Buying a Small Wind Electric System

Small Wind Electric Systems:

A California Consumer's Guide

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RENEWABLE ENERGY PROGRAM

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Introduction

Small wind energy systems are one of the fastest growing forms of customer-sited or "distributed" electric generation. After consumption has been reduced with available energy conservation measures, a small wind turbine is the next best energy investment for many small business owners and homeowners.

However, many consumers are not familiar with wind energy technologies and may not even know what questions to ask. This guide has been prepared by Evergreen Energy and funded in part by the California Energy Commission (Energy Commission) to provide consumers with the basic information they need to determine whether wind energy is an attractive option for them; and if so, what considerations are important in buying and installing a system.

Using This Guide

This guide is primarily oriented towards homeowners and businesses that are considering the installation of a grid-intertied wind energy system under the Energy Commission's Emerging Renewables Buydown Program (discussed later). When we refer to installations at homes, we are including homes, farms, ranches, and other businesses that might be able to use their wind energy resource. The Energy Commission's Buydown rebate program covers small wind turbines up to 10 kilowatts (kW), so this

guide does not attempt to cover topics relevant to larger systems. Nor does this guide discuss off-grid systems in any detail, since these systems are not covered by the rebate program. With the recent increases in electricity prices, many people are thinking seriously about using small wind and solar systems to generate part or all of their own electricity. If you are one of those people, this guide is designed for you.

Understanding the Technology

Windmills, Large Wind Turbines and Small Wind Turbines

A wind turbine is a device that uses wind energy to produce electricity. In contrast to a windmill's water pump, a wind turbine has an electrical generator. Water-pumping windmills have many blades because they have to produce high torque to lift water from a great depth. Wind turbines have only two or three blades because they need to spin at high speeds to drive the electric generator. Wind turbine blades are also more efficient at extracting energy from the wind than are the blades of a windmill.

Large wind turbines are usually installed in clusters called windfarms, where all of the power is sold to a utility or other electric service provider under a long-term sales contract. Many Californians have seen the windfarm developments in the Altamont Pass (southeast of San Francisco) or the similar developments in San Gorgonio Pass (near Palm Springs) and near Tehachapi. These utility-scale wind turbines often produce 500 kW of power or more and have rotor blades that are as much as 100 feet long. Very few individual consumers will have the need for a large-scale wind turbine to supply their own electricity.

The focus of this guide is on small wind turbines, which generally are defined as producing no more than 50 kW (approximately 67 horsepower). Small wind turbines are designed to be installed at homes, farms, and small businesses to offset utility power and reduce electric bills.

How Do Small Wind Turbines Work?

A wind turbine turns the kinetic energy in the wind into electrical energy. The heart of a wind turbine is the rotor, which usually is composed of two or three blades. The blades of a wind turbine are like the wings of an airplane. They have shapes (called airfoils) that are very efficient in converting the force of the wind into rotational energy. The rotary force produced by the blades drives an electrical generator, which converts the force into electricity.

The major components of a wind system are shown in Figure 1. While there are other configurations of wind turbines, the one shown is the most common type.

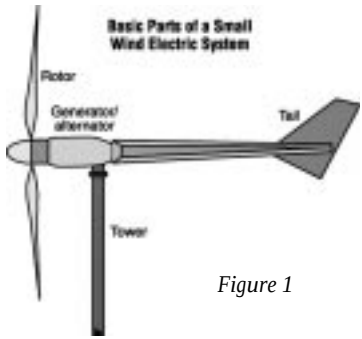

Figure 1

Figure 1
Components of a Wind System

Rotor: Consists of two or three blades.
Generator: Produces the electricity.
Tail: Aligns the rotor into the wind.
Tower: Places the wind turbine high enough that it has good exposure to the wind. There are many configuration and height options.
Foundation: The system of structural support concrete.

Wire Run: Conducts the electricity produced by the wind turbine to the power electronics.
Disconnect Switch: Allows the elctrical output to be isolated from the power electronics.
Power Electronics: Power conversion and conditioning equipment (usually an inverter) that makes the turbine power compatible with utility power. Also contains protective features to address safety and power quality requirements.
Batteries: Optional component that stores electricity and provides electricity during power outages.
Energy Meter: Records the net amount of electricity used (or produced) by the customer. A separate meter may be used to record the amount of electricity generated by the wind system.
Circuit Breaker Panel: The point where the wind system connects to the wiring of your home or business.

Both Wind Power and Utility Power at the Same Time?

Yes! It is a common misconception that your home at any given instant must be either entirely powered by the wind or entirely powered by the utility, and that your home is switched back and forth between the wind turbine and the utility. Instead, what happens is that power from your wind turbine combines with power from the utility to run your lights and appliances.

For example, when the wind is low and the wind turbine is not generating power, your electricity needs will be supplied completely by your utility company. When the wind turbine begins producing power, it supplies your needs and reduces the amount of power you buy from your utility. As a result, your utility meter will turn more slowly, lowering your electricity bill.

On the other hand, if your wind turbine produces more power than you need, the excess will be delivered to the utility grid (reducing the amount of power needed from other utility sources). Your electric meter will turn backwards, crediting your electricity bill.

Most of the time, your home or business will be receiving power from both your wind system and your utility company. The flow of energy is balanced between your wind turbine and the utility grid without any action or intervention from you.

