The U.S. Small Wind Turbine Industry

ROADMAP

A 20-year industry plan for small wind turbine technology

American Wind Energy Association

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American Wind Energy Association (AWEA)
Small Wind Turbine Committee

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FOREWORD

Millions of homeowners, farmers, and small business owners all across America dream of the day they can generate their own electricity from clean, sustainable renewable resources. They want the freedom of choosing how their electricity is produced, who produces it, and what environmental impacts their consumption generates. A full 91% of Americans support "investments in new sources of energy, such as solar, wind, and fuel cells," according to a Gallup poll conducted November 27, 2001.

For many of these Americans, small wind turbine technology offers the best near-term hope of supplying products to fulfill that dream. The task before the U.S. small wind turbine industry, its partners, and its supporters is to deliver the products Americans want at a price they can afford. This task requires progress on several fronts—from public policy initiatives, to technology development, to market development.

In addition to meeting the dreams of Americans for clean energy, the U.S. small wind turbine industry is also positioned to help the 2 billion people around the world who do not have access to electric power.

EXECUTIVE SUMMARY

VISION STATEMENT:

Our vision is to make small wind turbine technology[1] a significant contributor to America's clean energy supply portfolio by providing consumers with an affordable renewable energy option for their homes and businesses and to make wind energy a significant contributor to improving the quality of life and economic opportunities of people in developing nations worldwide through electrification.

[1] Small wind turbines (SWT) are defined as having a generating capacity up to 100 kilowatts (kW) (~60 ft rotor diameter).

Small wind turbine technology can be a meaningful contributor to our energy security, strategic technology, and long-term economic growth. Small wind turbines are a "distributed" generation source with a very attractive near-term potential for low-cost, rapid growth. Small wind turbines can mitigate our dependence on foreign energy supplies while providing distinct benefits to our domestic economy. Electricity generated by small wind turbines uses a clean, non-polluting energy source—the wind.

The AWEA Small Wind Turbine Committee recognizes the importance of collaborative planning and R&D partnering to the future vitality of the technology—especially because no segment of the industry is currently large enough to guide the entire infrastructure and competitive investments on its own. By developing this "roadmap," the U.S. small turbine industry is addressing the critical needs of small wind turbine technology and is ensuring U.S. industry leadership over foreign competitors. Our document is a framework that can serve to develop strategic plans for and investments in this technology and business—specifically as a U.S. strategic and national resource.

It is time for a combined effort on the part of government and industry to increase the contribution of small wind turbines to our electric generation mix. In 2001, annual sales of the U.S. small wind turbine industry amounted to about 13,400 turbines. We estimate that turbine sales will increase, and by 2020, small wind turbines could contribute 3%, or 50,000 MW, to America's electric supply. Increasing the energy contribution from this home-grown industry could increase our energy security and our gross national product as well as our energy supply. In the process, this technology will also give the public more energy choices and make electricity markets more competitive.

But a great deal of work must be done to realize the potential for small wind technology. The current products are too few in number, too expensive, and not reliable enough to ignite the market. Customers face too many obstacles in financing, permitting, and installing small wind energy systems, and most receive few, if any, financial incentives to investment from state and federal governments.

The long-term industry vision is of a major new category of home energy appliance. In order to achieve 50,000 MW the small wind turbine industry will have to grow to over $1 billion per year and employ over 10,000 people in manufacturing, sales, installation, and support. This is possible due to the sheer number of homes (15 million) and small businesses (1 million) that could effectively use small wind systems if the economics were favorable.

In this roadmap, the industry has identified barriers and appropriate near-term, mid-term, and long-term actions to address these barriers. The industry has also tried to prioritize these actions and identify priorities for R&D efforts. The roadmap is intended to help guide government and corporate policy towards the overall goal of making small wind a significant contributor to America's domestic energy supply.

Table 1: Summary of the Barriers Identified

Technology Barriers	Market Barriers	Policy Barriers
Near-term	***Near-term***	***Near-term***
-High cost of wind turbines -Insufficient product reliability	-Lack of effective standards -Low visibility of the industry and technology -Misconceptions about the wind resource	-Lack of federal incentives -Restrictive zoning -NIMBY and environmental concerns -Excessive interconnection requirements and unequal billing policies -Undervaluation of green energy -Disincentives in the tax code
Mid-term	***Mid-term***	***Mid-term***
-Turbine productivity hampered by power electronics issues -Domestic market requirement—quiet operation -Reliability -Need for better technology tools	-Insufficient capitalization -Complicated financial impact -Lack of multilateral bank funding for export markets	-Lack of more state-based incentives -Lack of sustained national incentives -Lack of interconnection standards -Lack of national models for net metering and zoning rules

"This is an exciting time for the small wind turbine industry. We are very close to the 'tipping point' where production volumes would skyrocket, causing production costs to plummet. With the right federal leadership and support in a few more states, I think we will get there." - Mike Bergey, Chair, AWEA Small Wind Turbine Committee

Table 2: *Summary Schedule of Actions*

	Technology Actions	Market Actions	Policy Actions
Near-Term (0-3 years)	- Reduce costs by new turbine development activity for low wind speed sites and new component development for SWT - Research reliability concerns such as lightning, corrosion, bearing lubrication, alternator winding insulation, electronics - Continue focused long-term research unique to SWT - furling, durability, blade aerodynamics, noise, and power electronics - Develop packages with other distributed generation and storage technologies	- Develop nationally recognized standards for participation in stimulus programs - Publish SWT articles in cornerstone magazines such as *Scientific American*, to create more "SWT buzz" - Revise new U.S. wind maps for SWT, 30 m hub height and .25 shear, new legends - Explain turbine micrositing - Provide information to remove misconceptions about the wind resource - Incorporate the value of environmental attributes of small wind into electricity prices	- Develop a strategy to work with state policies for inclusion of small wind - Develop a national policy for an SWT tax credit - Work to eliminate zoning restrictions - Develop model zoning ordinances and blueprint templates of zoning regulations, interconnection agreements, and other policies - Work to reduce excessive interconnection requirements
Mid-Term (4-10 years)	- Work to improve the reliability and reduce the cost of power electronics - Work to eliminate noise from small turbine designs - Develop consumer-friendly performance predictions - Improve analytical design tools - Continue the development of packages with other distributed generation and storage technologies	- Update national market study - Characterize the export potential for U.S. manufacturers and work with multilateral development programs - Establish consumer-friendly customer financing programs, including lease options - Increase the number of products available (models and size range) for different market segments - Increase outreach and education	- Influence/develop new state and national incentives - Disseminate and expand information on zoning regulations, interconnection agreements, and net metering rules - Develop a more consumer-friendly national interconnection standard
Long-Term (11+ Years)	- Develop hydrogen-based systems - Develop blackout protection strategies - Establish links with storage and other power technologies	- Stimulate the emerging micro-power revolution, of which SWTs are part	- Develop policies to help deliver higher service levels to rural customers
Crosscutting (Ongoing)	- Continually work to reduce cost and improve reliability - Continue to develop standards for reliability, durability, and longevity	- Continue to develop standards for reliability, durability, and longevity	- Continue to develop standards for reliability, durability, and longevity

The U.S. Small Wind Turbine Industry Roadmap is the result of collaboration over an 18-month period among the members of the Small Wind Turbine Committee of the American Wind Energy Association (AWEA). Many industry leaders contributed to this roadmap that will guide activities to achieve the vision of the small wind turbine industry of the United States.

State of the Small Wind Turbine Industry

The modern industry for small wind turbines was born in the energy crisis of the 1970s. Responding to the crisis, consumers turned to restored vintage designs from the 1930s, to newly manufactured machines based on the old designs, and to new wind turbine technologies developed to meet modern needs. Most of these turbines were connected to the utility grid. This surge in the U.S. small wind turbine industry, fueled by federal energy tax credits, state incentives, and high electricity prices, peaked in 1983. Then energy prices fell, federal energy tax credits expired, and state incentives gradually fell by the wayside. By 1986, the people who still wanted small wind turbines were interested in stand-alone or off-grid applications for remote homes. While serving this smaller domestic market, U.S. manufacturers expanded their efforts in markets overseas.

Since 1999, electricity prices have been rising again. People are once again concerned about the security of our energy supplies and the centralized generating facilities that rely on those sources of energy. And some people want independence from electric utilities. There is also a steadily increasing concern about global warming. State governments, under utility restructuring, have enacted significant incentive programs that buy down the initial cost of small wind turbine systems, thereby tunneling through the cost barrier. These incentives are funded through system benefit charge programs which are significant—totaling $3.5 billion in 2001 for programs that include incentives for small wind turbines. All these factors have increased interest in small wind turbines connected to the utility grid. Meanwhile, the U.S. industry continues to dominate the overseas market for small wind turbines.

In 2001, annual sales of the U.S. Small Wind Turbine Industry are estimated to be 13,400 turbines valued at about $20 million.[1] While this is about the same level as sales in the early 1980s, it is only about 2% of the value of sales of large wind turbines in the United States.[2] The success of the large wind turbine industry shows the impact of sustained, substantial support from government programs and policies (both at home and abroad). Support such as federal and state tax credits was discontinued in the mid-1980's for small wind systems. This led to a significant shrinking of the industry and a loss of momentum in technology and market development.

There are several good reasons why it is time for a combined effort from government and industry to increase the contribution of small wind turbines to our generation mix. First, there is the potential for real contribution to our energy supply. We project that small wind turbines could contribute 3% of U.S. electrical consumption by 2020. Second, small wind technology is a homegrown industry. While the market for other renewable energy technologies is dominated by foreign companies, the U.S. small wind turbine industry is the leader in markets at home and abroad.

Third, the market for small wind turbines also fuels companion industries, including those that market composite products, steel, towers, power electronic equipment, and construction projects. Fourth, while producing energy, small wind turbines produce no environmental emissions. Fifth, small wind turbines help meet the national need for energy diversification and national security. And finally, the American public overwhelmingly supports the expansion of renewable energy, and they stand to benefit from more choices about where their energy comes from.

Recently, the market for small wind turbines has been growing 40% per year. As we discuss later, the potential market for residential and business applications of small wind turbines is tremendous because it is clear that the turbines work and that people want them. However to realize our vision, significant challenges lie ahead in the market, policy, and technology areas. We

Small wind turbines could contribute 3% of U.S. electrical consumption by 2020.

must overcome these challenges as barriers to widespread use of small wind technology. Then, we devise actions needed to overcome these barriers. And finally, we devise a strategy of public/private cooperation to complete these actions and reach our goals. In the end, we expect to deliver small wind turbine products that people desire and that they can afford, allowing individuals to contribute to our energy security.

