Is wind power practical for you?

Small wind energy systems can be used in connection with an electricity transmission and distribution system (called grid- connected systems), or in stand-alone applications that are not connected to the utility grid. A grid-connected wind turbine can reduce your consumption of utility-supplied electricity for lighting, appliances, and electric heat. If the turbine cannot deliver the amount of energy you need, the utility makes up the difference. When the wind system produces more electricity than the household requires, the excess can be sold to the utility. With the interconnections available today, switching takes place automatically. Stand-alone wind energy systems can be appropriate for homes, farms, or even entire communities (a co-housing project, for example) that are far from the nearest utility lines. Either type of system can be practical if the following conditions exist.

Conditions for stand-alone systems

- You live in an area with average annual wind speeds of at least 4.0 meters per second (9 miles per hour)
- A grid connection is not available or can only be made through an expensive extension. The cost of running a power line to a remote site to connect with the utility grid can be prohibitive, ranging from $15,000 to more than $50,000 per mile, depending on terrain.
- You have an interest in gaining energy independence from the utility
- You would like to reduce the environmental impact of electricity production
- You acknowledge the intermittent nature of wind power and have a strategy for using intermittent resources to meet your power needs

Conditions for grid-connected systems

- You live in an area with average annual wind speeds of at least 10 miles per hour (4.5 meters per second).
- Utility-supplied electricity is expensive in your area (about 10 to 15 cents per kilowatt-hour).
- The utility's requirements for connecting your system to its grid are not prohibitively expensive.
- Local building codes or covenants allow you to legally erect a wind turbine on your property.
- You are comfortable with long-term investments.

Is your site right?

To get a general idea if your region has good wind resources, look at the DOE (Department of Energy) Wind Energy Resource Atlas in the Alt-E University section of our website. The maps will show you if wind speeds in your area are strong enough to further investigate the wind resource. Of course, the maps are just a starting point-- the actual wind resource on your site will vary depending on topography and structure interference. And a localized site with good winds, such as a ridge top, may not show up on the maps.

Another source for wind data is the National Climatic Data Center, (http://www.ncdc.noaa.gov/oa/ncdc.html) which collects data for selected sites and makes area wind data summaries available for purchase.

You will need site-specific data to determine the wind resource at your exact location. If you do not have on-site data and want to obtain a clearer, more predictable picture of your wind resource, you may wish to measure wind speeds at your location for a year. You can do this with a recording anemometer, we sell 2 different models $115 and $140. The most accurate reading is taken at "hub height" (i.e., the elevation at the top of the wind turbine tower). This requires placing the anemometer high enough to avoid turbulence created by trees, buildings, and other obstructions. The standard wind sensor height used to obtain data for the DOE maps is 10 meters (33 feet).

You can have varied wind resources within the same property. If you live in complex terrain, take care in selecting the installation site. If you site your wind turbine on the top or on the windy side of a hill, for example, you will have more access

to prevailing wind than in a gully or on the leeward (sheltered) side of a hill on the same property. Consider existing obstacles and plan for future obstructions, including trees and building, which could block the wind. Also realize the power in the wind is proportional to its speed (velocity) cubed (v^3). This means that the amount of power you get from your generator goes up exponentially as the wind speed increases. For example, if your site has an annual average wind speed of about 5.6 meters per second (12.6 miles per hour), it has twice the energy available as a site with a 4.5 meter per second (10 mile per hour) average ($12.6/10^3$).

Additional Considerations
In addition to the factors listed previously, you should also

- Research potential legal and environmental obstacles
- Obtain cost and performance information from manufacturers
- Perform a complete economic analysis that accounts for a multitude of factors
- Understand the basics of a small wind system
- Review possibilities for combining your system with other energy sources, backups, and energy efficiency improvements.
- If you use electricity for heating your home or water, nine time out of ten (even in northern climates) it's more cost effective to use solar heating systems to reduce the demand for that electricity than to produce it all with a wind turbine.
- You should establish an energy budget to help define the size of turbine that will be needed. **Since energy efficiency is usually less expensive than energy production**, making your house more energy efficient first will result in a less expensive energy system.

