be driven by the megawatt-class turbines. Articles like those in *North American Windpower* reveal that small projects scattered in a wide geographic area can offer substantial system benefits [2]. Even though there is a penalty for single or small projects (5%-15% increased cost/turbine), they can be matched by better distribution of income/value than direct sales of electricity to utilities from a centralized wind plant. Small- and medium-sized wind turbine manufacturers exist all over the world [3], but the volume of machines needed to meet the expected market is not currently available.

The value of displacing conventional energy versus direct sale of energy can be substantial (retail rate of $6-8/MWh versus wholesale rate of $2-3/MWh). The loss of Production Tax Credit (PTC) assistance from the independent sales of electricity is a burden for on-site users of wind energy, but not one that is too onerous to bear in these smaller configurations. The advantage of the increased value of displaced energy produced on site compared to direct sale of energy to a utility means that turbines can return value to the owner faster if interconnect can be allowed at higher power levels.

IV. Market Barriers Issues and Assessment

Expected Market in the United States

The American Wind Energy Association (AWEA) conducted a complete market survey of more than 250 wind industry members. The results were included in a report on other barriers [4]. The questionnaire revealed the following areas of concern in the small wind (<100 kW) industry: economics, lack of consistent incentives, zoning-permitting, and interconnection issues. Additional views were collected from the U.S. Department of Agriculture and consultations with manufacturers of mid-size and small-size turbines.

The market can take advantage of changing regulations to create sustainable growth for wind for small businesses and farms, given the Federal support in the United States of interconnection rules and individual states net-billing agreements. The turbine sizes that are most useful need to generate about 750 – 1,000 MWh per year in a decent (upper Class 3) wind regime. This is equivalent to a 250- to 300-kW unit. These sized units, returning $40,000 – $60,000/yr, would have simple paybacks in approximately 10 years. But this approach can only work if net billing is allowed and all the energy is used on-site (no wholesale sale of excess energy to the utility). This would help address the respondents' concern that economics is the driving factor in the turbines' perceived value.

Currently, the readily available turbine sizes are smaller than the long-term market sizes (10 to 50 kW, not 250 to 400kW), resulting in higher installed cost/kW. Economics are such that, even with net billing, it is difficult to recoup the initial cost of the system within a 15-year time frame. This has to be reduced to 10 years or less payback to obtain a rate of return that is acceptable for the high capital investment.

These smaller wind systems have worked in the United States, and when properly sized along with utility cooperation, the systems performed with few start-up problems or long-term difficulties [5]. But even the more successful projects have increased in size toward the utility-scale turbines because those are most readily available for projects. Also, siting projects in states with significant incentives (Illinois, Minnesota, Iowa, Colorado) shows that where local value is placed on renewables, it is readily implemented.

There is no specific problem with the turbine technology; the former sizes and designs are simply no longer in the production stream. The units that are available are at a premium because of low production volumes. Good turbines that are technically sophisticated are commercially available, but only for the smaller-size loads/energy use projects, delivering 100 to 150 MWh per year. But this energy level is not enough to offset the energy needed in most agricultural or food processing industries that are considered potential wind energy users.

Non-technical barriers are mostly political in nature. The lack of consistent interconnection standards across states hurts the utilization of wind in some markets. The wide range of net billing techniques used in different states means that there are widely varying returns for units even in areas of similar wind power potential. There is no simple solution for these policy differences, but focusing on the states with the better wind resources and agricultural/industrial base (Midwest, Rockies, Southeast coast) to improve the existing net billing rules would provide the most fertile ground for future wind energy growth for this market sector.

The existing mid-size turbine designs are from the 1980s and have historically been rugged, reliable, and readily reproduced. However, they are no longer the desired turbine sizes of choice for the utility-scale market and have fallen off the production horizon. This shows that large, megawatt-scale turbines have begun to displace conventional energy sources and that conventional energy costs have increased sufficiently so that wind is a viable economic consideration. But at present, the utility market is driving megawatt-size wind turbine production.

Current manufacturers are using the turbines that are still in production and trying to match these smaller-scale energy loads (120 – 175 MWh/year) to the performance of available turbines. A recent meeting in Amarillo, Texas, hosted by Entegrity Wind Systems [6] (formerly Atlantic Orient Corporation) introduced several agricultural businesses to the idea of wind turbines displacing conventional energy use on the farm and the expected economics for such systems.

The best incentives for the wind systems are currently the Federal funds available through Section 9006 of the U.S. Farm Bill and the guaranteed loan program of the U.S. Department of Agriculture. State programs have inconsistent support for renewables for the mid-size turbine market sector, with New Jersey the only state allowing the interconnection of up to 2-MW turbines and allowing net energy billing over a 12-month time frame.

The expected wind energy markets for farm, industry, and small businesses are for any business that has energy use and sufficient resource to justify the use of wind energy. This includes the following:

- Agriculture industry
  - Meat packing (large use of hot water/cooling facilities year round)
  - Food processing (industrial-scale plants that operate annually)
  - Peanuts, cheese, confined feedlots, etc.
  - Irrigation (center pivot units of 1/8 to 1/2 mile radius)
- Machining
  - Foundries (metal heating and industrial-sized movements of metal)
  - Metal smelting
- Small business – similar to home-size markets, similar-sized turbines.

These industries and businesses have traditionally been found in rural areas of the United States and as such have fewer impediments to zoning and use of wind energy because they have more suitable land space for turbine installation.

The expected COE has to be within 10% of the conventional sources of energy with expected annual growth in conventional energy to be 3% to 5% per year. Most agribusinesses will begin to lock in or hedge costs that they see as rising with other resources or long-term purchase agreements if they see the real costs as being equal to the projected costs in a 3- to 4-year time frame. Long-term planning for many businesses often includes an analysis of these types of operational expenses.

A case in point is the Owens-Corning fiberglass plant in Amarillo, Texas, which has considered installing wind turbines on the property to offset long-term energy costs every 2 to 3 years over the past 8 years. Conventional power purchase has been deemed the least-cost option. But the next period of review may change because the projected energy cost growth has doubled compared to estimates from 2004.

Studies of the seasonal wind resource variation show that the change in crop type and the watering schedule can be adjusted to meet the wind resource, allowing for maximum energy use during the production season. The variation with wind on power output is well understood, but with good cooperation between the user and the local utility/cooperative, the electrical problems are minimal and the only concern is the length of time the billing can be carried on the books. The New Jersey model allows wind energy from strong months to be used in the lower-production months. This is a good model that other states should consider; it would work well in any of the target areas: Midwest, Rocky Mountains, and Southeast coast.

By using the standard utility inter-tie connection, the mid-size wind systems can be standardized for the U.S. grid. Making the flow of energy seamless from the utility to the user and back is the goal. This retains the benefit of the production on-site and having the conventional energy source as the backup to supply all the energy needed for the plant/business operation at any time, whether or not the wind is blowing.

Expected International Market

Internationally, the market will be driven by the need for energy and the desire for clean energy, with economics also as a consideration but with the other two factors playing a more deciding role for or against wind. Again the desire is for the larger-scale turbines placed in very good wind regions for a better economic return on investment. But in many cases overseas, there is subsidized support for conventional energy prices at the federal level, and so the cost paid by the consumer is lower than the true value of energy. This places wind energy at a disadvantage unless strong federal policies offset the value for the energy from renewables. The feed-in tariff rules in Germany have aided the industry there for years, setting a very good value for the electricity sent to the utility grid. The Peoples Republic of China has a state goal for the use of renewables at local and industry levels. The current 5-year plan demands the use of a set amount of renewables. This type of support will continue to push the wind markets in those countries in the future.

V. Technical Barriers Issues and Assessment

Studies have consistently shown that most potential users of small- to mid-size wind turbines for the farm, industry, and small business sector request ruggedness and reliability (low long-term maintenance). Users do not want to be burdened with a system that takes too much time from their other ongoing operations. Unfortunately, without a vast installed dealer network, some service and oversight has to come from the local users of wind systems. So if potential users are more familiar with required procedures, expected performance, and the typical operational characteristics of the turbine they plan to use, they will be better able to monitor non-optimal conditions, controlling the turbine or shutting it down until a trained repair crew can make sure the turbine can be returned to full-time operational use.

The second most important concern is that because wind turbines are tall, they can attract direct lightning strikes. In the past, the conventional wisdom was that full lightning protection was impossible and that steps to minimize or offer alternate paths for the bolt/surge to dissipate without damage to components of the turbine were available, but not foolproof. Improved blade production methods have allowed for lightning pathways to be incorporated into the fabric of the blades and thus allow for the discharge of high-static conditions before they can build up to lightning-bolt levels. Improved electronics protection on the utility interconnection and the systems-controller sensors and electrical connections has improved turbine life and reduced downtimes.

For those units that are considered small scale but still require utility inter-tie inverters, the reliability and longevity of these electronics units is of concern. Experience shows that even with recommended grounding and protection devices, the possibility for inverter damage from direct or nearby lightning strikes is never fully mitigated. The loss for the user is lost energy while a unit is repaired, as well as the replacement costs for electrically and mechanically removing the unit to return it for repair and then properly re-installing the unit once it is returned.

None of these perceived barriers alone will stop the use of the technology. The wind turbine should still be considered like any other piece of industrial equipment; it is used to produce energy when the conditions are right and requires some small degree of supervision and attunement so that proper operation is readily noticed. When it's not "quite right," it is removed from service until it is repaired.

The turbine sizes are in two stages. The smaller systems of 10 to 60 kW would be used for the home and small businesses/farm. The mid-size turbines of 250 to 400 kW would be used for the larger industrial operations that can utilize the energy from a system this size, while maintaining the utility interconnection on this scale and installing the electrical connections on the owner's side of the utility meter. This distributed energy method of using what is needed on site would reduce stress on the utility lines, rather than becoming a large negative load outside the utility control. It would avoid many of the megawatt-scale system problems associated with utility system stability and interaction but still be of sufficient scale that a good economic return can be realized over time, thus making the mid-size wind turbines attractive to individual business operations.

VI. Recommended Areas of Technical Concentration

Technical problems are not as great a concern as the perceptual and economic issues. Large wind is getting a large boost from Federal and state incentives for large wind farm facilities (accelerated depreciation, Production Tax Credits, etc.). Unfortunately, this same level of support for farm/industry-sized turbines has been much less substantial.

California offers a generous state buyback policy of $2,500 for the first 7.5 kW, then $1,500/kW up to 30 kW. Ohio is another state with aggressive support for wind energy of similar scale. New Jersey has the fewest limits for a wind turbine system (2 MW installed capacity and 12-month billing for net metering). Other states offer programs (for a comprehensive overview of available incentive programs, refer to the Database of State Incentives for Renewable Energy at www.dsireusa.org [7].

A future incentive program might be based on the non-emission/creation of NOx or SOx. Distributed wind systems should be allowed to have their fair share of any tradable credits or value once carbon-based trading for greenhouse gases becomes widespread (probably in the next decade).

A ready market for distributed wind energy systems would be to allow rural electric cooperatives to install and operate their own wind facilities to offset energy costs from their wholesale supplier. This would match the rural connection, make the co-ops a maker of renewables rather than a skeptic of renewables, and match the expected windy areas of the nation to the key electrical providers in these areas.

A new possible boost to development will be the 25 x ’25 program that is endorsed by several key agribusiness firms and farm cooperatives. While the main focus of these programs is the use of agriculture products in non-conventional energy sources (biofuels/biomass), the adoption of the targets of 25% of the U.S. energy sources coming from our rich agricultural lands by the year 2025 will boost the use of dedicated wind energy sources. While most of the rhetoric included in the proposal that concerns wind energy is directed to large-scale wind farms, the benefit of distributed energy will have to be included in meeting this ambitious goal in the desired time frame. The expected impact to the numbers of units that can be installed is considered to be an increase on the order of 10% to 15% of the projections made in the summary table. Since there is no specific target or plan yet in place for this initiative, no impact is predicted from it. It is shown in our figures in the summary table.

Finally, educational development for small businesses, industry, and farms on how to use mid-size wind turbines to help meet their energy needs could be very helpful. Most potential users are simply not aware of how wind energy can help offset their energy costs, nor do they understand the technology or net metering. A few well-placed, successful, and publicized industry pilot installations could help lead the way toward larger-scale adoption across the industry sectors.

VII. Conclusions

The key concern for the wind industry will always be maximizing profit. When there is a market for a product or turbine type/size, such as the farm, industry, and small business market, a manufacturer will step up to meet that market potential. This will only happen when a long-term profit can be made for the company. When turbine sizes are available to meet a particular need, end users will compare costs to install/operate/maintain the turbine versus purchasing energy and will choose the option that makes economic sense. Unfortunately, the manufactured wind turbine sizes are, for the most part, below or above the required turbine sizes that can readily serve the farm, industry, and small business market.

However, things may change as larger-capacity net metering policies gain in popularity. One turbine manufacturer is in production right now for a 50-kW unit and is willing to ramp up production; indeed, they are trying to generate market interest to make this a sustained turbine size/style. They are placing turbines in areas of increased public view to gain valuable public acceptance, as well as providing the performance information online to demonstrate how the unit is operating over time.

The wind industry turbine manufacturers have drifted into producing higher-return, larger megawatt-scale turbines. Currently, one manufacturer [8] has a prototype 250-kW turbine undergoing testing, but this prototype has yet to be produced in volume. The designs are there, but production volumes of these turbines are currently very low and, thus, costs are high. Mid-size turbines are no longer in the production plans of major manufacturers.

The main issues for the farm, industry, and small business wind energy sector are more political than technical. The growth of this market sector will largely hinge on increasing fuel prices, net metering, and potential government incentives for clean energy technologies. The market will grow, but the rate of growth will depend on the convergence of these factors.

Table 4-1. Summary Information Table: Farm, Industry, and Small Business

Domestic Market		**Regions of Specific Interest**
(with net billing)		*(not year dependent)*
2010	200-300 turbines/yr	1. MidWest (Great Plains)
2015	500-700 turbines/yr	2. Inter-Mountain (Rockies)
2020	1,000 – 1,500 turbines/yr	3. Southeast Coastal Areas
International Market		**Countries of Specific International Interest**
(dependent on incentives)		*(not year-dependent)*
2010	100-200 turbines/yr	1. Western Europe
2015	200-300 turbines/yr	2. China/India
2020	400-600 turbines/yr	3. Russia
Key Technical Barriers		
Underdeveloped turbine sizes for irrigation market		
Maintenance availability		
Grounding/lightning susceptibility		
Inverter Reliability and Availability		
Key Market Barriers		
Net annual energy billing		
System costs, initial and long-term operation		
PTC/PPA unavailable to farmers/small businesses if energy not sold to third party		
Rural electric co-ops' permission to inter-tie		
Expected Turbine Size Range		
250 kW to 500 kW irrigation, industrial-sized loads		
10 kW to 60 kW net-billing applications, on-site use of energy		
Expected Turbine Coupling		
Mechanical (High Speed:__; Low Speed:__; Nominal speed:_____)		
Electrical (Voltage: 240 to 480; AC X , DC__; Variable__ Constant X)		
Thermal (Temperature: ______) Other: ___________		

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Chapter 5. “Small-Scale” Community Wind Power

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I. Executive Summary

This study estimates potential market growth and evaluates the major market and technical barriers that currently impede the development of “small-scale” community wind, a subset of the larger community-owned wind market utilizing turbines of 1 MW or less, to assist NREL, DOE, and the Wind and Hydropower Technologies Program in assessing potential technical research areas with large market opportunities. Market and technical questions are explored to identify high-priority areas for the Program to consider for future investment.

A clear and available market for “small-scale” community wind is established. The current size of this market segment is estimated at 11,000 turbines currently installed internationally, totaling 8.2 GW, which is approximately 20% of the 2005 EU wind market. As a mid-point forecast between lower- and upper-bound estimates, we expect this sector of the distributed wind turbine (DWT) market to grow to about 130,000 units, totaling 99 GW, by 2020. The U.S. “small-scale” community wind market and U.S. participation in the international market are currently facing major market and technical constraints that may be reduced or eliminated with focused Program support.

This study concludes that the “small-scale” community market would be enhanced by research and development efforts, with the following high-priority research areas identified and recommended to be considered in further, more detailed studies:

- Conducting grid-integration studies to identify the potential for “small-scale” wind development that would decrease or eliminate the need for transmission system upgrades
- Advancing innovative designs for mid-size turbines, rotors, and towers optimized for Class 3 winds, addressing productivity, installation, and maintenance issues
- Designing, testing, and certifying advanced remote-monitored controllers to simplify the grid interconnection process and to support weak rural distribution systems
- Developing technical training programs for mid-size turbine technicians (windsmiths)
- Developing easy-to-use computer tools for analyzing project economics and modeling wind resources to assist with siting, seeking project financing, negotiating power purchase agreements, and taking advantage of incentives

- Developing a set of regional model zoning ordinances and educating local planning officials to aid in the adoption of responsible siting requirements, while streamlining approval processes for “small-scale” community wind.

II. Application Background

The scope of this study addresses “small-scale” community wind, a subset of the larger community-owned wind market. “Small-scale” community wind is defined as projects utilizing mid-size turbines of 1 MW or less in nameplate capacity, where an entity from the local area has a significant financial stake in the project outcome. “Small-scale” community wind projects typically connect to 13.8-kV or lower distribution lines, either behind the meter—thus offsetting a portion or all of the electricity used on-site by a load in the community—or using a dedicated transformer with all energy sold to the interconnecting utility.

“Small-scale” community wind projects currently represent a decreasing segment of the larger community wind market because projects with larger turbines are becoming more economical, and turbines below 1 MW are increasingly less available for such projects. The trend can be seen in Figure 5.1, which shows large community wind projects in the advanced planning stages and projected to be commissioned by 2010. This study primarily examines the smaller segment shown in Figure 5.1.

In recent years, with advances in turbine production and technology, wind energy has become competitive with traditional forms of electrical generation, and community stakeholders have latched onto wind-derived energy as a way to diversify and revitalize rural economies and become more energy independent. Numerous schools, universities, farmers, Native American Tribes, small businesses, rural electric cooperatives, municipal utilities, and even abbeys have installed their own mid-size and large wind turbines to promote environmental responsibility and keep energy dollars local.

According to Windustry’s community wind project database, about 270 MW of community-owned wind projects are currently installed in the United States, representing $250 million in investment in rural communities. Of these, about 110 MW meet our definition of “small-scale” community wind, utilizing wind turbines under 1 MW. (See Appendix A for a table of “small-scale” community wind projects.)

