NorthWestern Energy

Montana Wind Power

A Consumer's Guide to Harnessing the Wind

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You can also learn more about wind energy and other renewable energy sources at MontanaGreenPower.org.

The primary source for this publication is *Small Wind Energy Systems*, published in April 1999 by the Minnesota Department of Commerce.

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Front cover: Martin Wilde
Coyote Energy, Inc.
4490 Trumble Creek Rd
Columbia Falls, MT 59912
(406) 892-1313 phone/fax
www.coyote-energy.com
marty.wilde@coyote-energy.com

Revised December 2004

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Contents

Introduction

Montana's wind energy resource is attracting the interest of farmers, business owners and other landowners, as well as utilities and large-scale developers. People find wind energy attractive for a variety of reasons, including its potential economic benefits and its less harmful impact on the environment when compared to coal and other electric power generation fuels.

The Montana Legislature is spurring development of the state's wind energy resource: legislation passed in 2001 provided for incentive payments to assist small commercial development.

The Montana Department of Environmental Quality (DEQ) is promoting wind energy development by collecting data at wind-monitoring sites around the state, analyzing energy potential based on the data and making the information available to the public. The goal is to provide reliable information on energy potential, thus helping individuals to assess more accurately the feasibility of investing in wind energy.

This manual is for people who are interested in installing small (100kW or less) wind energy systems. It provides information needed for an initial analysis to determine whether further investigation is justified. It answers these questions:

- How can wind power work for you?
- Is your business, farm or home a good site for a wind turbine?
- How much does a wind system cost and how much will it save you?
- How do you choose the right system?
- Where can you go for more help and detailed information?

How can wind power work for you?

Harnessing wind power is not a new idea, but the appearance and design of wind machines have changed considerably from the water-pumping windmills of the past. Before investing in a wind system, you need to consider the amount of wind power available and how this power can be used to meet your electrical or mechanical energy needs.

Although wind machines can be used to produce mechanical power, this manual focuses on electricity production. For electrical generation, the system consists of a rotor (i.e., blades) that drives an electrical generator, which produces electric power; a tower; and usually an inverter. Some wind machines also require a battery bank. A wind system used for mechanical power will have the rotor, the tower and mechanical linkage of some sort. Harnessing wind power includes using the power efficiently. Investing $1 in efficiency is equivalent to investing about $3 to $5 in generation capacity.

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines can be used to generate electricity.

How much electricity will a wind machine produce?

Although most small wind machines are rated according to peak wattage, nothing tells you more about a wind machine's potential performance than the swept area, or the area the blades cover when they are rotating. This is a more useful number because there is no standard for measuring peak wattage. See **Table 1** for the swept area of some small wind systems. Each manufacturer sets its own test standards, but all measure geometric areas in the same way.

A second number you'll need when evaluating a wind turbine is the Annual Energy Output (AEO). This is an estimate of the amount of electricity the wind system will produce in one year at the proposed site.

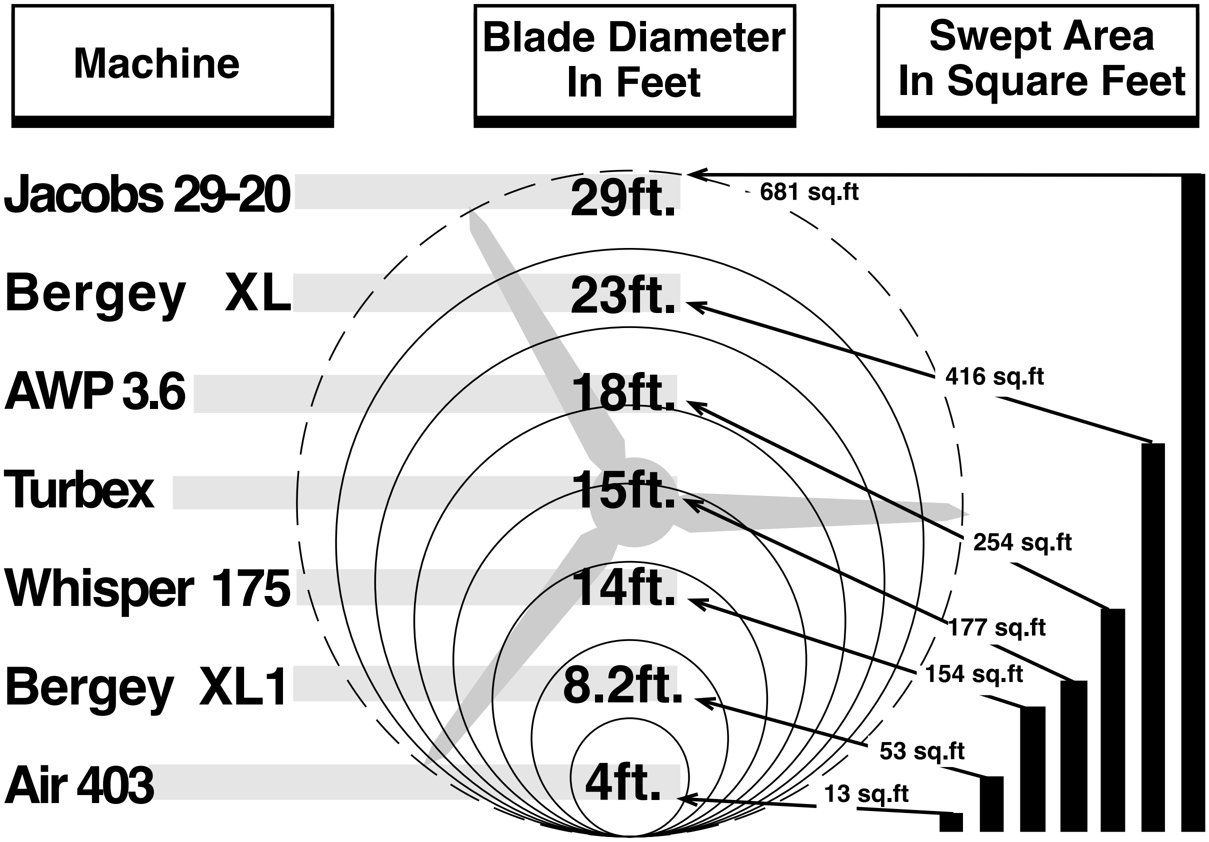

Table 1. —Swept area of some small wind systems

AEO (in kilowatt-hours per year, or kWh/yr) can be approximated using the following equation:

$AEO = (P \times A \times \%Efficiency \times 8760\ hrs/yr)/1000$

Where:

P = Average Power Density at site in watts/square meter

This data is available from a variety of sources, including the Montana high-resolution wind map (www.windpowermaps.org) and the Montana wind atlas.

A = Swept Area in square meters (1sqm = 10.76 sq.ft.)

Conventional Rotor: πr^2	r = Radius of blades
Darrius Rotor: $.85\ dh$	d = diameter of blades
H Rotor: $d \times h$	h = height of hub on vertical axis wind turbine

% Efficiency = Specific to each model of machine.

This shows how much of the potential energy in the wind that is converted to electricity. Small turbines are usually 12% to 30% efficient.