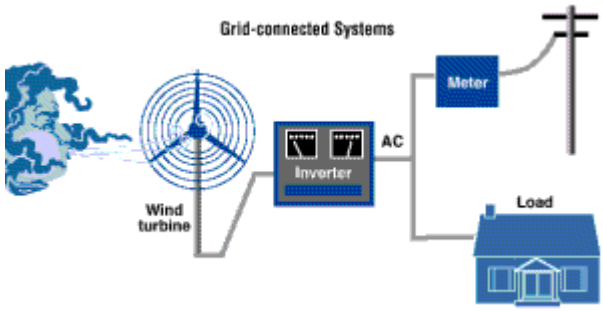
The Economics of Wind Power for Home Use
A residential wind energy system can be a good long-term investment. However, because circumstances such as electricity rates and interest rates vary, you need to decide whether purchasing a wind system is a smart financial move for you.

Grid-connected-system owners may be eligible to receive a small tax credit for the electricity they sell back to the utility. For 1996, it was 1.6 cents per kilowatt hour. The National Energy Policy Act of 1992 and the 1978 Public Utilities Regulatory Policy Act (PURPA) are two programs that apply to small independent power producers. PURPA also requires that the utility sell you power when you need it. Be sure you check with your local utility or state energy office before you assume any buy-back rate. Some Midwestern rates are very low (less than $.02/kWh), but some states have state-supported buy-back rates that encourage renewable energy generation. In addition, some states have "net billing," where utilities purchase excess electricity for the same rate at which they sell it.

Also, some states offer tax credits and some utilities offer rebates or other incentives that can offset the cost of purchasing and installing wind systems. Check with your state's department of revenue, your local utility, public utility commission, or your local energy office for information. You can also find up-to-date information about almost all of the financial incentives and rebates programs available in your state by going to the Database of State Incentives for Renewable Energy (DSIRE) on the web at: http://www.dsireusa.org/

Wind System Basics
All wind systems consist of a wind turbine, a tower, wiring, and the "balance of system" (BOS) components: controllers, inverters, and/or batteries.

Wind Turbines
Home wind turbines consist of a *rotor*, a *generator* mounted on a frame, and (usually) a *tail*. Through the spinning blades, the rotor captures the kinetic energy of the wind and converts it into rotary motion to drive the generator. Rotors can have two or three blades, with three being more common. The best indication of how much energy a turbine will produce is the diameter of the rotor, which determines its "swept area," or the quantity of wind intercepted by the turbine. The frame is the strong central axis bar onto which the rotor, generator, and tail are attached. The tail keeps the turbine facing into the wind.



A 1.5-kilowatt (kW) wind turbine will meet the needs of a home requiring 300 kilowatt-hours (kWh) per month, for a location with a 6.26-meters-per-second (14-mile-per-hour) annual average wind speed. Most turbines have automatic speed-governing systems to keep the rotor from spinning out of control in very high winds. This information, along with your local wind speed distribution and your energy budget, is sufficient to allow you to specify turbine size.

Examples of 900W to 3kW Turbines:

Aeromag
- *Lakota*

Bergey
- XL.1

Southwest Wind Power
- Whisper 100
- Whisper 200
- Whisper 500

Towers
To paraphrase a noted author on wind energy, "the good winds are up high." Because wind speeds increase with height in flat terrain, the turbine is mounted on a tower. Generally speaking, the higher the tower, the more power the wind system can produce. The tower also raises the turbine above the air turbulence that can exist close to the ground. A general rule of thumb is to install a wind turbine on a tower with the bottom of the rotor blades at least 9 meters (30 feet) above any obstacle that is within 90 meters (300 feet) of the tower.