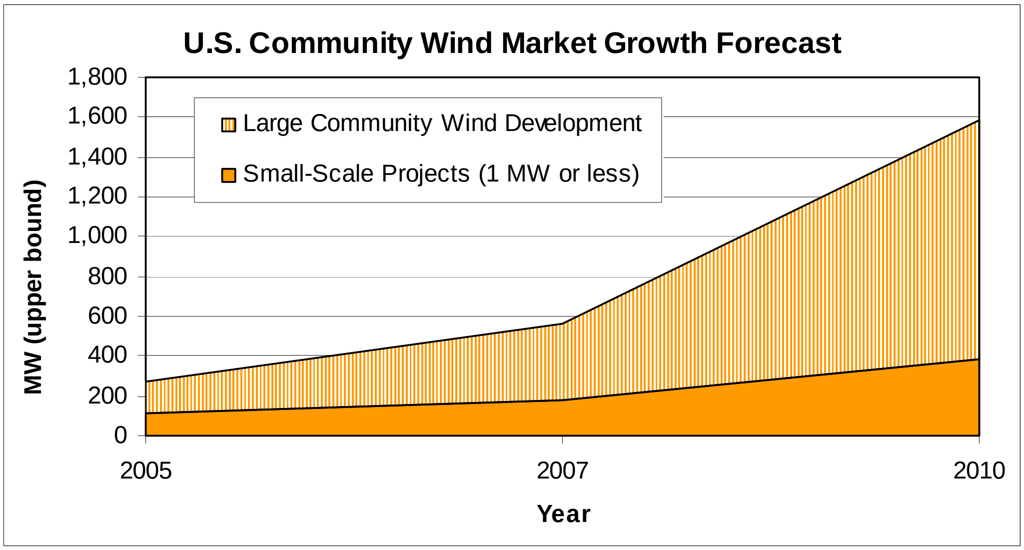

Figure 5-1. United States large- and small-scale community wind energy market upper-bound growth forecast

Unique business structures have been developed to aid community wind projects in taking advantage of federal and state incentives, such as the "flip" structure that involves an equity investor with a large passive tax appetite to allow community-owned projects to utilize the federal Production Tax Credit (PTC). Typically the equity investor is majority owner of the project for the first 10 years, when the tax credit is available to the project. The equity investor then flips its stake in the project to the community owners, usually accompanied by a payment from the community owners to the investor. This flip typically occurs in Year 11 or when the tax investor reaches the target return on investment, which is allowed to occur later.

Because of the wind industry's increasing focus on multi-megawatt turbines, the "small-scale" community wind sector is facing a major challenge of product availability. New cost-competitive mid-size turbine designs will be needed to ensure the future of the "small-scale" community wind market.

III. Current Status of Community Wind

The PTC has fostered rapid growth in large-scale wind development with periods of stagnation resulting from the advance planning requirements of large wind projects, typically 2 to 3 years, and the timing of extensions of the incentive, which have expired three times since it was created by Congress in 1992. This boom-and-bust cycle has caused apprehension for wind turbine manufacturing firms interested in opening facilities in the United States and led to major shortages of equipment, personnel, and business and legal expertise for smaller wind project developments while the incentive is available. Large wind turbines above about 900 kW are essentially unavailable for purchase for community wind projects until 2008, after the current PTC expires. In addition, very few suppliers are currently producing turbines in the 100- to 1000-kW range.

Elected officials across the United States and internationally are showing increased support for small and community wind. The 2005 Federal Energy Policy Act included a provision initiating

Clean Renewable Energy Bonds (CREBs) [1] that allow electric cooperatives, government agencies, tribal governments, non-profit organizations, and other entities that cannot utilize the PTC to apply for low-interest bonds to help finance wind and other renewable energy resources for local economic development. CREBs are an important new financing instrument for project ownership structures without a tax appetite and that don't quality for the PTC.

The state of Minnesota recently passed into law Community-Based Energy Development (C-BED), a special rate structure requiring utilities in the state to enter negotiations with qualifying, locally owned wind energy projects for payments in the first 10 years of the power purchase agreement at a higher rate than the past 10 years. The front-loaded payments are calculated based on a maximum of 2.7 cents/kWh net present value and the purchasing utility's discount rate that is used for daily business operations. This rate structure does not impact the utility's bottom line but greatly aids the wind project with debt service over the first 10 years of the project, helping to acquire financing, one of the major barriers for "small-scale" community wind project developments.

The state of Iowa recently passed a tradable production tax credit that can be sold to a third party. This incentive was passed to help level the playing field between large corporate-owned wind projects that can easily take advantage of the federal PTC and locally owned community projects for farmers, schools, and other non-profit organizations that are either tax-exempt or cannot take advantage of the federal PTC. The program provided incentives for up to 90 MW of wind projects and was fully subscribed within 3 weeks of its first availability.

Currently, there are at least 440 MW of new community-owned wind projects in the advanced planning stages, located mostly in the Midwest. The Governor of Minnesota has pledged that 800 MW of new C-BED projects be developed within the state. However, community wind project developers are expecting to utilize turbines larger than 1 MW for nearly all of this new capacity because of their better economics. Nebraska, Texas, and Colorado are also emerging as leaders in the community wind market. Other states, including Oregon and Washington, have taken an interest in community wind, commissioning several studies to examine the barriers, economic impacts, and best models for community wind energy development [2].

John Deere recently provided equity investments in several wind energy projects in Minnesota, Texas, and other rural areas in the United States and abroad, creating a business unit to provide project development, debt financing, and other services to farmers interested in harvesting the wind. Deere's new wind-energy initiative, supporting the company's goal of "helping its customers improve their profitability and productivity," signifies major growth potential in the market segment in attracting such a leading financial service provider.

More than 500 participants attended Windustry's third national Community Wind Energy Conference in Des Moines, Iowa, in March 2006 to learn about new models, best practices, and new state and federal programs that will promote community wind energy in the future.

IV. Market Barriers Issues & Assessment

Expected U.S. Market for "Small-Scale" Community Wind Applications

To date, about 110 MW of "small-scale" community wind capacity is installed in the United States, primarily in the Midwest [3][5]. Minnesota's experience with community wind may be viewed as an indicator of the potential market for community wind in the United States given sufficient incentives, adequate wind resources, and an ample supply of cost-effective mid-size wind turbines. In 1997, Minnesota enacted a production incentive available for the first 100 MW of "small-scale" wind projects (less than 2 MW each) that applied. After 5 years, the limit was reached, and in 2003 the state legislature extended the incentive to cover an additional 100 MW. This time, the incentive was fully subscribed within 6 months [4].[6] Even more indicative of potential growth is the fact that community wind projects in Minnesota are becoming cost competitive with larger commercial projects [5].

To estimate the future domestic market of "small-scale" community wind, this study examined both the DOE Energy Information Administration (EIA) U.S. wind capacity growth estimates and historical U.S. wind capacity growth. Because community wind has recently emerged in the U.S. market, these numbers do not specifically account for community wind growth but can be used in conjunction with recent "small-scale" community wind trends to create a reasonable estimate for future growth. Because "small-scale" community wind often competes with commercial wind in the market, using total wind capacity projections to estimate growth for this sector is not an unreasonable assumption.

Some areas have developed markets specifically for community wind energy. In November 2005, the Governor of Minnesota announced his administration's objective to have 800 MW of Community-Based Energy Development (C-BED) projects commissioned by 2010. With growing interest in several states including Colorado, Oregon, and Massachusetts, similar markets could be created for "small-scale" community wind projects, creating substantial market growth even greater than the wind industry in general.

EIA estimates that total U.S. capacity will grow at an average annual rate of 11% from 2005 to 2010 and then 3% from 2010 to 2020 [6]. However, from 1998 to 2003, installed wind capacity grew an average of 28% per year [7], and growth from 2004 to 2005 was a record 35% [8]. This study estimates a conservative annual growth rate for "small-scale" community wind to be 8%. With favorable policies, economic conditions, and sufficient supply of competitively priced mid-size wind turbines, the estimated average annual growth rate for this sector could be as high as 28%.

As shown in the Summary Information Table (Table 5-3), this study estimates that the cumulative installed U.S. capacity of "small-scale" community wind in 2010 has a lower bound of 220 units, totaling 160 MW, and an upper bound of 500 units, totaling 380 MW[7]. These estimates are based on the 110 MW of installed "small-scale" community wind capacity as of

[5] See Appendix A for a listing of community wind projects utilizing 100-kW to 1-MW wind turbines.
[6] Some of the projects listed in this cited report are turbines over 1 MW and therefore do not fit the definition of "small-scale" community wind for this study.

[7] Estimates assume an average turbine size of 750 kW, which is the current average for U.S. "small-scale" community wind projects utilizing turbines 1 MW or less, documented in the Windustry database.

2005, the current average “small-scale” community wind turbine size of 750 kW, and the estimated lower- and upper-bound growth rates discussed above. Assuming the same growth rates, the lower- and upper-bound estimates for the cumulative installed U.S. capacity for this sector are 320 to 1,700 units totaling 240 to 1,300 MW in 2015 and 470 to 6,000 units totaling 350 to 4,500 MW in 2020.

Regions of interest. Based on projects installed and planned as documented in Windustry’s community wind database, as well as responses to the January 2006 survey of 46 key industry participants conducted for this study, ten of the states of specific interest for the “small-scale” community wind market fall into three primary regions:

- Midwest (Minnesota, Iowa, Nebraska, Texas, North Dakota, South Dakota, Illinois)
- Northeast and Mid-Atlantic (including Massachusetts, New York, Vermont)
- West (Colorado, Montana, California, Oregon, Washington, Alaska).

Expected International Market for “Small-Scale” Community Wind Applications

The European Union (EU) has been the historic leader in community wind. In 2000, about 80% of installed wind turbines in Europe could be considered community wind [9]. By the end of 2005, Europe had 40.5 GW of installed capacity and therefore close to 32 GW of community wind [10]. Since Europe is by far the largest market for community wind, assuming that 25% of these turbines are 1 MW or less with an average turbine size of 750 kW, a fair estimate of the current international market in this sector is 11,000 turbines totaling 8.1 GW.

From 1995 to 2005, Europe realized an average annual growth in wind capacity and number of installations of 32% and 22%, respectively [11]. Using this historical information and recent trends, this study estimates the future international market for “small-scale” community wind to have a lower-bound annual growth rate of 10% and an upper bound of 22%. The slightly higher lower-bound estimate, compared to the U.S. estimate, reflects the fact that the “small-scale” community wind market is already firmly established in the EU. The upper-bound estimate is lower than the U.S. estimate for this sector, reflecting the maturity of the European market and the overall direction of the EU wind market toward large offshore wind development.

Starting with the estimated total installed capacity of 8.1 GW in 2005 and assuming an average turbine size of 750 kW, this study estimates that the international cumulative installed capacity in 2010 will have a lower bound of 17,000 units totaling 13 GW and an upper bound of 29,000 units totaling 22 GW (Table 5-3). Assuming the same growth rates, our lower- and upper-bound estimates for cumulative international installed capacity are 28,000 to 79,000 units totaling 21 to 59 GW in 2015 and 45,000 to 210,000 units totaling 34 to 160 GW in 2020.

Regions of interest. Responses to the survey conducted for this study indicate that the major international markets for “small-scale” community wind, offering substantial export opportunities for U.S. manufacturers of mid-size turbines, fall in the following regions:

- Europe (Germany, Spain, Denmark, Norway, Netherlands)
- Asia (China, India, Russia)
- South America/Central America

- Africa
- Canada.

Germany and Spain are of particular interest and currently are leading the EU in growth and installed capacity. These two countries accounted for 58% of the total wind capacity growth in the EU in 2005 and 70% of the total installed capacity in the EU [12]. Canada shows signs that it will follow the lead of many European nations by enacting feed-in tariff laws to encourage wind energy growth. To date, only Ontario has enacted a feed-in tariff, but there has been growing support by other Canadian provinces to enact similar tariffs.

"Small-Scale" Community Wind Technology Adoption Time Frame

The entire wind industry would benefit from a concerted media campaign with increased news coverage of positive reports on the successes of wind power, similar to current press conferences on "clean coal" and nuclear energy, and highly visible recommendations to elected officials to maximize the use of abundant wind resources for clean electricity generation within the next two decades. Global energy supplies are at a point where as much wind as possible needs to be installed on a short time frame to prove it can be successfully integrated into the grid and other existing infrastructure. Because distributed wind generation can be installed in a shorter turn-around time than large-scale wind farms, identifying and addressing the barriers for "small-scale" community wind should be considered a high-priority activity. Field studies on the distribution grid need to be conducted before and after distributed wind generation is installed so the costs and benefits can be clearly documented and highlighted for administrative and policy proceedings. Results and recommendations are critical in building arguments such as in Illinois, where Commonwealth Edison (ComEd) has proposed energy fees for community wind projects. ComEd plans to track the penalties for imbalance that FERC allows without giving credit for benefits such as reinforcing the grid.

Utilities often highlight the negative impacts of distributed generation in interconnection policy proceedings; however, the benefits to the grid are rarely recognized. For example, distributed wind turbines installed in strategic locations can provide reactive power support with substantial benefits to weak feeders that experience voltage-regulation problems. Technical guidance and strategies are critically needed for using the grid more efficiently.

Given the boom-or-bust cycles in the utility-scale wind turbine industry, small community wind project developers are often squeezed out of the market when manufacturers deal almost exclusively in large volume orders rather than the one or two turbines that many community wind projects seek. This is leading some community wind developers to consider smaller turbines in the 50-kW to 500-kW range as a viable alternative to the more cost-effective multi-megawatt turbines. Only a few turbine suppliers, including Energy Maintenance Services, Fuhrlander, and Entegrity have products available to fill this growing niche.

The lack of available mid-size wind turbines has led to other problems with the development of "small-scale" community wind projects. Because the PTC is difficult for most community wind project owners to utilize on their own because of the requirement for large passive tax appetites[8],

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[8] Passive tax refers typically to tax paid on rent, interest, and dividends, as opposed to earned income. A 1-MW wind project with a capacity factor of 33% has the potential to utilize about $55,000 per year based on the PTC's current level of 1.9 cents per kWh, which is above the level of many community members or groups wishing to *(footnote continued)*

equity partner investors must be found before financing can be secured. Power purchase agreements must be negotiated with the host utility, and insurance must be secured based on specific equipment orders. All of this means that the developers of community wind projects must juggle many balls, and the falling of one means the unraveling of an entire project. Once the project developer identifies an interested equity partner and secures financing, the availability of the PTC narrows the potential construction window. Inside that window, the developer must secure firm delivery on the turbine, tower, transmission/interconnection requirements, critical construction equipment including an adequate crane, permitting (including conditional use permit or zoning approval), project financing, and a power purchase agreement before the expiration of the PTC. While larger projects face these same obstacles, they are in a much better position to gain the attention of equipment manufacturers, contractors, investors, and financers.

Some “small-scale” community wind project developers have turned to the used wind turbine market for hardware to install in lieu of new equipment. There are several challenges with this. First of all, this equipment is typically not optimized for Class 3 sites where there is much interest in small wind projects. More important, these older designs are not able to take advantage of the technology advances that have occurred in the past two decades and often have not completed a comprehensive “remanufacturing” process.

Finally, some investors are beginning to look at biodiesel, landfill gas, biomass, cogeneration, and ethanol as investment opportunities. Unfortunately, if mid-size wind turbines cannot meet the needs of investors and owners in a reasonable time frame and supplement these technologies, the distributed generation market will move forward without the significant participation of “small-scale” community wind.

Based on analysis of critical path technologies, the following measures are expected to enhance the viability of the “small-scale” community wind market:

- Conducting more in-depth analysis of the steps needed to transition the utility grid from the one-way distribution of energy that it was originally designed for into an efficient multi-direction system that not only distributes electrons but also acts as an aggregator for electricity produced in rural areas.
- Incorporating voltage support capability into turbine designs to increase benefits from distributed wind generation in areas with weak grids. The technology already exists and needs to be made available to the U.S. market. One mechanism would be the development of a national standard or grid code for voltage support from distributed wind, similar to the Irish, Danish, and German grid codes, incorporating standard interconnection technical requirements for wind energy conversion systems.
- Designing reliable, easily installed, and easily maintained advanced mid-size wind turbines that are optimized for Class 3 wind regimes based on existing designs. This could be accomplished in a year with sufficient funding. Bringing that design to the prototype stage would take another year, followed by at least 2 years of beta testing. It would take another

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invest in wind energy. Tax-free institutions such as public schools, government agencies, and non-profit organizations suffer from the inability to utilize this incentive.

year to prepare the new product for the market, bringing the total timeframe for adoption to 5 years.

- Developing advanced controllers that meet a certified national standard. These could be designed in a year, with field testing and certification by a certifying agency like Underwriters Laboratories (UL) consuming another 2 years.
- Developing user-friendly computer tools for analyzing "small-scale" community wind project economics to assist with seeking project financing, negotiating power purchase agreements, and taking advantage of incentives.

Non-Technical Barriers for "Small-Scale" Community Wind Technology Adoption

As shown in Table 5-1, responses to the January 2006 survey of key DWT industry participants conducted for this study indicate that the most significant market barriers for "small-scale" community wind are turbine availability, economics, interconnection, and permitting[9]. New legislation supporting locally owned wind projects could include incentives for rural electric co-ops to develop their own projects and/or partner with their members, financial vehicles allowing capital for distributed wind projects to aggregate, and interconnection standards.

Turbine availability. As described above, large-scale wind turbine production continues to be driven by the PTC, which results in turbine shortages for the "small-scale" community wind market, inflated costs, and an industry emphasis on the largest turbines commercially available.

Economics. Coordinated public policy and consumer awareness programs are needed to aid "small-scale" community wind development in meeting market demand. Economic factors, in order of importance, include the following:

- Total installed cost
- Return on investment (perception of value)
- Inadequate net metering/net billing
- Lack of project financing
- Permitting costs and time
- Lack of utility-sponsored programs and marketing for wind
- Lack of financial incentives (rebates, buy-downs, loans)
- Lack of tax incentives (sales, property).

Interconnection. Connecting to the grid with rural electric co-ops and investor-owned utilities is ranked as an important market barrier for "small-scale" community wind. Increased awareness and support among public and private utility personnel will be necessary for wind to be included in utility-marketing distributed generation programs. A marketing and public awareness program targeted at utilities would benefit "small-scale" community wind, with particular emphasis on

[9] Online survey of key industry participants conducted in January 2006 for this study.

outreach to rural utility representatives highlighting customer satisfaction and community stakeholder benefits of generating electricity with locally owned mid-size wind turbines.

Permitting and siting. The development of a set of regional model zoning ordinances for mid-size wind turbines with consideration given to proper setbacks for sound levels and safety, attention to avian issues and wildlife areas, and visual impacts on the landscape, with different conditions based on land use and the size of projects, could help to streamline permitting processes for "small-scale" community wind projects. Dissemination of best-practice recommendations and education of local planning agencies can aid in the adoption of responsible and appropriate siting requirements for community wind projects.