"Batteries Not Included…"

If your home is already served by utility power, or utility service is available for a reasonable connection charge, you probably will choose not to include batteries as part of your wind system. The power produced by your wind turbine will either be used immediately in your home or delivered immediately to the utility system. In California, the utilities effectively bank your excess energy under a net metering program (see *Spinning the Meter Backwards* on page 5).

A wind turbine system without batteries can't power your house during an outage because there is too much variability in its output to reliably supply your electricity needs. For your system to provide backup power during outages, special equipment is needed. This equipment adds significantly to the cost and complexity of the wind system, and some customers prefer to use a conventional gas or propane generator for their backup power needs.

On the other hand, some people don't like the noise, pollution, or inconvenience of backup generators and prefer to invest in wind systems that can provide backup power during outages. These more complex systems will include a battery bank and a special multi-mode inverter that can operate either connected to or indepen-

dently of the power grid. These systems have some advantages over backup generators: they operate pollution-and noise-free, without any fuel tanks to refill; they work automatically, so that your power doesn't go out (even for a second); and you don't have to be at home to start up a generator when the power goes out.

Wind backup systems work much like the UPS (Uninterruptible Power Supply) systems for computers. During a power outage, multi-mode inverters isolate some or all of the home's electric circuits from the power grid, and supply power from the wind turbine and the batteries to those circuits. The batteries serve as a buffer between the constantly varying wind and household electrical loads.

Should You Be Grid-Independent?

If the cost of bringing utility power into your home exceeds $10,000, you should investigate the alternative of a grid-independent power system based on wind and/or solar energy. Wind energy system dealers can provide design assistance and pricing for these off-grid systems as well as the on-grid systems that are the focus of this guide. Remember, however, that Energy Commission rebates do not apply to off-grid systems.

Things to Like About Small Wind Systems

Saving Money

The main reason people invest in small wind systems is to save money. Historically, wind system sales have been concentrated in areas with high electricity costs, favorable policies, and incentive programs that help with the high initial cost of the equipment. California has all three elements in place and leads the market for small wind turbines today.

The average cost of utility-supplied electricity in California varies from about 13 to 26 cents per kilowatt-hour (kWh). The national average is 8.5 cents per kWh. The electricity rates for most California customers increased significantly during 2001, and most residential consumers will be paying about 26 cents per kWh for usage above 900 kWh per month.

A wind turbine pays for itself by reducing your utility bill and by insulating you from the full impact of future rate increases. After a typical payback period of between five and eight years, the wind turbine produces electricity that is virtually free (except for maintenance costs).

Saving the Planet

Small wind turbines do not burn fuel, so they produce no air pollution. When you generate your own electricity using wind power, you reduce the amount of electricity generated by conventional sources, including fossil fuel and nuclear power plants. In the case of nuclear power, you directly reduce the amount of radioactive waste produced.

Taken together, the reduction in pollution from thousands of individual small wind and solar systems is substantial. People really enjoy saving money and helping to save the planet at the same time. For many, a small wind system is a proud symbol of their commitment to environmental stewardship.

Spinning the Meter Backwards

Probably the greatest pleasure reported by the owners of small wind systems is watching their utility meter spin backward on a windy day. Under a net metering agreement, when the wind turbine produces more electricity than the home needs, the excess travels out to the utility power lines, spinning the utility meter backwards. The meter reading may be lower at the end of a windy month than it was at the beginning of the month!

Things You Might Not Like About Small Wind Systems

They Are Big and Tall, and They Move

It takes a good-sized rotor to generate enough electricity to significantly reduce a utility bill. Most home-sized wind systems are in the size range of 3 to 15 kW, which translates into a rotor diameter of 14 to 26 feet. Wind systems also need to be placed on top of a tall tower to rise above the turbulence (rough air) caused by the ground and by obstacles such as trees and buildings. Tower heights range from 30 feet to 120 feet, although the average is about 80 feet. Their size and placement may make them unsightly to some people.

Wind turbines spin much of the time, making them noticeable. Many people like to watch turbines spin and change directions like weather vanes, and say that turbines make them more aware of the weather. Other people just don't like the way they look.

They Make Noise

The tips of a small wind turbine blade can reach speeds of several hundred miles an hour in strong winds. At any wind speed, the blades will make some noise. The amount of noise generated depends on the particular model of wind turbine and on the wind speed. Most small wind turbines make less noise than a residential air conditioner, but even this may be objectionable to some people.

Your Neighbors Will Have To Live With Them Too

Most homeowners will have neighbors close enough to see and hear the wind turbine, and some may object to the noise or view. Consequently, the small wind turbine industry recommends customer property sizes of one-half acre or more for turbines up to approximately three kW and one acre or more for wind turbines above this size. Following this guideline will minimize, though not eliminate, the possibility of objections from neighbors.

Myths about Wind Turbines

There are a couple of often-repeated "facts" about small wind turbines that turn out to be untrue.

No Wind Means No Power

For grid-connected systems, the power grid supplies backup power when the wind is not blowing. As previously discussed, however, without batteries, your grid-connected wind system will not provide power during blackouts. Grid-connected systems with batteries, on the other hand, can provide power during blackouts. Off-grid wind systems have batteries, and often a backup generator, to help provide reliable power when the wind is low.

They Kill Birds

Unfortunately, a few birds have been killed from the thousands of small wind turbine installations, but this is very, very rare. A sliding glass door is more dangerous to birds than a small wind turbine is.