Energy generated from wind is still only a small portion of total energy production, but the potential has barely been tapped. Estimates are that wind power could produce three times more electricity than all conventional sources in the United States.

Table 2: Annual Energy Output (kilowatt-hours)

Average Wind Speed		Power Density watts/m²	Efficiency	Rotor Diameter (Meters)							
(mph)	(m/s)			1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0
9.0	4.0	75	0.28	144	325	578	1300	2311	3610	5199	7076
10.1	4.5	110	0.28	212	477	847	1906	3389	5295	7625	10378
11.2	5.0	150	0.25	258	580	1031	2321	4126	6447	9283	12636
12.3	5.5	190	0.25	327	735	1307	2940	5226	8166	11759	16005
13.4	6.0	250	0.21	361	812	1444	3249	5776	9026	12997	17690
14.6	6.5	320	0.19	418	941	1672	3763	6690	10452	15052	20487
15.7	7.0	400	0.16	440	990	1760	3961	7042	11003	15844	21565
16.8	7.5	490	0.15	505	1137	2022	4549	8087	12636	18195	24766
17.9	8.0	600	0.12	495	1114	1980	4456	7922	12378	17824	24261
19.0	8.5	720	0.12	594	1337	2377	5347	9506	14853	21389	29113
20.2	9.0	850	0.12	701	1578	2806	6313	11223	17535	25251	34369

The AEO formula provides only an approximation of electrical production. Actual production depends on a number of factors, including:

- wind speed distribution;
- changes in air density due to elevation and weather; and
- actual system efficiency.

Table 2 shows some AEO numbers for various rotor diameters and efficiencies. For a more detailed explanation of AEO, consult the books listed in the Further Reading section on Page 25.

An alternative to calculating the AEO is to use the manufacturer's projections. These numbers usually are for a site with a normal wind speed distribution at sea level. Your site will probably vary. All wind turbines will produce less electricity as elevation increases.

Towers. Estimating potential production should not be done without considering tower heights. Power available in the wind is proportional to the cube of the wind speed. Increasing your tower height also will increase your speed and consequently, your power production. See **Table 3**. The following formula will estimate the increase in wind speed:

$S/S_0 = (H / H_0)^{\sigma}$

σ is the "wind shear coefficient." It is a measurement of the surface roughness. For level, grass-covered range land, σ is equal to 1/7. Row crops and hedges will have an σ equal to 1/5. For a more detailed description of wind shear, consult *Wind Power for Home and Business* listed in the Further Reading section on Page 25.

S/S_0 is the number we are trying to find; it is the ratio between the new wind speed and the old wind speed. A ratio of 1.35 would indicate a 35% increase in wind speed.

For example if you know the wind speed at 30 feet and you want to know how much of an improvement a 100-foot tower would be, the equation would read like this:

$$S/S_0 = (100/30)^{1/7} = 1.20$$

The 100-foot tower would yield a 20% increase in wind speed. Because of the cubic relationship between power and wind speed, the potential power increases by 68%. These formulas are approximations of the real world.

Lattice towers secured with guy wires work well with turbines 10KW and smaller, such as this one on a ranch home near Deer Lodge.

Applications. Available power can be used in a number of ways. For example, you may choose to connect your wind-driven generator to your current electrical system so that you can draw power from either your utility or the generator. Another option is to make the generator independent of the utility and use the electricity directly for your home, farm or business. This will require batteries to store surplus electricity. If you use wind energy primarily for water heating, a large storage tank can be added with an electric heating coil directly connected to the output of a wind generator. This does not require the specialized electronics needed to hook up to the utility grid.

Utility connections. If your system is connected to an electric utility that allows net metering, you can feed excess electricity into the utility lines when you have more power than you need, and draw on utility power when the wind system cannot meet

The power available at 80ft is 1.5 times greater than the power available at 30ft.

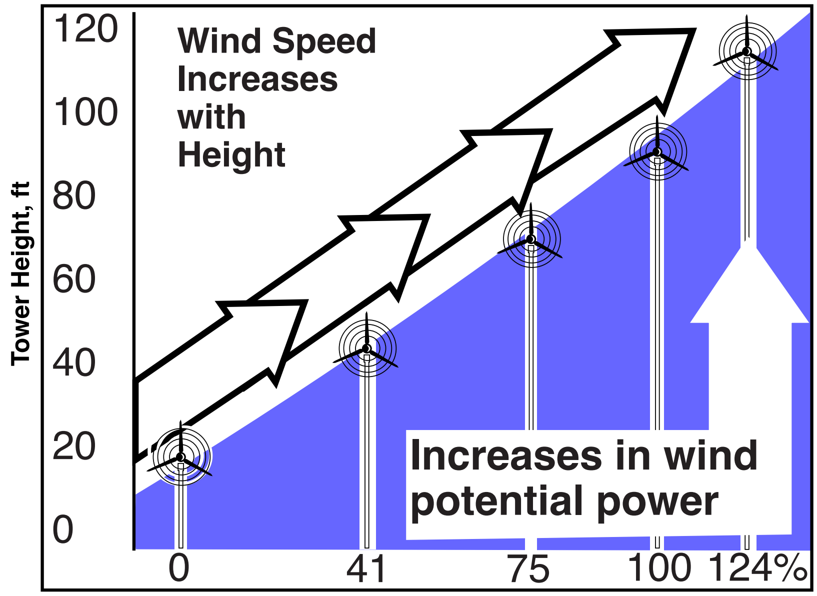

Table 3.—Wind speed increases with tower height.

your demand. Federal and state laws now require utilities to buy the excess power generated. The Montana Public Service Commission, in conjunction with the utilities and other interested parties, has developed rules that establish buyback rates.

Montana's net-metering law requires that Investor Owned Utilities (NorthWestern Energy and Montana-Dakota Utilities Co.) allow interconnection for generators under 50kW. A net-metered interconnection allows you to buy electricity from the grid at the retail rate and feed your excess electricity production into the utility grid. The utility credits your excess production at the retail rate. Note that the utility will not pay you for your excess production. The best you can do is to generate enough electricity to meet your demand. If you want to sell your electricity, the interconnection agreement is covered under qualifying facility regulations and the Public Utility Regulatory Policies Act (PURPA).

Quick Check
Here's a quick test of wind power feasibility, assuming you don't live in a state with a subsidy program and you want to recoup your investment in 15 years or less. Given these conditions, you should consider wind power if:

A) Your electricity costs more than 11 cents per kilowatt-hour (kWh);

B) Your area has an average wind speed of 11mph or more; and

C) You have one (1) acre of property or more.

In order to interconnect with the electrical grid, the inverter must meet certain technical standards, including islanding protection, over/under voltage disconnect, over/under frequency disconnect, automatic fault condition reset for loss of grid and voltage/frequency variations, ground fault interruption protection, disconnect switches, and a five-year warranty. Additionally, some wind machines require a suitably sized battery bank to interconnect.

Considering Montana's low wholesale electricity prices, the economics of small wind machines are much less attractive outside of a net-metered interconnection.