Table 5-1. 2006 Survey Responses on “Small-Scale” Community Wind Market Barriers

Community Wind Market Barriers	Not an issue	Moderately Low	Medium	Moderately High	Biggest Barrier	Response Average
Turbine availability	3% (1)	15% (5)	**29% (10)**	**29% (10)**	24% (8)	3.56
Economics/out-of-pocket costs (total installed cost)	0% (0)	12% (4)	30% (10)	**48% (16)**	9% (3)	3.55
Economics/perception of value (cost of energy, return on investment)	3% (1)	11% (4)	34% (12)	**37% (13)**	14% (5)	3.49
Connecting to the grid (rural electric co-op)	9% (3)	12% (4)	26% (9)	**32% (11)**	21% (7)	3.44
Connecting to the grid (investor-owned utility)	9% (3)	16% (5)	28% (9)	**38% (12)**	9% (3)	3.22
Inadequate net metering/net billing	9% (3)	24% (8)	24% (8)	**33% (11)**	9% (3)	3.09
Lack of financing	3% (1)	26% (8)	**35% (11)**	32% (10)	3% (1)	3.06
Permitting costs and time	6% (2)	23% (7)	**45% (14)**	16% (5)	10% (3)	3.00
Visual impacts/neighbor concerns	7% (2)	30% (9)	23% (7)	**37% (11)**	3% (1)	3.00
Lack of utility-sponsored programs and marketing for wind	6% (2)	25% (8)	**38% (12)**	25% (8)	6% (2)	3.00
Lack of incentives (rebates, buy-downs, loans)	9% (3)	27% (9)	27% (9)	**30% (10)**	6% (2)	2.97
Restrictive zoning	6% (2)	28% (9)	**44% (14)**	6% (2)	16% (5)	2.97
Lack of tax incentives (sales, property)	12% (4)	21% (7)	**36% (12)**	27% (9)	3% (1)	2.88
Low public awareness/support	10% (3)	**29% (9)**	**29% (9)**	**29% (9)**	3% (1)	2.87
Owner/Operator Convenience/Complexity (siting, installation, maintenance)	13% (4)	23% (7)	**37% (11)**	27% (8)	0% (0)	2.77
Wind myths (reliability, sound, aesthetics, safety, avian impact)	10% (3)	**32% (10)**	**32% (10)**	26% (8)	0% (0)	2.74
Lack of consumer access to wind resource information/maps	26% (8)	32% (10)	**42% (13)**	0% (0)	0% (0)	2.16

Time-Critical Nature of “Small-Scale” Community Wind Technology

Community wind projects are characterized by desires to own productive wind assets for the benefit of investor groups, public, educational, tribal, special district, or cooperative corporate entities. Often the motivation is to invest for the benefit of a local (usually rural) area by keeping money in the local economy, rather than paying for imported fuel resources or returning investment profits to remote owners. The projects aim to create, and keep, an economic surplus by using local wind resources, owning the means of production locally, and supplying power on an export basis to bring money into the local economy. These projects are normally of a scale that requires power purchase agreements with utilities or access to real-time markets that can absorb power in addition to the requirements of the local owning entity. At the same time, the scale of these projects does not generally offer access to markets for the lowest cost power because they are generally too small to achieve the economies of scale of larger commercial projects.

Critical timing issues impact numerous characteristics of “small-scale” community wind projects, including the following:

- The availability of the federal PTC or a comparable incentive and whether “small-scale” community projects can find business and tax structures to benefit from it
- For turbine prices and availability, mechanisms for encouraging the aggregation of “small-scale” community wind turbine purchases and the cooperation between community wind and large commercial projects can be created to help address these issues
- For access to low-cost financing, Clean Renewable Energy Bonds (CREBs), for example, are limited in amount and have short application deadlines[10], and USDA grant programs are not guaranteed to be fully funded
- The staying power of community wind power proponents is a factor. The leadership required to mount and sustain a community wind project proposal can be exhausted by the need for a long campaign to structure an entity, identify land, access wind data, complete required studies, obtain a conditional use permit or zoning approval, and secure easements, turbines, transmission access and terms, and negotiate a power purchase agreement
- Policy and program support is needed. There is tremendous potential for the renewable energy initiatives in the Farm Bill to grow to be a significant aspect of the rural economy, but technical guidance is needed to prepare the rural infrastructure in anticipation of more distributed wind generation. Once the grid integration issues are addressed, policies can be developed to give priority to local generation. Because the economics of the power from smaller wind projects do not readily win contracts in bulk-power markets focused on lowest costs, sources of additional support, either in policy or financially, must be located, engaged, and brought to bear on projects. The timing and effectiveness of programs and policies that support “small-scale” community wind projects have an important impact.
- The output of community projects can usually only be sold to a single buyer: an electric utility. Because most projects are in rural areas and many rural areas do not have access to effective competitive wholesale electric energy markets, the cooperation of an electric utility will be required to purchase the power produced by the community-owned project. Utility cooperation varies widely, depending on the market and policy conditions that impact utility generation acquisitions. Policy can create markets for community wind, as evidenced by initiatives in Iowa and Minnesota that are leading the way.

[10] Made available on 1/1/2006, applications are due 4/26/2006 for all CREBs to be issued before 1/1/2008.

Subsidy Market for "Small-Scale" Community Wind

The U.S. government offers a variety of incentives for wind projects, including USDA Farm Bill Section 9006 grants, the Production Tax Credit[11], an accelerated depreciation system, and the Renewable Energy Production Incentive (REPI)[12]; however, few are optimal or available for mid-size turbines. Community wind projects are beginning to receive some subsidies from states, although the current state subsidy market is still limited. In Minnesota, noteworthy exceptions are Xcel Energy's standardized purchase tariffs; Renewable Energy Production Incentive (Minnesota REPI); tiered tax rates[13]; Xcel Energy Renewable Development Fund; and standardized interconnection policies are noteworthy exceptions. Low-interest loans, grants, tax deductions, and technical assistance are also available in some states [13].

In the international community, particularly in EU countries, feed-in tariffs[14] have led to substantial community wind markets [14]. Germany has had a renewable tariff policy since 1991 and currently has more total wind capacity (more than 18,000 MW) than any other country in the world [15]. Ten countries[15] currently have some variation of a feed-in tariff for wind generation [16].

Utility Industry Impact of "Small-Scale" Community Wind

Community wind projects utilizing turbines less than 250 kW in size have negligible electrical impact on the distribution grid, whereas a 2-MW wind project can have a potentially significant electrical impact on a 12.47-kV rural distribution grid and limit locations for connection to the distribution grid. Excess generation from most community wind projects is sold directly to the local distribution utility or its wholesale provider at the established "avoided cost" or a relatively low wholesale rate in the 3¢ to 4¢ per-kWh range. Under this arrangement, the wind generation does not reduce the retail revenue of the local utility and thus should not affect the local utility's finances. Instead, the wind turbine becomes just another bulk power resource used by the wholesale power supplier in the area. Therefore, even though there are some exceptions, the local distribution utility should be indifferent to community wind generation.

Mid-size wind turbines used to provide power to schools or businesses under net metering policies can cause noticeable reductions in small utilities' retail revenue. In these instances, the local utility may discourage a large number of these installations. However, in general, "small-scale" community wind should have minimal impact, if any, on the utility industry's electrical system or finances.

[11] The Renewable Electricity Production Tax Credit (PTC) has expired three times since it was first enacted in 1992. The PTC provides $0.019/kWh and is currently effective until the end of 2007.
[12] REPI provides $0.015/kWh and was effective until the end of 2006.
[13] For more than 12 MW, the tax is 0.12 cents/kWh, between 2 MW and 12 MW the tax is 0.036 cents/kWh, and for projects between 0.25 MW and 2 MW the tax is 0.012 cents/kWh.
[14] Feed-in tariffs create a standard permitting process and a fixed price for electricity purchased from specified renewable electricity generators.
[15] This number does not include the United States, although Minnesota has initiated a limited renewable tariff and California currently has a renewable feed-in tariff for PV. Countries that currently have renewable tariffs for wind generation include Austria, Brazil, China, France, Germany, Greece, PEI (Canada), Portugal, Spain, and The Netherlands. For a complete listing of international renewable energy policies, see the International Energy Agency Global Renewable Energy Policies and Measures Database at www.iea.org/textbase/pamsdb/grresult.aspx?mode=gr

V. Technical Barriers Issues and Assessment

Technology Barriers for "Small-Scale" Community Wind

Four primary technical barriers have been identified that are slowing the widespread application of "small-scale" community wind projects. These barriers are listed in order of importance and share some commonality over a wide range of turbine sizes. Table 5-2 shows responses to the January 2006 survey of key DWT industry stakeholders conducted for this study on technical barriers for "small-scale" community wind.

Grid interconnection and integration. Interconnection processes could be greatly simplified by more sophisticated remote-monitored controllers, which are certified to meet a national standard. Such controllers can allow the turbine to support weak rural distribution systems while taming voltage excursions, flicker, and supplying reactive power support to the system, as well as monitoring system health and logging important system events.

Distributed generation grid-integration studies completed to date are just a starting point. More in-depth analysis is needed on what is required to transition the utility grid system from the one-way distribution of energy that it was designed to do into an efficient multi-direction system that not only distributes electrons but also acts as an aggregator for electricity produced in the rural areas of the countryside. The national grid is woefully inadequate to function this way today. The discussion must progress to understand what technologies are required to move forward.

Turbine and tower options. Technology is needed to optimize the next generation of mid-size wind turbines for Class 3 wind regimes. Advanced rotors with lower rotational speeds could yield longer fatigue life and lower acoustic emissions. Innovative tall towers, especially for refurbished machines, would boost energy capture while diminishing turbulence.

Installation and maintenance. Reliability and maintainability are becoming more of an issue for community wind projects as challenges with heavy crane access, a lack of trained technicians, and parts shortages are leading to delays in installation and increased turbine downtime. Easing the installation complexity while increasing the reliability and service intervals of future mid-size wind turbines, along with simplifying the troubleshooting and maintenance regimen, could make the community wind machine just another agricultural implement. The development of "wind smith" technical programs to provide for a larger set of skilled turbine technicians to aid in operations and maintenance of community-owned projects will be key.

Performance projections. Although current resource assessment techniques have yielded satisfactory results, a more timely means of quantifying a wind regime must be found. Wind resource modeling coupled with short-term on-site measurement and correlation to a base station has been helpful for numerous sites in Iowa. Wind resource assessment programs specifically targeting "small-scale" community wind projects coordinated with rural economic development agencies could greatly aid the market. Wind forecasting, which is becoming fairly common in the larger wind farms, could be applied to distributed systems and add value to their energy product.

Community wind can make it possible for small rural groups to take an active role in their energy future while providing all the benefits of placing clean generation close to the point of use. By spreading distributed generation over a broad area, energy security and grid stability can be greatly improved.

Table 5-2. 2006 Survey Responses on "Small-Scale" Community Wind Technical Barriers

Community Wind Technical Barriers	Not an issue	Moderately Low	Medium	Moderately High	Biggest Immediate Challenge	Response Average
Grid interconnection	7% (2)	7% (2)	28% (8)	**38% (11)**	21% (6)	**3.59**
User-friendly peformance ratings for mid-sized and refurbished turbines	4% (1)	29% (7)	**38% (9)**	29% (7)	0% (0)	**2.92**
Hardware & shipping costs	11% (3)	30% (8)	**37% (10)**	7% (2)	15% (4)	**2.85**
Manufacturer support	4% (1)	28% (7)	**48% (12)**	20% (5)	0% (0)	**2.84**
Installation	8% (2)	**35% (9)**	**35% (9)**	19% (5)	4% (1)	**2.77**
Product Reliability	12% (3)	**38% (10)**	23% (6)	23% (6)	4% (1)	**2.69**
Maintenance costs	12% (3)	31% (8)	**42% (11)**	15% (4)	0% (0)	**2.62**
Power electronics & software	4% (1)	**48% (12)**	36% (9)	12% (3)	0% (0)	**2.56**
Sound levels/quiet operation	8% (2)	**48% (12)**	28% (7)	16% (4)	0% (0)	**2.52**
Engineering or reengineering of specific turbine components	15% (3)	**50% (10)**	10% (2)	20% (4)	5% (1)	**2.50**
Designing self-erecting capabilities	24% (6)	**40% (10)**	8% (2)	24% (6)	4% (1)	**2.44**
High cut-in speed/complete turbine redesign	13% (3)	**58% (14)**	17% (4)	13% (3)	0% (0)	**2.29**

Complexity of "Small-Scale" Community Wind Technology Barriers

Each of the barriers discussed in the previous section presents substantial technical challenges that can be reduced or eliminated by focused R&D efforts.

The electricity grid is regarded as the most complicated system that humankind has ever constructed. Understanding its limitations and how to utilize it more efficiently should be a national priority. Building on and expanding the scope of distributed wind generation grid integration studies, such as those performed by Tom Wind and Mike Michaud, focusing on key states, can help to show that the traditional approach of extensive upgrades to the transmission system is not always the most economic and efficient way to expand the market for renewable energy. Conducting these studies will take the cooperation of utility companies; researchers; politicians at the local, state, and national level; and community groups examining the actual and potential impact of distributed wind generation on existing transmission and distribution infrastructure. More detailed studies must be carried out on the local distribution level to define where added generation can be connected with minimal system upgrade costs, which typically are assigned to interconnecting project owners.

A new generation of mid-size turbines designed for low-wind regimes will obviously require the application of many technologies and require a substantial investment. This process could begin immediately and take advantage of new technologies or design methods that become available during the design. Use of innovative tower concepts for new or refurbished systems is likely to require substantial design analysis to ensure that dynamic interaction problems will not be induced by the new towers. The basic technology required for this process is available now.

VAR (volt-amperes reactive) support will be very valuable for mid-size turbines located on weak distribution systems. Power electronics systems should be developed and made available as soon as possible.

Federal support in the form of technical assistance, information dissemination, and university research programs will be very important to establishing a trained workforce to operate, maintain, and design "small-scale" community wind projects. The wind industry is unlikely to create "wind smith" training programs at community colleges or wind-engineering programs at universities tailored toward mid-size wind turbines without federal or state support.

The economics of community wind projects rely on credible wind data, turbine-performance data, and energy projections. It is essential that tools be available for establishing and confirming mid-size turbine performance projections in a timely manner.

Expected Turbine Size to Meet "Small-Scale" Community Wind Market

The optimal turbine size for the "small-scale" community wind market ranges significantly depending on ownership, availability of land, ability to contribute significant amounts of renewable energy to the grid, ability to acquire financing, ease of operations and maintenance, state incentives, and ease of interconnection. The range most frequently cited in the January 2006 survey conducted for this study was 100 kW-1 MW because of the intersection of many of the previously mentioned factors. If cost-competitive turbines in this range are made available, many "small-scale" community wind projects may opt to install one or multiple machines of a smaller size than the multi-megawatt-class machines advanced by the major turbine manufacturers. They would do this because of the simpler design and lower capital requirements of the smaller machines, making maintenance and financing easier. High thresholds on net-metering rules in several states[16] allow for matching turbine size to the load at the site for medium-size loads, such as schools, businesses, and many manufacturing facilities. Respondents also indicated that machines in this range are of appropriate sizes to match loads of hospitals, public schools, and small industry and have a similar return on investment as the multi-megawatt machines with a smaller investment threshold.

Currently, only a few commercial models are available in this size range, including the Suzlon 950 kW; the Fuhrlander FL 100, FL 250, FL 600, and FL 1000; the EMS 65 kW; and the Entegrity 50 kW. However, production numbers are limited, and manufacturers are challenged to keep up with the market growth rate for this size range, making it difficult for "small-scale" community wind developers to obtain equipment.

Required Cost of Energy to Compete in "Small-Scale" Community Wind Market

The primary alternatives to "small-scale" community wind are large-scale community wind and commercial wind projects. Based on current incentives that are driving community wind development in Minnesota (currently $0.01/kWh REPI) and Iowa ($0.015/kWh Personal Renewable Energy PTC), the necessary cost of energy for most community wind projects to be competitive is, therefore, roughly within $0.015 of commercial wind farms [17], which is currently around $0.05/kWh.

The survey of industry participants conducted for this study indicated a range of $0.03-0.15/kWh in the retail cost of energy for wind systems to compete in the community-scale distributed generation market, with most responses between $0.05 and $0.08/kWh.

Seasonality and Geographic Nature of Wind Resource

Community wind projects are generally connected to the grid and, therefore, typically have no need for storage; however, wind regime characteristics are both seasonal and geographic in nature. Many locations suitable for "small-scale" community wind experience more wind in winter months but have higher electricity loads in summer months. The more closely the wind resource matches local load (peak coincidence), the more valuable the wind resource and economic benefit of the project. Annualized net metering can also aid "small-scale" community wind market.

Interconnection processes and access to the grid vary considerably on a geographic basis. Windy rural areas have low population densities and weaker girds than more populated regions, making costs high and availability low for interconnection points. More in-depth analysis of these issues will allow for greater understanding of how best to utilize existing resources and more efficiently design upgrades and additions to distribution systems to facilitate more distributed wind generation in rural areas.

Impact of Intermittency

Intermittency is a significant issue for "small-scale" community wind applications. Schools and large businesses purchase electric power under utility tariffs that typically have both demand and

[16] In Iowa and Virginia, the size limit for net-metered wind energy facilities is 500 kW, and in California net metering is allowed up to 1000 kW in name plate capacity (DSIRE).

energy charges. If the community wind turbine is used to offset power purchases for a school or large business, then the intermittent power output may not be able to reduce the demand charge significantly in the electric power bill. Because up to two-thirds of the electric bill can be for the demand charge, the power bill savings from the wind turbine would be much less because of the intermittency. If the school or business could switch tariffs to one that only has energy charges, then the power bill savings would be at a rate about equal to the retail rate.

One way to mitigate the loss of value caused by intermittency is to install equipment that stores either electrical or thermal energy. The added cost of electrical storage equipment, such as a battery and inverter, is typically only justified for smaller off-grid applications where the price of utility power is high. However, using wind generation to reduce natural gas or fuel oil usage for heating is potentially cost effective in some cases, especially if heat can be stored in the form of hot water. The cost effectiveness derives from the fact that a larger wind turbine can be justified as a result of the increased need for electricity for heating. This type of project also requires a control system to determine when and how much of the wind generation output is converted into heat for storage rather than simply used to offset electric usage. Using a wind turbine with a thermal heat storage unit has the potential to greatly reduce natural gas or fuel oil usage for heating. One barrier to this concept is the restriction that the Federal PTC only applies to power sold to a third party, rather than to power used locally for offsetting electrical usage or saving natural gas.

If the entire output of a community wind turbine is simply sold on a wholesale basis to the local utility, electricity storage is not likely to be cost-effective because the added cost of the electrical storage equipment is usually much higher than the cost of incorporating the variable output with the utility's other generation resources. Even if the local wind generation penetration is very high, such as in Denmark, electrical storage would probably only be cost effective on a large scale at a central facility, such as with pumped hydro or compressed-air energy storage.

Interface for "Small-Scale" Community Wind

Typical interfaces for "small-scale" community wind installations are dedicated three-phase transformers connecting to distribution feeders (typically 13.8 kV or lower) for projects consisting of one or a few mid-size turbines, in comparison to dedicated three-phase substations connected to the transmission system (69 kV and higher) for multiple large-turbine projects. Appropriate fuses, breakers, relays, and other switch gear are needed for large-scale applications to ensure power system safety under abnormal operating conditions. Standardization for appropriate integration studies and required interconnection equipment for single or small aggregations of large turbines (in the 0.5-20 MW installed capacity range) has happened in many states in response to increased levels of distributed generation resources on systems. Larger projects will still require an extensive engineering study to determine the appropriate equipment necessary to safely interconnect.

Most community wind applications sell power to the grid, although many "small-scale" installations offset at least a portion of the power coming in. Specific applications typically have power electronics available to condition the power generated because power from wind turbines above about 30 kW is three-phase, 60 Hz, and around 600V. The only interface technology needed is a transformer to step up or down the voltage. Further research in the area of reactive power compensation, voltage support, and flicker mitigation will add value to distributed wind generation for interconnecting utilities and can help minimize or eliminate the need for distribution feeder upgrades.