They Are Noisy

Small wind turbines can be heard outdoors above background noise if you are within a few hundred feet, but few owners find the noise level objectionable. Typically, small wind turbines cannot be heard indoors.

They Interfere With TV and Radio

All modern wind turbines, large or small, have blades made of fiberglass or wood. Both of these materials are transparent to electromagnetic waves such as radio and television, so there is no chance of electrical interference.

Understanding the Wind Resource

What Is Wind?

The wind is caused by the uneven heating of the earth's surface. As air heats up near the ground, the hot air rises, causing low pressure zones near the ground. Air moves from high pressure areas to low pressure areas to balance out the differences. The bigger the pressure difference between air masses, the stronger the winds.

Characteristics To Understand

Power in wind—the cubic thing: One of the most important characteristics of wind is that its energy varies as the cube of its speed. If wind speed is doubled, the energy content increases by a factor of eight (2 x 2 x 2 = 8). This means that small differences in wind speed can mean big differences in the power output of a wind turbine. It also means that there is little energy available in light breezes, and there is an overabundance of energy available in high winds.

Turbulence hurts: Turbulence is disturbed, chaotic air flow caused primarily by obstructions. Turbulence creates larger forces on wind turbine blades and reduces their performance.

Obstructions: When air flows over or around a tree, a house, or similar obstruction, it causes eddies that expand and flow downstream. Eventually the air straightens out again, but the turbulent air behind obstructions should be avoided.

Ground effects: The ground slows wind down. Therefore, wind speed increases with height above the ground and a wind turbine on a taller tower will produce more energy than a wind turbine on a shorter tower. In many cases, a taller tower will shorten the payback period of the wind system.

Sheltering hurts: In hilly or complex terrain, the wind will follow channels, much like a river. A wind system's performance will be unsatisfactory if it is placed on the leeward or sheltered side of a hill.

Elevation helps: People who live on top of hills really do have more wind. In general, wind resources increase with relative altitude. The increase in wind speed with a taller tower is magnified by the cubic relationship of the power in the wind. A common mistake is installing a wind turbine on a short tower. It's like putting a solar system in a shady area.

Wind Maps and Weather Stations

The primary tools for evaluating wind resources are the California wind maps provided in the U.S. Department of Energy's Wind Energy Atlas of the United States. These maps, one covering northern California and one covering southern California, show different wind classes that provide a general indicator of the wind resource in a particular area. These maps, along with an explanation of the wind energy classifications, can be found at the following web sites:

(for northern California)
http://rredc.nrel.gov/wind/pubs/atlas/maps/chap3/3-54m.html
(for southern California)
http://rredc.nrel.gov/wind/pubs atlas/maps/chap3/3-55m.html.

Wind areas are classified from lowest (Class 1) to highest (Class 7) wind speed. In general, the best prospects for small wind systems are in areas that are Class 2 or higher. However, local terrain factors are particularly important to consider. For more information, see *Is the Wind Resource Good Enough* on page 10.

Meteorological or weather station data are available for many sites in California, but these data are not as useful as one might expect. Weather station or airport data are often taken by wind sensors (anemometers) that are poorly sited. The use

of data from such anemometers would underestimate wind turbine performance.

Testing Wind Resources

Site-specific wind studies are mandatory for large, commercial windfarm projects. By contrast, site-specific studies are seldom done for small wind turbine projects because the cost is too high and the time required is too long. A detailed wind study might cost $2,000 to $8,000 and take up to a year. Many home and small business owners find they cannot justify such costs in the case of a small wind system. It is becoming easier to find an existing system in more areas to gauge expected performance in nearby sites.

California Programs and Rules

The California Energy Commission Emerging Renewables Buydown Program

The California Energy Commission (Energy Commission) offers rebates of up to 50 percent on the total installed cost of qualified small wind turbines (up to 10 kW) for customers of Southern California Edison, Pacific Gas & Electric, San Diego Gas & Electric, and Bear Valley Electric. Only equipment that has been certified by the Energy Commission qualifies, and all equipment must carry at least a five-year warranty. The systems must be installed by a licensed contractor or electrician unless the homeowner installs the system him or herself.

The program originally was scheduled to expire in 2002. A law was passed in 2000 extending funding for the Energy Commission rebate program until at least 2012. If the California Legislature approves the Energy Commission's recommendations, the follow-on rebate program will receive 50 percent more funding, and the size limit for wind turbines will increase to 50 kW. Energy Commission Buydown rebates are reserved on a first-come, first-served basis until available funding is exhausted. Reservations last nine months, and in certain cases 18 months; systems must be installed in that period to receive a rebate.

Full details on the Buydown rebate program are available from the Energy Commission. For contact information, see the *Getting Help* section of this guide.

The CPUC Self-Generation Incentive Program

In July 2001 the California Public Utilities Commission (CPUC) launched a new program to encourage customers to install small generating units to lessen the load on the electricity grid. Like the Energy Commission's Buydown rebate program, the CPUC program offers rebates, but the CPUC program differs in that it is administered by the utilities, it covers generators from 30 kW to 1,000 kW, and it covers both renewable energy technologies and fossil-fueled generators such as fuel-cells and microturbines. The CPUC program is funded at $125 million per year and is set to expire at the end of 2004.