Montana's electric cooperatives evaluate each interconnection on a case-by-case basis. The Montana Electric Cooperative Association has adopted a model net-metering policy, but each cooperative is free to make its own policy.

Battery storage. If you don't interconnect your generator with the power grid, you'll need storage batteries to provide electricity when sufficient power is not available from the wind system. Depending on your wind resource, you should plan to have enough battery storage capacity to meet your electricity needs for three to five days. Lead-acid batteries are the least expensive, most practical means of storing electrical energy. These are larger than car batteries and have thick lead plates for deeper discharge and repeated cycling over many years. Car batteries can be used, but they have a limited life under deep-cycle conditions.

Most monitoring systems include an anemometer and a wind vane. The anemometer measures wind velocity, while the wind vane registers direction. Both instruments should be mounted on a pole or tower that is as close as possible to the height of the wind machine.

Wind systems with battery storage are generally more expensive. In addition, they are not as efficient because power is lost during battery storage and through DC to AC conversion. In remote locations, however, where extending a utility line would be costly, wind systems with battery storage are an excellent alternative to fossil fuel generators. Another possibility is to combine a wind system with a solar electric system. This "hybrid" system is often the most cost-effective way to generate electricity in remote locations. If your site requires a line extension, this could be a cheaper alternative.

Do you have a good site?

Finding the best possible site for your wind machine is critical and should be done carefully. Follow these basic steps in site selection:

- Observe wind and terrain characteristics;
- Determine the general wind resource in your area;
- If necessary, measure wind speed at each site being considered; and
- Check for legal restrictions.

The available power in wind is determined by three factors:

1) Wind speed;
2) Air density; and
3) Wind characteristics or turbulence (less turbulence equals more power)

Of the three, wind speed has the greatest effect on available power. There are four methods used to determine wind speed at a site:

1) Empirical data collection;
2) Correlation;
3) Totaling anemometer; and
4) Real time data collection.

Wind machines are not the easiest answer to your energy needs. While the fuel is free, the equipment is not. The first, and easiest, step to reducing your energy bill is efficiency. Investing $1 in conservation will yield the same effects as in investing $3-5 in generation.

The wind resource in your area. A Wind Resource Map prepared by the National Renewable Energy Laboratory shows the state's wind resource by wind power classification. The map was developed using a computerized mapping process that takes into account terrain characteristics such as elevation, vegetation and surface roughness. The map is available online at: www.windpowermaps.com. You may be able to get wind speed data from a nearby weather station. This data is usually standardized to 33 feet (10 meters). The wind speeds at the top of a taller tower will be higher. You can find specific wind data for Montana in the *Montana Wind Energy Atlas — 1987 Edition*, available online: www.energizemontana.com.

Site observation/empirical data collection. Your own observation can be useful in assessing the wind energy potential of your site, although it is easy to overestimate the wind energy potential of a windy site. Take some time to observe the wind; wind speeds of 9 to 12.3 mph (4 to 5.5 m/s) cause constant motion of leaves and small twigs and extend flags or streamers. This is the range where most turbines begin to produce power.

Check the topography of your land for obstacles such as trees, buildings and hills, which slow the wind from certain directions. If your land has a large, open, flat area or a ridge or hilltop with exposure to winds from most directions, it has greater potential as a wind energy site. Lower areas, ravines, river bottoms and wooded sites generally are not practical for wind systems. However, there are exceptions. You also can examine the vegetation at your site. If the conifers all lean in the same direction, this is a good sign. This phenomenon is called flagging. Use the Griggs-Putnam Index to approximate the average annual wind speed. For example, if all the branches are on one side of the trunk, this indicates an average annual wind speed in the 13-16 mph range.

While flagging indicates strong winds, the absence of flagging does not necessarily mean you don't have good wind. For a more detailed discussion of flagging and the Griggs-Putnam Index, consult *Wind Energy Basics* listed in Further Reading on Page 25.

Also, don't discount your instincts. If you've lived in an area for a few years and believe the wind blows all the time, you're probably right. If you are new to an area, ask people who have been there awhile.

If there is an airport or weather station nearby, check there for wind-speed data. If the topography of the weather station is similar to that of your site, its wind data may approximate yours. Take into account that small airports usually are sited in areas that are sheltered from the wind. Also, weather data usually is standardized to 33 feet, and the instrumentation is often on or near a building. Your wind machine should be on a taller tower and above surrounding obstacles. This means that the wind speed at your site at hub height may be higher than what the weather station or airport is reporting. Airport or weather data can show you the seasonal

1	North Dakota	1,210
2	Texas	1,190
3	Kansas	1,070
4	South Dakota	1,030
5	Montana	1,020
6	Nebraska	868
7	Wyoming	747
8	Oklahoma	725
9	Minnesota	657
10	Iowa	551
11	Colorado	481
12	New Mexico	435
13	Idaho	73
14	Michigan	75
15	New York	62
16	Illinois	61
17	California	59
18	Wisconsin	58
19	Maine	56
20	Missouri	52

MONTANA RANKS FIFTH among the top 20 states for wind energy potential, as measured by annual energy potential in the billions of kWh, factoring in environmental and land-use exclusions for wind class of 3 and higher. Source: *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States, Pacific Northwest Laboratory, 1991*. For more information, see the American Wind Energy Association web site: www.awea.org.

A converted cell phone tower, complete with climbing bars, supports this turbine at a home north of Butte.

trends in the wind speeds. If these preliminary indications are favorable, the next step may be to monitor the wind speed.

Wind speed monitoring. When considering wind power, most people ask what the average annual wind speed is and how to get that number. The usual response is that you must monitor the wind speed at your site for at least 12 months, preferably longer, to determine whether a wind generator will work for you. For a home system, this isn't necessary. The costs involved in collecting wind data may not be justified when compared to the total cost of a small wind machine. There is no economic formula to determine this, but it doesn't make much sense to spend $1,200 on instrumentation if your wind machine costs only $3,000. You can get close to the actual number by making an educated guess using the empirical methods described above.

If you decide to monitor wind speeds, you have several options. The first is to buy a weather anemometer and record observations on a regular basis. This is the least expensive way to collect wind data, but it has disadvantages. For the data to be valid, you must be methodical in collecting it. Recording one instantaneous wind speed per day won't do. If you can't record multiple wind speeds throughout a day, the quality of your data is questionable. A second option is to automate data collection by installing a data collection board in a personal computer. This method works, but the computer must stay on all the time, and there are additional costs. Since these are not plug-and-play components, some computer hardware and software knowledge is necessary.

A third option is to invest in an anemometer system specifically designed for collecting wind data. The least expensive systems simply average the wind speed over time and cost $200 to $300. These systems usually are sold without towers. While the average wind speed is a useful measurement, it also is important to know the wind speed distribution. More sophisticated systems usually consist of a portable tower, instrumentation and a data logger.

These systems are reliable and accurate, but they are expensive. After collecting data, you have equipment that may or may not be useful to you. The secondary market for used towers and data loggers is limited. If you buy a used system, consider new instrumentation. This will help ensure quality data.