VI. Recommended Areas of Technical Concentration

The U.S. “small-scale” community wind market and U.S. participation in the international “small-scale” community wind market have major growth potential but are currently facing major market and technical constraints that could be addressed with focused support. In particular, turbine production numbers are limited, and manufacturers are not keeping up with the rate of market growth for this size range, making it difficult for “small-scale” community wind developers to obtain equipment. Reliability and maintainability are becoming more of an issue for community wind projects as challenges with heavy crane access, a lack of trained technicians, and parts shortages are leading to delays in installation and increased turbine downtime.

The Future

A new generation of mid-size turbines designed for low-wind regimes will obviously require application of many technologies and a substantial investment. This process could begin immediately and take advantage of new technologies or design methods that become available during the design. Use of innovative tower concepts for new or refurbished systems is likely to require substantial design analysis to ensure that dynamic interaction problems will not be induced by the new towers.

Based on market and technical issues discussed above, the following high-priority areas are recommended for future investment with more detailed studies.

Grid interconnection and integration. Interconnection processes could be greatly simplified by more sophisticated remote-monitored controllers that meet a certified national standard. Such controllers can allow the turbine to support weak rural distribution systems while taming voltage excursions and flicker and supplying reactive power support to the system, as well as monitoring system health and logging important system events.

Distributed-generation grid-integration studies completed to date are just a starting point. More in-depth analysis is needed on what it will take to transition the utility grid system from the one-way distribution of energy that it was originally designed for into an efficient multi-direction system that not only distributes electrons but also acts as an aggregator for electricity produced in rural areas. The national grid is woefully inadequate to function this way today. What is required to develop an infrastructure that would more easily integrate distributed wind technology?

Turbine and tower options. Innovative tall towers, especially for refurbished machines, would boost energy capture while diminishing turbulence. Easing the installation complexity while increasing the reliability and service intervals of future mid-size wind turbines, along with simplifying the troubleshooting and maintenance regimen, could make the community wind machine just another agricultural implement.

Installation and maintenance. NREL’s expert assistance in the development of technical training programs for mid-size turbine “windsmiths” can help increase the availability of installation and maintenance crews for smaller community-owned projects.

Performance projections. Easy-to-use computer tools for analyzing “small-scale” community wind project economics would assist with seeking project financing, negotiating power purchase agreements, and taking advantage of incentives. User-friendly wind resource modeling with on-site measurement correlations could make annual power prediction much easier.

Zoning and permitting. Development of a set of regional model zoning ordinances for mid-size wind turbines with consideration given to proper setbacks for sound levels and tower fall zones, attention to avian migration patterns and wildlife areas, visual impacts on the landscape, with different conditions based on land use and the size of projects could help to streamline the permitting process for community wind projects. National participation combined with education of local zoning agencies can aid in the adoption of responsible and appropriate siting requirements of community wind projects.

Table 5-3. Summary Information Table: "Small-Scale" Community Wind Power

Domestic Market Potential for "Small-Scale" Community Wind		
(cumulative installed capacity)		
2005	110 MW	150 Units
2010	160 – 380 MW	220 – 500 Units
2015	240 – 1,300 MW	320 – 1,700 Units
2020	350 – 4,500 MW	470 – 6,000 Units
Regions (States) of Specific Interest		
1. Midwest (Minnesota, Iowa, Nebraska, Texas, North Dakota, South Dakota, Illinois)		
2. Northeast and Mid-Atlantic (including Massachusetts, New York, Vermont)		
3. West (Colorado, Montana, California, Oregon, Washington, Alaska)		
International "Small-Scale" Community Wind Market		
(cumulative installed capacity)		
2005	8.1 GW	11,000 Units
2010	13-22 GW	17,000-29,000 Units
2015	21-59 GW	28,000-79,000 Units
2020	34-160 GW	45,000-210,000 Units
Regions of Specific Interest		
1. Europe (Germany, Spain, Denmark, Norway, Netherlands)		
2. Asia (China, India, Russia)		
3. South America/Central America		
4. Africa		
5. Canada		
Key Market Barriers		
1. Turbine availability		
2. Economics		
3. Interconnection		
4. Permitting/Siting		
Key Technical Barriers		
1. Grid interconnection and integration		
2. Turbine and tower options		
3. Installation and maintenance		
4. Performance projections		
Expected Turbine Size Range		
1 MW or less for "small-scale" community wind applications		
Expected Turbine Coupling		
Voltage: 540 V to 660 V AC		
Typically connecting to distribution level voltages of 13.8 kV or less		

VII. Conclusions

The market for "small-scale" community wind projects is substantial and growing, attracting increasing attention from policy makers, community groups, and economic development professionals. With an estimated 150 turbines currently installed nationally in "small-scale" community wind applications (utilizing turbines 1 MW or less) totaling 110 MW, and an estimated 11,000 turbines installed worldwide totaling 8.1 GW, forecasts based on recent growth rates of the entire wind industry indicate the potential for a substantial market in this sector. Based on lower- and upper-bound growth estimates, this sector is expected to grow to an estimated 470-6,000 "small-scale" community wind turbines totaling 350 to 4,500 MW in the United States and 45,000 to 210,000 turbines totaling 34 to 160 GW internationally.

However, major barriers still exist for community groups seeking to invest in wind energy. Notably, these issues include the boom/bust cycle created by the federal PTC, causing limited availability of field-tested, economical turbines; components; construction crews; operations and maintenance professionals; and experts in business, finance, and legal matters.

Significant attention must be paid to the design and delivery of new mid-size turbine models in the 100- to 1,000-kW range, sized for moderate loads such as schools, businesses, and government buildings and optimized for Class 3 wind regimes with the capability to provide reactive power and voltage support to weak distribution feeders. Addition of such capability will add value to distributed wind energy for utilities, giving it the ability to lessen or mitigate the need for feeder upgrades and reduce transmission congestion.

New tower technologies, such as self-erecting designs, have the potential to decrease the upfront costs of construction, as well as reduce or eliminate the scarcity of cranes.

The development of and support for education programs for technicians skilled in routine and special maintenance of mid-size wind turbines will aid greatly in providing support for current and future "small-scale" community wind projects, as well as help to create a new job sector.

Extension of the PTC for periods of 5 to 10 years, rather than the past 2- to 3-year extension periods, could develop a more stable market for wind energy. A more stable overall wind industry will allow many of the critical market barriers to be addressed by smaller businesses that can develop expertise in all areas of "small-scale" community wind energy development. Steady wind industry growth can also help increase equipment availability; business and financial planning; and crews for construction, operation, and maintenance.

The United States market for "small-scale" community wind and the major international markets for "small-scale" community wind, offer substantial growth and export opportunities for future mid-size turbine suppliers, and project developers. Favorable policies, economic conditions, and the sufficient availability of competitively priced mid-size turbines will help ensure that this sector continues to grow and enable the DWT industry to become one of the leading renewable energy distributed generation industries.

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XI. Appendix A

Table 5-4. Community-Owned Wind Projects Utilizing Turbines from 100 kW to 1,000 kW

Location	State	Name	Owner	Size	# of turbines	Manufacturer	Model	Date of commissioning	Ownership structure
Royal	IA	Clay-Everly Central School District	Clay-Everly Central School District	95	1	Windmatic	17s-95	1986	School
Belcourt	ND	Belcourt	Turtle Mt. Chippewa	100	1	NEG Micon	100 kW	1997	Tribal
Fort Totten	ND	Fort Totten	Spirit Lake Sioux	100	1	NEG Micon	100 kW	1997	Tribal
Boston	MA	IBEW Local 103	IBEW Local 103	100	1	Fuhrlaender	100 kW	2005	Locally owned
Marshalltown	IA	Consumers Energy	Consumers Energy	108	1	Micon	108	2004	Locally Owned
Miner County	SD	City of Canova	City of Canova	108	1	NEG Micon	108	3/1/2002	Municipal Utility
Miner County	SD	City of Carthage	City of Carthage	108	1	NEG Micon	108	5/1/2003	Municipal Utility
Richardton	ND	Richardton	Richardton Abbey	125	1	Silver Eagle	125 kW	1997	Locally Owned
Laker	MI	Laker Elementary School	Laker Elementary school	195	3	Nordtank	65 kW	2005	School
Richardton	ND	Sacred Heart Monastery	Sacred Heart Monastery	200	2				Locally Owned
Miner County	SD	City of Howard	City of Howard	216	2	NEG Micon	108	10/1/2001	Municipal Utility
Boise	ID	Bob Lewandowski	Bob Lewandowski	216	2	NEG Micon	108 kW	2003	Locally Owned
Adair	IA	Schafer Systems, Inc.		225	1	Vestas	225 kW	1994	Locally Owned
Lac qui Parle	MN	Lac qui Parle High School	Lac qui Parle High School	225	1	NEG Micon	225 kW	12/4/1997	School
Riverton	UT	Camp Williams, Utah National Guard	Camp Williams, Utah National Guard	225	1	NEG Micon	225 kW	2000	Government Agency
Near Rochester	NY	Lorax Energy	Harbeck Plastics	250	1	Fuhrlaender	250 kW	2002	Locally owned
Joice	IA	Windway Technologies	Northwood-Kensett School	250	1	Nordex	250	2005	School
Nevada	IA	Story County Medical Center	Story County Medical Center	250	1	Nordex	250 kW		Locally Owned
Princeton	MA	Princeton Muni Light	Princeton Muni Light	320	1	Enertech	320 kW	1984	Municipal Utility
Nevada	IA	Nevada High School	Nevada Highschool	450	2	WinWorld	200 & 250 kW	1998	School
Akron	IA	Akron-Westfield School District	Akron-Westfield School District	600	1	Vestas		1999	School
Forest City	IA	Forest City School District	Forest City School District	600	1	NEG Micon	600 kW	1999	School
Hull	MA	Town of Hull	Town of Hull	660	1	Vestas	V-47	2001	Municipal Utility
Near Valley	NE	Omaha Public Power District	Omaha Public Power District	660	1	Vestas	V-47	2001	Municipal Utility
Wall Lake	IA	City of Wall Lake	Wall Lake Municipal Utilities	660	1	Vestas	660 kW	2003	Municipal Utility
Stuart	IA	Stuart Municipal Utilities	Stuart Municipal Utilities	660	1	Vestas	660 kW	2005	Municipal Utility
American Windmill Museum	TX	American Wind Power Center	American Wind Power Center	660	1	Vestas	V-47	2005	Locally Owned
Riverton	UT	Camp Williams, Utah National Guard	Camp Williams, Utah National Guard	660	1	Vestas	660 kW	2005	Government Agency
Clay County	MN	Moorhead Public Service #1		750	1	NEG Micon	750 kW	1999	Municipal Utility
Clay County	MN	Moorhead Public Service #2		750	1	NEG Micon	750 kW	8/23/2001	Municipal Utility

Location	State	Name	Owner	Size	# of turbines	Manufacturer	Model	Date of commissioning	Ownership structure
Eldora	IA	Eldora-New Providence Community School District	Eldora-New Providence Community School District	750	1	NEG Micon		2002	School
Lenox	IA	Lenox Municipal Utilities	Lenox Municipal Utilties	750	1	NEG Micon	750 kW	2003	Municipal Utility
Rosebud Sioux Reservation	SD	Rosebud Sioux	Rosebud Sioux Tribe	750	1	NEG Micon	750	2003	Tribal
Pipestone	MN	Pipestone School	Pipestone School	750	1	NEG Micon	750 kW	2004	School
Waverly	IA	Waverly Light and Power	Waverly Light and Power	900	1	NEG Micon	NM 900/52	2001	Municipal Utility
East of Petersburg	ND	East of Petersburg	Minnkota Power Cooperative	900	1		900 kW	2002	Rural Electric Cooperative
Valley City, Oriska	ND	Valley City, Oriska Hills	Minnkota Power Cooperative	900	1	NEG Micon	900 kW	2002	Rural Electric Cooperative
Lincoln County	MN	Hendricks Wind I LLC	Thomas Daggett	900	1	NEG Micon	900 kW	5/15/2002	Farmer owned
Lincoln County	MN	Borderline Wind LLC	Jay Gislason	900	1	NEG Micon	900 kW	12/31/2003	Farmer owned
Nobles County	MN	Sieve Windfarm	Don & Janet Sieve	950	1	NEG Micon	950 kW	12/2002	Farmer owned
Spirit Lake	IA	Sprit Lake Community School District	Spirt Lake Community School District	1,000	2	NEG Micon	250 & 750 kW	1992 & 2001	School
Sibley	IA	George Braaksma, et al	George Braaksma, et al	1,200	2	NEG Micon	600 kW	1996	Locally Owned
Lincoln	NE	Lincoln Energy System	Lincoln Energy System	1,320	2	Vestas	V-47	1999	Investor owned utility
Lincoln	NE	Lincoln Electric System	Lincoln Electric System	1,320	2	Vestas	V-47	1999	Municipal Utility
F.E. Warren Air Force Base	WY	F.E. Warren Air Force Base	F.E. Warren Air Force Base	1,320	2	Vestas	660 kW	2005	Government Agency
Spring View	NE	Nebraska Public Power District	Nebraska Public Power District	1,500	2	Enron	Z-46	1998	Investor owned utilty
Springview	NE	Nebraska Public Power District	Nebraska Public Power District	1,500	2	Enron	Z-46	1998	Municipal Utility
Alta	IA	Waverly Light and Power	Waverly Light and Power	1,500	2	Zond	Z-50	1999	Municipal Utility
Murray County	MN	Ed Olsen Wind LLC	Olsen Farms	1,500	2	NEG Micon	750 kW	12/1/2001	Farmer owned
Pipestone County	MN	Kas Brothers Wind LLC	Richard and Robert Kas	1,500	2	NEG Micon	750 kW	12/2/2001	Farmer owned
Dodge County	MN	BT LLC 2002	Brandon McNeilus	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Dodge County	MN	Burmese Children Support	Burmese Children Support	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Dodge County	MN	GarMar Foundation 2002	GarMar Foundation	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Dodge County	MN	GM LLC 2002	Garwin McNeilus	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Dodge County	MN	McNeilus Windfarm (2002)	Grant McNeilus	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Dodge County	MN	SG, LLC	Silvester Stoeckel	1,800	2	NEG Micon	900 kW	2002	Locally Owned
Nobles County	MN	Wisconsin Public Power	WMMPA and WPP	1,800	2	NEG Micon	900 kW	2002	Municipal Utility
Nobles County	MN	Western Minnesota Municipal Power	Local Goverment Joint Powers	1,800	2	NEG Micon	900 kW	1/11/2002	Municipal Utility
Rock County	MN	Minwind I	Cooperative of Farmers	1,900	2	NEG Micon	950 kW	10/2002	Farmer owned
Rock County	MN	Minwind II	Cooperative of Farmers	1,900	2	NEG Micon	950 kW	10/2002	Farmer owned

Location	State	Name	Owner	Size	# of turbines	Manufacturer	Model	Date of commissioning	Ownership structure
Dodge County	MN	Ashland Windfarm	Garwin McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Asian Children Support	Asian Children Support, Inc.	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Bangladesh Children Support	Bangladesh Children Support, Inc.	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	BT LLC 2003	Brandon McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	GarMar Foundation 2003	GarMar Foundation	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	GM LLC 2003	Garwin McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Grant Windfarm	Grant McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Indian Children Support	Indian Children Support, Inc	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	McNeilus Windfarm (2003)	Grant McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Salvadoran Children Support	Salvadoran Children Support, Inc.	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Dodge County	MN	Zumbro Windfarm	Brandon McNeilus	1,900	2	NEG Micon	950 kW	2003	Locally Owned
Martin County	MN	SMMPA	SMMPA	1,900	2	NEG Micon	950 kW	2003	Municipal Utility
Pipestone County	MN	Bisson Windfarm LLC	Peter & Maurine Bisson	1,900	2	NEG Micon	950 kW	10/1/2003	Farmer owned
Pipestone County	MN	Boeve Windfarm LLC	Gary & Gail Boeve	1,900	2	NEG Micon	950 kW	10/1/2003	Farmer owned
Pipestone County	MN	Windcurrent Farms	Steve & Jane Tiedeman	1,900	2	NEG Micon	950 kW	10/1/2003	Farmer Owned
Pipestone County	MN	CG Windfarm LLC	Corey Juhl	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Pipestone County	MN	Fey Windfarm LLC	Douglas & Pamula Fey	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Pipestone County	MN	K-Brink Wind Farm LLC	Aleanor Kruisselbrink	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Pipestone County	MN	TG Windfarm LLC	Tyler Juhl	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Pipestone County	MN	Tofteland Windfarm LLC	Dean & Jennifer Tofteland	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Pipestone County	MN	Westridge Windfarm LLC	Dan & Mary Juhl	1,900	2	NEG Micon	950 kW	10/1/2003	Locally Owned
Nobles County	MN	Western Minnesota Muni Power Agency		1,900	2	NEG Micon	950 kW	12/15/2003	Municipal Utility
Chandler Hills	MN	Great River Energy	Great River Energy	1,980	3	Vestas	660 kW	1998	Rural Electric Cooperative
Lincoln County	MN	Autumn Hills LLC	Northern Alternative Energy	1,980	2		990 kW	2/1/2001	Farmer Owned
Algona	IA	Iowa District Wind Energy Project	Cedar Falls, Algona, Ellsworth, Estherville, Fonda, Montezuma, Westfield Municipal Utilities	2,250	3	Zond	750	1998	Municipal Utility
Dodge County	MN	McNeilous, Garwind	Garwin McNeilous	3,000	2	Vestas	1500 kW	2004	Locally Owned
Chandler	MN	Chandler Hills Phase II	Great River Energy	3,960	6	Vestas	V-47	2001	Rural Electric Cooperative

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Distributed wind energy systems provide clean, renewable power for on-site use and help relieve pressure on the power grid while providing jobs and contributing to energy security for homes, farms, schools, factories, private and public facilities, distribution utilities, and remote locations. America pioneered small wind technology in the 1920s, and it is the only renewable energy industry segment that the United States still dominates in technology, manufacturing, and world market share.

The series of analyses covered by this report were conducted to assess some of the most likely ways that advanced wind turbines could be utilized apart from large, central station power systems. Each chapter represents a final report on specific market segments written by leading experts in this field. As such, this document does not speak with one voice but rather a compendium of different perspectives, which are documented from a variety of people in the U.S. distributed wind field.