For customers interested in wind power, the CPUC program will pay a rebate of up to $4.50 per watt or 50 percent of the project costs, whichever is lower. Like the Energy Commission program, the CPUC program requires wind turbines to carry a five-year warranty and to meet certain equipment qualifications. You must apply for funding through your utility company and funding may be reserved for up to one year.

For further information on the CPUC Self-Generation Incentives Program, please contact your local utility. See the *Getting Help* section of this guide for contact information.

State Tax Credit

Recently passed legislation allows you a 15 percent tax credit on your out-of-pocket costs if you purchase a wind system no larger than 200 kW between January 1,

2001 and January 1, 2004. For purchases between January 1, 2004 and January 1, 2006, you are allowed a tax credit of 7 1/2 percent. Out-of-pocket costs are your costs after deducting any other municipal, state, or federal sponsored financial incentives. For example, if the Energy Commission rebate covers 50 percent of your costs, the tax credit would apply only to the remaining 50 percent.

Net Metering

California utilities are required by state law (California Public Utilities Code, Section 2827) to offer "net metering" for wind energy systems up to 1,000 kW through 2002. (Starting in January 2003, the system size limit is scheduled to be reduced to 10 kW.) Under net metering, any excess electricity your system generates goes back to the utility grid and spins your meter in reverse, which effectively means you are getting credited for all the excess electricity you generate at the same rate you pay for the power you use.

Another way of looking at net metering is that the utility banks your excess wind energy for use at a later time. In California, energy banking is done over a 12-month period. This means that any excess electricity you generate during high-wind months is available to reduce your utility bill during low-wind months. Only a few other states provide for net metering on an annual basis; this approach provides significant additional savings to customers who produce more electricity than they consume during some months of the year. If you end up with excess energy at the end of the annual period, however, you will not necessarily be paid for the excess—you may end up giving it to the utility company.

Utility Interconnection

California's net metering law limits the requirements utilities can impose on customers seeking to interconnect eligible solar and wind systems to the electric grid. The law requires equipment to be certified as complying with national safety and power quality standards (UL 1741, IEEE 929-2000, and IEEE 519) and to be installed in accordance with local and national electrical codes. Systems meeting these requirements can be interconnected without additional tests or equipment.

To interconnect your system, you must first have your installation approved by the local permitting authority, usually a building or electrical inspector. Then you need to complete the utility's interconnection agreement, which can be obtained by contacting your local utility (see the *Getting Help* section of this guide).

Zoning and Permitting Issues

When you install a small wind system, a building permit is required by local ordinances and by the Energy Commission's Buydown rebate program. The building permit must be obtained before any construction relating to your wind turbine installation begins.

Building permits are obtained from the planning office for the city or county with jurisdiction over your property. There will be specific permit application procedures and fees for different parts of the permitting process. Submitting an application typically involves submitting a plot plan (a map of your property showing the location of existing structures and the proposed wind system), a description of the components of the wind system, and a structural analysis of the tower.

Height Restrictions

Small wind turbines must be installed on relatively tall towers so that their rotors can operate in smooth air. Towers 60 to 100 feet tall are typical. Some cities and counties in California have explicit language in their local ordinances authorizing

tall towers as a permitted use of property. However, most local jurisdictions have never directly addressed wind turbines in their zoning ordinances, so wind turbines are limited by default to the standard height restriction of 35 feet. Although this height restriction can accommodate the smallest wind generators (about two kW or less), it is inappropriate for larger systems.

In local jurisdictions that have not explicitly authorized taller wind towers as a permitted use, installing a tower taller than 35 feet requires a conditional use permit or variance. Obtaining these special authorizations is often a lengthy and expensive process.

This is the greatest obstacle to widespread use of small wind systems in California. The Energy Commission's rebate program will cover up to half of the cost for these special permits, which can cost as much as $6,000, but only if your project is ultimately permitted. Because the Energy Commission rebate is paid only after a wind system is installed, you will have to bear the entire expense if your reservation is not approved.

Fortunately, some California counties have specifically written small wind systems into zoning ordinances as permitted uses or conditional uses. These counties include Kern, Solano, and Santa Cruz. Obtaining a building permit for a tall tower is relatively easy in these jurisdictions. We anticipate that the process will improve over time as local governments become more aware of the technology, and local residents begin demanding more installation-friendly treatment.

In response to the problems with permitting small wind systems, the state of California passed Assembly Bill 1207, which requires cities and counties, excluding some densely populated areas, to enact ordinances that are friendly to siting small wind turbines. If these jurisdictions fail to enact new ordinances before July 1, 2002, the installation of a small wind system becomes a "use by right" and permits cannot be denied. In both cases, with and without a new ordinance, AB 1207 sets specific requirements on issues such as tower height, set-back requirements, noise levels, and structural analysis requirements.

California is the first state to enact a permitting regulation for small wind systems that overrides local ordinances. AB 1207 sunsets in three years, but perhaps by then small wind systems will be better understood and supported by local officials.

Would A Wind System Make Sense For Me?

Whether or not a wind system makes sense for you depends on a number of factors. In this section we discuss the most important factors to help you answer this question.

Is the Wind Resource Good Enough?