State of Small Wind Turbine Technology

The U.S. small wind turbine industry offers a wide assortment of products for various applications and environments. Machines range in size from those that generate 400 watts (W) of electricity for specific small loads such as battery charging for sailboats and small cabins, to 3–15 kilowatt (kW) systems for a home, to those that generate

Figure 1: Small wind turbines are being sold for use in many different environments.

up to 100 kW of electricity for large loads such as a small commercial operation.

Small wind turbines can operate effectively in most of the rural areas of the United States. In fact, about 60% of the United States has enough wind for small turbines to generate electricity. Today's small turbines have been designed for high reliability with only two or three moving parts and therefore have relatively low maintenance requirements.

Thanks to continuous development within the industry and in collaboration with the U.S. Department of Energy (DOE) small wind turbine projects, several new features are in development for incorporation into commercial turbines. Advanced airfoils, super-magnet generators, smart power elec-

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tronics, very tall towers, and low-noise features will help reduce the cost of electricity and increase the acceptability of this technology.

Small wind technology has been improving since the 1970s. However, it is still generally acknowledged that more work is needed to improve operating reliability, eliminate noise concerns, and lower manufacturing and installation costs. There is much to be done both to incorporate the technologies currently under development and to enhance manufacturing. As an example of the cost reductions that are possible, the industry estimates that high-volume manufacturing alone could reduce costs 15–30%.

Key elements of our vision

1. Enhance America's energy diversity and security
2. Increase competition in electric markets by giving consumers the choice of a clean power source
3. Develop small wind turbines as a household energy appliance and business tool (by lowering competitive energy costs)
4. Build an industry to meet the explosive growth potential
5. Contribute to rural infrastructure development worldwide

Modern small wind turbines are not like our grandparents' wind generators from the 1920s and 1930s. Today's small turbines borrow from aerospace technologies with sophisticated, yet simple, designs that allow them to operate reliably for up to a decade or longer without maintenance. Current products are designed for operational lives of 20 to 30 years, and they have withstood everything, short of a direct hit from a tornado, that Mother Nature can throw at them. As small wind turbine technology has matured, the products have become mechanically simpler and more robust.

As shown in Table 3, small wind turbines are very competitive with other renewable energy technologies that are suitable for homes, farms, and small businesses. Small wind systems, for example, cost less than half the price of comparable photovoltaic systems. We do not foresee a time when solar electric systems will be less expensive than small wind systems. Solar electric systems do have the advantage of wider geographic applicability, and they can be used in denser suburban or even urban environments. However, the wind resource in a good area can lead to much higher capacity factors for small wind compared to a solar electric system operating in the same environment. Both technologies have the potential for significant cost reduction and for substantial roles in distributed generation markets. In our experience, the public is most concerned with finding a clean technology they can afford, whether that be wind or solar or a combination of both.

Responding to more active markets in the last few years, the small wind turbine industry has increasingly adopted advanced component technologies and state-of-the-art design tools such as three-dimensional solid modeling and computational fluid dynamics. Technologies such as unique high-efficiency airfoils, neodymium-iron-boron "super-magnet" generators, pultruded FRP blades, graphite-filled injection molded plastic blades, special purpose power electronics, and tilt-up tower designs have both lowered costs and increased efficiency. The long-term vision of the industry is to produce small wind turbines that are accepted as common household appliances in the same way that heating and air-conditioning systems are today. By virtue of their compelling economics, these new turbines will achieve high market penetration in areas with lower

Table 3: Comparison of Home-Based Renewables

Status of the Technologies	Small Wind	Solar Thermal Electric	Photovoltaics
Status	Commercial	Demo	Commercial
Installed cost	$4/Watt	$10/Watt	$8/Watt
Payback Period	15 Years	30+ Years	25 Years
Cost Potential	$1.50/W in 2010	?	$3/W in 2010
Typical Site	Rural	Southwest	Suburban
Available Resources	Poor–Great	Poor–Good	Poor–Good

housing densities and sufficient wind resources.

People, however, do not tend to live where the wind howls, so achieving high market penetration rates will require small wind turbines that are specially designed to work effectively in low wind resource areas. These turbines of the future will need to have relatively larger rotors to capture more energy. But they cannot sacrifice robustness because even areas with low average wind speeds experience severe weather. The new turbines must be extremely quiet, so that they are seldom heard above the local background noise. They must be able to operate for 10 to 15 years between inspections and/or preventive maintenance, and they must offer a reasonable expectation of a 30- to 60-year operating life. Most important of all, the small wind turbines of the future must be affordable without significant subsidies.

Achieving these goals will require further advances in small wind turbine technology, major improvements in small turbine manufacturing, and more efficient installation techniques. The U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) have critical roles to play in accelerating the development and adoption of new small wind turbine technology and manufacturing techniques. A close working relationship between DOE/NREL and the small turbine industry is important today, and it will become increasingly important as international competition heats up over the next five to ten years. All parties need to realize that large wind turbines are now in their seventh or eighth generation of technology development, while small wind turbines are only in their second or third.

For its part, the industry is striving to reduce the cost of electricity generated by small wind turbines. In 2002, typical 5- to 15-kW residential wind turbines cost about $3,500 per installed kilowatt. These turbines produce about 1,200 kWh per year of electricity per kilowatt of capacity in an area with a DOE class 2 wind resource.[2] By 2020, the industry hopes to have lowered the installed cost to between $1,200 and $1,800 per kilowatt (smaller systems being relatively more expensive) and to have raised the productivity level to 1,800 kWh per installed kilowatt. If these goals are met, the 30-year life cycle cost of energy will be in the range of $0.04 to $0.05/kWh, lower than virtually all residential electric rates in the country today.

To further enhance the attractiveness of small wind turbines to consumers, there is also a need for meaningful, appropriate, and cost-effective standards and a certification program for them. Some new entrants to the industry have signifi-

Costs and electricity production for typical 5- to 15- kW residential wind turbines

	2002	2020
Cost/kW	$3,500	$1200–1800
Annual Electricity Production (kWh)	1,200	1800

[2] Numbers provided by Mike Bergey, chairman AWEA Small Wind Turbine Committee, Jan. 15, 2002.

cantly underestimated the engineering rigor and expense required to deliver a reliable small wind turbine product. And, in light of recurring instances of exaggerated claims, consumers have had trouble sorting out reasonable from unreasonable claims of performance. The standards and certification programs that exist for large wind turbines are not appropriate for small wind turbines. Appropriate standards for small wind turbines are under development by the international industry and by research institutions. However, the U.S. industry and DOE must also work to ensure that related standards, such as electrical grid interconnection standards, are justified and do not unduly raise the costs of owning a small wind turbine.

The industry believes that research cooperation between the private and public sectors is strategically important if the U.S. industry is to maintain its leadership position. The engineering challenges presented by the interlocking disciplines of aerodynamics, structures, controls, electrical conversion, electronics, and corrosion prevention are formidable. There are also a number of generic technology opportunities that are not likely to be fully explored by the private sector alone. Government and industry must work together to build a better small wind turbine.

To assist industry in addressing technology barriers, four models of government/industry collaboration are employed.

1. Research conducted at national laboratories and universities with input from members of the industry.
2. Applied research projects conducted at the facilities of small wind turbine companies with support from the government through competitive procurement.
3. Applied research projects involving companies, universities, and national laboratories.
4. Privately funded research and development.

The opportunities offered by improved technology can be achieved through the cooperative activities discussed in this roadmap for the small wind turbine industry. Work by industry members, research institutes, state and local governments, and DOE can help increase the contribution of small wind turbines to the electricity generation mix.

THE MARKET POTENTIAL

In 2001, we estimate that 13,400 small wind turbines were manufactured in the United States. More than 50% of these were exported. We believe that both the domestic and foreign market for small wind turbines will continue to grow. This roadmap is designed to accelerate this growth to its maximum potential.

U.S. Market

We estimate that small wind turbines have the potential to contribute up to 8% of U.S. electrical demand in 2020. Our industry goal is to install turbines that will generate at least 3% of U.S. electrical demand in 2020 or 6-8% of residential electricity demand. This will require small wind turbines installed with a total generating capacity of 50,000 MW.

The most recent public market study for small wind generators was the A. D. Little study sponsored by DOE in 1981. [2] That report (the ADL study) projected a market potential of 3.8 million small wind systems installed in grid-connected applications. If the average generating capacity of these systems were 10 kW, then the potential contribution to the nation's generation mix would be 38,000 MW.

The 1981 ADL study was quite conservative. Although it considered wind resources, electricity costs, and available incentives, it excluded more than 100 counties with high population densities. Today, we know that many of these counties have small wind systems and that thousands of properties in these counties