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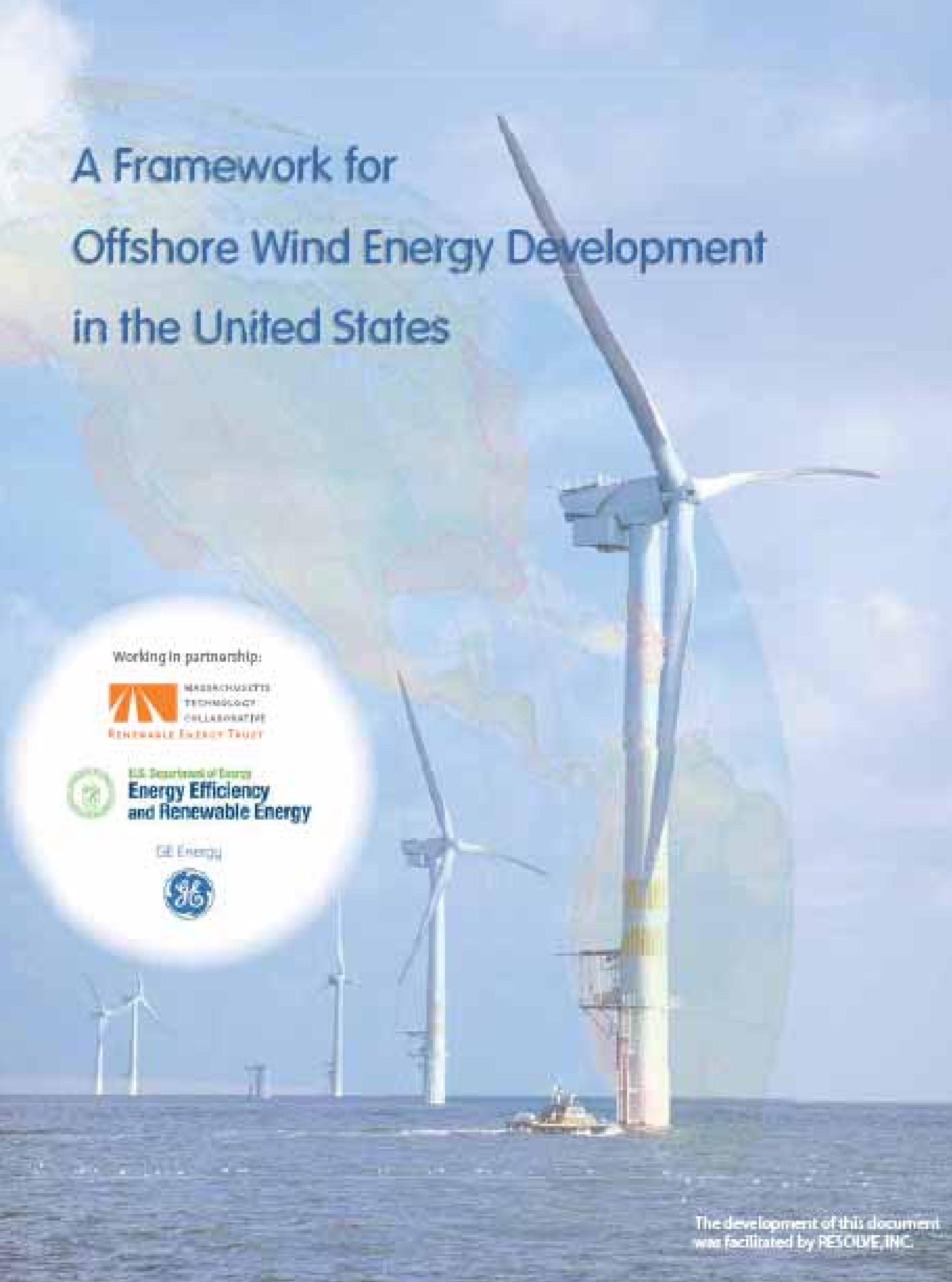
A Framework for Offshore Wind Energy Development in the United States



Working in partnership:

MASSACHUSETTS TECHNOLOGY COLLABORATIVE
RENEWABLE ENERGY TRUST

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Cover Art: Arklow Bank Offshore Wind Power Facility, Ireland - 25 MW. *Courtesy of GE Energy.*
Map: U.S. Continental Shelf Boundary Areas. *Image courtesy of Minerals Management Service.*

September 2005

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Executive Summary

The offshore renewable sector has changed over the past three years and can no longer be regarded as "tomorrow's potential" but as a developing industry in its own right … With continuing support from national governments and the coming together of the required industrial knowledge there is the potential to develop a new and distinct industry that not only generates clean electricity but also brings major long-term economic benefits, however, this new sector needs stability, commitment and innovation.

The World Offshore Renewable Energy Report 2002-2007
Douglas Westwood Limited for Renewables UK

The creation of this document, *A Framework for Offshore Wind Energy Development in the United States*, was organized and supported by the United States Department of Energy (U.S. DOE), GE, and the Massachusetts Technology Collaborative (MTC) in anticipation of the growing interest in offshore wind as an energy source. The potential to address a variety of serious environmental and energy supply concerns and leverage significant economic and technology development opportunities calls for a focused, coordinated approach to planning, research and development, and policy development for this new industry. Each member of this Organizing Group arrived at this conclusion from different perspectives that proved to be both complementary and synergistic.

MTC administers the Renewable Energy Trust, which seeks to maximize environmental and economic benefits for the Commonwealth's citizens by fostering the emergence of sustainable markets for electricity generated from renewable sources. GE built, operates, and owns Ireland's first offshore wind plant, demonstrating its 3.6 megawatts (MW) offshore wind equipment and services technologies for the growing offshore market. The U.S. DOE supports wind energy research and development, and is expanding efforts to increase the viability of offshore wind power as a substantial opportunity to help meet the nation's growing needs for clean, affordable energy. These interests were the catalyst driving the collaboration, initially focusing on the Northeast, to explore the potential for the creation of a U.S. offshore wind energy industry.

Wind energy has been the world's fastest growing energy source on a percentage basis for more than a decade. If growth trends continue at the same pace, wind capacity will double approximately every three to four years. This trend can be largely attributed to the public's growing demand for clean, renewable energy and to wind technology's achievements in reliability and cost-effectiveness.

Offshore wind has emerged as a promising renewable energy resource for a number of reasons: the strongest, most consistent winds are offshore and in relative proximity to major load centers—particularly the energy-constrained northeastern United States; the long-term potential for over-the-horizon siting and undersea transmission lines counters the aesthetic and land-use concerns associated with on shore wind installations; and wind as a fuel is both cost-free and emission-free.

More than 600 MW of offshore wind energy is currently installed worldwide—all of it off the coast of Europe in shallow waters less than 20 meters deep. However, with serious projects being proposed in the waters off the Northeast coast, the Mid-Atlantic coast, and the Gulf Coast, interest in developing offshore wind energy resources in the United States is clearly growing. The U.S. DOE estimates that there are more than 900,000 MW of potential wind energy off the coasts of the United States, in many cases, relatively near major population centers. This amount approaches the total current installed U.S. electrical capacity.

In January 2004, New England came dangerously close to experiencing a blackout during a severe cold spell as a result of limited natural gas supplies being diverted away from electricity generating plants to meet demands for home heating.[1] Those in charge of managing New England's electric grid are uncertain

1. ISO New England, Inc., Market Monitoring Department. *Interim Report on Electricity Supply Conditions in New England During the January 14-16, 2004 "Cold Snap"*. May 10, 2004.

Nysted Offshore Wind Farm
at Rødsand, Denmark
Photo by Laura Wasserman

how the region will continue to meet peak demand for electricity beyond the year 2006. Offshore wind is one of the Northeast's local renewable energy sources with the potential to address the anticipated unmet demand.

States in other regions—including the Mid-Atlantic, the Gulf Coast, and the Great Lakes—are also beginning to consider the potential role for offshore wind in addressing their particular energy concerns, paving the way for a national offshore wind energy collaboration.

Sustainably tapping the U.S. Outer Continental Shelf's vast wind resource will require addressing formidable engineering, environmental, economic, and policy challenges. This *Framework* identifies these challenges and suggests a comprehensive approach to overcoming them. A principal focus is to broaden the available wind resource potential through the development of technologies and policies that will allow turbines to be responsibly sited in deeper water and further offshore.

Interestingly, the move towards offshore wind energy development is leading to a convergence of two of society's most pressing environmental challenges: to curtail the emissions of noxious and heat-trapping gases being released into the atmosphere and to sustainably manage our ocean resources.

Earth's oceans and atmosphere are both in peril. As recent studies document, our oceans face a greater array of problems than ever before in history.[2] In particular, unprecedented concentrations of carbon dioxide, nitrogen oxide, and other emissions resulting from the combustion of fossil fuels threaten to alter the composition of the atmosphere and undermine the integrity of both aquatic and terrestrial ecosystems. An aggressive push for renewable energy production will start us down a path to reducing these environmental and public health threats.

The critical, overarching context for this renewable energy development initiative is the urgent need for policies to guide the sustainable use and conservation of ocean resources, acknowledged at the state and national levels. It is imperative that offshore wind energy is included as an integral part of the ocean management dialogue and that the development of a U.S. offshore wind energy industry is conducted in a way that supports the improved health and management of our nation's marine resources.

The *Framework* lays out the challenges and suggested strategies for addressing them in the following five areas:

- Technology Development
- Environmental Compatibility
- Economic and Financial Viability
- Regulation and Government Policies
- Leadership Coordination

Issues and proposed approaches were identified with input from more than 60 experts via interviews and workshops sponsored by the Organizing Group. Participants represented a wide range of relevant expertise and perspectives. An effort was made to encompass the full range of questions and concerns regarding the potential for siting wind energy systems offshore, and engagement in this process was not limited to parties with a positive stance on offshore wind energy development.

2. The Pew Charitable Trusts. *America's Living Oceans: Charting a Course for Sea Change*. 2003.

Strategies for Addressing Challenges and Achieving Sustainable Offshore Wind Energy Development:

Advance Technology Development

Current offshore wind energy system designs have been adapted from land-based versions and deployed in shallow waters off northern European coastlines for more than a decade. Offshore wind energy technology is evolving toward larger-scale and fully marinized systems that can be deployed in a range of water depths across a wider range of geographical areas.

Strategies:

- Develop Design Standards for Offshore Wind Energy Systems
- Integrate Environmental Condition and Design Parameters
- Tailor Support Structure Designs to Site-Specific Conditions
- Achieve High Levels of Wind System Availability and Performance through Optimized Approaches to Operations and Maintenance
- Address Power Transmission and Grid Interconnection Issues
- Develop and Leverage Expertise

Achieve Environmental Compatibility

Beyond technical and economic issues, the sustainability of an offshore wind power industry in the United States will depend on focusing on environmental compatibility and impact mitigation as high design priorities, and on improving understanding of the interactions that will occur between offshore wind development and marine ecosystems in the United States.

Strategies:

- Identify Current Conditions and Trends of Marine Ecosystems and Ocean Uses
- Identify Potential Areas for Offshore Wind Energy Development
- Identify Potential Impacts and Environmental Changes from Offshore Wind Energy Systems
- Identify Appropriate and Effective Mitigation Strategies for Potential Environmental Impacts and Conflicting Uses
- Document and Quantify Environmental Benefits

Achieve Economic and Financial Viability

Although today's costs of offshore wind energy production are higher than onshore, expectations are that several factors working together will make the development of offshore wind energy sources more cost effective. These factors include technology innovations, stronger wind regimes, economies of scale from large-scale development, close proximity to high-value load centers, and incentive programs responding to the public's growing demand for clean energy.

Strategies:

- Develop Current Understanding of Costs of Offshore Wind Energy Systems and Implement Research and Development Opportunities for Cost Reduction
- Evaluate Ownership and Financing Structures and Associated Risks
- Increase Availability of Long-Term Power Purchase Agreements
- Develop Confidence in Technology among Financial, Insurance, and Public Sectors

Clarify Roles for Regulation and Government Policies

Achieving a cost-competitive offshore wind energy industry will require significant advances in the technology and policy arenas. Many of the challenges require an integrated approach. For example, public acceptance of offshore wind facilities is linked to development of a credible planning and permitting process that ensures the recognition of public benefits from use of the resource.

Strategies:
- Establish a Process for Siting and Development that Gains Public Acceptance
- Develop Policies with a Tiered and Phased Incentive Program to Foster Early Development of Offshore Wind Energy
- Create Stable Rules and Processes for Transmission and Grid Integration

Establish Leadership, Coordination, Collaboration, and Support

A national collaborative can play an important role as it works to coordinate and leverage the resources to address the challenges in an efficient and synergistic manner. The level of resources needed to fund a collaborative approach will depend on the form the collaborative takes and on the roles its members play in providing and recruiting technical and financial support. Regional collaboratives will also be useful for addressing regional and local planning challenges and needs.

Strategies:
- Establish a Credible Mechanism for Leadership, Collaboration, and Support for Offshore Wind Energy Development
- Create and Maintain a Vision of Offshore Wind as Part of the Mainstream Energy Mix
- Attract, Apply, and Coordinate Resources
- Establish and Implement a Mechanism for Convening Parties Interested in Offshore Wind Energy
- Develop and Support a Coordinated Research Program to Accomplish Technical, Environmental, Economic, and Regulatory Goals
- Support Integration of Activities in All Arenas

Next Step

The next step in this process will be to create an Organizational Development Plan for an *offshore wind collaborative*, with an initial focus on the waters of the Atlantic off the Northeast coast. The plan will propose a clear role for this new partnership in implementing the agenda put forth in the *Framework*, making the case for establishing a multi-sector cooperative effort to address key aspects of the U.S offshore wind energy development strategy. The plan will describe the organizational structure; define relationships and responsibilities among collaborators; define specific opportunities and benefits of participation for industry, government, and non-governmental partners; and establish funding needs and sources.

Introduction, Origins, and Purpose

Introduction

Offshore wind is an emerging renewable energy source. It is realizing rapid growth in Europe, where national commitments to greenhouse gas reductions are driving renewable energy development. In the northeastern United States, two of the country's first large offshore wind energy projects are currently involved in the planning and permitting process. There are several supporting factors encouraging broader wind energy development in the United States, including growing public demand and policy initiatives for clean power sources, fossil fuel price and supply volatility, and concerns over climate change. Although there are significant opportunities for continuing wind energy development on land in some parts of the country, the future potential for offshore development may be even larger. The magnitude of the offshore potential rivals the current installed electrical capacity of the United States. Thus, it is timely to look ahead to determine how offshore wind can become a meaningful component of the U.S. energy mix.

This document, *A Framework for Offshore Wind Energy Development in the United States*, lays out the pathway for defining and achieving the potential for offshore wind energy in the United States, with an emphasis on the Northeast as an initial focus for regional development.

The United States Department of Energy (U.S. DOE), Massachusetts Technology Collaborative (MTC), and GE organized and supported preparation of this document to identify challenges facing the development of a robust offshore wind energy industry in the United States and to stimulate dialogue on how to sustainably develop offshore wind power. This Organizing Group reached out to more than 60 interested parties—some already supportive of offshore wind energy development and others with serious concerns about this new type of ocean-based development. These included representatives from federal and state agencies, industry, non-governmental organizations, and research institutions. The Organizing Group sincerely thanks all who contributed their time and expertise to the development of this *Framework*.

Origins

In the summer of 2003, representatives from GE approached MTC with the idea of establishing a collaborative process to explore the opportunities for developing the wind resources in deep water off the coast of New England. GE had been working with researchers from the University of Massachusetts (UMass) Massachusetts Institute of Technology (MIT), and the Woods Hole Oceanographic Institution (WHOI) on a research agenda for deep-water offshore wind, but was looking for a more comprehensive approach that would engage regulatory agencies, policy makers, environmental advocacy groups, and other industry partners as well.

In 2002, MTC designed and implemented the Cape and Islands Offshore Wind Stakeholder Process to provide the public with an objective forum to discuss the proposal by Cape Wind Associates to construct 130 wind turbines in Nantucket Sound off the coast of Cape Cod. The process created a venue for engaging more than 40 stakeholders in a series of meetings, with the primary objective of making the joint federal/state/regional permitting process for the Cape Wind project as transparent and understandable as possible to facilitate productive participation by concerned citizens.

GE hoped that MTC could develop a similar collaborative process that would lead to a strategy for deploying offshore wind energy systems in a way that anticipated and avoided some of the more controversial issues surrounding projects currently in development.

The Commonwealth of Massachusetts is uniquely positioned to pursue the sustainable development of its offshore wind resources. It was among the first states to establish a Renewable Portfolio Standard (RPS) that sets a target for the amount of electricity sold on the retail market that must be generated from renewable energy sources (4% by 2009). New England's increasing dependence on natural gas has created a need for alternative energy sources. Offshore wind energy is an attractive option due to the significant wind resources off the coast, and the limited land resources that make the development of utility-scale, land-based wind farms in New England problematic.

Early in 2004, representatives from GE and MTC were invited to Washington to discuss the idea of a collaborative process with staff from the U.S. DOE's Wind and Hydropower Technologies Program. U.S. DOE was considering funding offshore wind research and development projects as part of its Low Wind Speed Technology (LWST) program, and expressed interest in the concept. Following a series of meetings in Massachusetts, MTC, GE, and U.S. DOE agreed to commit funds and staff time to pursue the creation of a collaborative planning process and this resulting *Framework* document.

MTC, GE, and U.S. DOE provided funding for a series of short-term pilot research projects drawn from the agenda developed earlier in conjunction with GE as an initial step to support the ongoing participation of MIT, WHOI, and UMass in the dialogue on the future of offshore wind energy development in the United States. These projects address some baseline technical and policy questions.

To initiate the overall collaborative planning process, the Organizing Group issued a joint Request for Proposals in July 2004 and RESOLVE, Inc., was hired to facilitate development of this *Framework.* The Organizing Group worked with RESOLVE to identify individuals representing the environmental, industry, regulatory, and marine interests whose input would be critical. These individuals were invited to a two-day workshop in Washington, D.C., in February 2005 to help develop the scope for this *Framework* by exploring the full range of technical questions, environmental concerns, and possible strategies for addressing them. A second meeting was held in Boston for those who were unable to attend the February workshop.

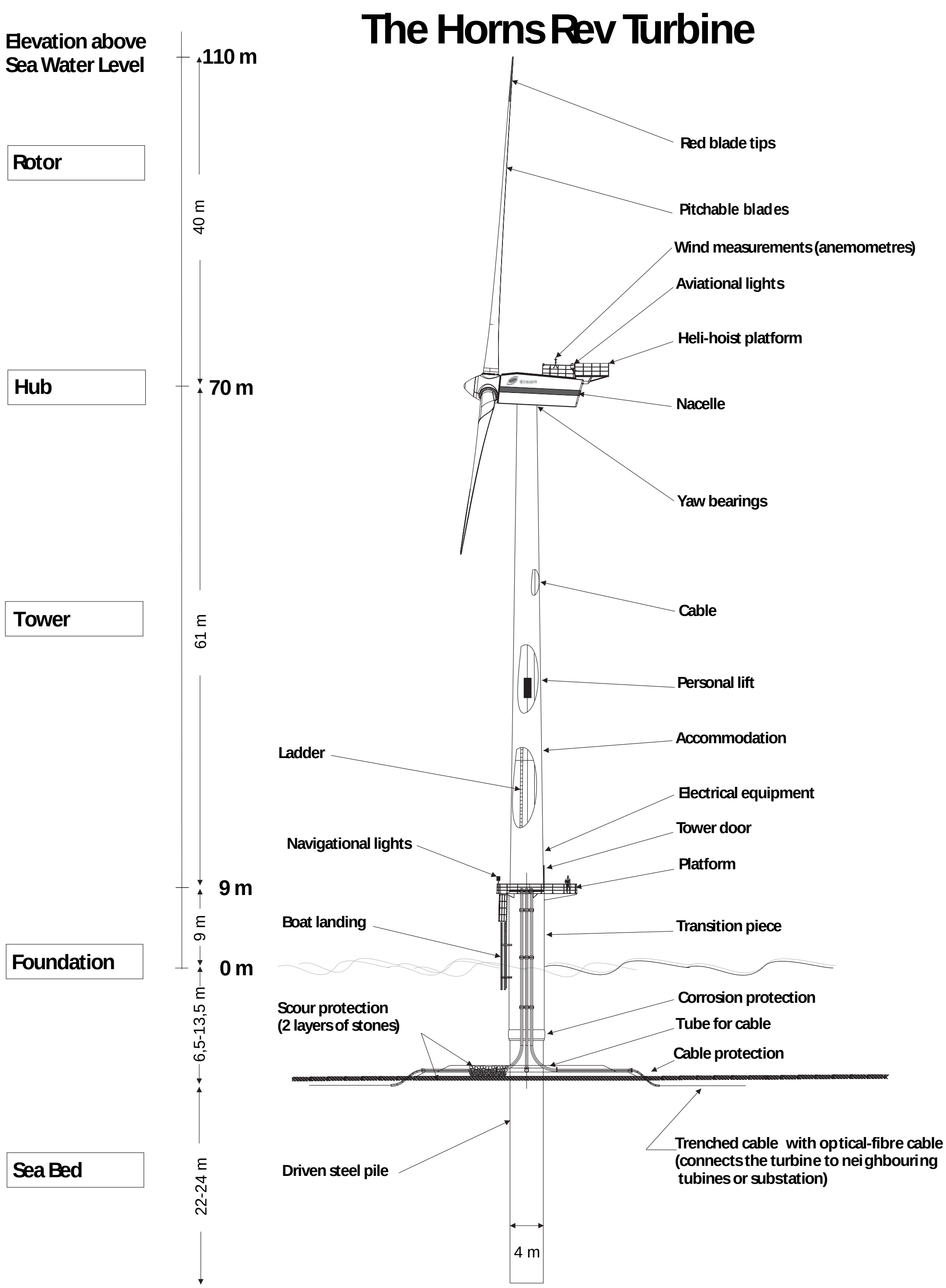
Purpose

The purpose of this *Framework* is to propose an agenda designed to address the technical, environmental, economic, and regulatory issues critical to enabling the development of offshore wind energy as a commercially, politically, socially, economically, and environmentally sustainable energy resource. A principal focus is to broaden the available wind resource potential through the development of technologies and policies that will allow turbines to be responsibly sited in deeper water and further offshore.