Small wind systems need only a modest wind resource to be effective, but there are many parts of California that simply are not windy enough. Wind resources are divided into seven categories or classes, each covering a range of annual average wind speeds, with a Class 1 area having the lowest average speed. In general, a Class 2 resource or higher is required for effective use of wind. However, there will also be areas within Class 1 zones that have higher average wind speeds due to higher elevation or local wind channeling. Conversely, there will be areas in Class 2 or higher zones that will be inappropriate because they are sheltered from the prevailing wind. Most wind system owners have Class 2 or 3 wind resources. Residential systems are uncommon in areas with Class 4 or higher resources.

Generally speaking, a person's intuition is a fairly good indicator of wind potential. If you think you have a good wind resource, you probably do. People who live in poor wind resource areas generally report that it doesn't seem very windy most of the time. Another indication of the wind resource is whether there are small wind systems already operating in your area. If so, then there's a good chance that you would have adequate wind resources.

In most situations it is not necessary to test the wind speed at a prospective site. Wind energy system manufacturers and dealers can supply estimates of expected performance for specific models in different wind classes and with different tower heights. A good place to start is the manufacturer's web site (see *Getting Help*).

Do I Have the Space?

The wind industry recommends that potential customers have at least one-half acre of property for wind systems up to approximately three kW, and one acre or more for larger wind energy systems. Wind energy systems are relatively large, and they need to be placed on tall towers. With few exceptions, they should not be installed on the roof of a home or building, since they would cause vibrations and place large forces on the structure during storms.

You might also consider free-standing towers, which some wind turbine companies are making available. These take up less than one square foot, meaning that your property size can be considerably smaller.

Will I Be Allowed To Install A System?

If you meet the recommended property size requirements, you may still not be able to install a wind system if you have restrictive zoning ordinances or covenants. If your homeowners' association, for example, prohibits any structure from extending more than five feet above the roof of your home, then you probably won't be able to install a 60 to 120 foot tower in your backyard.

In areas where zoning ordinances prohibit installing systems higher than 35 feet, some people are installing smaller wind turbines (up to approximately two kW) on 30 to 35 foot towers. While shorter towers will reduce wind system performance, this may be the only available option in these areas.

Can I Afford a Wind System?

Wind energy systems are less expensive than comparably-sized solar electric systems, but they are still quite expensive. Fortunately, the Energy Commission's Buydown rebate program substantially reduces the initial cost of the systems. For example, the price of a 10 kW residential wind system that initially costs $33,000 will drop to $16,500 after the Energy Commission rebate, at the current rate. This is still a lot of money, however, and it is reasonable to question whether it is a good investment.

Recently, some less expensive systems have become available. Smaller three kW systems that can produce enough energy for a medium sized home are available for less than $15,000 before any rebates. Depending on your personal objective, even smaller one kW systems are available for under $5,000.

A wind system is a good investment in the same way that buying a home is a better investment than renting a home. In both cases, you are paying off a purchase and your equity grows each month. In the case of your electrical bill, you will be paying the money out anyway.

However, if you borrow money to buy a wind system, your payments will typically stop after five to eight years (depending on the financing you choose). After that, the energy from your wind system will be virtually free (except for

upkeep costs) for the 20 to 30 year life of the system. In many cases, the monthly payment on a loan for a wind system will be offset by the monthly savings on your electric bill.

Some manufacturers and dealers have structured their prices to include the Energy Commission rebates so that their customers only need to pay the 50 percent out-of-pocket amount and don't have to wait for the rebate (e.g., pay $16,500 on a system costing $33,000). Some buyers can afford a cash purchase while others require, or just prefer, financing for the system. Financing for homeowners is relatively simple using home equity loans. These loans often carry attractive terms, and because the wind system is considered a home improvement, the interest expenses may be tax deductible

Financing for businesses is generally available, but usually will have higher interest rates. Some public programs for financing renewables are also under development by the State of California.

Will It Provide Power During Blackouts?

Yes, it can, but only if you are willing to make the wind system more costly and complicated. Systems with batteries and sophisticated power electronics are capable of providing backup power during outages, but a system that shuts down during blackouts will be less expensive and requires less maintenance. Systems without batteries are more common and have the shortest payback period.

If you configure a wind system to provide backup power, the normal practice is to install a sub-panel off of your main electrical panel. This sub-panel is connected to the main panel through an inverter with a built-in transfer switch. In the event of a power outage, the inverter senses the outage and isolates the sub-panel, supplying it with power from the wind system and/or batteries. Your most essential loads are connected to the sub-panel so that they continue to have power. These essential loads are typically the refrigerator, freezer, water pumps, fan blowers, and one or two rooms with their lights, televisions, and radios. Very large loads such as air conditioners, electric heaters, electric ranges, hot water heaters, and larger pumps (e.g., swimming pool pumps) are usually not connected to the backup power system because they would drain the reserves too quickly.

Being Neighborly

You should seriously consider how your neighbors are likely to react to your putting up a small wind energy system. The attitude that "It's my property, and I'll put up any darned thing I want to" is not the best approach. Many people feel strongly about the need to preserve the landscape, views, history, or peace and quiet of their neighborhoods. For them the possible intrusion of a wind energy system is a cause for great concern.

We recommend that you talk to each of your neighbors within approximately 500 feet of your home or business before purchasing a wind energy system. Understand your neighbors' natural fear of the unknown and be prepared to respond to the "myths" listed earlier (noise, birds, TV interference, etc.). Of course, if there are any small wind turbines already in your neighborhood, you will probably have an easier time addressing any concerns.