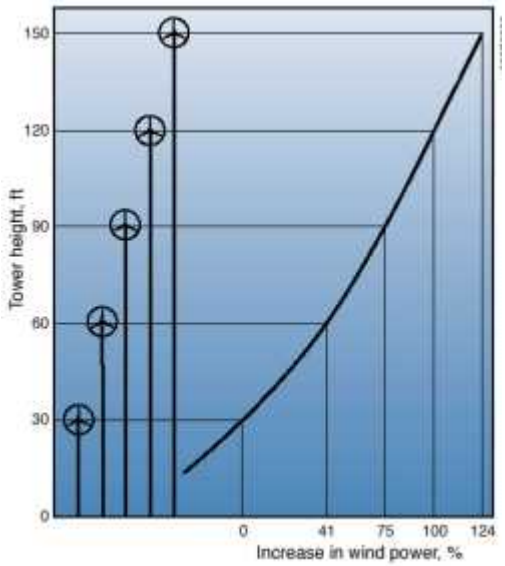
Experiments have shown that relatively small investments in increased tower height can yield very high rates of return in power production. For instance, to raise a 10-kW generator from a 18-meter (60-foot) tower height to a 30-meter (100-foot) tower involves a 10% increase in overall system cost, but it can produce 25% more power.

There are two basic types of towers: *self-supporting* (free standing) and *guyed*. Most home wind power systems use a guyed tower. Guyed-lattice towers are the least expensive option. They consist of a simple, inexpensive framework of metal strips supported by guy cables and earth anchors.

However, because the guy radius must be one-half to three-quarters of the tower height, guyed-lattice towers require enough space to accommodate them. Guyed towers can be hinged at the base so that they can be lowered to the ground for maintenance, repairs, or during hazardous weather such as hurricanes. Aluminum towers are prone to cracking and should be avoided.

Balance of System
Stand-alone systems require batteries to store excess power generated for use when the wind is calm. They also need a charge controller to keep the batteries from overcharging. Deep-cycle batteries, such as those used to power golf carts, can discharge and recharge 80% of their capacity hundreds of times, which make them a good option for remote renewable energy systems. Automotive batteries are shallow-cycle batteries and should not be used in renewable energy systems because of their short life in deep cycling operations.

In very small systems, direct current (DC) appliances operate directly off the batteries. If you want to use standard appliances that require conventional household alternating current (AC), however, you must install an inverter to convert DC electricity to AC. Although the inverter slightly lowers the overall efficiency of the system, it allows the home to be wired for AC, a definite plus with lenders, electrical code officials, and future homebuyers.



Wind tower height increases power output

For safety, batteries should be isolated from living areas and electronics because they contain corrosive and explosive substances. Lead-acid batteries also require protection from temperature extremes.

In the simplest of wind power grid-connected systems, the only additional equipment is an inverter that makes the turbine output electrically compatible with the utility grid. No batteries are needed. The Bergey Excel and Southwest Wind Power's Whisper Link are examples of grid-connected wind turbine systems that don't use batteries.

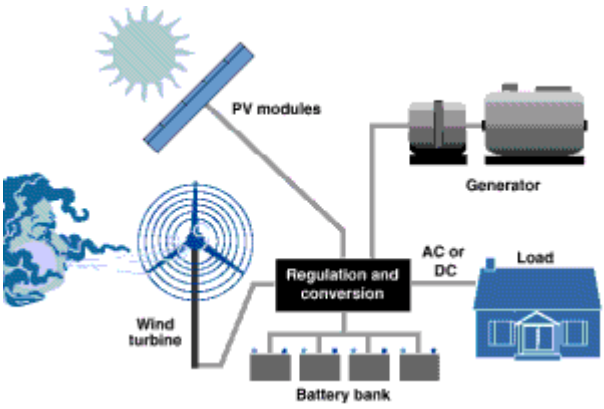
There are also wind turbine systems which are both grid-connected and have a battery bank. While these systems are generally about 30% or more expensive due to the extra equipment required, they provide the added benefits that they will provide backup power to your home in case of a blackout and can also easily be combined with solar electric panels without having to buy a separate inverter. Most electric wind generators can be connected to the dual-purpose inverter systems. Contact the Alternative Energy Store for more details on sizing one to fit your needs.