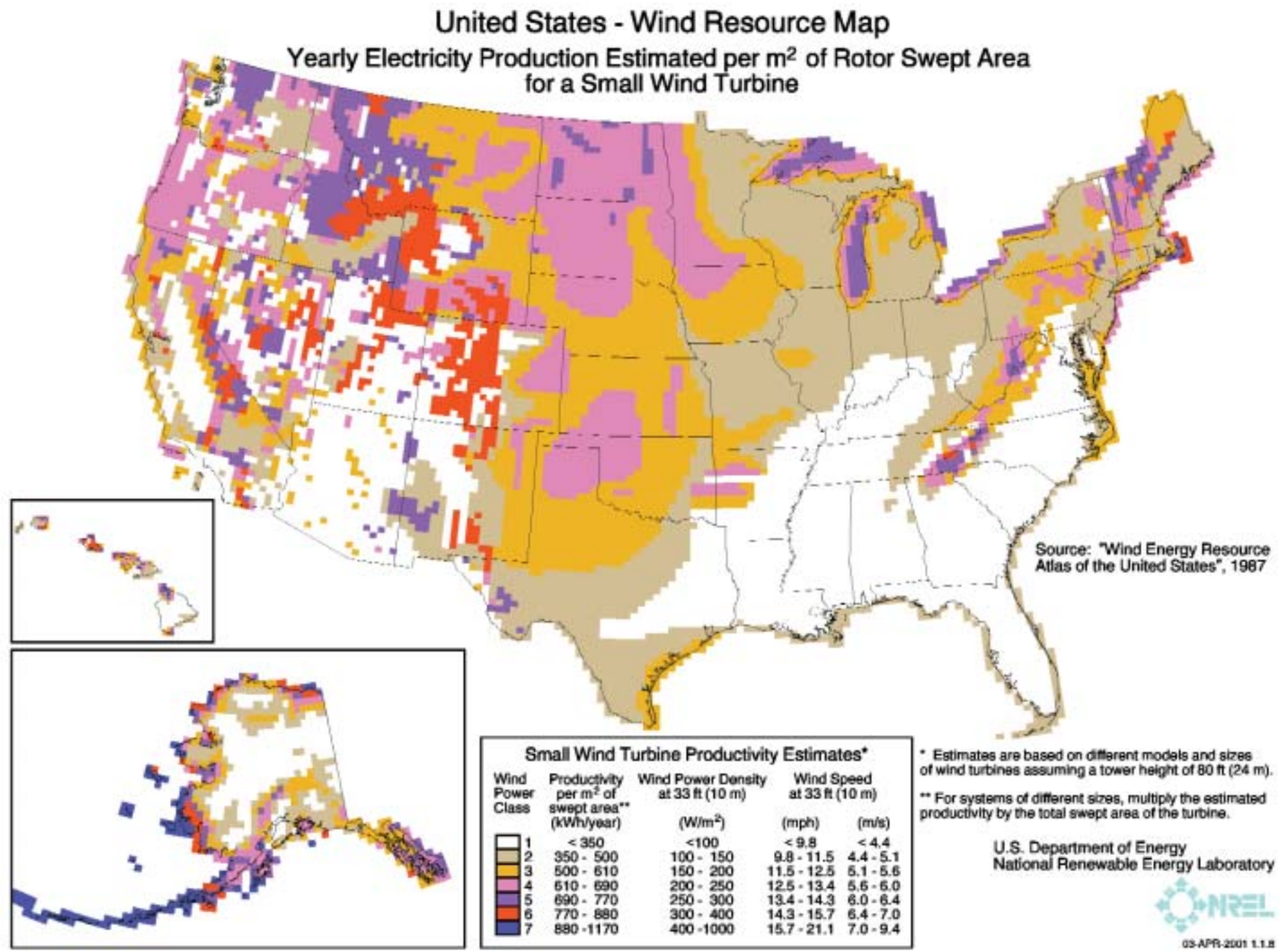

Figure 2: Energy production for small wind turbines in the United States.

The goal for the small wind turbine industry is a generating capacity of 50,000 MW or the ability to satisfy 3% of U.S. electrical demand in 2020.

Table 4: Residential Market Potential for Small Wind Turbines

Millions of U.S. Homes Connected to the Utility Grid

	2000	2010*	2020
Homes with 1/2 to 1 acre of land	N.A.**	12.0	13.9
Homes with more than 1 acre of land	21.6	25.2	29.3
Gross potential number of homes for wind turbines	21.6	37.2	43.2
Net potential number of homes for wind turbines	7.6	13.0	15.1

*The number of homes has been growing 1.54% per year (U.S. Census Bureau, American Housing Survey, Census Bureau: Washington, D.C., 1998).
**Appropriate small wind technology not yet available for lots under one acre.

are suitable for small turbines. We also know more about the wind resource and can better estimate the number of homes in suitable wind regimes.

In this roadmap, we estimate the potential contribution of small wind turbines by dividing the market into sectors.

Rural Residential Market Sector—Distributed Generation

The largest potential market for small wind turbines is for homeowners in rural areas where wind-generated electricity can reduce utility bills. In 1998, American homes used 1.1 trillion kWh or 35% of total electricity sales. Electricity consumption in the residential sector exceeds the consumption in either commercial or industrial sectors. Homeowners buy wind turbines to reduce their electricity bills, and federal laws (such as PURPA 210) guarantee their right to use them.[3] While some wind turbines may be installed when a new home is built, most market opportunities will be for installations at existing homes. A small wind turbine produces energy that is either consumed immediately in the home or transferred to the power grid and consumed by a neighbor.

In 2020, there will be approximately 43 million homes with 1/2 acre or more of land. Of these homes, we estimate 65% will be prevented from using small wind technology because the wind resource is not sufficient,[4] because of restrictive zoning and covenants, or because of proximity to airports or other sensitive areas. This will leave 15.1 million homes with the potential to install a small wind turbine. If each of these homes installed a 7.5-kW machine, the total contribution to generating capacity would be 113,000 MW. (see Table 4)

Other Domestic Markets

When combined, other markets for small wind turbines in the United States offer significant opportunities to expand electric generation capacity. For example, about two million medium-sized commercial buildings[5] are candidates for small wind turbines of 10 to 100 kW. In addition, public facilities such as schools and government buildings could also use small wind turbines at suitable sites.

Another distributed generation market sector includes industrial and commercial customers who are connected to the

[3] To meet the electrical needs of a typical home, a small wind turbine in a moderate wind regime must have a rotor diameter of 16 to 25 feet and sit on a tower from 60 to 150 feet tall. These dimensions are not suitable for homes on small lots.
[4] The homes will be located in areas with DOE wind class 1. DOE wind class 2 or 3 is considered necessary with today's technology for effective production of electricity with small wind turbine generators.
[5] Fewer than 25,000 square feet under one roof.

utility grid and may have back-up generation requirements, which could easily be integrated with a larger small turbine. Since the utility rate structure is typically different from the residential market (e.g. demand charges), further study is needed to specifically define this market.

Where the utility grid is not available, stand-alone or hybrid[6] systems could provide electricity for homes, communities, water pumping, and telecommunications services. The Energy Information Administration (EIA) estimates that there are 200,000 off-grid homes in the U.S. This is already a very active market for small wind systems.

There are also a number of off-grid communities that are remote, isolated, and produce their electricity with diesel or gasoline generators. Alaska, for example, has 91 villages powered by diesel generators, serving a population of about 42,000 people. In addition, several hundred miscellaneous remote facilities are powered by diesel generators ranging in size from 2 to 250 kW.

In addition, water pumping for livestock and off-grid facilities is still a sizable market. In the early part of the 20th century, the United States had about three million mechanical windmills in operation, supplying water for homes, farms, and livestock. Today, there are also new wind-electric water pumping systems for which the turbine can be located where there is good exposure to the wind, and it does not have to be located near the well and pump. However, for low wind speed sites, the mechanical water pumper still offers more economic water pumping.

Deregulation of the telecommunications industry and the rapid growth in wireless systems has spawned growth in the development of remote broadcast facilities. The preferential method of powering these facilities is hybrid systems that combine generation from solar, wind, and diesel systems.

These other markets could contribute up to 25,000 MW of generating capacity by 2020. From this discussion, we conclude that the total installed capacity for small wind turbines in 2020 could be 140,000 MW across all markets. However, the goal of the AWEA Small Wind Turbine Committee is to install 50,000 MW of small wind turbines by 2020. (See Tables 4 and 5)

According to figures taken from the most recent EIA documents, the total generating capacity in the U.S. in 1999 was approximately 745,000 MW. According to the EIA *Annual Energy Outlook 2001*,

Table 5: Other Potential Markets for Small Wind Turbines in the United States in 2020 [3]

	Units	Avg size in kW	Total MW
Commercial buildings	675,000	25	16,875
Public facilities	160,000	50	8,000
Off-grid homes	150,000	3	450
Off-grid communities	200	250	50
Water pumping	350,000	1	350
Telecommunications	2,000	2	4
Total			25,729

[6] Hybrid systems combine other generation such as solar cells or gas generators along with storage batteries to provide reliable power off-grid.

THE MARKET POTENTIAL

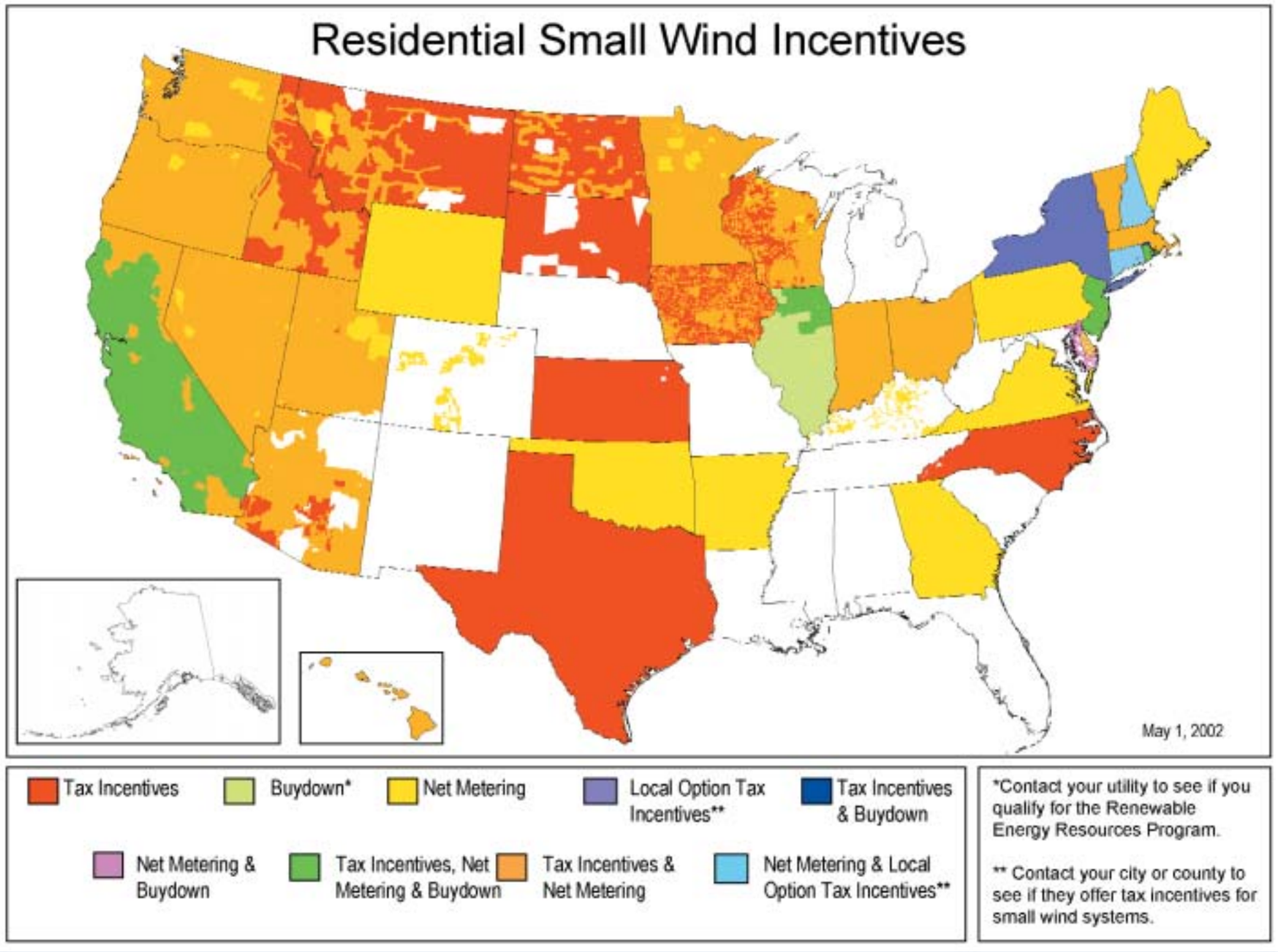

Figure 3: Incentives for small wind turbines in residential applications.