How Large Should My System Be?

A small wind system should be sized so that its annual production is no greater than your annual electricity use. Under California's current rules, you cannot make money by producing more electricity than you need and selling it to the utility or a neighbor. You will make money, however, by reducing your electric bill. Smaller sys-

tems that produce just a portion of your requirements work fine and will give you a good return on your money as well.

The size of your wind energy system, rated in kW of capacity, and your wind resource, will determine how much energy is produced. It is often better to compare the rotor areas of small turbines, as explained later, but rated capacity is the most straightforward way to describe the sizes of various small wind turbines.

There are many small wind turbine models certified under the Energy Commission's Emerging Renewables Buydown rebate program. Eligible models are offered from several manufacturers and range in rated power capacity from about 400 watts to 10,000 watts (10 kW). Because wind turbines have different rated wind speeds, chosen at the manufacturer's discretion, it is not possible to make accurate performance comparisons based on the manufacturer's rated capacity.

A more useful way of sizing a small wind turbine is to calculate the predicted monthly performance based on the manufacturer's performance curves and standardized wind conditions. This method follows the performance rating procedures recommended by the American Wind Energy Association. You can obtain these predicted performance figures from a wind turbine manufacturer or through your dealer. Please note that your turbine's performance may vary.

Multiple wind turbines can be installed to provide greater energy production. However, some restrictions apply concerning eligibility for the Energy Commission Buydown rebates, as outlined in a later section. Again, you should avoid installing a wind energy system (or combination of systems) that is predicted to produce more electricity than you use in a year, because you may not receive compensation for the excess from your utility. Installing systems that will only provide a portion of your electricity is fine; in fact, you can install additional wind capacity later if you want to increase the contribution from wind energy.

Buying Wisely—How to Shop for a Wind System

The Importance of Reliability and Longevity

Wind turbines operate thousands of hours per year, often under harsh conditions. The wear and tear on a small wind turbine has been compared to putting 100,000 miles a year on a car. When you consider the tremendous forces they must endure under windstorm conditions, you can see that wind turbines take a real beating over time.

We recommend that you compare warranties, predicted lifetimes, and most importantly, the manufacturer's and turbine model's reputations, when shopping for a small wind system. Comparing products based on price or price/performance alone is not recommended. Turbine models must pass certain minimum reliability bench marks to be certified by the Energy Commission, but not all "CEC certified" wind turbines have the same expected reliability and longevity.

Performance at Low Wind Speeds

A common mistake made by small wind turbine buyers is putting too much emphasis on low wind speed performance. In reality, there is very little energy available in winds below about 12 mph due to the cubic relationship between wind speed and energy. For example, there is only one-eighth (12 percent) of the energy of a 12 mph wind in a six mph wind. For most locations it is the performance of the wind turbine between 12 mph and 20 mph that will have the biggest effect on overall energy production performance.

Compare Energy, Not Power

Wind turbines typically have a rated power, measured in kW, and a rated wind speed, measured in mph. The actual performance of a wind turbine is described by a performance curve of power output versus wind speed, called a power curve. Rated power, a measure of the power produced at a certain wind speed, is simply a point on the power curve chosen by the manufacturer. The problem is that turbine manufacturers choose different rated wind speeds, making direct comparisons of rated power a very misleading gauge of relative performance.

The best way to compare the performance of small wind turbines is to compare predicted energy production. The only predictions we recommend are those calculated in accordance with the performance estimating procedures developed by the American Wind Energy Association (AWEA). The AWEA methods assume standardized wind conditions, and their predictions produce figures that are like the Environmental Protection Agency's estimated gas mileage for cars. Like the mileage ratings for cars, your performance may vary, but you can nonetheless make useful product-to-product comparisons.

For most people, the most understandable unit of measure is monthly electricity production in kilowatt-hours (kWh). This is how you are billed by your utility. You may want to compare production estimates from your wind system dealer to your average monthly electricity use to see how much of your electricity needs the wind system would be likely to offset.

The best way to determine your average monthly electricity use is to look at your electric bills over the past year. If you do not have these records, you can get your history from your utility company. Simply add up the kilowatt-hours you have consumed each month and divide the total by 12.

Predicting Performance and Economics

The performance of a wind turbine depends on wind speed, tower height, wind shear, turbulence, and air density. Manufacturers typically supply charts or tables that take these variables into consideration and use standardized wind speed distribution models to predict energy production performance. Some also provide spreadsheet models that allow technically-minded consumers to perform their own calculations. For most people, however, the performance prediction tables provided by the manufacturer should be sufficient.

Economic analyses are also usually available from the manufacturer and/or dealer. The simple payback period—the number of years required to recoup the initial investment through saving in utility bills—is the most common figure of merit. Small wind systems usually have payback periods ranging from five to nine years. Because the expected operating life of a small wind turbine is typically 20 to 30 years (it varies between manufacturers), electricity generated by your system is virtually free for 11 to 25 years or even more. Some small wind turbines built in the 1930s are still operating 70 years later, so longer lifetimes are possible (provided that turbines are properly maintained and have occasional component overhauls or replacement).

Rate of return is another figure of merit that is used for comparing various investments. Current rates of return for small wind systems are typically between 10 percent and 25 percent after tax. When comparing a wind turbine investment with alternatives, such as CDs or mutual funds, it is important to factor in the taxes due

on most other investments. No taxes are due on the money you save with a wind electric system.