Usually the system has an anemometer and a wind vane. The anemometer measures wind velocity, while the wind vane registers direction. Both instruments should be mounted on a pole or tower that is as close as possible to the height at which your wind machine will be mounted. If your anemometer is mounted too low, it will underestimate the actual wind resource available. It is generally recommended that the hub height for small machines be tetween 60 feet and 120 feet. Your anemometer also should be within this range.

To generate data for all seasons, average wind speeds along with distribution and peak gust information should be recorded for a minimum of three months, but ideally for a full year. Wind speed data can then be used with performance data for various wind machines to determine the expected output for each machine at your site.

If you collect data for a short time, it can be correlated with existing data to produce a model of the wind speeds at the potential site. To do this, you need to develop a "correction factor." For example, assume you have collected average wind speeds of 12.8 mph, 10.8 mph and 10.4 mph for the last three months, and the published data from a nearby site for the same three months is 10.9, 10.2 and 9.5. Dividing your data by the published data will give you the following deviation factors: 1.174, 1.059 and 1.095. Averaging these results in a correction factor of 1.109. You can multiply the remaining published data by this correction factor to estimate wind speeds at your site. This method involves a fair amount of interpretation, and some sites do not correlate well.

America used 3,200 billion kilowatt-hours of electricity in 1998. The Energy Information Agency predicts that consumption will increase to 4,400 billion kilowatt-hours in 2020. No single energy source can deliver all the electricity we need to fuel our economy.

If you are considering a large project, on-site data is a necessity. These systems require taller towers—40 or 50 meters. They include multiple levels of instrumentation and data loggers that can be accessed remotely. Assessing a site's potential for utility-scale wind development is an expensive undertaking that requires committing significant financial resources.

Zoning restrictions and insurance

If your site is in a remote or agricultural area, you may not need to worry about legal restrictions. You should, however, check with your city or county for zoning regulations, building codes and electrical codes. Restrictions may be placed on the height and distance of your wind generator from property lines and roads. Generally, in Montana, zoning officials are unfamiliar with wind machines. However, some cities and counties have written ordinances specifically addressing wind turbines and towers. Be prepared to educate officials about small wind machines and how they differ from utility-scale turbines.

It is a good idea to talk with your neighbors before installing your machine and tower. Sometimes visual impact and noise can become issues. If you plan to interconnect with your electric utility, you should determine its policies concerning interconnection. Federal and state laws require utilities to interconnect with "small power producers," but policies and required equipment vary. Contact your utility before installation.

Once your system is installed, it should be insured. Most insurance companies are unfamiliar with the term "wind turbine." Most will be satisfied if you refer to your system as a windmill and tower. Explain that you want to include the system as an "appurtenant structure" on your current homeowner policy. The policy should cover the installed cost of the system. Liability insurance is another question. There are very few instances where wind machines have failed catastrophically and injured someone, but it could happen. You'll have to decide the likelihood of an accident occurring at your site. Contact your insurance company while you are planning the installation.

In off-grid applications, wind systems often are installed in tandem with another generation source, usually photovoltaics. Considering Montana's weather patterns, this makes a lot of sense. When the wind isn't blowing, the sun usually shines.

Wind system costs and savings

The cost of a wind energy system includes the initial purchase price plus maintenance costs.

Maintenance costs. All machines require maintenance, and wind turbines are no exception. Total annual maintenance costs are usually estimated to be 2 to 2.5 percent of the initial machine cost. Maintaining a small wind machine typically involves a once- or twice-a-year inspection and possibly lubrication.

Calculating savings. To estimate the cost-effectiveness of your wind system, you need the following information:

- Total cost of the installation. Include conduit and electrical materials, plus all hardware and inspections These incidentals can add up to a significant amount; and
- Expected annual energy output of the machine, in kilowatt-hours, based on the manufacturer's production estimates for the wind speed data at the intended site.

Simple payback. The worksheet on page 15 will help you calculate how long it will take energy savings to pay for the machine. Remember, however, that simple payback does not take into account loan interest charges or operating and maintenance expenses. The worksheet should be viewed as a rough estimate; if the results are favorable, more precise calculations will be needed.

A hybrid wind-solar system provides some of the energy needs at Spa Hot Springs in White Sulphur Springs.

Choosing the right system

Selecting a system that is the right size is extremely important. Your first step is to find out how much electricity you consume. Generally, a 10kW (7.3m) machine produces enough power for the average home, and a 20kW (8.8m) machine is adequate for the average farm. The key to making the best choice is to know your needs, including how you plan to use the electricity. It's wise to evaluate your energy use and implement conservation and efficiency measures before investing in a wind turbine. Saving energy is more cost-effective than generating it. NorthWestern Energy offers its customers energy audits, or you can perform your own. The time involved is well spent.

Wind machines differ in size and design. There are two types of wind machines: *drag* and *lift*. A Savonius machine is an example of a drag machine. Although there are some drag devices, most wind machines used for electrical production are lift machines. Lift machines are further classified by their axis orientation. Vertical-axis machines have a vertically oriented drive shaft. Few residential-sized machines are of this type.

Horizontal-axis machines are the most common and are designed either as upwind or downwind. In the upwind models, the wind passes through the blades before going past the tower. In a downwind machine, the wind moves past the tower before striking the blades. To be most efficient, horizontal-axis wind machines must hold the rotors directly into the wind. Large turbines use motorized controls to hold the rotor into the wind. Residential-scale turbines track the wind passively, usually through a tail vane.

Finally, wind machines must protect themselves from high winds. Most small machines do this by passively turning the rotor out of the wind. This is called furling, and there are a variety of designs that accomplish this. For a further discussion of furling and machine design, see Paul Gipe's book, *Wind Energy Basics*, listed in the Further Reading section on page 25.

As with any major purchase, before you buy a wind machine you should shop around for the best balance of value and quality. The style and height of the tower are as important as the wind machine. Wind speeds increase with elevation. Towers should be at least 60 feet tall, preferably taller. The bottom of the rotor blades should be 30 feet above any obstacle that is within 300 feet. Usually the tallest tower height used for small machines is 120 feet. To make sure that you receive all the pertinent information from each dealer, use the following as a checklist:

- Rotor diameter;
- Annual energy output (in kilowatt-hours) at various average wind speeds;
- Rated power output or generator rating (expressed in kilowatts);
- Rated wind speed — wind speed at which the machine reaches the rated power output;
- Cut-in speed — wind speed at which the machine starts to produce power; and
- Survival wind speed — maximum wind speed the machine is designed to withstand.

Some electric utilities have learned what many people living off the grid have discovered for themselves: anyone more than ¼ to ½ mile from the utility line who has an average wind speed of 9 mph will find wind energy more economic than a line extension or other alternatives. The Electric Power Research Institute has gone so far as to suggest that in some cases it may make more economic sense to remove some underused transmission lines in the United States and serve the loads with hybrid stand-alone power systems rather than continue maintaining the line.

