

CLEAN ENERGY CHOICES



**Tips on Buying and Using
Renewable Energy at Home**

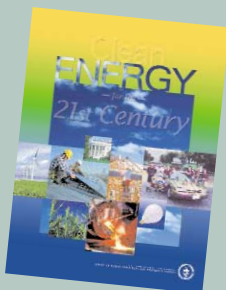


U.S. DEPARTMENT OF ENERGY
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

For more information on Clean Energy:

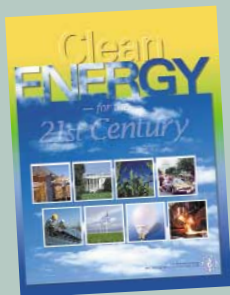
Clean Energy for the 21st Century brochure

This 8-page brochure describes the programs and initiatives of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. Discover the breadth and depth of our programs and the wide range of customers we serve.



This brochure will help you gain a greater understanding of the ways in which we're working to ensure a secure and prosperous energy future for America. Document no. DOE/GO-10099-911.

Clean Energy for the 21st Century poster



This attractive poster displays a variety of energy efficiency and renewable energy technologies. Great for science fairs and energy-related events, the poster is a colorful reminder of the impact that energy has on our everyday lives. Quantities are limited to five copies per request.

To order the Clean Energy for the 21st Century brochure and/or the poster, visit our Web site at www.eren.doe.gov/cleanenergy or call 1-800-363-3732.

Our Web site also features downloadable versions of the brochure, information on current clean energy events, related links, and other information.

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INTRODUCTION

A Consumer's Guide to Renewable Energy

What is Renewable Energy?

Certain forms of energy are called “renewable” because these fuel sources are constantly replenished and will not run out. Renewable energy—like the sun and wind—is readily available throughout the United States. Renewable energy technologies take this energy and convert it into usable forms of energy—most often electricity, but also heat, chemicals, or mechanical power. These technologies are often described as “clean” or “green” because they produce little or no pollutants.

Most renewable energy comes directly or indirectly from the sun. The sun's rays transmit solar energy that can heat and light homes, heat water, cook food, generate electricity, and power industrial processes. Heat from the sun causes air temperature differences that, along with the Earth's rotation, cause the wind to blow. The wind powers generators that

produce electricity or mechanical energy. Sunlight is vital to growing plants and trees, also called biomass. Using biomass to generate electricity, fuel vehicles, and yield chemicals is called bioenergy.

Hydropower uses the power in flowing water to operate turbines that generate electricity. The hydrologic cycle, in which water is evaporated into the atmosphere and then falls back to Earth as rain or snow, is powered by the sun. But not all renewable resources come directly from the sun. Geothermal energy uses the heat deep inside the Earth to produce electric power.

Mankind has used renewable energy for thousands of years. Sunlight gives light and warmth, wind powers sailboats, biomass from trees makes fires, water turns turbines, and geothermal hot springs are used for practical and spiritual purposes.

Homes in all regions of the United States can take advantage of renewable energy.





Photovoltaic panels produce renewable energy for the home.

continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often.

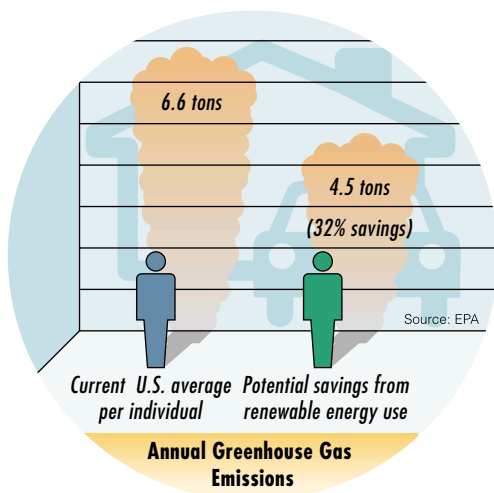
Other pollutants are released into the air, soil, and water when fossil fuels are burned. These pollutants take a dramatic toll on the environment. Air pollution contributes to lung diseases like asthma. Acid rain from sulfur dioxide and nitrogen oxides harms plants and fish. And nitrogen oxide contributes to smog.

Energy independence is another reason to use renewable energy. The United States imports more than 50% of its oil, up from 34% in 1973. Foreign oil imports can be disrupted by political upheavals, trade disputes, and embargoes. Replacing some of our petroleum with biofuels made from organic matter could save money and strengthen our energy security.

Why Use Renewable Energy Now?

Today we cook food, fuel cars, and heat homes primarily by burning fossil fuels that were created over millions of years. Using coal, oil, and natural gas is a convenient way to meet our energy needs, but these fuels are in limited supply. They are being used far more rapidly than they were created, and they will eventually run out. In addition, a significant portion of the country's nuclear capacity will likely be retired by 2020. At the same time that our nuclear capacity drops and fossil fuel supplies decline, our need for electricity will grow. U.S. electric generation capacity needs are projected to increase by 33% during the next 20 years (Energy Information Administration). Renewable energy can help fill this gap.