Hybrid Wind Systems

According to many renewable energy experts, a stand-alone "hybrid" system that combines wind and solar electric panels (also known as photovoltaic (PV) modules) offers several advantages over either single system.

In much of the United States, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when there is less sunlight available. Because the peak operating times for wind and solar panels occur at different times of the day and year, hybrid systems are more likely to produce power when you need it.

For the times when neither the wind generator nor the solar panels are producing electricity (for example, at night when the wind is not blowing), most stand-alone systems provide power through batteries and/or an engine-generator powered by fossil fuels.



If the batteries run low, the engine-generator can be run at full power until the batteries are charged. Adding a fossil-fuel-powered generator makes the system more complex, but modern electronic controllers can operate these complex systems

automatically. Adding an engine-generator can also reduce the number of solar electric panels and batteries in the system. Keep in mind that the storage capability must be large enough to supply electrical needs during non-charging periods. Battery banks are typically sized for one to three days of windless operation.

The Cost Factor

Photovoltaics is an attractive technology in many ways, but cost is not one of them. Small wind turbines can be an attractive alternative, or addition, to those people needing more than 100-200 watts of power for their home, business, or remote facility. Unlike PV's (solar electric panels), which stay at basically the same cost per watt independent of array size, wind turbines get less expensive with increasing system size. At the 50 watt size level, for example, a small wind turbine would cost about $8.00/watt compared to approximately $6.00/watt for a PV module. This is why, all things being equal, PV is less expensive for very small loads. As the system size gets larger, however, this "rule-of-thumb" reverses itself. At 300 watts the wind turbine costs are down to $2.50/watt ($1.50/watt in the case of the Southwest Wind Power's Air X), while the PV costs are still at $6.00/watt. For a 1,500 watt wind system the cost is down to $2.00/watt and at 10,000 watts the cost of a wind generator (excluding electronics) is down to $1.50/watt. The cost of regulators and controls is essentially the same for PV and wind. Somewhat surprisingly, the cost of towers for the wind turbines is about the same as the cost of equivalent PV racks and trackers. The cost of wiring is usually higher for PV systems because of the large number of connections.

For homeowners connected to the utility grid, small wind turbines are usually the best "next step" after all the conservation and efficiency improvements have been made. A typical home consumes between 800-2,000 kWh of electricity per month and a 4-10 kW wind turbine or PV system is about the right size to meet this demand. At this size wind turbines are much less expensive.

Reliability

In the past reliability was the "Achilles Heel" of small wind turbine products. Small turbines designed in the late 1970's had a well-deserved reputation for not being very reliable. Today's products, however, are technically advanced over these earlier units and they are substantially more reliable. Small turbines are now available that can operate 5 years or more, even at harsh sites, without need for maintenance or inspections and 5-year warranties are available. The reliability and cost of operation of these units is equal to that of photovoltaic systems.

Wind Energy

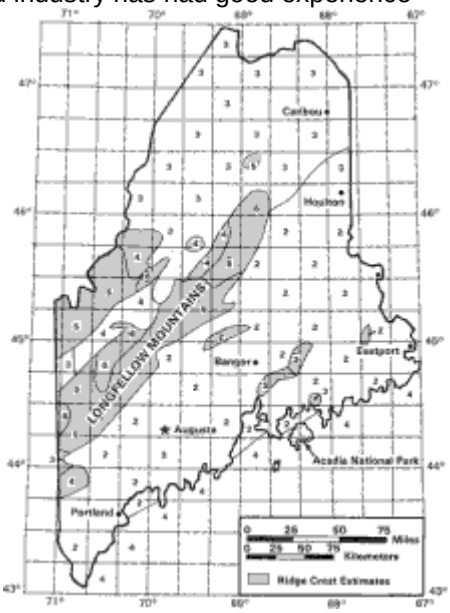
Wind energy is a form of solar energy produced by uneven heating of the Earth's surface. Wind resources are best along coastlines, on hills, and in the northern states, but usable wind resources can be found in most areas. As a power source wind energy is less predictable than solar energy, but it is also typically available for more hours in a given day. Wind resources are influenced by terrain and other factors that make it much more site specific than solar energy. In hilly terrain, for example, you and your neighbor are likely to have the exact same solar resource. But you could have a much better wind resource than your neighbor because your property is on top of the hill or it has a better exposure to the prevailing wind direction. Conversely, if your property is in a gully or on the leeward side of the hill, your wind resource could be substantially lower. In this regard, wind energy must be considered more carefully than solar energy.