Wind System Cost Worksheet
(for calculating simple payback)

Capital costs (fill in only blanks that apply)		
Wind generator	(1)	____________
Tower and foundation	(2)	____________
Inverter (if needed)	(3)	____________
Batteries (if needed)	(4)	____________
Installation costs	(5)	____________
Shipping costs	(6)	____________
Other	(7)	____________
Total capital costs (add 1-7)	(8)	$____________
Projected AEO(kWh)	(9)	____________
Annual energy cost saving (electric retail rate x line 9*)	(10)	$/yr__________
Simple payback (line 8 ÷ line 10)	(11)	____________

*Only if net metered. Otherwise, use wholesale or "avoided" cost.
Example, based on a typical 20kW machine in a 6 m/s (13.4 mph) average annual wind speed

Capital costs		
Wind generator	(1)	$16,500
Tower (80 feet)	(2)	$5,144
Inverter	(3)	$3,900
Batteries	(4)	n/a
Installation and foundation costs	(5)	$3,000
Shipping costs	(6)	$ 700
Other hardware	(7)	$ 800
Total (add lines 1-7)	(8)	$30,044
Projected annual energy output	(9)	42,000 kwh
Annual energy cost savings (based on electric retail rate of 7 cents per kWh)	(10)	$2,940
Simple payback (30,044 ÷ 2940)	(11)	10.2 years

If power rates increase, the payback time will be shortened.

Purchasing a small wind system: step by step

Before you purchase a wind turbine, you should address the following issues about the proposed site:

- Average annual wind speed;
- Prevailing wind directions;
- Vegetation and buildings at the site;
- Type of energy storage and whether the system will be net-metered; and
- Legal and environmental restrictions, if any, on installing a small wind energy system.

You should also:

- Determine your year-round electrical requirements;
- Determine how you can reduce electrical demand;

Most frost-free refrigerators use heat to keep the frost down. You pay for this twice—first in added electric usage and second in having to run the fridge longer to offset this heat contribution. Look into replacing your major appliances with energy-efficient models.

- Evaluate your site and its wind energy potential;
- Select a likely site, obtaining an anemometer and monitoring wind speeds for three to 12 months, if necessary;
- Survey available small wind energy systems and obtain information from manufacturers;
- Make a preliminary selection;
- Consult your local utility about interconnection costs and requirements if your machine will be interconnected with the power grid;
- Evaluate the initial cost, as well as the cost per kilowatt-hour of electricity, for the machine you are considering buying (use the worksheet on page 15 to compare these costs with your utility rates and roughly calculate your investment payback);
- Consider potential tax breaks;
- Check manufacturer or dealer warranties and/or maintenance contracts; and
- Check electric equipment for utility connection or electrical storage, if needed.

And here are two other items to consider:

- If your calculations are favorable, it is wise to do a more sophisticated analysis of your wind energy potential and potential profitability before buying a machine.
- If you intend to sell some or all of the electricity generated, the utility buyback rate as well as the incentive payments available from the state will affect the profitability of your investment.

The U.S. is a leading producer of small wind turbines. In fact, four U.S. manufacturers command about one-third of the global wind power market. During a recent year, the market for small wind systems (those with less than 100kW of generating capacity) grew more than 35%. The U.S. has about 15-MW of nameplate capacity of small wind turbines, and the industry averages a 50-50 domestic-international sales mix. AWEA expects continued growth in this market.

Finding installation and maintenance support

The manufacturer/dealer should be able to help you install your machine. Many people elect to install machines themselves. Before attempting to install your wind turbine, ask yourself the following questions:

- Can I pour a concrete foundation?
- Do I have access to a crane or another means of erecting the tower safely?
- Do I know the difference between AC and DC power?
- Do I know enough about electricity to safely wire my turbine?
- Do I know how to safely handle and install batteries?

If you answered no to any of the above questions, you probably should have a dealer or contractor install your system. Contact the manufacturer for help or call the Montana Department of Environmental Quality (406-841-5204). NCAT or your local utility can provide a list of local system installers.

Find out if the installer is a licensed electrician. Montana law permits homeowners to do electrical work on their own homes. If a contractor installs the system, a licensed electrician must do the electrical work. Ask for references and check them out. You may also want to check with the Consumer Protection Office, 1424 Ninth Ave., P.O. Box 200501, Helena, MT 59620-0501. You can also check www.montangreenpower.com for renewable energy dealers in Montana.

Financial Incentives

Low-interest loans

Alternative Energy Revolving Loan. The 2001 Legislature established an alternative energy revolving loan account to issue low-interest loans, up to $10,000 but not less than $5,000, for five years. The loan program is aimed at homes and small businesses. Contact the Department of Environmental Quality for information:

Metcalf Building Office
1100 N. Last Chance Gulch
P.O. Box 200901
Helena, MT 59620
406-841-5204

Tax Credits

Property Tax Exemption. In addition to other energy-related tax benefits, a portion of the appraised value of certain non-fossil energy property is eligible to be exempt from property taxation for up to 10 years following the date of installation. Eligible property includes alternative energy-generating systems, such as those that use sun, wind, hydropower, solid waste or the decomposition of organic wastes. Up to $20,000 of the value of a system installed in a single-family residential building can be exempt from property taxation, or up to $100,000 of a system installed in a multi-family residential dwelling or a nonresidential structure.

"There is a strong case for revived interest in wind power. It could be very competitive…It certainly can be the essential ingredient of pollution-free power systems. And it is such a gentle alternative to high temperature combustion, fission, and fusion schemes."
— *William Heronemus, 1972*

Application for property tax-exempt status must be submitted to the county assessor's office by March 1 to be considered for exemption that tax year. For installations made after March 1, an application for property exempt status must be submitted before the following March 1 to be considered for exemption starting the following tax year. Applications may be submitted for installations made within 10 years prior to the given tax year, but will be eligible for property tax exemption only for the remainder of 10 years from the date of installation. A state property tax-exemption form is available at your county assessor's office.

State Tax Credit. Montana taxpayers producing or using wind-generated electricity or manufacturing wind energy-generating equipment are entitled to a state tax credit of 35 percent of their investment of $5,000 or more in depreciable property of a wind energy-generation system located in Montana, less the value of any state or federal government grants received.

The credit may only be taken against net income produced by the eligible equipment or by associated new business activity; that is, it must be a commercial operation. If the taxpayer claims a federal tax benefit on the wind system, then the state tax benefits for the system do not exceed 60 percent of the eligible costs of the system.

The tax credit must be taken the year the equipment is placed in service; however, any portion of the tax credit that exceeds the amount of tax to be paid may be carried over and applied against state tax liability for seven years following. Taxpayers may not take this credit in conjunction with any other state energy or state investment tax benefits, or with the property tax exemption for non-fossil energy property.

For more on tax incentives, visit the Department of Environmental Quality's Energize Montana website: www.energizemontana.com.

Besides producing electricity, wind machines also can be used to aerate ponds, heat water or pump water.

Net Metering

In Montana, electric distribution consumers of investor-owned utilities can install small, grid-connected renewable energy systems to reduce their electricity bills using "net metering." Under net metering, electricity produced by the renewable energy system can flow into the utility grid, spinning the electricity meter backwards. Other than the renewable energy system and appropriate meter, no special equipment is needed. With net metering, consumers can use the electricity they produce to offset their electricity demand on an instantaneous basis. But if the consumer happens to produce any excess electricity (beyond what is needed to meet the customer's own needs at the moment), the utility gives the customer credit for that excess electricity. Ask your utility about its net metering policy. Net metering simplifies this arrangement by allowing the consumer to use any excess electricity to offset electricity used at other times during the billing period.