Notes:
1. Incentives change often.
2. Net metering has not been determined for all municipal utilities and rural electric cooperatives.

the projection for 2020 is 1,060,000 MW of generating capacity and 4,804 billion kWh in demand.

Although the domestic potential for small wind generating capacity is estimated at 140,000 MW in 2020, we do not believe that this is a realistic goal. The limitation we see is market growth, not manufacturing capacity or sales and support infrastructure. The growth of small wind turbine markets, even with attractive incentives and favorable policies, will not match the pace of market penetration of other common household electrical devices with lower price tags and easier implementations.
Our goal of 50,000 MW of small wind capacity by 2020 is aggressive but achievable given the right public policy environment, particularly over the next ten years. Fifty gigawatts (50,000 MW) of small wind turbines in 2020 would produce an estimated 132 billion kWh of clean electricity per year, or approximately 3% of projected total U.S. demand. At this level of capacity, small wind systems would be providing 6-8% of residential sector electrical demand. The EIA Annual Energy Outlook document forecasts that the residential electric sector demand will be 1,701 billion kWh in 2020.

Growing the domestic market from its current installed capacity of 15–18 MW to 50,000 MW in 2020 would require a doubling of the market each year for several years and then require sustained sales growth in the range of 50–55% per year. In this scenario, the domestic small wind turbine industry would reach annual sales of $1 billion and employ approximately 10,000 people in 2020.

Export Market

U.S. manufacturers of small wind turbines currently export more than 50% of their production and have a leading

share of the world market for this technology. The foreign market for grid-connected wind turbines is fueled by electricity prices more than double those faced by U.S. consumers. In addition, it has been estimated that about 2 billion people in the world do not have access to electricity for domestic, agricultural, or commercial uses.[7] The traditional method of providing electricity by extending the distribution grid has proved to be expensive and poorly suited to the low consumption levels of communities in developing nations. And the number of homes without electricity is increasing because the birthrate is outpacing the electrification rate.

Small-scale renewable energy systems (wind, micro-hydro, and solar) are often less expensive to install than line extensions. Small turbines are less expensive to operate and produce much less carbon dioxide per kilowatt hour than diesel generators do. Small wind systems can be used to electrify single homes (<500 W) or villages (<50 kW). There are also a myriad of special uses of wind electricity, such as making ice for coastal fishing villages, charging batteries for distribution to single homes, and purifying water for drinking.

Developing countries have a high potential demand for small wind systems because they normally do not have major electrical power plants serving rural areas. However, the people are usually too poor to buy small wind systems and need financial assistance from their government in order to afford them. This assistance is, today, almost exclusively directed to subsidizing extension of the grid and installing diesel generators. A breakdown of the estimated export market potential for 2000, 2010, and 2020 time frames is shown in Table 6.

Table 6: Potential Markets for Small Wind Turbines in Foreign Countries

	2000			2010			2020		
	Number (millions)	Avg size (kW)	Total MW	Number (millions)	Avg size (kW)	Total MW	Number (millions)	Avg size (kW)	Total MW
Single home systems	150.0	0.2	30,000	195.0	0.3	58,500	260.0	0.4	104,000
Village systems	3.8	10.0	38,000	4.9	10.0	49,000	6.6	10.0	66,000
Facilities	7.0	1.0	7,000	9.1	1.5	13,650	12.2	2.0	24,400
Miscellaneous	5.0	1.0	5,000	6.5	1.5	9,800	8.7	2.0	17,400
Totals			80,000			130,950			211,800

Source: AWEA Small Wind Turbine Committee, 2001.

[7] World Bank, 2000.

Identifying and prioritizing barriers is an important prerequisite to industry planning. Different companies and other stakeholders often have differing views on the most important barriers, and there is a natural tendency to focus on short-term challenges. Reaching consensus on the barriers required a number of meetings and sizeable investment in time, but this consensus provides the foundation for plotting the path to a billion-dollar industry.

Outlined below are technology, market, and policy barriers for the near-term, mid-term, and long-term time frames.

Near-Term (0–3 Years) Technology Barriers

High costs of wind turbines

Although people want small wind turbines, most find the price is too high. System costs can be reduced by increasing production rates and advancing the technology. Regarding production rates, small wind turbines are produced in limited quantities, so there are only limited economies of mass production. Advances in technology, such as new airfoils for blades, super-magnet generators, and power electronics can make small wind turbines cheaper to build, more productive, and more reliable. The cost to consumers can be reduced with incentives.

Insufficient product reliability

It is a substantial challenge to design, manufacture, and install small wind turbines that are low in cost and yet rugged enough to withstand 20 to 30 years of operation in weather that is often severe. Small wind turbine technology development is both art and science. The true measure of a new design is often not known until several years of operation at dozens of sites. At present, there is no way to effectively duplicate the wear and tear of the real world during the product development stage. As a result, reliability has historically been the Achilles heel for small wind turbine technology.

Near-Term Market Barriers

Lack of effective standards

As the domestic market continues to expand, consumers need protection from unscrupulous suppliers chasing the latest trend in search of wealth. Further, responsible small turbine manufacturers need a baseline for establishing turbine performance and credibility. There are existing international safety and draft national performance standards for small turbines that could be used by state or national incentive programs. The issue is the cost to meet the testing and documentation requirements of these standards.

The existing design standards are primarily related to structural safety and do not directly address issues of reliability, durability, and longevity. There is no equivalent to *Consumer Reports* in the small wind industry.

Low visibility of the industry and technology

There are relatively few small wind turbine installations, so people just do not see small wind turbines very often. In addition, the companies of the small wind turbine industry have limited resources and capabilities to promote the technology. Unlike the solar industry, there are no Fortune 500 companies involved at this time in the small wind industry. Adding to the issue, DOE has focused the majority of its resources and publicity on solar technologies.

Misconceptions about the wind resource

The attention given to wind farm developments in high-wind areas has convinced some people that they must have an exceptional wind resource in order to benefit from wind technology. However, small wind turbines are designed to operate effectively in the lower wind speed areas where most people live and work. DOE wind maps have inadvert-ently exacerbated the problem by classifying wind regimes according to their potential for wind farm development.

Near-Term Policy Barriers

Lack of federal incentives

For small wind turbines, there has been no federal tax incentive or deployment program since 1985. The resulting lower level of business activity has affected industry expenditures on research and development and has slowed the pace of innovation. DOE has supported sporadic initiatives for research and development on small wind turbines since 1985. However, this level of investment by the federal government has not been sufficient to realize the potential for cost reductions or leveraged deployment.

Restrictive zoning

Most local jurisdictions limit the height of structures in residential and sometimes other zones to 35 feet. This restriction was developed nearly 100 years ago to ensure that the height of structures would not exceed the capability of fire fighting equipment to pump water. Today, this height limit is a significant obstacle to siting small wind turbines.

To make effective use of the wind, small turbine towers must be at least 60 feet high and well above obstacles (such as trees) in their vicinity. Wind speed increases with height above the ground. Turbulence, the disruption of the wind flow around obstacles, increases near the ground and reduces energy output of small wind turbines.

Putting a small wind turbine on a short tower is like putting a solar panel in the shade. For many residential applications, systems of 5 to 15 kW, turbines need to be on towers from 80 to 120 feet tall. The 35-foot height restriction causes unnecessary expense and delay when getting a building permit and opens up opportunities for neighbors to oppose the permit because of either legitimate concerns or underlying historical animosities.

NIMBY and environmental concerns

Because there are few installations of small wind turbines, the neighbors of people planning to install a small wind turbine system and the local zoning boards that must approve permits typically do not have a fair basis for understanding the noise, visual, and other impact of the turbines. They fear the worst and act accordingly. Consumers who need approval from zoning boards often run into objections presented by concerned neighbors. Dealing with these objections can demand considerable time and expense.

Excessive interconnection requirements and unequal billing policies

Even though the federal Public Utility Regulatory Policies Act (PURPA section 210), gives all Americans the right to interconnect small wind turbines and to receive payment for excess electricity production, the policies of many utilities discourage the use of these systems. Many utilities have limited experience with customer-owned generation. They may use the same process for approving 500-MW gas turbine co-generation facilities and 10-kW residential wind installations.

It sometimes takes more hours of labor by the customer and the wind turbine vendor to gain the approval for interconnection than it took to build and install the wind turbine itself. Weak or uninterested public utility commissions can allow utilities to effectively thwart the federal rights provided under PURPA. Interconnection standards that have emerged in the last five years have required small wind turbines to deliver to the utility grid power that is of higher quality than the power delivered by the utility to its customers. Meeting these excessive standards increases the cost of the wind generating systems.

In more than 35 states, there is a policy called net metering, in which consumers receive the retail rate for electricity they generate in excess of their consumption. But even under net metering, there is a great variation from state to state and utility to utility concerning the accounting periods, capacity limits, limits to participation, and cost/benefit of net excess generation. This creates uncertainty in the marketplace.

Undervaluation of green energy

No economic credit is given for having a nonpolluting energy source. For every kWh produced by a small wind turbine, 102 pounds of carbon dioxide, 0.57 pounds of sulfur dioxide, and 0.34 pounds of nitrogen oxide emissions are avoided.