Wind energy follows seasonal patterns that provide the best performance in the winter months and the lowest performance in the summer months. This is just the opposite of solar energy. For this reason wind and solar systems work well together in hybrid systems. These hybrid systems provide a more consistent year-round output than either wind-only or PV-only systems. One of the most active market segments for small wind turbine manufacturers is PV-only system owners who are expanding their system with wind energy.

Remote Systems Equipment

The balance-of-systems (BOS) equipment used with a small wind turbine in a remote application is essentially the same as used with a solar electric (or PV) system. Most wind turbines designed for battery charging come with a regulator to prevent overcharge. The regulator is specifically designed to work with that particular turbine. PV regulators (solar charge controllers) are generally not suitable for use with a small wind turbine because they are not designed to handle the voltage and current variations found with turbines. The output from the regulator is typically tied into a DC source center, which also serves as the connection point for other DC sources, loads and the batteries. For a hybrid system the PV and wind systems

are connected to the DC source center through separate regulators, but no special controls are generally required. For small wind turbines a general rule-of-thumb is that the Ampere-Hour (AH) capacity of the battery bank should be at least six times the maximum renewables charging current, including any PV elements. The wind industry has had good experience using battery banks that are smaller than those typically recommended for PV applications.



Being Your Own Utility Company

The federal PURPA regulations passed in 1978 allow you to interconnect a suitable renewable energy powered generator to your house or business to reduce your consumption of utility supplied electricity. This same law requires utilities to purchase any excess electricity production at a price (avoided cost) usually below the retail cost of electricity. In about a half-dozen states with "net energy billing options" small systems are allowed to run the meter backwards, so they get the full retail rate for excess production. Because of the high overhead costs to the utilities for keeping a few special hand-processed customer accounts, net energy billing is actually less expensive for them. Most of these systems do not use batteries. The output of the wind turbine is made compatible with utility power using either a line-commutated inverter or an induction generator. The output is then connected to the household breaker panel on a dedicated breaker, just like a large appliance. When the wind turbine is not operating, or it is not putting out as much electricity as the house needs, the additional electricity needed is supplied by the utility. Likewise, if the turbine puts out more power than the house needs, the excess is instantaneously "sold" to the utility. In effect, the utility acts as a very big battery bank and the utility "sees" the wind turbine as a negative load. After over 200 million hours of interconnected operation we now know that small utility-interconnected wind turbines are safe, do not interfere with either utility or customer equipment, and do not need any special safety equipment to operate successfully.

Hundreds of homeowners around the country who installed 4-12 kW wind turbines during the go-go tax credit days in the early 1980's now have everything paid for and enjoy monthly electrical bills of $8-30, while their neighbors have bills in the range of $100-200 per month. The problem, of course, is that these tax credits are long gone and without them most homeowners will find the cost of a suitable wind generator prohibitively expensive. A 10 kW turbine (the most common size for homes), for example, will typically cost $28,000-35,000 installed. For those paying 12 cents/kilowatt-hour or more for electricity in an area with an average wind speed of 10 mph or more (DOE Class 2), and with an acre or more of property (the turbines are big), a residential wind turbine is certainly worth considering. Payback periods will generally fall in the range of 8-16 years and some wind turbines are designed to last thirty years or more.