Why is net metering important? There are three reasons net metering is important. First, as increasing numbers of primarily residential customers install renewable energy systems in their homes, there needs to be a simple, standardized protocol for connecting their systems into the electricity grid that ensures safety and power quality.

Second, many residential customers are not at home using electricity during the day when their systems are producing power, and net metering allows them to receive value for the electricity they produce without installing expensive battery storage systems.

Third, net metering provides a simple, inexpensive, and easily administered mechanism for encouraging the use of renewable energy systems, which provide important local, national and global benefits.

Net metering provides a variety of benefits for both utilities and consumers. Utilities benefit by avoiding the administrative and accounting costs of metering and purchasing the small amounts of excess electricity produced by these small-scale, renewable energy-generating facilities. Consumers benefit by getting greater value for some of the electricity they generate, by being able to interconnect with the utility using their existing utility meter and by being able to interconnect using widely accepted technical standards.

The only cost associated with net metering is indirect: the customer is buying less electricity from the utility, which means the utility is collecting less revenue from the customer. The revenue loss is roughly comparable to having the customer reduce electricity use by investing in efficiency measures, such as compact fluorescent lights and energy-efficient appliances.

Meters. The standard kilowatt-hour meter used by the vast majority of residential and small commercial customers will rotate in either direction. However, it usually registers rotations only, not direction. This means that if you send electricity to the electrical grid without telling the power company, you may end up paying for it. When you become net-metered, the meter will be changed. With the new meter, the "netting" process associated with net metering happens automatically—the meter spins forward (in the normal direction) when the consumer needs more electricity than is being produced, and spins backward when the consumer is producing more electricity than is needed in the house or building.

Safety. During the last decade, there has been tremendous technological progress in the design of the equipment that integrates

The Montana Department of Environmental Quality's **Energize Montana** website provides information on energy efficiency and renewable energy at home, at work or at school. **www.energizemontana.com**

Explore the pages of the **Montana Green Power** website to learn more about wind and other renewable energy technologies in Montana. You'll find the latest renewable energy news, information on planning and designing your own solar, wind and micro-hydro systems, activities for the classroom, updates on utility restructuring, and links to other useful sites. **www.montanagreenpower.com**

A small wind turbine provides part of the power needs of the Learning and Spirit lodge on the Northern Cheyenne Reservation near Busby.

small-scale generators with the utility grid. Called "inverters" because they were originally designed only to "invert" the DC electricity produced by solar arrays and wind turbines to the AC electricity used in our homes and businesses, these devices have evolved into extremely sophisticated power-management systems.

Inverters now include all the necessary protective relays and circuit breakers needed to synchronize safely and reliably with the utility grid, and to prevent "islanding" by automatically shutting down when the utility grid experiences an outage. Moreover, this protective equipment operates automatically, without any human intervention needed.

Most new inverters comply with all nationally recognized codes and standards, including the National Electrical Code (NEC), Underwriters Laboratories (UL), and the Institute of Electrical and Electronic Engineers (IEEE). These systems are now operating safely and reliably in every state in the nation. A net-metering system used by a customer-generator must include, at the customer-generator's own expense, all equipment necessary to meet applicable safety, power quality and interconnection requirements established by the National Electrical Code, National Electrical Safety Code, Institute of Electrical and Electronic Engineers, and Underwriters Laboratories.

The Montana Law. A "net metered system" is a facility for the production of electric energy that:

- uses as its fuel solar, wind, or hydropower;
- has a generating capacity of not more than 50 kilowatts;
- is located on the customer-generator's premises;
- operates in parallel with the distribution services provider's distribution facilities; and
- is intended primarily to offset part or all of the customer-generator's requirements for electricity.

The legislation also requires that a distribution services provider allow net metering systems to be interconnected using a standard kilowatt-hour meter capable of registering the flow of electricity in two directions. The distribution services provider shall charge the customer-generator a minimum monthly fee that is the same as other customers of the electric utility in the same rate class.

Net Metering Calculation. In calculating the net energy measurement, the distribution services provider measures the net electricity produced or consumed during the billing period, in accordance with normal metering practices. At the end of the month, if the customer has generated more electricity than was used, the utility credits the net kilowatt-hours produced at the wholesale power rate. If customers use more electricity than they generate, they pay the difference.

On January 1, April 1, July 1, or October 1 of each year, as designated by the customer-generator as the beginning date of a 12-month billing period, any remaining unused kilowatt-hour credit accumulated during the previous 12 months must be granted to the electricity supplier, without any compensation to the customer-generator. With wind generation, it makes sense to choose a date that occurs after the least windy part of the year.

Net metering allows homeowners who are not home when their systems are producing electricity to still receive the full value of that electricity without having to install a battery storage system. The power grid acts as the customer's battery backup, which saves the customer the added expense of purchasing and maintaining a battery system.

By adopting net metering early, a utility establishes itself in a leadership role in providing customers the option of generating some of its own electricity. The 1997 Montana net metering legislation effectively applies only to the NorthWestern Energy and Montana Dakota Utilities. Electric cooperatives are not required to provide net metering, though electric cooperatives have adopted individual net metering policies.

Public Utility Regulatory Policy Act (PURPA). Under existing federal law (PURPA, Section 210), utility customers can use the electricity they generate with a wind turbine to supply their own lights and appliances, offsetting electricity they would otherwise have to purchase from the utility at the retail price. But if the customer produces any excess electricity (beyond what is needed to meet the customer's own needs) and net metering is not allowed, the utility purchases that excess electricity at the wholesale or 'avoided cost' price, which is much lower than the retail price. The excess energy is metered using an additional meter that must be installed at the customer's expense. Check with your utility for the buyback rates for electricity you produce. Net metering simplifies this arrangement by allowing the customer to use any excess electricity to offset electricity used at other times during the billing period. In other words, the customer is billed only for the net energy consumed during the billing period.

Small Wind Energy Equipment Manufacturers and Dealers

See the *Home Power Magazine* website — www.homepower.com — for a list of small wind system manufacturers.

For a list of Montana renewable energy businesses, visit the Montana Green Power website: www.montanagreenpower.com. There may be additional dealers and manufacturers not included in these lists. Inclusion on the lists does not constitute endorsement by the National Center for Appropriate Technology.

For more information on wind energy, contact:

National Center for Appropriate Technology
P.O. Box 3838
Butte, MT 59702
Toll Free: 800-275-6228
http://www.ncat.org

Wind Glossary

Anemometer — An instrument used to measure the velocity of the wind

Cut-in speed — The wind speed at which the turbine begins to produce electricity. Blades may rotate at speeds lower than this.

Cut-out speed — The wind speed at which the turbine will turn out of the wind in order to protect itself from damage.

Distributed Generation — A small-scale power-generation technology that provides electric power at a site closer to customers than central station generation. The term is commonly used to indicate non-utility sources of electricity, including facilities for self-generation.

Green energy — A popular term for energy produced from renewable energy resources or, sometimes, from clean (low-pollution) energy sources.