Disincentives in tax code

Companies that buy fuel or electricity can deduct these costs as business expenses, reducing their reported profits and their tax liability. Companies investing in energy-producing equipment, on the other hand, must capitalize the investment, increasing reported profits and tax liabilities. The accelerated depreciation schedule for wind energy investments helps, but does not level the playing field.

Mid-Term (4–10 Years) Technology Barriers

Turbine productivity hampered by power electronics issues

Because small turbines operating at variable speed produce variable frequency and variable voltage output, power electronic converters are used to modify the wild AC into standard 60-cycle AC. The old inverter technology was too unreliable. The new inverter technology is too expensive. The industry needs lower cost, reliable power electronics.

Domestic market requirement—quiet operation

High-growth domestic markets demand quieter wind turbines, especially when turbines are sited in residential neighborhoods. Turbine noise can be caused by gearboxes, blade shape, tower shadow, etc. Small turbines operate at high RPM and tend to spin even if they are furled (pointed out of the wind); there needs to be a way to make them extremely quiet under all conditions.

Long-term reliability

As mentioned above, reliability is a long-term issue that is difficult to predict because the wind is such a variable environment for a piece of machinery. How a turbine withstands the long-term effects of the wind is often known only after several years of operation at dozens of sites. There needs to be a way to effectively duplicate the wear and tear of the real world during the product development stage. This will require the development and verification of accelerated testing protocols for reliability, durability, and longevity.

Need for better technology tools

Many small turbines use a passive overspeed control such as furling. In furling, the force of the wind turns the rotor sideways, just as farm water-pumping windmills have done for 100 years. So far, no computer codes have ben able to predict the performance or assist in the design of furling mechanisms. This means such designs need to be performed empirically, raising development costs. Better computer codes are needed to help reduce design costs.

Mid-Term Market Barriers

Insufficient capitalization

U.S. small turbine manufacturers are entrepreneurs who have a deep dedication to renewables, but who also have limited resources. Their businesses lack the capitalization to effectively promote mass markets, exploit design-to-cost technology options, or provide forward pricing to accelerate market adoption. They struggle in a capital intensive business that requires substantial investments in technology and overcoming institutional barriers. While the solar industry has consumed billions in investment over the last two decades, the small wind turbine industry has attracted far less capital.

Complicated financial impact

For consumers, purchases like small wind turbines that have longer lifetimes are more difficult to understand financially. Consumers generally look at monthly cash flow or direct out-of-pocket expenses and rarely consider life-cycle costs. They also do not tend to consider tax consequences fully. This makes it

difficult for them to compare small wind turbines with other potential investments.

Lack of multilateral bank funding for export markets

The World Bank and Global Environmental Facility have been funding substantially more solar projects than small wind projects, even though the cost of electricity from small wind turbines is lower than from solar electric products. [2] There is a need for the small wind industry and its partners to provide in-house technology expertise to the World Bank, which has proven to be successful for the solar industry.

Mid-Term Policy Barriers

Need for more state-based incentives

Currently, four states (California, Illinois, New Jersey, and Rhode Island) offer substantial rebate or buy-down programs to promote the installation of renewable energy equipment. Rebates typically range from 50 to 60% of the installed small wind system cost, resulting in significant savings. Other states, such as Wisconsin, offer production-based incentives. (See the appendix for a full listing of state incentives in 2002.) If more states offered incentives, the sales and production volume for small wind turbines would increase.

Need for sustained national incentives

As mentioned above, the lack of federal incentives slows the pace of industry growth to meet the market demand. Other traditional energy source technologies are being subsidized, and as noted above, federal tax policies actually encourage the use of fossil fuel and utility power.

Need for national models for net metering and zoning rules

There are too many state, county, and city jurisdictions for the wind industry to address the policy needs of each. For example, in California there are 538 counties and incorporated cities. A 2001 industry study estimated that addressing the zoning barriers with new ordinances in each jurisdiction would cost more than $20 million and would require more than 200 person-years of effort. This finding led to a state zoning bill, AB1207. National regulations, like those passed for satellite TV, would be very helpful to the industry.

Lack of interconnection standards

Few states have standardized interconnection requirements, and many public utility commissions give utilities broad discretion on policies towards customer-owned generation. Some utilities have used this freedom to discourage competition through excessive requirements for equipment, special tests, and additional insurance.There is a need for a national interconnection standard developed by a technically recognized body.

This roadmap of the U.S. small wind turbine industry identifies the background, status, and potential of the market for small wind turbines. The roadmap points to technology, market, and policy goals and the specific actions necessary to meet these goals. Many groups will need to participate in the activities described here in order to realize our vision of U.S. small wind turbines as a significant contributor to America's energy supply portfolio.

These high-priority goals have been identified by the AWEA Small Wind Turbine Committee to overcome the barriers identified in the previous section. Under each goal are listed specific actions that can be taken by the industry working in concert with federal, state, and local governments to meet these goals. Progress on these items in the near-term, mid-term, and long-term timeframes will help make the vision of this roadmap a reality.

Near-Term (0–3 Years) Technology Goals and Actions

Reduced cost of energy resulting from turbines that operate in low-wind regimes

Actions
- Develop U.S. technology for low-cost, robust rotors optimized for low wind speed regimes.
- Develop low-cost, very tall towers.

Turbine cost reduction through improvement of the performance and efficiency of small wind turbines

Actions
- Support cost-shared component development projects.[8]
- Conduct applied research projects aimed at improving the efficiency of small wind turbines through better integration of subsystems.[9]
- Develop advanced airfoils suitable for small wind turbines.
- Develop advanced permanent magnet alternator and other generator technology suitable for small wind turbines.

Reduced tower and installation costs

Actions
- Develop advanced, lower-cost foundation or anchoring systems for towers.
- Develop automated processes for tower fabrication.
- Develop alternate, lower-cost tower designs.

Improved turbine reliability

Actions
- Develop test methods for reliability issues like "extreme events."
- Gather multi-year data on turbine performance, reliability, operation, and maintenance.
- Develop structural safety standards for the small turbine industry.

Increased participation of small wind turbines as a technology option in domestic government programs

Actions
- Work with the Federal Energy Management Program to develop small wind projects at federal facilities.
- Promote small wind turbines for homeland security and other military operations.

Reduced manufacturing costs by increasing the volume of production

Actions
- Engage manufacturing consultants to advise individual manufacturers on improved manufacturing techniques, improved throughput time, and development of a manufacturing plan.
- Encourage small turbine manufacturers to explore state incentives for building manufacturing businesses.

[8] In-house research projects are supported by the government through competitive, cost-shared procurement that may include cost sharing by the companies involved.
[9] Universities, research institutes, and companies work together on applied research projects.

Development of equipment and processes for mass production of small wind turbine systems

Actions
- Support company-specific in-house activities to improve manufacturing processes.
- Support development of components designed specifically for mass production.

Mid-Term (4–10 Years) Technology Goals and Actions

Development of improved power electronics[10]

Actions
- Support cost-shared company research on power electronics equipment.
- Conduct applied research on generic power electronics issues.

Reduction of noise produced by small wind turbines

Actions
- Develop a noise measurement and reporting standard for small wind turbines (different from the IEC 61400-11 addition to the noise test standard).
- Conduct cost-shared, company-specific, in-house noise reduction projects.
- Conduct applied research on generic noise issues of small wind turbines.

Creation of higher-definition performance predictions based on resource to help customers in site selection[11]

Actions
- Initiate research to better understand the higher turbulence and shear environments in which small wind turbines operate.
- Develop an improved performance prediction methodology for small wind turbines.
- Develop a Web-based performance prediction capability based on high-definition wind maps.
- Develop improved guidelines for micrositing considerations for small wind turbines.

Improvement in the reliability and durability of small wind turbines

Actions
- Develop improved life-cycle testing protocols and analytical methods for small wind turbines.
- Develop better understanding of design load characterization for enhanced reliability, durability, and longevity.
- Identify design elements necessary to achieve 50-year operating life.
- Perform durability and reliability testing for environmental extremes.
- Support company-specific, in-house reliability enhancement projects.

Reduced maintenance requirements of small wind turbines

Actions
- Support company-specific, in-house projects to reduce maintenance requirements.
- Conduct applied research on generic maintenance issues through hardware verification projects.

Enhanced analytical tools for small wind turbine design

Action
- Enhance design techniques and capabilities, particularly rotor aerodynamics and dynamics that are unique to small wind turbines.

Improved understanding of passive control of small wind turbines

Action
- Conduct applied research on generic passive control issues for small wind turbines.

[10] Such as for conversion, optimization of wind turbine generator operation, storage, etc.
[11] Now that wind maps have better resolution (down to 400 m^2) we should be able to weed out sites that will result in poor performance and give realistic assessments of performance for small wind turbines.

Long-Term (11+ Years) Technology Goals and Actions

Develop hydrogen-based systems

Action
- Establish link with other hybrid power technologies such as micro gas turbines, PV panels, diesel and other fuel generators, and any new power generating technologies that may develop.

Establish links with storage and other power technologies

Action
- Establish links with storage and other power technologies such as hydrogen generation and storage, batteries, natural gas sequestration, and any new storage technologies that might develop.

Near-Term (0–3 Years) Market Goals and Actions

Development of additional efficient and effective standards

Actions
- Create U.S. and international IEC standards to address reliability, durability, longevity, noise, and power performance.
- Complete the IEC 61400-2 draft safety standard.
- Complete development of a cost-effective and efficient certification program for small wind turbines.

Development of stronger, certified distribution channels and support

Actions
- Develop generic installation and maintenance training programs for small wind turbines.
- Pursue technologies of communication with distributed generation installations (remote monitoring).
- Develop certification program for installers.

Development of a consumer-friendly performance rating system

Actions
- Update and reconcile the AWEA performance standard with the IEC 61400-12 for small wind turbines.
- Promote adoption of the AWEA estimated annual energy output parameter.

Increased visibility and credibility of small wind turbines

Actions
- Encourage DOE to give small wind greater visibility through policy incentives, studies, and speeches.
- Publish in cornerstone magazines such as *Scientific American* and *Popular Science* to highlight small wind as an important technology.
- Publicize the new generation of products coming out of government-supported development contracts.
- Increase outreach to state energy offices and other important local and regional stakeholders.
- Create a significant federal deployment initiative for small wind turbines to prime important markets.