Performance

The rated power for a wind turbine is not a good basis for comparing one product to the next. This is because manufacturers are free to pick the wind speed at which they rate their turbines. If the rated wind speeds are not the same then comparing the two products is very misleading. Fortunately, the American Wind Energy Association has adopted a standard method of rating energy production performance. Manufacturers who follow the AWEA standard will give information on the Annual Energy Output (AEO) at various annual average wind speeds. These AEO figures are like the EPA Estimated Gas Mileage for your car, they allow you to compare products fairly, but they don't tell you just what your actual performance will be ("Your Performance May Vary").

Wind resource maps for the US have been compiled by the Department of Energy. These maps show the resource by "Power Classes" that mean the average wind speed will probably be within a certain band. The higher the Power Class the better the resource. We say probably because of the terrain effects mentioned earlier. On open terrain the DOE maps are quite good, but in hilly or mountainous terrain they must be used with great caution. The wind resource is defined for a standard wind sensor height of 33 ft (10 m), so you must correct the average wind speed for wind tower heights above this height before using the AEO information supplied by the manufacturer. Wind turbine performance is also usually derated for altitude, just like an airplane, and for turbulence. Wind turbine manufacturers can usually provide computer-aided performance predictions for their turbines at virtually any site.

As a rule of thumb wind energy should be considered if your average wind speed is above 8 mph (most, but not all, Class 1

and all other Classes) for a remote application and 10 mph (Class 2 or better) for a utility-intertied application. If you live in an area that is not too hilly then the DOE wind resource map can be used to fairly accurately calculate the expected performance of a wind turbine at your site. In complex terrain a judgment on the site's exposure must be made to adjust the average wind speed used for this calculation. In most situations it is not necessary to monitor the wind speed with a recording anemometer prior to installing a small wind turbine. But in some situations it is worth spending $300-1,000 and waiting a year to perform a wind survey. Contact the Alternative Energy Store to discuss these details more.

Frequently Asked Questions

How do they work? The wind turbine, which is installed on top of a tall tower, collects wind energy and converts it into electricity. The turbine output is then made electrically compatible with the utility and the output is fed into the household wiring at the breaker panel.

The home is served simultaneously by the wind turbine and the utility. If the wind speed is below 7 mph there will be no output from the wind turbine and all of the needed power is bought from the utility. As the wind speed increases the turbine output increases and the amount of power purchased from the utility is proportionately decreased. When the turbine output is more than the house needs the extra electricity is sold to the utility. All of this is done automatically. There are no batteries in a modern residential wind system.

The wind turbine typically lowers your utility bill by 50-90%. It is not uncommon for homeowners with total electric homes and Bergey turbines to have monthly utility bills of $8-15 for part of the year. In northern parts of the country, where less air conditioning is used, the bills can be very low year round.

What size would I need for my home? Homes typically use anywhere from 350 to 2,000 kilowatt-hours of electricity per month. Depending upon the average wind speed in the area this will require a wind turbine rated in the range 1 to 15 kilowatts. Look at your current electric bill to get an idea of how many kilowatt-hours you consume per month. Then look at the specifications on Alternative Energy Store's website for different wind turbines and what the manufacturers claim for power production (kilowatt-hours) per month at different average wind speeds.

Who should consider buying one? A wind turbine is a relatively large device and it is not suitable for urban or small-lot suburban homes. We recommend a property size of one acre or more. The economics of a wind system are determined by the average wind speed in the area, the availability of rebates or tax credits, and the cost of electricity. As a general rule-of-thumb, we recommend that you have at least a 10 mph average wind speed and be paying 10¢/kilowatt-hour or more for electricity. We have wind resource maps for the entire US on our website, just go to our Alt-E University section of our website to find them. Residential wind turbines have been installed in all 50 states.

Will it help the environment if I install a wind turbine at my home? Wind turbines produce no pollution and by using wind power you will be offsetting pollution that would have been generated by your utility company. Over its nominal 30 year life a 10kW will offset approximately 1.2 tons of air pollutants and 200 tons of greenhouse gases.