Tower Types—Considerations

The tower is an integral and important part of a wind electric system. While customers sometimes build their own towers or adapt existing towers for use with a wind turbine, most towers are purchased along with the turbine from the wind turbine manufacturer. Manufacturers carefully engineer these towers for a particular turbine, taking into account such factors as forces, vibration, deflection, blade clearance, and foundation requirements for various soil conditions. There are two main types of towers, guyed and self-supporting, as shown in Figure 2. Guyed towers have guy-wires anchored out some distance from the tower's base. Guyed towers are less expensive and have less expensive foundations, but they do take up more space. Self-supporting towers are heavier and more expensive because they lack the supporting guy wires, but they take up far less space.

The main structure of the tower will be either lattice type or tubular. Lattice towers have primary vertical members that are braced with numerous welded or bolted horizontal or diagonal braces. Lattice towers can be climbed for inspections and maintenance. Tubular towers are formed from pipe, tubing, or rolled sheet steel. They can only be climbed if they have climbing steps.

Some towers are hinged at their base so that they can be tilted up or down. Guyed tilt-up towers are very popular with very small wind turbines because they make it easy for the customer to install the system. As wind turbines get bigger and heavier, however, the forces involved with raising and lowering the machine introduce higher risks. In general, tilt-up towers are most appropriate for wind turbines up to about three kW.

Towers are usually fabricated from steel, galvanized for long-term corrosion protection. The galvanizing process coats the steel with zinc, providing a silver finish that dulls over time. Structural wood poles, such as telephone poles, make very good towers for smaller wind turbines. The difficulty in climbing these poles, however, makes inspections and maintenance more problematic.

In general, a higher tower finds better wind speed and wind quality (lower turbulence). In any case, you must have a tower that places the wind turbine well above trees and other obstacles in the vicinity. As a general rule, small wind turbines should be 30 feet above any obstacle within 300 feet. Pay particular attention to the direction of the prevailing wind.

Figure 2

Unless you are near an airport you do not need to get Federal Aviation Administration (FAA) approval or add aircraft warning lights, unless your turbine height exceeds 200 feet. Near airports, however, you will need to investigate FAA height restrictions relating to the distance from the closest runway. Your dealer, manufac-

turer, or the regional FAA office can help sort this out. If you are very close to an airport you may have to obtain FAA permission to erect your tower.

In order to obtain a building permit, most cities and counties in California require a structural analysis of the tower and foundations. The analysis, covering extreme wind and seismic conditions, must be stamped by a California-registered professional engineer. Manufacturers can typically provide this analysis, but you may be charged an additional fee to have your analysis individually stamped (wet stamped) by a structural engineer, civil engineer, or an architect.

Is It Too Good to be True?

"If it seems too good to be true, it probably is" are words to keep in mind when shopping for a small wind turbine. Over the years, a steady stream of "breakthrough" wind turbines has promised exceptional performance at an incredibly low price. Sometimes the claimed performance violates the laws of physics, promising more power than the total kinetic energy available in the wind. These often well-meaning entrepreneurs usually do not have the engineering background to perform proper calculations and tests.

There have also been out-and-out frauds in the wind business where the entrepreneur set out to intentionally defraud the public. This has been possible, at least in the short term, because most people aren't experts on the physics of wind energy, and they have a hard time sorting out reasonable claims from unreasonable ones. Who wouldn't be tempted to buy a new wind turbine "twice as efficient as anything on the market"?

Most of the popular models of small wind turbines operate at about the same efficiency. The energy production you should expect will be closely related to the swept area of the rotor blades, which is based on the diameter of the rotor. If you are offered a product that promises to run your whole house with a turbine that is much smaller than conventional products, it's time to start asking hard questions. Another way to protect yourself is to make sure the wind turbine manufacturer is a member in good standing of the American Wind Energy Association, and/or that the dealer who sold you the wind turbine can provide references from prior satisfied customers.

California Energy Commission-Approved Wind Turbines

Only Energy Commission-approved small wind turbines are eligible for the Commission's Buydown rebate. Small wind turbines must meet international design standards or show a substantial track record of successful operation in order to be approved by the Commission. Consumers can have confidence that such wind turbines are mature products that will provide years of reliable service. Remember that currently the Energy Commission's Buydown rebate program only covers grid-connected wind turbines up to 10 kW. Turbines too small for use in grid-connected applications or turbines larger than 10 kW are not listed by the Commission.

The American Wind Energy Association

The American Wind Energy Association (AWEA) is the trade association for the wind energy industry in the United States. AWEA has over 600 members, including all of the major American suppliers of small wind systems. AWEA members must subscribe to AWEA's Code of Ethics and manufacturers are strongly encouraged to follow AWEA standards for the performance rating of small wind turbines. The AWEA performance rating standard,

which is based on expected annual energy production, provides a consumer-friendly way of directly comparing products.

AWEA also provides a very informative web site [www.awea.org] with a special section on small wind systems and several E-mail based discussion groups on wind energy topics. One of the AWEA discussion groups, "aweawind-home," is dedicated to people interested in home-sized wind turbines. To subscribe, send an E-mail message to "awea-wind-homesubscribe@egroups.com."