Offshore Wind Energy Potential: Background

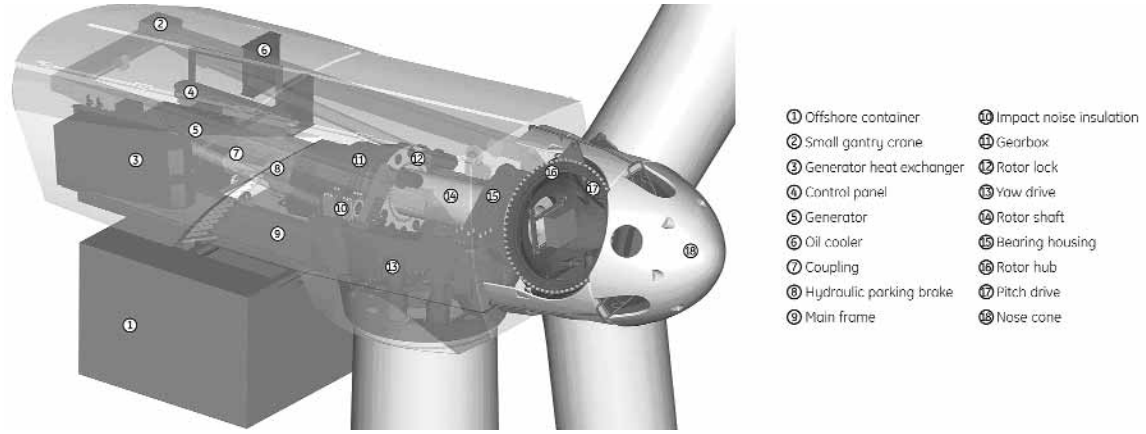
Overview of Offshore Wind Technology

This section discusses the primary components of an offshore wind energy system: turbines, towers, foundations, and the balance of plant (supplemental equipment necessary for a fully commissioned system). An illustration of an offshore wind turbine is shown below.



Principal Components and Dimensions of an Offshore Wind Turbine

Graphic courtesy of Horns Rev wind project, Denmark (http://www.hornsrev.dk). Copyright Elsam A/S.



Principal Components of an Offshore Wind Turbine Layout
Graphic courtesy of GE Energy (http://www.gepower.com/businesses/ge_wind_energy/en/index.htm).

The primary and most visible part of an offshore wind energy system is the turbine. Most turbines operating today are composed of a three-bladed rotor connected through the drive train to the generator, which are housed in the nacelle.

Several manufacturers have recently engineered wind turbines specifically for offshore applications. These machines are based on proven technology but have been designed to meet the needs of a more remote and demanding offshore environment. Manufacturing trends indicate that future turbines will be larger than today's typical size of 2 to 4 megawatts (MW).

The tower provides support to the turbine assembly, housing for balance of plant components, and importantly, a sheltered interior means of access for personnel from the surface.

Wind turbine support structure design is driven by site-specific conditions: water depth, wind/wave conditions, and seabed geology. The three standard offshore foundation types in shallow water are monopile, gravitation, and multi-leg, with the monopile type being the most common. Floating turbines may be feasible as long-term options in even deeper water.

The combined action of wind and waves introduces a whole new set of engineering challenges to the design of these wind energy systems operating in offshore waters.

Additional components of an offshore wind project are the undersea electrical collection and transmission cables, the substation, and the meteorological mast. Electrical cabling is split into two functions: collection and transmission. The collection cables connect series of turbines together and are operated at a distribution grade voltage. The outputs of multiple collection cables are combined at a common collection point (or substation) and stepped up in voltage (such as 69, 115, or 138 kilovolts) for transmission to shore. The transmission cable(s) delivers the project's total output to the onshore electric grid, where the power is then delivered to loads. A substation is typically sited offshore but it can alternatively be sited onshore.

Most wind energy plants have a meteorological mast that plays an important role in the project development process and serves two primary purposes. First, the meteorological mast is erected to collect on-site wind resource data at multiple heights. The measurement program is generally conducted for a year to verify the project area's meteorology and sea state conditions. Second, after the wind park is installed and commissioned, the data from the meteorological mast serves new functions, such as power performance testing, due diligence evaluation, and operation maintenance management.

Wind as a Component of the Energy Mix

Wind energy has been the world's fastest growing energy source on a percentage basis for more than a decade. If growth trends continue at the same pace, wind capacity will double approximately every three to four years. This trend can be largely attributed to the public's growing demand for clean, renewable energy sources and to wind technology's achievements in reliability and cost-effectiveness.

The cost of wind power has fallen by 80% over the past 30 years, making it one of today's lowest-cost sources of electricity. Despite this growth, wind power still represents less than 1% of the total electricity generation base of the United States.

At the end of 2004, the current worldwide installed wind capacity exceeded 47,300 MW. Most of this is based in Europe, with Denmark and some regions of Spain and Germany realizing 10% to 25% of their electricity from wind-based generation. The United States accounts for 14%, or 6,740 MW, of the world's total wind power. This amount meets the electricity requirements of more than 1.6 million average American households. By the year 2020, the U.S. wind industry projects that 100,000 MW of wind can be built in the country. This would supply 6% of the nation's electricity at that time, which is nearly as much electricity as hydropower provides the nation with today.

Boston's Newest Landmark, the International Brotherhood of Electrical Workers' Wind Turbine off Interstate 93

Besides its demonstrated cost competitiveness onshore, wind is an attractive energy option because it is a clean, indigenous, and non-depletable resource, with long-term environmental and public health benefits. Once a wind plant is built, the cost of energy is known and not affected by fuel market price volatility. This, along with its economic benefits in terms of employment through manufacturing, construction and operational support, makes wind an attractive technology with which to diversify the nation's power portfolio and help relieve the pressure on natural gas prices.

The growth of wind energy in the United States has been impeded by several expiration/renewal cycles of the federal Production Tax Credit (PTC), inhibiting sustainable momentum. State incentive programs (e.g., Renewables Portfolio Standards, Systems Benefit Charge programs) have provided some market opportunities and led to regional growth spurts. The European experience, in contrast, has been policy driven with long-term development goals and time horizons. This has succeeded in making Europe the home to the majority of the world's wind energy development. It has also spurred the development of offshore wind, which is seen as a solution to dwindling siting opportunities on land.

The United States as a whole has abundant acreage and contains large pockets of windy rural lands, most of which are found in the sparsely populated areas west of the Mississippi. With slightly more than half the country's population living in the coastal zone, it would be necessary to upgrade the transmission grid to allow for the interstate transfer of large amounts of wind power to the population centers. This would require huge investments, preceded by lengthy regulatory and legislative approvals. Tapping the strong winds offshore, which are much closer to urban load centers, can provide an alternative to these transmission challenges.

Ocean Wind Energy Resources in the United States and Northeast

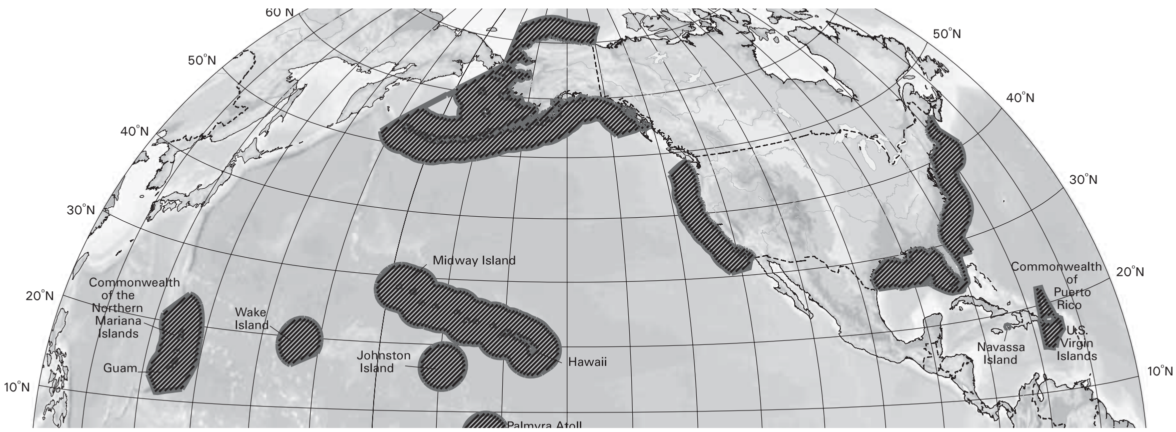
Modeling studies of the wind resources along the east and west coasts of the United States indicate large areas of strong winds (greater than 7.5 meters per second) within 50 nautical miles of shore. Additional resources are available in the Gulf Coast and Great Lakes regions, but these have yet to be fully characterized. These windy areas are substantially greater in size than those on land along the shorelines and within the adjacent interior spaces. The National Renewable Energy Laboratory (NREL) has determined that the offshore resource between 5 and 50 nautical miles along the Atlantic and Pacific coasts alone could support up to roughly 900 gigawatts (GW) of wind generation capacity—an amount similar to the current installed U.S. electrical capacity.[3] This estimate excludes significant areas that will likely be found development-prohibitive due to environmental concerns, and competing ocean uses. Even as these general exclusions are refined in the future, the vast potential for offshore wind energy is compelling.

Most of the total potential offshore wind resources exist relatively close to major urban load centers, where high energy costs prevail and where opportunities for wind development on land are limited. This is especially true in the densely populated Northeast, where nearly one-fifth of the national population lives on less than 2% of the total land area. At the beginning of 2005, there were only 184 MW of wind generation based in this region, or less than 3% of the country's total wind capacity. The

3. Musial, W. and S. Butterfield. *Future for Offshore Wind Energy in the United States*. Proceedings of EnergyOcean 2004 Conference, NREL/CP-500-36313. 2004.

lack of alternatives to natural gas and coal, scarcity of large open spaces available to utility-scale wind development, and the difficulty of importing large amounts of wind energy from other parts of the country using the existing transmission grid will greatly enhance the appeal of offshore wind energy development in the Northeast.

Offshore wind energy is also an attractive option for the Northeast at this time because slightly more than half the country's identified offshore wind potential is located off the New England and Mid-Atlantic coasts, where water depths generally deepen gradually with distance from shore. While most of the Northeast and Mid-Atlantic's development potential is in deep water (greater than 30 meters), the initial siting of offshore wind systems in relatively shallow waters will facilitate a transition to deeper waters further from shore as the technology is advanced. The West Coast does not offer a similar proving ground because water depths drop off sharply close to shore.



U.S. Continental Shelf Boundary Areas
Image courtesy of Minerals Management Service.

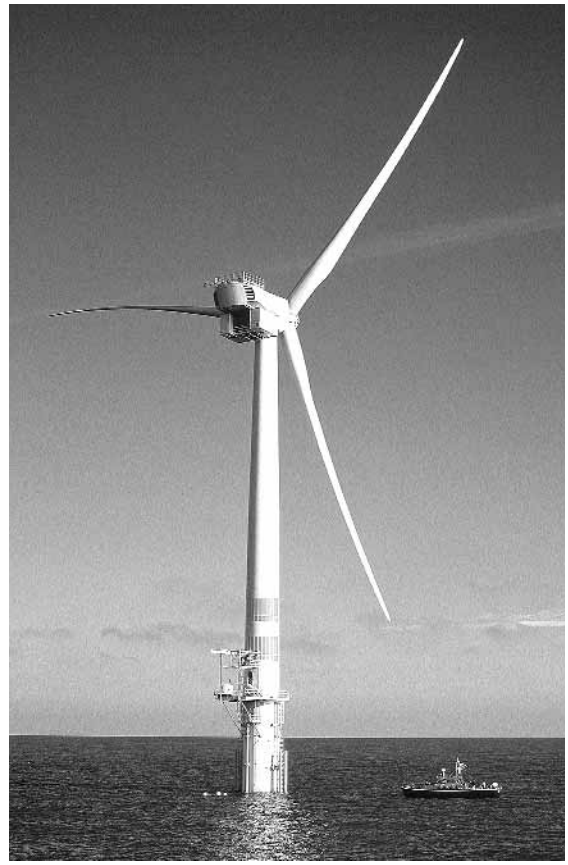
The Economics of Offshore Wind and Other Energy Resources in the Northeast

Conventional energy prices are expected to climb. Energy supply and price volatility are significant risks as well, if recent experience with oil, gas, and coal is any indication. The Northeast is particularly vulnerable because the region has virtually no indigenous supply of natural gas and oil, which are responsible for a large fraction of the region's baseload electricity supply and the majority of its peaking capability. As the Northeast seeks indigenous alternatives to oil and natural gas, offshore wind is among the most promising options.

European offshore wind project costs generally range between \$0.08 and \$0.15 per kilowatt-hour, which is almost double that of onshore projects. Construction and accessibility, which are the leading cost drivers, are much more difficult at sea. For example, the majority of the cost of an offshore wind project is attributable to its balance of plant components, including the foundation/support structure, installation, and transmission, as opposed to an onshore project, where most of the costs reside with the wind turbines. The high construction costs for offshore development make cost reduction, particularly in the balance of plant components, a key component of achieving competitive offshore wind energy development.

Historically, as new technologies become commercially available, costs come down due to increased efficiency, reduced service requirements, and economies of scale, even when there are initially steep learning curves. For onshore wind development, capital costs have dropped by 15% on average for every doubling of capacity. The European Union predicts there will be at least 40,000 MW of offshore wind energy in Europe by the year 2020, representing an annual growth rate of 30% from the current 600 MW. This compares with an actual annual growth rate of 35% during the past seven years for all wind energy development in Europe. For U.S. offshore wind energy development, taking advantage of what has been learned from offshore oil and gas marine construction can contribute to wind energy cost reduction efforts.

The energy scenario for the Northeast pertains not only to price and supply, but to environmental quality as well. A reduction in greenhouse gases and other pollutants from fossil fuel plants is a regional priority within the regulatory and legislative bodies of most states. Offshore wind energy has the potential to make a favorable contribution to this scenario because of its projected downward cost trajectory, its vast supply within close proximity of major load centers, and its status as a clean, non-polluting technology. All three issues—cost, supply, and environmental quality—will ultimately determine the future value and desirability of all energy sources, including offshore wind.



Arklow Bank Offshore
Wind Power Facility, Ireland

The Opportunity to Pursue Offshore Wind Energy

Interest and experience in offshore wind energy development is growing. European countries have been installing turbines off their coastlines for more than a decade, while the United States is getting started with two serious project proposals located off the coasts of Massachusetts and New York. Sustaining and building on this momentum will require leadership and the collective action of all interested parties to pursue a logical path toward an achievable goal.

Offshore wind energy is a vast resource with tremendous potential for addressing future energy needs and spurring new economic development opportunities. But as a relatively young industry having no track record in the United States, there is much to be learned about its challenges and benefits; the unknowns are great. Therefore, it is imperative that those having common interests in environmental quality, energy security, and economic vitality work together so that the benefits of offshore wind energy can be realized.

Coincident with the increased interest in production of electricity from winds offshore is the renewed attention to development of policy directed at offshore ocean uses. The work of the U.S. Commission on Ocean Policy and a parallel effort by the Pew Oceans Commission have focused public attention on the fragile, complex nature of the marine environment; and the importance of this public trust resource to environmental and economic health of the country. The U.S. Executive Branch, Congress, and private and non-governmental sectors are now considering ways to enhance governance and regulations associated with the development and conservation of ocean resources. The integrated, careful approach to building an offshore wind industry in the United States proposed in this *Framework* has the potential to significantly support and inform this move towards more effective, sustainable ocean management.

Strategies for Addressing Challenges and Achieving Sustainable Offshore Wind Energy Development

This section presents the details of the *Framework* for sustainable offshore wind energy development in the United States. It lays out the challenges and suggested strategies to address each in the following five areas:

- Technology Development
- Environmental Compatibility
- Economic and Financial Viability
- Regulation and Government Policies
- Leadership Coordination

The activities are categorized by the general timeframe in which efforts would likely occur or reach completion: near term, medium term, and long term. These time frames are approximate in nature and dependent on several factors. They are mainly intended to define the relative timing and sequence of activities.

The activities reflect the results of individual consultation and workshop discussions with a wide range of interested parties representing a broad spectrum of interests. The activities also are interdependent to varying degrees, with outcomes likely affecting each other.

1 Advance Technology Development

Advance Technology Development

Current offshore wind system designs have been adapted from land-based versions and deployed in shallow waters off northern European coastlines over the past dozen years. To date, monopile and gravity foundation designs have been suitable for this environment. Offshore wind technology is evolving toward larger-scale and fully marinized systems that can be deployed in a range of water depths across a wider range of geographical areas.

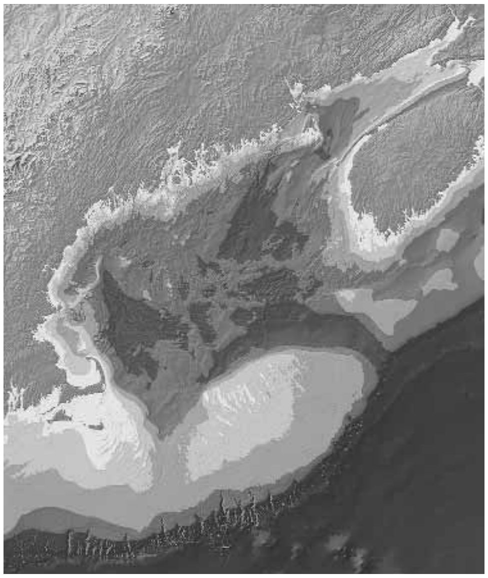
Offshore wind systems must be tailored to the marine environment. For the support structure, variable site conditions in terms of water depth, wave spectra, currents, sea bed geology, and other factors will require the availability of multiple design options, each one suitable to a particular class of design criteria. Offshore system designs are in the early stages of development—with new technologies emerging—that will need to be fully tested and successfully demonstrated before an offshore wind industry can emerge and realize its potential.