Don't I have to take wind measurements for a year or more? No. For residential systems the cost of taking wind measurements is not justified in most situations. Wind resource data published by the US Dept. of Energy is sufficient to predict performance. In very hilly or mountainous areas, however, it may be prudent to take wind data before purchasing a system to ensure that your site in not in a sheltered area.

Are wind turbines reliable, and what about maintenance? Aeromag, Bergey and Southwest Wind Power turbines have only 3 or 4 moving parts and do not require any regular maintenance. After a 66 month test of one of Bergey's 10 kW units, Wisconsin Power & Light concluded that, "The turbines' reliability could not be improved upon." The Bergey turbines are designed to last 30 years or more and they operate completely automatically.

Do they make noise or interfere with TV reception? Small wind turbines do make some noise, but not enough to be found objectionable by most people. They do not interfere with TV reception.

Will the utility company allow me to hookup a wind generator? Federal regulations (PURPA) require utilities to allow

you install a wind generator and to pay you for any excess power you produce.

Will I have to change any of the wiring in my house? No, a wind turbine is easily retrofitted to virtually any home without need of changing any wiring or appliances. In some states a second utility meter will be added, however, so that the utility can know how much electricity you have sold to them.

What about towers? Usually a tower of between 80-120 feet is supplied along with the wind turbine. Towers this tall are required to get above the turbulence generated by obstacles and trees on the ground. Also, wind velocity, and, therefore, wind turbine performance, increases as you get higher off the ground. For most situations an 80 or 100 foot tower is sufficient. The most economical type of tower is the guyed lattice type, but other types that are hinged or have no guy wires are also available.

How much do they cost? A small 1kW wind turbine system that produces about 300kWHrs per month in a 12 mph average wind, can cost as little as $5000 to $7000. 1 A 10 kW wind turbine costs approximately $28,000-35,000 to install. The equipment cost is about $25,000 and the rest is shipping and installation. Even smaller and more basic wind turbine systems, such as those based upon Southwest Wind Power's Air-X can be purchased for $1000 to $2000. These systems are frequently a good fit for powering a small weekend cabin.

How are they as an investment? That depends on your cost of electricity and average wind speed. The wind system will usually recoup its investment through utility savings within 6-15 years and after that the electricity it produces will be virtually free. Compared to purchasing utility power, a wind system can be a good investment because your money goes to increasing the value of your home rather than just paying for a service. Many people buy wind systems for their retirement because they are concerned about utility rate increases.

How would I proceed to have a wind turbine installed at my home? There are two routes: For Bergey wind generator systems you can work with an authorized Bergey installer for a complete turnkey installation or you can purchase an Aeromag, Southwest Wind Power or Bergey system directly from the Alternative Energy Store and have the unit installed yourself. The first route requires less work on your part and offers a higher level of after-sales support. The self-installation route offers significant savings. We would be happy to discuss the various approaches with you to determine which is best for your situation.

How can I get more information? We would be happy to send you further information on our small wind turbines or answer any of your questions. Just email us at support@AltEnergyStore.com. You can stay abreast of the developments in wind energy and help support lobbying efforts for renewable energy by joining the American Wind Energy Association (Tel: 202-383-2500). An individual membership costs $50 per year.

We also highly recommend Paul Gipe's book "Wind Power for Home and Business", Chelsea Green Publishing, White River Junction, VT. This $35.00, 400-page paperback book can be purchased from many local bookstores, or at The Alternative Energy Store's Bookstore.

Recommended Website Links

Alternative Energy Store

- Main Website: www.AltEnergyStore.com
- Alt-E University: www.AltEnergyStore.com/cart/university/index.html
- Wind Turbine Section: shop.altenergystore.com/go.asp?Cc=WINDTWR

American Wind Energy Association – www.awea.org

Aeromag – www.aeromag.com

Bergey Wind Power – www.bergey.com

Southwest Wind Power – www.windenergy.com