Grid — A network of power lines or pipelines used to move energy.

Independent power producer (IPP) — An electricity generator that sells power to others but is not owned by a utility.

Investor-owned utility (IOU) — A utility with stock-based ownership.

Kilowatt — A unit of power equal to 1000 watts. Electric motors and wind machines measure their capacity in kilowatts.
746 watts = 1horsepower.

Kilowatt-hour — A unit of energy. 1 kilowatt-hour is the equivalent of ten 100-watt lightbulbs left on for one hour. The utility company charges you by the kilowatt-hour.

Public Utility Regulatory Policies Act (PURPA) — A 1978 federal law that requires electric utilities to purchase electricity produced from certain efficient power producers (frequently using renewable energy or natural gas). Utilities purchase power at a rate equal to the costs they avoid by not generating power themselves. State regulatory agencies establish the based on local conditions.

Public Service Commission (PSC) — A state government agency responsible for the regulation of public utilities within a state or region. A state legislature oversees the PSC by reviewing changes to utility laws, rules and regulations and approving the PSC's budget. The commission usually has five Commissioners appointed by the governor or legislature. The PSC focuses on adequate, safe, universal utility service at reasonable rates while also trying to balance the interests of consumers, environmentalists, utilities and stockholders.

Renewable energy — Energy derived from resources that regenerative or for all practical purposes cannot be depleted. Types of renewable energy resources include moving (hydro, tidal and wave power), thermal gradients in ocean water, biomass, geothermal energy, solar energy and wind energy. Municipal solid waste (MSW) also is considered a renewable energy resource.

Renewables portfolio standard (RPS) — A (proposed) minimum renewable energy requirement for a region's electricity mix. Under an RPS, every electricity supplier would be required to provide some percentage of its supply from renewable energy sources. RPS proposals frequently ease that requirement by including a tradeable credit system under which electricity suppliers can meet the requirement by buying and selling renewable generation credits.

Restructuring — The process of changing the structure of the electric power industry from one of guaranteed monopoly over service territories to one of open competition between power suppliers for customers.

Universal System Benefits Charge (USBC) — A required fee (also known as a public benefits charge) from all electricity customers to fund programs aimed at the public good that may no longer be feasible for the utility to provide in a competitive electricity market. These programs include energy conservation, support for renewable energy use, low-income assistance, and research and development.

Turbine — A device for converting the flow of a fluid (air, steam, water or hot gases) into mechanical motion that in turn produces electricity.

Unbundling — The process of separating a service into component parts and permitting customers to buy each separately. Utility unbundling, overseen by regulators, generally requires utilities to ensure that the price of each service accurately reflects the cost of that service (plus a margin for profit). In this way, unbundling helps ensure that customers for what they receive and are not forced to subsidize services they do not use.

Wind power class — A classification system that rates the quality of the wind resource in an area based on the average annual wind speed. The scale ranges from 1-7, with 1 representing the poorest wind energy resource and 7 representing the best.

Wind power density — A classification system that measures the amount of power contained in a given area for conversion by a wind turbine. Measured in watts per square meter.

Further Reading

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Patel, Mukund R. 1999. *Wind and Solar Power Systems*. CRC Press.

Piggot, Hugh. 1997. *Windpower Workshop*. Center for Alternative Technologies Publishing.

Righter, Robert. 1996. *Wind Energy in America: A History*. University of Oklahoma Press.

Iowa Wind Energy Manual. 2002. Iowa Wind Energy Center. http://www.energy.iastate.edu/WindManual/IowaWindManual.html

Small Wind Electric Systems. 2001. National Renewable Energy Laboratory.

Wind Power Websites

American Wind Energy Association (AWEA)

Wind, a clean and renewable source of electric power, is also the world's fastest growing energy source. Since 1974 the American Wind Energy Association (AWEA) has advocated the development of wind energy as a reliable, environmentally superior energy alternative in the United States and around the world.

http://www.awea.org

Electric Power Research Institute (EPRI)

The Electric Power Research Institute (EPRI) is recognized as a world leader in creating science and technology solutions for the energy industry and for the benefit of the public. EPRI's technical program spans virtually every aspect of power generation, delivery, and use, including environmental considerations. The organization serves more than 1,000 energy organizations worldwide and draws on a global network of technical and business expertise to help solve energy problems.

http://www.epri.com

Energy Resources Research Laboratory (ERRL)

The ERRL at Oregon State University has managed the data collection, quality assurance and analysis for the Bonneville Power Administration's wind energy resource studies since 1978 and manages other data management activities for transmission line research. It maintains a large data base of wind data for the Pacific Northwest. This web page summarizes the wind statistics of the five Bonneville Power Administration's long-term wind monitoring sites in the Pacific Northwest.

http://www.me.orst.edu/ERRL/index.html

Guided Tour on Wind Energy

Want to know where wind energy comes from? Want to learn about the Coriolis Force, global winds, geostrophic wind, wind speed measurement, the wind rose, wind shear, and wind shade? Need to find a wind shade calculator, information about wind turbine components, rotor blades, and wind energy economics? Answers to all your questions about wind energy can be found at the Danish Wind Turbine Manufacturers Association's Guided Tour on Wind Energy. The website includes wind resource calculators and features more than 100 animated pages on wind resources, wind turbine technology, and economics. Each of the nine tours is a self-contained unit, so you may take the tours in any order.

http://www.windpower.dk/tour/index.htm

Identifying High Wind Resources

Knowing where a high wind resource may exist is valuable to a wind energy project developer or potential wind energy user because it allows them to choose a general area of estimated high wind for more detailed examination. NREL identifies and gathers data for wind resource maps of the United States and foreign countries. These maps help developers or users find areas worthy of detailed wind resource monitoring.

http://www.nrel.gov/wind/database.html

Montana Anemometer Loan Program

The Montana Department of Environmental Quality and partners are currently administering a state anemometer loan program free to the general public. A total of eight 20-meter anemometers are currently deployed in the field. In addition, DEQ plans to instsall four anemometer stations on state-owned land.

Contact Kathi Montgomery, Montana Department of Environmental Quality—406-841-5280

Montana Wind Cluster Program

The Wind Cluster Program has two main focus areas in wind energy technology. The first area concentrates on improving the structural performance of wind turbine blades so that they will meet severe service requirements over their design lifetime with minimum blade weight and cost. Blade weight and cost are significant elements in the overall cost of wind generated power, and improved technology can have a significant impact in this area. This program is now recognized as a major contributor by the National Laboratories and the wind industry. The second focus area is to assist in the development of the outstanding wind resources in Montana and the region. Efforts to date have led to a major avian study and a demonstration project at the Blackfeet Community College, both of which have received major independent funding in the last year. Continuing efforts will shift toward studies related to distributed generation in cooperation with Montana Power Company. The Wind Program is well on its way to establishing facilities and expertise necessary to serve as a national resource in wind technology, with an increasing presence in national meetings and publications, as well as a significant impact on the educational program in the four participating universities and colleges and on local industry.

http://biology.dbs.umt.edu/more/windex.htm

National Wind Coordinating Committee (NWCC)