Completion of high-definition wind mapping for all states and for international markets

Actions
- Complete high-definition wind maps for each of the 14 states targeted by the AWEA Small Wind Turbine Committee as offering the best opportunities for small turbine installations. (Measurements taken at 24 meters [80 feet] above the ground.)
- Complete high-definition wind maps for the next 16 states on the AWEA Small Wind Turbine Committee's pri-ority list.
- Modify existing international wind resource maps for small turbine characteristics such as height, class descriptors, and approximate kilowatt-hours of production.
- Develop an improved performance prediction methodology for small wind turbines.

- Develop a Web-based performance prediction capability based on high-definition wind resource maps.

Mid-Term (4–10 Years) Market Goals and Actions

Improved definition of the market to be used for business planning

Actions
- Update the 1981 A.D. Little market study for small wind turbines in the United States.
- Characterize the export potential of U.S. technology.

Increased customer options for purchase and financing of small wind turbines

Actions
- Expand availability of plug-and-play systems suitable for mass marketing.
- Establish consumer-friendly customer financing programs, like those available for car buyers.

Increased number of products available (models and size range) for different market segments

Actions
- Support company in-house product development projects.
- Encourage state support for small wind turbine product development.
- Encourage greater investment in the small wind turbine industry.

Incorporation of environmental benefits into the value of wind turbines

Action
- Support development of effective green tags market for distributed generations.

Increased outreach and education on small wind turbines

Actions
- Develop state-specific consumer guides for small wind turbines.
- Develop a guide on wind power for school programs.
- Increase programmatic involvement for small wind turbines in the National Wind Coordinating Council, the National Association of State Energy Officials, the Utility Wind Interest Group, the National Council of State Legislators, and others.

Increased participation of small wind as a technology option in international development projects

Actions
- Support the establishment of in-house technology expertise in small wind at U.S. AID, the World Bank, U.N. Development Program, and other multilateral development programs.
- Develop effective response to foreign tied-aid competition.
- Promote easier and more effective export finance programs.
- Educate Congress and the public on the importance of spending on foreign aid assistance.
- Encourage World Bank to make renewable purchase decisions based on least cost instead of defaulting to PV.

Long-Term (11+ Years) Market Goals and Actions

Stimulate the micro-power revolution

Action
- Develop a strategy with outreach materials to address the micro-power market.

Near-Term (0–3 Years) Policy Goals and Actions

Supportive national policies to promote market development

Action
- Create supportive national policies (tax credits, regulations).

Supportive state policies to promote market development

Actions
- Promote creation of state incentive programs that reduce first costs (e.g.- rebates).

- Promote creation of state incentives that stimulate electricity production (e.g., set up incentives that increase with tower height.)[12]

Removal of systemic height restrictions normally found in residential locations

Actions
- Provide information encouraging elimination of height restrictions to local governments and bodies making such regulations.
- Circulate model regulation regarding permissive zoning for small wind turbines.
- Promote state and national legislation that can override local restrictions.

More information to address aesthetic, noise, and environmental concerns

Actions
- Create a credible white paper on avian issues for small wind turbines.
- Develop technology to reduce noise.
- Develop building permit reference materials relating to aesthetics, noise, environmental impacts, property values, etc.
- Develop videos to highlight the visual non-intrusiveness of small wind turbines.
- Develop a voluntary contribution program to remove obsolete and orphaned wind turbines.

Removal of interconnection barriers

Actions
- Provide information to utilities and public utility commissions that will help remove unnecessary and expensive requirements in the areas of power quality, safety, and performance standards.
- Participate in development of a national interconnection standard.

Equitable utility billing and interconnection cost policies

Actions
- Promote net metering.
- Promote simplified interconnection contracts.
- Promote protection against unwarranted insurance requirements.
- Provide expert testimony at rate hearings.

Credit for green attributes

Action
- Discuss the environmental benefits of small wind, including the green attributes.

Reduction or elimination of disincentives to investment in small wind turbines

Action
- Address disincentives to investment in small wind turbines (tax code, sales taxes, property taxes, etc).

Mid-Term (4–10 Years) Policy Goals and Actions

Support state policies for small wind incentives

Action
- Continue to work with states to develop new policies

Disseminate information on market barriers

Action
- Streamline information on zoning regulations, interconnection agreements, and net metering to guide development of state incentives.
- Develop streamlined interconnection requirements

Long-Term (11+ Years) Policy Goals and Actions

Develop strategies to deliver high-level electric service to rural customers

Action
- Work with rural electric cooperatives to devise incentives for rural customers and to streamline the interconnection process.

[12] Action suggested by M. Sagrillo.

"Many more people would buy small wind systems if they were cheaper. But, we can't make them cheaper unless many more people buy them."

David Blittersdorf, President, AWEA.

All emerging industries and products have faced this basic "chicken and egg" dilemma. Some never made it over the hump and eventually faded from the marketplace. Some got over the hump by virtue of massive corporate investment (in R&D and forward pricing), and others made it into the mainstream by steadily improving cost and functionality. The small wind industry is composed of innovative, small, struggling firms that lack the resources to develop mass-production designs and build large factories in anticipation of quantum increases in sales. Steady improvement is the most likely route for firms offering small wind turbines. In Washington, this is sometimes referred to as sustained orderly development.

Sustained orderly development is the recognition that there are not likely to be "silver bullets" that will radically transform the glide slope of market penetration for small wind turbines. Steady improvements in the products and sustained public sector support offer the best hope of delivering the industry's vision of a "new home appliance" and making small wind turbines a notable contributor to our national energy supply. Although economics are a barrier, the exciting thing about residential and small business markets is that once the numbers work for one home, they work for 10,000 homes. This gives the small wind turbine industry explosive growth potential.

Public Policy

A primary element of sustained orderly development for small wind turbine technology is related to public policy. Smart subsidies, which enable customers to tunnel through the cost barriers, are critically important in aggregating demand. Federal and state subsidies and incentives need to dovetail for a total package that provides enough stimulus to move the market. Removing institutional market barriers, such as tower height restrictions and undue interconnection costs, is also an important part of the recipe.

In addition to efforts by the U.S. government, some states have good policy environments for small wind turbines. Many of these states offer rebate or buy-down programs that are typically funded with system benefit charges assessed to retail electricity sales. Funds generated by these system benefit charges can be designated by legislatures to subsidize renewable energy projects and promote industry development.

In 2002, four states offered these rebate incentives for small wind turbines: California, Illinois, Rhode Island, and New Jersey. The requirements for specific turbines are determined on a state-by-state basis, and typically these incentives are only for small turbines that are connected to the grid. Other states offer tax credits, sales or property tax incentives, and net metering for small turbine owners.

The various stimulus packages are shown in the map of state incentives presented in Figure 3. As the number of states offering stimulus packages for small turbines increases, there will be further sustained orderly development of the market.

In order to meet the market goals of the AWEA Small Wind Turbine Committee, more incentives are needed. An additional two or three states per year need to implement stimulus programs for small wind turbines over the next six to ten years. It is also critically important that the federal government does its share with a significant (25 to 40%) tax credit or rebate program.

Research, Development, and Demonstration

Federal, and to a lesser extent, state R&D programs need to provide greater resources for small wind turbine technology development, and the industry must continue to devote significant resources to product development. The DOE research program on wind energy cannot be effective if it concentrates solely on long-range, high-risk R&D. Instead, the federal R&D program must support development of advanced products and components and attack other cost drivers such as technology for manufacturing and installation, outreach for consumer education, support for policy and market transformation, and work on generic basic technology.

DOE now has a wind energy R&D budget of about $40 million, of which about $3 million, or 8%, is spent on programs to

develop small wind turbines. As technology for large wind turbines "graduates" and requires less public sector support for the next few years, spending on small wind technology should significantly increase.

Small Wind Turbine Industry
The small turbine industry must be open to new entrants and should not foreclose any investment options. Private capital will remain the cornerstone of the substantial investments that will be necessary if this is to become a billion-dollar industry. Likewise, the industry should pursue all viable market diffusion models, from full-service dealerships to "big box" chain stores to "Dell-like" direct sales programs.

Cooperative Strategy
The members of the industry will continue to develop products and processes to meet market demand. DOE, national laboratories, test centers, and universities will work with industry partners to conduct basic and applied research, development, and testing to improve small wind technology. Organizations representing utilities, standards-making bodies, regulatory agencies, and every level of government will participate in market and policy actions to remove barriers. Consumers will express their will by seeking out this environmentally friendly technology in spite of the barriers that still exist.

To address policy barriers, industry and government entities work together to propose, review, advocate, and help implement policies that support development of small wind technology while safeguarding

The market for small wind turbines in the United States is also affected by the activities of the Wind Powering America (WPA) Program. This DOE activity works to educate the general public on wind energy and its uses. The general public has specifically requested information on small wind turbines at various state workshops being organized under WPA. This grassroots level of interest stems from many sources, such as the desire for independence from the utility grid, the urge to reap the environmental benefits of renewable energy, the desire to make a public statement about the environment in a visual way by using small wind turbines, and the desire to use a renewable technology that is cost competitive over the life of the small wind turbine. Further, the agricultural community has historically used wind energy and may be more comfortable with small wind turbines.

Under the WPA activities, members of the AWEA Small Wind Turbine Committee were asked to rank the states from high to low priority for focused WPA small turbine activities. Not only were the states ranked, but the specific state activities were rated as well. These activities include the development of state-specific guides for consumers on small wind electric systems; distribution of Clean Power Estimator—an economic tool to help residential consumers and small business owners understand the economics of a small turbine system; and the development of better wind resource assessment maps.

The top 14 states designated by the AWEA Small Wind Turbine Committee have been targeted for the state-specific activities listed above. The targeted states are California, New Jersey, New York, Illinois, Pennsylvania, Minnesota, Washington, Oregon, Vermont, Colorado, Massachusetts, Idaho, Arizona, and Rhode Island. These states also receive high priority for workshops on small turbine technology under the WPA outreach and market development activities, in hope of stimulating the domestic market.

Further, Wind Powering America small turbine activities will be determined in conjunction with the AWEA Small Wind Turbine Committee.

the public interest. The industry also lobbies at the national, state, and local level for policies that remove barriers and compensate for subsidies to other energy technologies.

The following tables summarize wide-ranging discussions of the AWEA Small Wind Turbine Committee about the timing of actions to overcome barriers and reach the goals described in this roadmap.