Installing Your Wind System

Professional Installation vs. Self Installation

Homeowners can install small wind turbines, although most are installed by professional wind system dealers. Owners can install systems less expensively (saving typically 10 to 15 percent on installation costs), but the labor associated with self-installation does not qualify for rebates. In addition, self-installed systems carry a less comprehensive warranty. For example, the costs to diagnose a problem at your site or send faulty equipment back to the factory might not be reimbursed for a self-installed system. It will cost you more to have a dealer install your turbine, but you can expect a higher level of service, including complete installation services and aftersales support. In addition, professional installation labor costs qualify for the Energy Commission's rebate.

Step by Step

Follow these steps for installing a small wind system at your home or business:

1. Get One or More Quotes

The first step in installing a small wind system is to get one or more price quotes for equipment or a complete installation. You need a price quote or a purchase agreement to reserve a rebate from the California Energy Commission. A list of approved products can be found on the Energy Commission's web site at www.consumerenergycenter.org/buydown/certified_smallwind.html

2. Get a Rebate Reservation

You will need to reserve an Energy Commission rebate to ensure that you will receive it once your system is installed. Fill out a reservation form and submit it to the Energy Commission along with a letter of intent or purchase order, a vendor data record, and a copy of your utility bill. For new construction, a letter explaining that your home will be connected to one of the eligible utilities will suffice. More information and the required forms are available at: www.consumerenergycenter.org/buydown/forms.html

3. Inform Your Neighbors

Inform your neighbors about your plans to install your wind system well before you start the work. It is both common courtesy and smart neighborhood politics.

4. Permits

You will need a city or county building permit for the construction work, and the Energy Commission requires a final inspection sign off before you claim your rebate. Getting a building permit, particularly for taller towers, can be an arduous and expensive process. Installations along the coast may also need a permit from the Coastal Commission.

5. Utility Interconnection Agreements

You or your dealer should contact your local utility company several weeks prior to installing your system. The utility needs time to review your system and issue the necessary paperwork. Contact information for each of the utilities is listed in *Getting Help*.

6. Installation

Typically, the tower foundations and wire run are constructed before the wind system equipment is delivered to the site. Once these are done and the equipment is delivered, erecting the wind turbine and tower go surprisingly quickly.

7. Final Inspection

The completed wind system installation will be inspected by a local building inspector. If the inspector finds something that needs to be reworked, this must be done before you can receive a sign off on the installation.

8. Applying for Your Rebate

To receive your rebate, the Energy Commission requires you to submit your building permit showing final inspection sign off, the final purchase invoice, a copy of the full five-year warranty, and a recent utility statement verifying utility electrical service at the installation location. For a copy of the Reservation Confirmation and Claim Form, go to: www.consumerenergycenter.org/buydownforms.html.

9. Long-Term Maintenance

All wind energy systems will require periodic maintenance or inspections. Follow the manufacturer's recommendations for optimum performance and years of production.

Getting Help

California Energy Commission Buydown Rebate Program

- General Information:
  1516 Ninth Street. MS-25
  Sacramento, CA 95814
  Phone: (800) 555-7794 (in California)
  or (916) 654-4058 (outside California)
  E-mail: renewable@energy.state.ca.us
  Internet:
  www.consumerenergycenter.org/buydown/index.html
- List of Certified Small Wind Turbines:
  www.consumerenergycenter.org/buydowncertified_smallwind.html
- List of Registered Small Wind Turbine Dealers:
  www.consumerenergycenter.org/buydown/retailers.html

California Utility Companies

Pacific Gas & Electric Company

- General Information:
  Phone: (415) 973-2628
  Internet: www.pge.com
- Net Metering Application Form:
  www.pge.com/002_biz_svc/pdf/e_net_app.pdf
- Net Metering Tariff:
  www.pge.com/customer_services/business/tariffs/pdf/E-NEM.pdf
  www.pge.com/customer_services/business/tariffs/doc/E-NEM.doc
- Self-Generation Incentive Program:
  Phone: (415) 973-6436
  E-mail: selfgen@pge.com
  Internet: www.pge.com/002_biz_svc/selfgen/index.shtml

San Diego Gas & Electric Company

- General Information:
  Phone: (858) 650-6166
  Internet: www.sdge.com

- Self-Generation Incentive Program:
  [Administered Through the San Diego Energy Office]
  Phone: (619) 595-5630
  Internet: www.sdenergy.org/selfgen

Southern California Edison Company

- General Information:
  Phone: (626) 302-6242 or (626) 302-9680
  Internet: www.sce.com
- Self-Generation Incentive Program:
  Phone: (800) 736-4777
  Internet: www.scespc.com/sgip.nsf

National Renewable Energy Center

National Wind Technology Center
Internet: www.nrel.gov/wind

Small Wind System Manufacturers

Bergey Windpower
Phone: (405) 364-4212
Internet: www.bergey.com

Southwest Windpower
Phone: (520) 779-9463
Internet: www.windenergy.com

Wind Turbine Industries
Phone: (209) 267-1303
Internet: www.windturbine.net

American Wind Energy Association

- General Information:
  122 C Street, NW, Suite 380
  Washington, DC 20001
  Phone: (202) 383-2500
  Fax: (202) 383-2505
  E-mail: windmail@awea.org
  Internet: www.awea.org
- Small Wind Systems Section:
  www.awea.org/smallwind/california/html
- State-by-State Section for CA:
  www.awea.org/smallwind/california.html

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