A U.S. consensus-based collaborative formed in 1994, the National Wind Coordinating Committee (NWCC) identifies issues that affect the use of wind power, establishes dialogue among key stakeholders, and catalyzes appropriate activities to support the development of an environmentally, economically, and politically sustainable commercial market for wind power. NWCC members include representatives from electric utilities and support organizations, state legislatures, state utility commissions, consumer advocacy offices, wind equipment suppliers and developers, green power marketers, environmental organizations, and state and federal agencies.

http://www.nationalwind.org/default.htm

Quick Facts about Wind Energy

What is wind energy? The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like. To learn more about the wind, including wind energy links, more quick facts, homeowner help, visit:

http://www.eren.doe.gov/wind/web.html

Renewable Resource Data Center (RReDC)

The Renewable Resource Data Center (RReDC) provides information on several types of renewable energy resources in the United States, in the form of publications, data, and maps. An extensive dictionary of renewable energy related terms is also provided. The News section announces new products on the REeDC, which is supported by the U. S. Department of Energy's Resource Assessment Program and managed by the Photovoltaics Technology Division of the Office of Energy Efficiency and Renewable Energy.

http://rredc.nrel.gov/

Small Wind Energy Systems for the Homeowner

In the 1920s and '30s, farm families throughout the Midwest used wind to generate enough electricity to power their lights and electric motors. The use of wind power declined with the government-subsidized construction of utility lines and fossil fuel power plants. However, the energy crisis in the 1970s and a growing concern for the environment generated an interest in alternative, environmentally friendly energy resources. Today, homeowners in rural and remote locations across the nation are once again examining the possibility of using wind power to provide electricity for their domestic needs. This publication will help you decide whether a wind system is practical for you. It will explain the benefits, help you assess your wind resource and possible sites, discuss legal and environmental obstacles, and analyze economic considerations such as pricing.

http://www.eren.doe.gov/erec/factsheets/wind.html

Solar and Wind Easements

Montana's solar and wind easement provisions allow property owners to create solar and wind easements for the purpose of protecting and maintaining proper access to sunlight and wind. While 32 other states have solar easement provisions, only three other states have created specific provisions for the creation of wind easements. Montana's solar easement law was enacted in 1979 and the wind easement was enacted in 1983.

Contact Louise Moore, Montana Department of Environmental Quality—406-841-5280

The Saudi Arabia of Wind Energy

Concern over air pollution, global warming, and diminishing oil and gas supplies has generated increasing interest in more sustainable sources of energy. Wind power, according to William A. Brakken, a consultant on public policy, environmental, and energy issues, is one of the most promising—particularly for the wind-swept Great Plains. In this article, Brakken examines both the current state of wind energy development and its future prospects, including the potential for small-scale, dispersed facilities versus large-scale wind farms. Includes sidebars about wind speed, small-scale models in the United States, renewable energy in a restructured market, and coal versus wind power.

http://www.nwaf.org/pubs/nwreport/dec_1997/4.html

Utility Wind Interest Group (UWIG)

The Utility Wind Interest Group (UWIG) is a non-profit corporation whose mission is to accelerate the appropriate integration of wind power for utility applications through the coordinated efforts and actions of its members, in collaboration with public and private sector stakeholders. Membership is open to utilities and other entities that have an interest in wind generation.

http://www.uwig.org

Wind Directory

The American Wind Energy Association's Directory of Wind Industry Members is produced by AWEA's Membership Services Department. Search it to obtain wind energy services and equipment from companies who have demonstrated a commitment to wind and renewable technology and adhere to AWEA's code of business ethics.

http://www.awea.org/directory/

Wind Energy Atlas

This atlas estimates wind energy resource for the United States and its territories and

indicates general areas where a high wind resource may exist. This information is valuable to wind energy developers and potential wind energy users because it allows them to choose a general area of estimated high wind resource for more detailed examination. A siting document, such as that written by Hiester and Pennell (1981), can assist a potential user in going from wind resource assessment to site selection.

http://rredc.nrel.gov/wind/pubs/atlas/

Wind Energy Manual

Though specific to Iowa, this online *Wind Energy Manual* addresses most of the technical, environmental and policy issues surrounding wind energy development. The site also gives visitors a history of wind energy, a primer on wind and wind power, descriptions of wind energy systems, wind energy data and conversion tables, a bibliography, plus links to businesses, organizations and government agencies involved in wind energy.

http://www.energy.iastate.edu/WindManual/IowaWindManual.html

Wind Energy Potential in the United States

Estimates of the electricity that could potentially be generated by wind power and of the land area available for wind energy have been calculated for the contiguous United States. The estimates are based on published wind resource data and exclude windy lands that are not suitable for development as a result of environmental and land-use considerations. Despite these exclusions, the potential electric power from wind energy is surprisingly large. Good wind areas, which cover 6 percent of the contiguous U.S. land area, have the potential to supply more than one and a half times the current electricity consumption of the United States. Technology under development today will be capable of producing electricity economically from good wind sites in many regions of the country.

http://www.nrel.gov/wind/potential.html

Wind Energy System Credit

Montana allows a 35% tax credit for an individual, partnership or corporation which makes an investment of $5,000 or more in a wind electricity generating system or facilities to manufacture wind energy equipment. Eligible property includes wind energy system equipment, transmission lines, and equipment used in the manufacture of wind energy devices.

http://www.energizemontana.com

Wind Energy System or Manufacturing Facility Credit

Montana allows a 35% tax credit for an individual, partnership or corporation that makes an investment of $5,000 or more in a wind electricity generating system or facilities to manufacture wind energy equipment. Eligible property includes wind energy system equipment, transmission lines, and equipment used in the manufacture of wind energy devices.

Contact the Montana Department of Environmental Quality —406-444-2544

Wind Powering America

Wind Powering America is a commitment to dramatically increase the use of wind energy in the United States. This initiative will establish new sources of income for American farmers, Native Americans, and other rural landowners, and meet the growing demand for clean sources of electricity. Through Wind Powering America, the United States will achieve targeted regional economic development, protect the local environment, reduce air pollution, lessen the risks of global climate change, and increase energy security.

http://www.eren.doe.gov/windpoweringamerica/

Wind Potential in the United States: U.S. Wind Maps

The wind in the United States could produce more than 4.4 trillion kWh of electricity each year—more than one and one-half times the 2.7 trillion kWh of electricity consumed in the United States in 1990. This website includes a map that shows annual average wind resources using the seven wind power classes, which are ranges used to describe the energy contained in the wind. Maps showing the U.S. annual wind power resource, annual wind power resource in Alaska and Hawaii and the percent of U.S. land area with an annual wind resource of Class 3 or above can also be found at:

http://www.nrel.gov/wind/usmaps.html

Windustry

Focuses on economic development from wind energy, valuation of environmental benefits, and distributed generation. Windustry promotes wind energy through educational materials and technical assistance to rural landowners, local communities and utilities, and state, regional, and nonprofit groups. Windustry's website features: wind basics, wind opportunities, wind turbine sites, a wind calculator, curriculum, resource library, and news and events.

http://www.windustry.org/default.htm

National Center for Appropriate Technology