Table 2: Summary Schedule of Actions (First appeared in Executive Summary)

	Technology Actions	Market Actions	Policy Actions
Near-Term (0-3 years)	- Reduce costs by new turbine development activity for low wind speed sites and new component development for SWT - Research reliability concerns such as lightning, corrosion, bearing lubrication, alternator winding insulation, electronics - Continue focused long-term research unique to SWT - furling, durability, blade aerodynamics, noise, and power electronics - Develop packages with other distributed generation and storage technologies	- Develop nationally recognized standards for participation in stimulus programs - Publish SWT articles in cornerstone magazines such as *Scientific American*, to create more "SWT buzz" - Revise new U.S. wind maps for SWT, 30 m hub height and .25 shear, new legends - Explain turbine micrositing - Provide information to remove misconceptions about the wind resource - Incorporate the value of environmental attributes of small wind into electricity prices	- Develop a strategy to work with state policies for inclusion of small wind - Develop a national policy for an SWT tax credit - Work to eliminate zoning restrictions - Develop model zoning ordinances and blueprint templates of zoning regulations, interconnection agreements, and other policies - Work to reduce excessive interconnection requirements
Mid-Term (4-10 years)	- Work to improve the reliability and reduce the cost of power electronics - Work to eliminate noise from small turbine designs - Develop consumer-friendly performance predictions - Improve analytical design tools - Continue the development of packages with other distributed generation and storage technologies	- Update national market study - Characterize the export potential for U.S. manufacturers and work with multilateral development programs - Establish consumer-friendly customer financing programs, including lease options - Increase the number of products available (models and size range) for different market segments - Increase outreach and education	- Influence/develop new state and national incentives - Disseminate and expand information on zoning regulations, interconnection agreements, and net metering rules - Develop a more consumer-friendly national interconnection standard
Long-Term (11 + Years)	- Develop hydrogen-based systems - Develop blackout protection strategies - Establish links with storage and other power technologies	- Stimulate the emerging micro-power revolution, of which SWTs are part	- Develop policies to help deliver higher service levels to rural customers
Crosscutting (Ongoing)	- Continually work to reduce cost and improve reliability - Continue to develop standards for reliability, durability, and longevity	- Continue to develop standards for reliability, durability, and longevity	- Continue to develop standards for reliability, durability, and longevity

Table 7: Research Priorities Identified

Research Area	Continuing Research	Future Research
Reduce cost	- Low-cost robust rotors with advanced airfoils - Low-cost, very tall towers - Turbine optimized for low wind speed	- Larger small turbine development (50–100 kW) - Improve performance and efficiency
Reduce manufacturing costs	- Develop tailored, efficient manufacturing plans - Equipment and processes for mass production	- Recyclability - Coating equipment
Improve reliability	- Develop improved turbine standards - Gather multi-year turbine data - Research topics w/reliability impact	- Design test methodology for “extreme events”
Power electronics	- Reduce cost and improve reliability of power electronics - Develop optimized converter technology	- Develop power electronics design for integrating power and storage technologies and improving overall system energy efficiencies
Reduction of noise	- Understand aeroacoustic phenomena - Noise measurement standard	- Design strategies to reduce noise
Better analytical tools	- Wind/economic prediction - Aeroelastic models with furling	- Integrated design tool
Improve overspeed control knowledge	- Expand analytical tools to handle furling, stall/furling	- Develop design tool based on improved aerodynamic data
Distributed generation applications	- Control strategies to combine power and storage sources - Control strategies to combine power and heat applications	- Real-time optimization for electricity, heat, and secondary uses

ENDNOTES

1. Bergey, Mike, "The Sleeping Giant: The Role of Small Wind in America's Energy Future,"in Proceedings of Windpower 2001. American Wind Energy Association: Washington, D.C., June 7, 2001.
2. Arthur D. Little, Inc., Near-Term High-Potential Counties for SWECS. Solar Energy Research Institute: Golden, CO, BE-9-8282, 1981.
3. Energy Information Agency, Annual Energy Review 1998. Government Printing Office: Washington, D.C., DOE/EIA-0384(98), 1998.
4. U.S. Census Bureau, American Housing Survey, Owner-occupied, 1991-1997. Government Printing Office: Washington, D.C., 1998.

NOTES

NOTES

APPENDIX-DETAILED LIST OF STATE INCENTIVES

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
ALASKA	Power Project Revolving Loan Fund State Loan Program: interest rate tied to municipal bonds.			Loan term related to the life of project.	N/A	96
ARIZONA	Personal tax credit		25% of the cost of a renewable system, up to $1,000, may be carried forward up to five years			97
	Sales tax exemption for equipment		Up to a $5,000 deduction.			
					Tucson Electric Power: wind < or equal to 100 kw NEG based on fixed seasonal rates Arizona Public Service: wind < or equal to 10 kw NEG based on avoided cost	
ARKANSAS					Small wind: agricultural or commercial: < or equal to 100 kW, residential: < or equal to 25 kW Arkansas Public Service Commission to establish rates, terms and conditions	96
CALIFORNIA					Max capacity of 1 MW; annualized calculation; credit for NEG is based on either baseline/over-baselines rates, or on time of use rates, and is carried over month to month; any NEG at the end of annual period is credited to the utility without compensation to the customer-generator.	93
	Energy Innovations Small Grant (EISG) Program. "Intended to determine the feasibility of energy technology and science innovations for new energy concepts whose feasibility are not yet established."		$2 to $2.5 million per year; $75,000 per project.	Expires September 2002.		
	Public Interest Energy Research Grants (PIER). Funds R&D efforts not adequately funded by competitive and regulated markets.		$62.5 million/year	Expires in 2012		
	Public Benefits Fund: Renewable Energy Trust Fund		$70.2 million for existing wind projects ($/kWh credit); $162 million for new renewable projects, which must be installed by the end of 2001 ($/kWh); $54 million for emerging technologies 10 kW or less for wind (buydown).	Expires in 2012		

STATE INCENTIVES

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
COLORADO					Max capacity: 10 kW; NEG carried from month to month, and granted to the utility at the end of the annual period. PSCo customers only.	
CONNECTICUT	Public benefits fund. Must be a direct economic benefit to the state of Connecticut. Available in the form of grants, direct or equity investments, contracts or other actions which support research, development, manufacture, commercialization, deployment and installation of renewable energy technologies.		$118 million over five years-- renewable energy investment fund	Enacted in April 1998		11.6% (3.1 total) 3,282k
					Net metering rules, regulations, and conditions to be decided by the Department of Public Utility Control.	
IDAHO	40% income tax reductionin the year of installation, and 20% each year for the next 3 years. Maximum deduction of $5,000 in any one year.					
	"Low Interest Loans for Renewable Energy Resource Program: residential loans from $1,000 to $10,000, and commercial loans from $1,000 to $100,000, both at a 4% interest rate, to be repaid in 5 years or less. Several restrictions can be viewed at: http://www.idwr.state.id.us/energy/Financial/loanr.htm					
					Only customers of Idaho Power Company (although all utility companies have the opportunity to pass a net metering tariff because of a PUC order); all technologies under 100 kW eligible.	

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
ILLINOIS					Small wind < or equal to 40 kW NEG avoided cost Commonwealth Edison only Property tax exemption Maybe $ in ComEd settlement fund	91
	Special property tax assessment.					
	Alternative Energy Bond Fund Program: not applicable to residential projects.					
	Renewable Energy Resources Program Grants	Rebates available for small systems; grants available for large.				
	Public benefits program: Renewable Energy Resources Trust Fund. Grants, loans, and other incentives available.		Expected to produce $100 million/year for the ten year length, 50% of which goes to the Renewable Energy portion of the fund.	10 year program, to end in 2007		
	Public benefits program: Clean Energy Community Trust (CECT). Grants, loans, venture capital support, and other financial incentives available. Must demonstrate benefit to Illinois environment or economy.		$200 to $225 million for efficiency and renewables.			
IOWA	Opportunity for local government to assess wind turbines at a special valuation for property tax purposes.					97
	Sales tax exemption		Wind energy equipment and all materials used to manufacture, install, or construct wind energy systems 100% exempt.			
	Alternative Energy Loan Program. 0% interest loans for up to half of the project cost up to a maximum of $250,000.	Small wind (< 10 kW), is eligible for 10% of the available funds, while big wind (> 10 kW) is eligible for 20% of the funds.	Depends. In 1996, $1.8 million per year was allocated for the years 1997-1999.			
					Net metering law in dispute; however, currently NEG purchased at avoided cost. Other details unknown.	

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
KANSAS	Renewable Energy Grant Program		About $400,000--$500,000 per year. Typical award from $10,000--$50,000; max limit of award: $50,000.			98
	Property tax exemption					
					Net metering law under consideration: Senate Bill 299, introduced in February 2001; not yet signed into law.	
LA	None	None			None	87
MASSACHUSETTS	Renewable Energy Trust Fund.	Will focus on large wind farms. Plans to put $ on resource assessment DG - "Still, limited awareness among potential consumers, lack of technical and financial information, and problems providing financing to consumers hamper wide scale commercialization...."	$150 million over a five year period; approximately $20 million per year for an undefined period beyond 2002.			58
	Alternative Energy Patent Development: Corporate and personal.		Allows income tax deductions for any income received from the sale of or royalty income from a patent that is deemed beneficial for energy conservation or alternative energy development. May be used for 5 years after it is granted.			
					QFs < or equal to 60 kW Monthly NEG avoided cost All utilities	
	State sales tax exemption. Applicable to residential systems only.		100% exemption from the sales tax on a wind system and all related equipment.	Enacted in 1977		
	State income tax credit.		15% credit against the state income tax for the cost of a renewable energy system (including installation) installed on an individual's primary residence. Max limit of $1,000; can be carried over from first year.			
	Property tax exemption.		100% exemption.	Allowable for a period of 20 years after installation.		
	Solar and Wind System Deduction. Includes costs incurred from installing the unit. Aplies only to commercial and industrial projects.		Exemption from the corporate excise tax for the length of their depreciation period.			