Pathways to achieving long-term success lie partly in gaining a better understanding of the environmental conditions that offshore structures must accommodate in the Atlantic waters off the Northeast coast, and how these structures will interact with both the physical and biological environment. Knowledge gaps can be closed through targeted research and measurement programs. Pathways to success also rely on leveraging the knowledge resident in marine research and engineering disciplines, including the offshore oil and gas industry, which has built and maintained offshore structures for decades. Also, engagement with the international offshore wind industry will provide invaluable lessons learned from offshore projects while the experience base is establishing itself in the United States.

Strategies:

- Develop Design Standards for Offshore Wind Energy Systems
- Integrate Environmental Condition and Design Parameters
- Tailor Support Structure Designs to Site-Specific Conditions
- Achieve High Levels of Wind System Availability and Performance through Optimized Approaches to Operations and Maintenance
- Address Power Transmission and Grid Interconnection Issues
- Develop and Leverage Expertise

To achieve viable offshore U.S. wind energy technologies, the issue of site accessibility limitations (a result of harsh conditions that can occur in the ocean) and the resulting impacts on turbine



Gulf of Maine Bathymetry

availability, reliability, safety, and project economics must be addressed. The development of a viable regional service infrastructure and strategies will overcome these and other barriers. The anticipated injection of large amounts of new wind-based generation into the existing transmission grid will need to be managed technically through well-planned studies and conceptual designs, with the added benefit of maximizing the market value of wind-based electricity.

Advance Technology Development

Progress is needed on several fronts to advance wind technology to accommodate the long-term challenges of sustainable offshore wind energy development, as outlined below. Further, it will be important for engineers to design an offshore wind system with appropriate consideration of issues related to maintaining the integrity of marine ecosystems and minimizing adverse impacts.

Strategy 1.1
Develop Design Standards for Offshore Wind Energy Systems

Develop standards and guidelines that establish minimum specifications for offshore wind structures.

Near Term:

- Build upon existing results of International Electrotechnical Commission 61400-3, which is a pending international design standard for offshore wind turbines.[4]
- Collaborate with marine engineering disciplines experienced in deep water applications to determine the parameters needed to address engineering, environmental, and other criteria.
  - Collaborate with Minerals Management Service and other regulatory bodies in anticipation of their safety and inspection oversight role.
- Conduct a gap analysis to identify standards, guidelines, and design parameters that are lacking or unavailable, and recommend approaches for addressing deficiencies.
- Compile and evaluate the applicability of lessons learned from onshore turbine design and siting, including design approaches for minimizing environmental impacts (e.g., avian interactions).

Strategy 1.2
Integrate Environmental Condition and Design Parameters

Quantitative information about the geologic, oceanic, biological, and atmospheric environments is necessary to establish design criteria for offshore wind system structures.

Near Term:

- Compile a comprehensive inventory of existing empirical databases and sources (e.g., a wind and wave spectrum resource atlas, habitat maps, species distribution and relative abundance).
- Identify sources of design parameters established for offshore structures in other industries (e.g., American Petroleum Institute) and marine engineering applications.
- Assess and apply integrative and predictive models (e.g., hindcasting) to construct regionally consistent summaries of design parameters.
- Assess the adequacy of existing databases to define design parameters and identify critical data gaps.

Medium Term:

- Develop and implement a measurement plan to obtain missing critical data.
- Develop advanced measurement sensors and techniques to obtain data that are too expensive or impractical to collect using conventional means.
- Compile an atlas of offshore design parameters.

Strategy 1.3
Tailor Support Structure Designs to Site-Specific Conditions

Suitable support structure designs, including bottom-attachment techniques, are needed to accommodate a range of site conditions found in the Northeast.

Near Term:

- Define foundation design classifications and the governing design parameters and step functions.
- Determine design classes appropriate for offshore conditions and environmental

4. Quarton, D.C. *An International Design Standard for Offshore Wind Turbines*. Proceedings of World Renewable Energy Congress VIII. Elsevier Ltd, 2004.

sensitivities in the Northeast, and develop preliminary design specifications.
- Conduct preliminary costing studies for the leading classes and prioritize components having cost reduction potential.
- Evaluate available foundation design tools for simulating all load conditions, including those introduced by the tower and turbine components; identify gaps and priorities.
- Develop a research program to address foundation design uncertainties and to pursue the development of advanced designs with cost reduction objectives.
- Assess the need for testing facilities (e.g., wave motion simulation platform, blade testing facilities, full-scale ocean test beds).

Medium Term:
- Advance the development and validation of numerical computer models to accurately simulate dynamic loads imposed throughout the entire wind turbine structure by atmospheric and hydrodynamic forces.
- Tailor system designs for environmental compatibility and low potential impacts on marine ecosystems.

Strategy 1.4
Achieve High Levels of Wind Energy System Availability and Performance through Optimized Approaches to Operations and Maintenance

Parallel efforts are needed to develop advanced technology and infrastructure to facilitate the construction and reliable operation of offshore wind plants.

Near Term:
- Assess typical field failure conditions and the ability to detect and diagnose them with advanced monitoring techniques.
- Conduct research into self-diagnostic and intelligent systems (e.g., enhanced Supervisory Control and Data Acquisition) that can be integrated into the turbine operating system, and optimized fleet maintenance models.

Medium Term:
- Develop specialty sensors and software.
- Investigate methods to improve accessibility of projects from land.
  - Interact with regulatory agencies, including: Minerals Management Service (MMS), Occupational Safety and Health Administration (OSHA), and Federal Aviation Administration (FAA) to establish approved access and personnel transfer procedures.
- Form a collaborative task group to define infrastructure requirements, identify existing resources available in marine industries, and explore opportunities for developing local and/or regional offshore wind infrastructure capability.

Long Term:
- Deploy, test, and analyze results.

Strategy 1.5
Address Power Transmission and Grid Interconnection Issues

The delivery and injection of large amounts of wind-based generation into existing electrical grids requires long-range planning, potential investments in system upgrades, and effective grid management and operating strategies.

Near Term:
- Evaluate the ability of the Northeast's coastal grid to accept large injections of wind generation and determine necessary levels of grid upgrades and associated investments.

Medium Term:
- Monitor advancements in transmission cable technology for their applicability to offshore wind projects.
- Assess the direct current (DC) alternative for long-distance transmission, including trade-off studies with alternating current (AC) transmission.
- Assess the concept of long-range transmission trunk lines for interconnecting wind plants at sea.
- Obtain representative data on expected wind plant production variability at multiple time scales (e.g., 1-second, 10-minute, and 1-hour) so that potential grid impacts can be simulated.
- Conduct a technology and cost feasibility analysis of alternatives to conventional electric production and delivery (e.g., non-electric options such as pneumatic air, hydrogen); assess opportunities.
- Coordinate with regional transmission system planners to ensure scenarios for large levels of offshore wind power are included in system upgrade and expansion analysis and planning.
- Evaluate impact of large amounts of wind energy on: 1) power system functioning; and 2) wholesale market design and efficiency.

Long Term:
- Assess and advance the capabilities and value of short-term forecasting of wind plant output to optimize grid system operations.

ADVANCE TECHNOLOGY DEVELOPMENT

Strategy 1.6
Develop and Leverage Expertise

Investments in intellectual resources and experience building are essential to the advancement of the state-of-the-art offshore wind energy systems.

Near Term:
- Support participation by appropriate parties in international collaborative activities to stay abreast of technological developments and lessons learned from project experiences abroad.
  - Attend conferences, workshops, and technical task group meetings.
  - Seek joint research initiatives, including the utilization of existing offshore projects to collect relevant research and validation data on loads, structural dynamics, and environmental parameters.
- Build a broader base of knowledge about wind energy in the oil and gas industry to facilitate integration goals.
  - Participate in joint conferences and workshops.
  - Include oil and gas industry representatives on offshore wind technology task groups.
- Initiate collaborative discussion with experts in marine biology, wildlife behavioral sciences, fisheries, and other relevant disciplines.

Medium Term:
- Develop and support interdisciplinary research and training activities in offshore wind energy.
  - Facilitate public-private sector interactions.
  - Promote international student exchanges between universities and work-study programs with industry.

2 Achieve Environmental Compatibility

Wind power offers environmental benefits, but wind energy installations often face opposition due to potential, perceived, and actual environmental impacts. Beyond technical and economic issues, the sustainability of an offshore wind power industry in the United States will depend on focusing on compatibility and impact mitigation as high design priorities, limiting the known impacts, and improving understanding of the interactions that will occur between offshore wind development and marine ecosystems in the United States.

Strategies:
- Identify Current Conditions and Trends of Marine Ecosystems and Ocean Uses
- Identify Potential Areas for Offshore Wind Energy Development
- Identify Potential Impacts and Environmental Changes from Offshore Wind Energy Systems
- Identify Appropriate and Effective Mitigation Strategies for Potential Environmental Impacts and Conflicting Uses
- Document and Quantify Environmental Benefits

The offshore environment is a vast and important public trust resource. Marine ecosystems provide a variety of essential services critical to the well-being of all biological species, including humans.

Demonstrating the compatibility of offshore wind energy systems with ecological systems and human uses of the ocean will be required for offshore wind energy development to proceed with the necessary public support.

In order to proceed responsibly with the siting of offshore wind energy systems, it will be important to first characterize the marine environment to understand current conditions. This is an opportunity to build on what has already been documented about the ecology and uses of the offshore environment. The next step will be to identify gaps in knowledge and begin new research to answer pertinent questions. The strategy for addressing environmental and other marine use issues will necessarily include data collection, synthesis of existing data, and new research into effects of wind energy systems offshore and the technologies for studying them.

The offshore wind resource, particularly in the Northeast, is enormous. Discussion about development of offshore wind energy systems often focuses on the location of the strongest wind resource. However, in order to identify environmentally appropriate and publicly acceptable sites, locations selected for development should combine the strongest wind resource with areas of least impact on marine ecosystems, sensitive species, and other uses of the ocean.

As a preliminary screen, narrowing environmental research to sites with the best wind resource will help create manageable research projects that concentrate on specific geographic areas and, therefore, particular marine species, geology, and ocean uses.

In addition, existing methodologies for determining the environmental impacts of constructing and operating turbines and transmitting electricity to shore should be reviewed. Where well-developed procedures do not exist, the next task will be to develop new methods for identifying and measuring impact. Lessons from other offshore developments—for example, oil and gas drilling facilities—could be useful. However, new techniques and methods will be needed that apply directly to wind facilities. This will require coordination among academic institutions, public and non-governmental organizations, and the private sector.

Beyond ecological and habitat concerns, research into the potential impacts of wind energy systems on archeological resources, and existing military, commercial, recreational, and other marine activities will also need to be undertaken in order to identify potential sites for development.

These challenges will best be addressed through an interactive, multi- and inter-disciplinary, tiered evaluation process that incorporates adaptive management techniques. There are limits to the ability to predict impacts absent actual experience with offshore installations; initial developments must be used effectively as learning laboratories to reduce uncertainty about how wind energy systems interact with the marine environment.

As impacts are better understood, mitigation strategies to reduce or eliminate the impact should be investigated. Mitigation techniques in use by other offshore ocean industries and in Europe should be assessed. Where relevant, these methods should be applied to the development and modification of offshore wind energy systems in the United States. As systems progress through the construction, operation, upgrade, and/or decommissioning stages, new mitigation techniques may be required as unanticipated impacts arise. High priority should be placed on developing protocols for incorporating lessons learned into future facility design.

Photo courtesy of NOAA Photo Library (http://www.photolib.noaa.gov/).

Finally, quantification and documentation of the environmental and health benefits of offshore wind energy systems, such as the lack of harmful emissions, will be important in order to fully characterize the public benefits of offshore wind development. Protocols for quantifying, describing, and publicizing these benefits are needed, and may require the development of new tools and methods to provide complete and accurate measures of the benefits.

Achieve Environmental Compatibility

Overall Approach

It is essential that current knowledge of environmental and user group sensitivities be incorporated into the offshore wind energy system design process at the earliest stage and that the process engages industry, government, academic research institutions, environmental groups, and user interest groups on an ongoing basis.

Some of the following activities will proceed concurrently rather than in sequence:

- Identify site characteristics that would be promising or discouraging to offshore wind development.
- Document existing uses, including Marine Protected Areas (MPAs) and sensitive habitat types, migration corridors, commercial fishing areas, shipping routes, and other uses.
- Overlay existing uses/sensitive areas with wind resource and wind development criteria to identify

the areas with least conflicts and highest wind development potential. Focus on these highlighted areas:
- Establish preliminary criteria for areas to avoid or eliminate from consideration.
- Identify information gaps.
- Engage in necessary data collection.
- Develop protocols for establishing site-specific baseline information, and monitoring protocols for assessing impacts during and after construction.
- Permit initial development at initially screened sites and monitor for ecosystem interactions using established protocols.
- Determine how to mitigate documented impacts, through engineering or site re-configuration where possible.
- Cycle data generated through this process back into screening process.
- Create opportunities to vet lessons learned through formal and informal peer review processes including all interested parties.

Achieve Environmental Compatibility

This tiered process could be designed through a Programmatic Environmental Impact Study (PEIS). Additional detail on the implementation of this process is provided in the strategies below.

Strategy 2.1
Identify Current Conditions and Trends of Marine Ecosystems and Ocean Uses

In order to be sensitive to unique marine environmental conditions and ensure that wind energy system development results in minimal impacts on ecosystems and other uses of the marine environment, it is imperative to establish current marine conditions and trends prior to siting facilities. Activities to gather information on the current and past states of marine ecosystems and on other uses of the ocean could include:

Near Term:
- Compile existing information on current conditions and trends of marine habitat and geology.
  - Assemble compiled existing information on migration patterns, critical habitats, and species abundance and distribution to begin to define first tier areas that would be excluded for consideration.
  - Create/compile Geographic Information System (GIS) formats for this data.
  - Make existing information public and accessible.
  - Conduct workshops to facilitate interdisciplinary cooperation.
- Incorporate information available about migration patterns of marine species (e.g., what is known from fisheries' by-catch, stock assessments, marine mammal and pelagic and seabird distribution) to identify past and current conditions and identify known characteristics of high-use feeding, nursery, and migration areas.
  - Take advantage of existing initiatives and models for mapping multiple characteristics (e.g., Gulf of Maine Mapping Initiative, National Oceanic & Atmospheric Administration's marine geological survey).
  - Explore approaches used in Europe and determine what can be applied in the U.S.
  - Collaborate with scientific and research institutions and other industries that are conducting similar research and mapping activities.
- Create and/or integrate GIS information on ocean uses, including fishing areas, fixed structures, shipping, recreation areas, marine archeological sites, and military security zones.
- Create collaborative marine wildlife working groups consisting of representatives from leading scientific institutions, consulting firms, non-governmental organizations, state and federal government agencies, and others to continue to identify research needs, conduct studies, and modify the information database for ocean ecosystems and marine uses.
- Begin research on known information gaps (e.g., electromagnetic field and noise impacts on marine mammals; sea bed conditions).
- Define obvious exclusion zones; determine geographic focus for developing protocols.

Medium Term:
- Identify information gaps that require additional research and develop research road map.
- Develop protocols, criteria, and models for monitoring studies and other research needs.

Strategy 2.2
Identify Potential Areas for Offshore Wind Energy Development

To responsibly develop offshore wind energy systems, it will be necessary to overlay the best available information on wind resources and environmental conditions.

Near Term:
- Develop a process for screening for sensitivity.
- Develop preliminary criteria for excluding sites.
- Combine marine use/environmental information with meteorological, oceanographic, geologic, and other data parameters to develop constraint maps for use in determining sites most suitable for wind energy development.
- In consultation with interested parties, develop criteria for how to determine sites with fewest anticipated adverse impacts.

Medium to Long Term:
- Monitor and assess the ecosystems and habitat use at sites of high development potential.
- Conduct a strategic environmental assessment that is updated periodically to incorporate what is learned about impacts (see Strategy 2.1).

Strategy 2.3
Identify Potential Impacts and Environmental Changes from Offshore Wind Energy Systems

In order to improve support for and reduce opposition to offshore wind energy systems, including concerns about impacts on the natural and human marine environment, development efforts must be thoughtful, forward-thinking, and anticipate potential impacts with an eye on preventing them from occurring. Methods to accomplish this include:

Near Term:
- Establish a methodology for determining and evaluating environmental footprints of offshore wind energy systems, including construction activities, acoustic and lighting impacts, changes in sediment transport, and avian and marine mammal interactions.
- Review information on other offshore uses (e.g., oil/gas platforms, minerals collection, European wind projects) for impacts/changes and apply knowledge to determine potential impacts of offshore wind energy systems.
- Develop protocols and new technology to assess and monitor impacts.
- Apply analogous lessons learned from onshore wind facilities to offshore sites, systems, and plans.

Medium Term:
- Conduct preliminary pre-construction monitoring of proposed development sites.
- Monitor sites that are developed, during and after construction.
- Identify gaps in information and conduct assessments to fill gaps.
- Incorporate lessons learned into the strategic environmental assessment.
- Develop methods to measure and evaluate cumulative impacts of wind energy systems.

Photo courtesy of NOAA Photo Library (http://www.photolib.noaa.gov/).

Long Term:
- Monitor existing wind energy systems for impacts and changes to marine environment.
- Incorporate new information into design process.

Strategy 2.4
Identify Appropriate and Effective Mitigation Strategies for Potential Environmental Impacts and Conflicting Uses

Achieve Environmental Compatibility

The introduction of offshore wind facilities will affect the environment in a variety of ways. The goal is to fully understand the interactions, and reduce harmful effects to the greatest extent possible through site layout, choice of structural components and materials, and construction/operation methods. In addition, unforeseen impacts (permanent or temporary) could result. Activities to address mitigation options and opportunities include:

Near Term:
- Develop a forum for early and continuing dialogue among offshore wind system engineers and marine interests.
- Review mitigation strategies of other offshore ocean uses (e.g., oil/gas platforms, mineral extraction) and identify those applicable to offshore wind energy systems.
- Investigate European mitigation strategies and apply those appropriate for the U.S.
- Working with regulators and affected interest groups, determine acceptable impact thresholds.
- Identify mitigation triggers and options for decommissioning offshore wind projects.

Achieve Environmental Compatibility

Medium Term:
- Develop new technology, strategy, and mitigation approaches.
- Improve wind plant technology, research methods, and facility design, incorporating adaptive management techniques.
- Collaborate with engineers and other technical specialists to develop mitigation measures or redesign systems to reduce impacts to acceptable levels.

Strategy 2.5
Document and Quantify Environmental Benefits

Like all clean, renewable energy sources, offshore wind energy development will result in environmental and public health benefits. It is also likely to produce unique benefits to the human and marine environment. In order to fully evaluate and publicize the benefits of offshore wind energy systems, the following activities should be undertaken:

Near Term:
- Quantify and describe qualitative environmental benefits.
- Develop new tools and methods to quantify environmental benefits.
- Identify benefits of facilities and resulting wind power generation in terms of greenhouse gas emission reductions, air quality improvements, and national energy security.