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
MINNESOTA		Minnesota Agricultural Improvement Loan Program - specifically for small wind.	Up to 45% of loan, up to $100,000 of loan principal for up to 10 years.	Enacted in 1995		92
	Value-Added Stock Loan Participation Program. Interest rate subsidized by RFA, generally to about 4%.		Up to 45% of loan, up to $24,000 of loan principal for up to 8 years.	Enacted in 1994 and up for renewal in 1997. Unclear whether it was renewed.		
	Wind and Photovoltaic Systems Exemption. Excludes value added to property value by a renewable energy system from property taxes.		Systems < 2 MW are 100% exempt, while systems > 2 MW are 91% exempt.	Enacted in 1992		
	Wind and Solar Equipment Sales Tax Exemption.			Expired?		
	Wind Energy Generation Grants. Available on a first come, first serve basis until new wind capacity statewide totals 100 MW.		1.5 cents/kWh paid for systems < 2 MW for ten years (payments can go past the 2005 expiration).	Enacted in July 1997, expires January 1, 2005.		
				Established in 1983	Max capacity of 40 kW Applies to IOUs, municipals, and rural cooperatives NEG purchased at average retail rate (total annual class revenue from sales of electricity minus the annual revenue resulting from fixed charges, divided by the annual class kWh sales)	
	Ability to create wind easements (voluntary contracts), which protect access to wind for a wind energy system.		For the purpose of taxes,easements may decrease property value, but not increase it.	Enacted in 1978		
MISSOURI	Low-Cost Efficiency Loan Funds. Available only to public schools (K-12) and local governments.		Loans are determined on an individual project basis, with fixed interest rates below market level.	Enacted in 1991		95

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
MONTANA	Commercial or Net Metering System Investment Credit -- Alternative Energy Systems. $5,000 minimum investment. Excess after the first year can be carried over for 7 years.		35% tax credit for manufacturing plants producing alternative energy generating equipment, a business facility with a renewable energy system, or alternative energy generating equipment.	Enacted in May 2001.		99
	Property tax exemption. Exempts value added by renewable energy system to property value from property taxes.		Applies to systems with up to a $20,000 value for a single-family dwelling; up to $100,000 value for a multi-family residential dwelling or a nonresidential structure.	Exemption may be claimed for up to 10 years after installation.		
	Alternative Energy Revolving Loan Account. Applicable for residential and commercial customers for the purpose of building alternative energy systems to generate energy for their own use and for net metering.					
	Ability to create wind easements, which protect access to wind for a wind energy system.			Enacted in 1983		
					Small wind < or equal to 50 kW Annual NEG credited to following months, and at the end of annual period is granted to utility Applies to all utilities	
NEBRASKA	Low Interest Loan Program for Energy Efficiency. To secure a loan, approach your own financial institution, which will then approve the project on financial terms. The Energy Office is then contacted by the financial institution, which then buys half of the loan at 0% interest so that the total interest on the loan "from the borrower's perspective" will be half the market rate obtained through their private lending institution.					99
	Creation of wind easements allowed.					

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
NEW JERSEY	Full sales tax exemption for solar and wind energy systems.		Full exemption from 6% sales tax.	Expired in 2000. New legislation?		65
	New Jersey Clean Energy Program: State rebate program. Medium systems (>10-100kW) receive a $4/watt rebate; larger systems (>100 kW) receive a $3/watt rebate. Systems producing more energy than needed by the renewable energy system owner are not eligible.	Small Systems (<10kW), receive a $5/watt rebate, to decrease over time as more energy systems are added. Rebates available up to 60% of system costs.	$358 million over the next three years (2001-2003), 25% of which will support class I renewables (the other 75% goes to energy efficiency).			
					Max capacity: 100 kW NEG credited to the following month and purchased by the utility at the end of the billing period at avoided cost.	
NEW MEXICO	System benefits charge Public benefits fund: supports the use of renewable energy for school districts, cities, towns, villages, and counties.		Up to $4 million available.	Enacted in 2000 Enacted in 1998	Renewables < or equal to 10 kW NEG carried forward month to month, or paid at avoided cost by the utility Utility chooses which method for credit. All utilities	58.9% (77.7 total) 1,740k
NEVADA	Property tax exemption		Any value added by the renewable energy system is subtracted from total property value for tax reasons.	Applies for all years following installation.		
					10 kW or less. Limit of 100 customer-generators for each IOU. Customer can choose to have NEG credited toward the next month's bill. Utilities are not required to pay avoided cost for NEG.	

STATE INCENTIVES

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
NEW YORK	Renewables R&D Grant Program. Provides funds for projects focusing on product and technology development, rather than installation of renewable energy systems.		Annual funds average around $2 million. Funds up to 50% of project (generally providing between $10,000 and $200,000 per project).			85
	New York Energy $mart(SM) Loan. Any commercial, industrial, retail, agricultural, non-profit, or multifamily facility is eligible for this program. Must be customer of one of 6 IOU's in NY.		Interest rates reduced by 4.5%.	5 year term.		
	Public Benefits Fund.		$150 million annually.	Expires June 30, 2006.		
					High Value PV and Wind solicitation $1.3M - spring 2000 (net metering law not applicable to wind)	
NORTH DAKOTA	Income tax credit		3%/ year for five years for the cost of equipment and installation (5% if installed before January 1, 2001).			97
	Large Wind Property Tax Incentive (100 kW or larger).		70% reduction in property taxes	Construction must begin before January 1, 2011.		
	Geothermal, Solar, and Wind Property Exemption			Five year period following installation.		
	Large wind sales tax exemption (100 kW or larger).		Construction must begin before January 1, 2011.			
OKLAHOMA					IOU's and rural cooperatives under the Commission's jurisdiction are required to file net metering tariffs for customer-generators. 100 kW or less. No state-wide limit. Customers may request that utilities purchase NEG, but utilities are not required to do so.	95

STATE	Incentives	Incentives Specifically for Small Wind	Type and Amount of Funding	Length of Program	Net Metering	% - rural land/total land area
OREGON	Property tax exemption. Added value of renewable energy system shall not be included when evaluating the property for tax purposes.		100% exemption.	Expires in 2012		98
	Business Energy Tax Credit ("Betsy"). Must replace at least 10 percent of the electricity, gas or oil used; max. limit of $10,000,000 per project. Only applies to businesses!		35% tax credit over 5 years	Enacted in 1980		
	Residential Energy Tax Credit. Equipment, installation, and interconnection costs are applicable.		60 cents credit/ estimated kWh to be produced, up to $1,500 in the first year .	Enacted in 1978		
	Small Scale Energy Loan Program (SELP). Energy savings must be able to pay majority/all of loan; applies to commercial/industrial and municipal/schools projects.		Amount varies.	Enacted in 1981		
	Public Benefits Fund.		$8.7 million/year			
					Small wind < or equal to 25 kW Annual NEG carried month to month or credited at avoided cost At end of annual period, NEG granted to utility for use in low income program Applies to all utilities	
	Municipal and local authorities may establish wind access laws.					
PENNSYLVANIA	Public Benefits Fund. Created for the purpose of promoting the development and use of renewable energy		Varies according to utility.			90
	Low-income renewable energy pilot programs		Provide renewable energy system to decrease electricity costs.			
					10 kW or less. NEG credited at the end of each month to utility.	

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RHODE ISLAND	Public benefits fund.		Approximately $3 million over 5 years?	Program reviewed in August 2001.		43
	Personal Tax Credit. Based on maximum system cost of $15,000.		Beginning with 25% in 2000, but declining by 5% every year until 2004.	2000-2004		
	Property tax exemption. Renewable energy systems cannot be assessed at more than the value of a conventional heating, hot water, or other energy production system.			Expires 12/2004		
	Sales tax credit.		Refund of any tax paid.	Expires 12/2004		
					PUC order of 1988; requires IOU's to provide net metering contracts; max of 25 kW or less; NEG at end of month credited to following month; NEG at end of annual period credited to IOU.	
SOUTH DAKOTA	Property tax exemption. May be taken for 3 years after installation; is not applicable to energy systems that produce energy for resale.		Exempts entire assessed value of residential systems from property tax, and 50% installed cost of commercial systems.			98
TEXAS	Property tax exemption.		Exempts 100% of the value added by a renewable energy system to the assessed property value.			96
				Enacted in 1985	PUC Ruling. 50 kW max; NEG purchased by utility at avoided cost at the end of the billing cycle.	
UTAH			10% of the cost of installation, up to $50,000.	Expires December 31, 2006.		96
			25% of the cost of installation, up to $2,000.	Applicable January 1, 2001, through December 31, 2006.		

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	High Technology Product Manufacturers Excise Tax Exemption		100% exemption from excise tax.	Expires in 2004.		94
	Sales and use tax exemption. Must have at least 200 watt generating capacity.		100% exemption from sales tax.	Expires June 30, 2009.		
	"Washington State University Energy Program: assistance in finding solutions to energy problems that utilize renewable energy, including: technical assistance, education, workshops, field assistance and user-centered solutions. http://www.energy.wsu.ed					
					Max capacity: 25 kW; NEG at the end of each month is credited to the following month's bill; NEG at the end of the annual billing period is granted to the utility with no compensation to customer-generator.	
WISCONSIN	Property tax exemption. "Does not include equipment or components that would be present as part of a conventional energy system or a system that operates without mechanical means."		Exempts 100% of the value added by a renewable energy system to the assessed property value.			94
	"Renewable Energy Assistance Program (REAP): applies to renewable energy systems incorporated into construction projects; half of grant available at purchase of equipment, the other half given upon completion of project; available to businesses, municipalities, and nonprofit organizations.		10% to 20% of a project, up to $75,000.			
	Public benefits fund. State awards grants for low income, energy efficiency and renewable energy services.		Approximately $3.8 million to fund renewable projects.	To be re-evaluated after 2005.		
	Demand Side Applications of Renewable Energy (DSARE); only for WI northeastern 23 counties.		$1.25 million.			
					All technologies < or equal to 20 kW Monthly NEG purchased at retail for renewable energy systems only (non-renewable generated energy purchased at avoided cost).	
	Opportunity to apply for permits that guarantee wind access.					

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WYOMING					Max capacity: 25 kW; NEG at the end of each month can be credited or compensated to the bill for the following month; NEG at the end of each year shall be sold to utility at avoided cost.	99

"This table was created based upon a report ""Looking Outside - Lessons Learned from Renewable Energy Funds in Other States or Regions"" written by Ryan Wiser and Kevin Porter. The net metering column information was found on the Green Power Network - Net Metering, http://www.eren.doe.gov/greenpower/netmetering, latest revision July 2001. Other information on state tax, property tax and loans was found on http://www.dcs.ncsu.edu/solar/dsire/financial.html, latest revision September 2001. Rural land information from: http://www1.stateline.org/fact.do?factId=721 (Data is from Highway Statistics '98, Federal Highway Administration, U.S. Dept. of Transportation); Land information from: http://ga.water.usgs.gov/edu/wetstates.html (Data is from the Statistical Abstract of the United States, 1987