Medium Term:
- Develop tools to monitor and evaluate tourist and recreational uses of area around wind energy developments to determine if use changes.
- Determine if habitat changes resulting from introduction of new structural features on the seabed have beneficial aspects.
- Develop tools to measure indirect benefits (e.g., reduced pollution from fossil fuel generated electricity, reduced destruction of lands) and incorporate into environmental assessment.

3 Achieve Economic and Financial Viability

Although today's costs of offshore wind energy production are higher than onshore, expectations are that several factors working together will make offshore wind energy sources more cost effective. These factors include technology innovations, stronger wind regimes, economies of scale from large-scale development, close proximity to high-value load centers, and incentive programs responding to the public's growing demand for clean energy. Other influential factors are the uncertain price and supply of conventional energy sources, especially natural gas and oil, and the increasing regulatory pressures on emissions reductions by fossil fuel generation plants. The economic fate of offshore wind energy, therefore, rests on a combination of internal and external factors.

Strategies:
- Develop Current Understanding of Costs of Offshore Wind Energy Systems and Implement Research and Development Opportunities for Cost Reduction
- Evaluate Ownership and Financing Structures and Associated Risks
- Increase Availability of Long-Term Power Purchase Agreements
- Develop Confidence in Technology among Financial, Insurance, and Public Sectors

One of the key challenges is to implement an offshore program that achieves cost-competitiveness. Various engineering, environmental, and regulatory/policy action items have been recommended within this *Framework* to gain overall acceptance from several different and important perspectives. But economic viability will also have to be achieved in order for offshore wind energy systems to become a reality in a sustainable way. Therefore, proposed approaches and solutions to offshore development in all their dimensions must have favorable economics as a primary objective.

A related challenge is the fact that many costs and risk factors are not known or well understood. Concerted efforts are needed to understand all costs throughout the life cycle of a wind project, from concept development to decommissioning. Much can be learned from ongoing activity in Europe, but new challenges will arise as installations move into deeper water.

Another challenge is to attract developers, investors, energy customers, insurers, and the public at-large toward active participation in offshore development. The large levels of investment and risk required of offshore wind development may require a different profile of market participants compared to onshore wind projects, at least at the outset. These participants will likely require a fairly high degree of confidence in the technology and its ability to supply power safely and reliably over the long term before they get substantially involved. This presents a classic chicken-and-egg dilemma: how to provide sufficient investments in a concept so that it reaches a level of maturity whereby future investments become self-sustaining. This challenge could be addressed through public policy and other models.

Photo courtesy of NOAA Photo Library (http://www.photolib.noaa.gov/).

Many economic uncertainties can be overcome with new ideas, targeted research, field experience, and multi-disciplinary collaboration, including offshore oil and gas experience. The following action items are designed to identify and address specific unknowns in an interactive fashion with the other strategic areas. A desired outcome is the discovery of the best pathways for achieving major cost reductions. The proposed activities are also intended to engage the financial and insurance communities and identify viable business models.

Strategy 3.1
Develop Current Understanding of Costs of Offshore Wind Energy Systems and Implement Research and Development Opportunities for Cost Reduction

Near Term:
- Survey the European wind industry experience and develop a database of reliable cost data and establish reliable material and installation costs and future cost trajectories for designs most appropriate for the U.S..
- Produce a detailed life-cycle cost breakdown for all components of a project, including hardware, labor, support services, transmission, planning, permitting, maintenance, and decommissioning.
- Identify and prioritize components having largest cost reduction potential.
- Identify unknown cost and risk factors.
- Conduct cost sensitivity and trade-off studies.

Medium Term:
- Quantify potential for economies of scale.
- Identify and prioritize best opportunities for cost reduction, and define barriers to cost reduction.
- Supply feedback to siting, engineering, and design research efforts.

Strategy 3.2
Evaluate Ownership and Financing Structures and Associated Risks

Medium Term:
- Compare current ownership/financing structures and risk assessment approaches for onshore and offshore projects.
- Identify sources of risk and liability, their associated uncertainties, and mechanisms for addressing them.
- Identify existing types and cost of available insurance coverage and new types that may be warranted.
- Characterize risk impacts on access to and terms of financing and insurance.
- Propose new ownership and financing structures tailored to offshore wind.
- Develop models for pooling or subsidizing risk for early projects.

Strategy 3.3 Increase Availability of Long-Term Power Purchase Agreements

Near Term:
- Identify barriers to long-term power purchase agreements.

Medium to Long Term:
- Work on a collaborative basis to address barriers.
- Investigate role of government directly purchasing energy from offshore wind.
- Investigate positive linkages with state Renewable Portfolio Standard programs, long-term Renewable Energy Credit programs, and others.

Achieve Economic and Financial Viability

- Investigate how control of large amounts of wind will affect long-term resource adequacy.
- Assess impacts of wind energy on long-term development and provision of other resources in the overall RTO/ISO resource portfolio.

Achieve Economic and Financial Viability

Strategy 3.4
Develop Confidence in Technology among Financial, Insurance, and Public Sectors

Near Term:
- Address challenges to public acceptance to increase likelihood that facilities can be developed in a cost-effective manner.

Medium to Long Term:
- Proactively collaborate with financial, insurance, and public sectors to identify and address issues.
- Target these sectors in outreach programs.
- Address barriers in the technology, environmental, and regulatory/policy arenas that negatively impact long-term planning.

Long Term:
- Attain desired confidence levels via demonstration projects.

4 Clarify Roles for Regulation and Government Policies

While policies for offshore oil and gas development are well established, offshore wind energy development is unprecedented in the U.S. and therefore is unfamiliar ground for the regulatory and policy arenas. Federal and state agencies have been using the existing regulatory frameworks to permit proposed offshore wind projects, but additional planning and resource management strategies are needed to address the specific requirements of a robust offshore wind energy development, as well as other emerging ocean renewable energy technologies such as wave, current, and tidal power.

Strategies:
- Establish a Process for Siting and Development that Gains Public Acceptance
- Develop Policies with a Tiered and Phased Incentive Program to Foster Early Development of Offshore Wind Energy
- Create Stable Rules and Processes for Transmission and Grid Integration

Until passage of the Energy Policy Act of 2005, one component of the permitting process for offshore wind projects was regulated under the Rivers and Harbors Act as implemented by the Army Corps of Engineers (ACOE). The ACOE, as a federal agency authorizing activities, also implemented the National Environmental Policy Act (NEPA) for these projects. Many questions have been raised regarding the suitability, adequacy, and appropriateness of the Rivers and Harbors Act for the permitting of private facilities that use public resources in the ocean. A frequent comment is that the Act does not provide a mechanism for compensating the public for the private use of the ocean resource.

With the passage of the Energy Policy Act of 2005, the U.S. Department of Interior's Minerals Management Service (MMS) received authority to act as the lead agency for permitting offshore wind projects. The MMS is also the agency responsible for regulating offshore oil and gas development. The Act requires the Secretary of the Interior to establish appropriate payments to ensure a fair return to the United States from these projects, and to share revenues associated with projects within 3 miles of state waters with the appropriate coastal states. The Act also provides for coordination and consultation with affected state and local governments, promotes competition, and requires a comprehensive regulatory program.

The initial projects will provide government approval authorities with the first domestic experience in decision-making and interagency coordination for offshore wind projects, including weighing various public interests to determine if the project is contrary to the public interest.

High-level federal efforts are underway to address use of the oceans, coasts, and Great Lakes in a coordinated and integrated manner. To meet the challenges raised by the U.S. Commission on Ocean

Policy, President George W. Bush issued an Executive Order on December 17, 2004, establishing the U.S. Ocean Action Plan (OAP) with the intent of making the Nation's waters cleaner, healthier, and more productive. The policies carried out under the plan and related activities will establish strong partnerships between federal, state, tribal, and local governments; the private sector; international partners; and other interests. The Executive Order created a new Cabinet-level Committee on Ocean Policy to focus on accomplishing the themes in the OAP, including infusion of sound science in resource management decisions, promotion of ocean literacy, strengthening of infrastructure facilities, advancment of observation and modeling capabilities, and fostering of interagency partnerships.

Nysted Offshore Wind Farm at Rødsand, Denmark
Photo by Jack Coleman

In addition to the regulatory management issues that face the development of offshore wind, there are several policy issues that will also arise. Government agencies have played significant roles in supporting other energy sources, through financial support for research and development, production tax credits, state renewable portfolio standards, and through direct energy purchases of energy. In order for offshore wind energy to be commercially successful in the highly competitive energy markets, similar government efforts may be needed.

Another challenge in the regulatory arena before offshore wind can become viable is the need for methods to coordinate planning for siting and development on a regional basis. As part of the effort to plan proactively to address siting issues and minimize conflicts with other uses, regional collaboration mechanisms will be needed. Planning must also appropriately reflect the principles of the *Environmental Justice Strategy Executive Order 12898*.

In the coming months, MMS will issue interim guidelines and develop regulations for offshore wind projects. These regulations and policies will play a pivotal role in shaping the course and pace of future offshore wind energy development. Collaboration, outreach, education, and planning efforts will be needed to facilitate deployment of offshore wind energy systems.

Strategy 4.1
Establish a Process for Siting and Development that Gains Public Acceptance

To address concerns about the siting of offshore wind energy systems, it will be important to clarify the process of designating and allocating potential sites, address compensation for use of the public wind and ocean resources, and plan for integration of facilities with existing marine uses and environmental constraints. The activities that may need to be part of this effort include:

Clarify Roles for Regulation and Government Policies

Near Term:

- Identify regulatory solutions that establish a predictable and transparent process:
  - Engage in public education and outreach about the need to develop an appropriate approval process for offshore wind energy.
  - Consult with interested groups about the development of regulations regarding siting, development, and leasing/licensing procedures.
- Develop a streamlined approach that incorporates the existing regulations that will still apply with the new regulations and policies being developed through a collaborative process.
  - Link with ocean policy groups and coordinate with other ocean planning efforts.
  - Conduct outreach and education.
- Establish an environmental review process for offshore wind energy development to be implemented at the appropriate geographic levels.

Medium Term:

- Continue with short-term activities as needed.
- Establish a streamlined permitting and siting process for small- or limited-scale demonstration projects, perhaps with cooperative funding for projects.

- Develop regulatory standards for operation, decommissioning, and environmental mitigation.

Strategy 4.2
Develop Policies with a Tiered and Phased Incentive Program to Foster Early Development of Offshore Wind Energy

While the goal is to have cost-competitive offshore wind energy in the next decade, reaching the point of cost-competitiveness will take action and experience. As initial projects are developed, incentive programs will be needed to foster and support them.

Clarify Roles for Regulation and Government Policies

Near Term:
- Develop different scenarios and options for creating incentives.
  - Develop government (state and federal) long-term purchase agreements.
  - Analyze the desirability and feasibility of a government role in developing a DC transmission line running parallel to the Northeast coast to interconnect multiple offshore wind facilities and potentially other types of ocean-based energy facilities.
  - Support demonstration projects and shared infrastructure investments that will lead to cost competitiveness.
  - Analyze the benefits of continuing and expanding existing renewable energy supports, including tax credits, renewable energy credits, and others.
  - Co-locate wind energy with wave and current energy technologies for improved economies.
  - Grant access to pollution reduction credits.
  - Identify methods and resources to fund common or shared infrastructure.

Strategy 4.3
Create Stable Rules and Processes for Transmission and Grid Integration

It will be important to create a predictable transmission and grid integration regulatory environment to facilitate the interconnection of future offshore wind energy facilities. Activities to address this goal include:

Near Term:
- Monitor national and regional power system rulemaking regarding implications for offshore wind energy.
- Coordinate with state and local energy providers.

Medium to Long Term:
- Commission an analysis of the barriers, challenges, and options for addressing grid integration. The analysis should include recommendations for implementation activities.

5 Establish Leadership, Coordination, Collaboration, and Support

Achieving a cost-competitive offshore wind industry will require significant advances in the technology and policy arenas. Many of the challenges require an integrated approach. For example, public acceptance of offshore wind facilities depends on the existence of a credible planning and permitting process that ensures the recognition of public benefits from use of the resource. Once environmental concerns are identified, impacts can be addressed through employment of different types of turbines and foundations. Economic incentives and investor decisions, as well as the predictability of power purchases and prices, play a key role in the development of technologies appropriate for large-scale, deep-water applications.

Strategies:
- Establish a Credible Mechanism for Leadership, Collaboration, and Support for Offshore Wind Energy Development
- Create and Maintain a Vision of Offshore Wind as Part of the Mainstream Energy Mix
- Attract, Apply, and Coordinate Resources
- Establish and Implement a Mechanism for Convening Parties Interested in Offshore Wind Energy
- Develop and Support a Coordinated Research Program to Accomplish Technical, Environmental, Economic, and Regulatory Goals
- Support Integration of Activities in All Arenas

Integrating all of the various efforts to address challenges and developing a mechanism to foster integration of collaboration among interested parties will improve the likelihood of offshore wind development success. Many groups have expressed an interest in ongoing, proactive collaboration to identify issues early and address them in ways that minimize unnecessary conflicts. Leadership on a national and regional level will be needed.

Resources from multiple sources will be an essential component of the *Framework*'s implementation. Government agencies, especially the U.S. DOE, are currently investing in technology programs that support renewable energy. Other government agencies, like the Army Corps of Engineers and state authorizing agencies, will need to invest resources in permitting and environmental issues. Sixteen states have clean energy funds and are investing in renewable energy development. Significant technology development resources will also come from manufacturers of wind energy system components and from other private investments, supplemented by government support in some cases. A reasonable set of initial priority actions will need to be gleaned from the ambitious overall agenda set forth in this *Framework*.

A national collaborative can play an important role as it works to coordinate and leverage the resources to address the challenges in an efficient and synergistic manner. The level of resources needed to fund a collaborative approach will depend on the form the collaborative takes and on the roles its members play in providing and recruiting technical and financial support. Regional collaboratives will also be useful for addressing regional and local planning challenges and needs.

Collaborative forums, whether at the national or regional level, could consider any of the following strategies:

Strategy 5.1
Establish a Credible Mechanism for Leadership, Collaboration, and Support for Offshore Wind Energy Development

Near Term:

- Form well-defined and chartered collaborative organization(s) at the national and regional level to serve as the clearinghouse, coordination body, and source of spokespeople for the vision of sustainable offshore wind energy.
  - Determine whether each collaborative organization will be a new, freestanding organization or part of an existing one.
  - Determine the organizational and governance structure for each organization and its activities.
  - Drawing from the strategies outlined in this *Framework*, establish priorities for national and regional activities.
  - Develop five-year and annual work plans for the activities of each organization (suggested activities are outlined below).

Strategy 5.2
Create and Maintain a Vision of Offshore Wind as Part of the Mainstream Energy Mix

In order to ensure forward momentum for offshore wind, it is important that there are spokespeople and advocates for the vision who are highly visible to government entities, energy trade associations, public interest groups, and the media.

Near Term:

- Publicize the formation of the collaborative organization(s).
- Develop informational materials, website, and an outreach and marketing plan.

Photo courtesy of NOAA Photo Library (http://www.photolib.noaa.gov/).

- Implement the outreach and marketing plan with an intensive schedule of presentations, informational meetings, and media appearances and press releases.
- Establish coalitions with organizations having related goals.

Establish Leadership, Coordination, Collaboration, and Support

Establish Leadership, Coordination, Collaboration, and Support

Medium Term:
- Develop progress reports and projected timetables for key milestones in the development of offshore wind energy capability, and disseminate this information as above.

Strategy 5.3
Attract, Apply, and Coordinate Resources

Adequate resources will be essential to accomplishing the strategies, as will the prioritization of where resources will be targeted and how they will be allocated.

Near Term:
- Develop a database of existing and potential funding sources that could be made available to implement elements of the *Framework*.
- Develop estimates of funding levels required for each element of the *Framework*.
- Act as a clearinghouse to track research activities and funding sources, and to identify additional funding needs.
- Develop a funding plan for sustaining or increasing the resources needed to implement the *Framework*.

Medium Term:
- Monitor funding availability and needs, and update priorities and fund raising activities.
- Identify opportunities to coordinate with other collaborative efforts in support of offshore renewable energy development (wave, current, and tidal).

Strategy 5.4
Establish and Implement a Mechanism for Convening Parties Interested in Offshore Wind Energy

Regular interaction among those having a stake in offshore wind development will foster coordination and synergy. Interested parties need to convene for proactive purposes, such as prioritizing issues and discussing options to address potential conflicts and opportunities, as well as for information exchange.

Near, Medium, and Long Term:
- Develop a stakeholder involvement plan, through consultation with stakeholders.
- Survey stakeholders annually to update issues and priorities to be addressed collaboratively.
- Plan and conduct workshops at least annually on specific issues.

Strategy 5.5
Develop and Support a Coordinated Research Program to Accomplish Technical, Environmental, Economic, and Regulatory Goals

Research is needed on many fronts to address the challenges of developing offshore wind energy. Support for technological research may be the largest and most challenging task. Research on environmental issues may be more site-specific in nature, but methodology development can be undertaken in the near term and later replicated across many sites. Policy analysis will be an ongoing task. On many research topics, defining the questions from multiple viewpoints will be necessary to ensure that the research is credible and acceptable to all interested parties. Coordination and team building among researchers from government (federal and state), industry, and academia is also an important objective.

Near Term:
- Build on interaction mechanisms described in Strategy 5.4, above, to collaboratively review research programs, results, and outstanding issues.
- Facilitate the organization of collaborative research programs.

Medium Term:
- Publicize research progress and results.

Strategy 5.6
Support Integration of Activities in All Arenas

It will be important for those working in various areas outlined in the *Framework* to periodically compare notes and obtain feedback as developments on various fronts emerge.

Near, Medium, and Long Term:
- Use national and regional collaboratives to bring together the full range of interests to discuss developments and findings.
- Evaluate progress in implementing the strategies on a regular basis, in consultation with interest groups and stakeholders.
- Develop web-based resources to assist in ongoing integration and outreach.

Closing Comments

Offshore wind energy is poised to be an important part of the solution to what the National Commission on Energy Policy has called "America's energy stalemate." The recommendations outlined in this *Framework* are meant to serve as a compass to guide development of wind energy resources off the coasts of the United States.

Given the urgent need to meet future domestic energy needs while minimizing the addition of heat-trapping gases and toxic emissions into the atmosphere, the question this document attempts to address is not whether we should pursue offshore wind energy development but rather: *how can we develop this important new industry here in the United States in a way that will allow us to tap this vast resource in the most sustainable way?*

Successful offshore wind energy advancements will depend on a robust partnership among organizations, businesses, and agencies with diverse resources and expertise. This *Framework* calls for an unprecedented level of engagement in order to fully develop offshore wind energy's significant economic, environmental, and energy security opportunities for the United States.

Nysted Offshore Wind Farm at Rødsand, Denmark
Photo by Carl Borchert

Participant List

Participation in these workshops to inform development of the *Framework for Offshore Wind Development in the United States* does not necessarily constitute support for offshore wind development in general or in any particular region.

Offshore Wind Energy Collaborative Workshop

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Notes