Even if we had an unlimited supply of fossil fuels, renewable energy is attractive because it is better for the environment. Burning fossil fuels sends greenhouse gases into the atmosphere. These gases trap the sun's heat in the atmosphere, contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen in the past century. If this trend



Using renewable energy reduces greenhouse gas emissions, which contribute to global warming.

What Renewable Energy Technologies Make Sense for Consumers Now?

Many renewable energy technologies make sense for consumers today. Prices have dropped during the past 20 years and the technologies have improved. Using renewable energy is easier than ever. Alternative fuels such as biodiesel and ethanol are becoming more widely available, and new vehicles that feature advanced fuel system technologies are now on the market. Utilities are starting to offer “green power” programs, in which you can opt to obtain electricity from renewable energy sources. Many states are in the process of deregulating electric utilities, which means that in the coming years, you will be able to choose your electric supplier just like you choose a long-distance phone company now. In California, Pennsylvania,

It's better for the environment (and cheaper) to improve the efficiency of your energy use than to produce more energy to meet inefficient consumption. Before investing in renewable energy technology, take stock of your current energy usage. Could you increase the energy efficiency of your home? To find out, conduct a home energy audit, which will tell you where you are using the most energy in your home. A companion booklet available from the U.S. Department of Energy (DOE), *Energy Savers: Tips on Saving Energy & Money at Home*, provides information on energy audits and is an excellent resource for improving the energy efficiency of your home. (It's available online at www.eren.doe.gov/consumerinfo/energy_savers.) By making a few of the improvements suggested in the booklet, you can save 10% to 50% on your energy bills.



Whether you purchase green power, add renewable energy to your home, or drive an alternative fuel vehicle, it is better for the environment and cheaper to reduce your energy use first, then meet your energy needs with renewables.

Massachusetts, Illinois, and other states, competitive markets are under way and green marketers are selling electricity from renewable energy sources like wind, biomass, and hydropower.

Other Clean Energy Sources

Even by combining energy efficiency measures and renewable energy generation, most of us will have to use fossil fuels to meet our energy needs. But we can use the cleanest energy sources available. For instance, natural gas burns much cleaner than other fossil fuels, and can be used to heat your home, provide water heating, and power appliances such as clothes dryers, usually at a



Homes of all sizes and styles can use renewable energy for power, heating, cooling, and lighting.

This thermal photograph shows heat escaping from the home in the white, yellow, and red areas. Efficiency improvements can save 10% to 50% on energy bills.



lower cost than electricity. Natural gas vehicles also provide a cleaner alternative to gasoline.

How to Use this Booklet

This booklet will help you assess which clean energy choices are right for you. These renewable energy technologies are available today and are being used by homeowners across the country. We also tell you what renewable energy technologies will be available soon and describe the technology developments that are expected during the next 20 years. And, at the end of each chapter you will find a list of resources to help you find further information on the top-

ics covered. Many of the resources listed here were used as references in developing this booklet. The organizations and Web sites listed will get you started buying and using renewable energy in your own home.

We also address how to make sure you get the most for your investment. Taking a few moments to read this booklet will help you become a more savvy energy consumer and, after you choose to use clean energy, will help the environment by reducing pollution and preserving our natural resources.

Renewable Energy and Energy Efficiency RESOURCES

Energy Efficiency and Renewable Energy Clearinghouse (EREC)

1-800-363-3732

P.O. Box 3048

Merrifield, VA 22116

TDD# 1-800-273-2957

EREC is the U.S. Department of Energy's source for information and publications on renewable energy and energy efficiency.

Energy Efficiency and Renewable Energy Network (EREN)

<http://www.eren.doe.gov>

EREN is the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's primary Web site. Through this site you can access literally hundreds of pages containing information and resources on renewable energy technologies. Be sure to visit the Consumer Energy Information site (<http://www.eren.doe.gov/consumerinfo/>) for information on how to put renewable energy to work in your life.

BUYING GREEN POWER

Sorting Out Your Choices

Just a few years ago, we did not have the ability to choose our electric service. Currently, the electricity industry is undergoing changes that will bring choice to many consumers across the country. Already, utility customers can choose to obtain electricity from clean generation sources—also known as green power.

Green power is electricity that is generated from renewable energy sources like the sun, wind, water, plants, and the Earth's internal heat. Facing deregulation and competition, utilities are focusing on their customers' preferences. In survey after survey, customers request electricity generated by green power, and utilities are responding.



Wind energy is one type of green power.

What is Green Pricing?

Because using these technologies generally costs more than existing fossil-fuel generation, some utilities are selling consumers green power at a slightly higher cost than fossil-fuel generated electricity, called green pricing. More than 50 green pricing programs are under way across the country. One way to look at green pricing programs is that they offer you a “vote” in what types of energy sources your utility will use. Your vote could result in new renewable energy facilities being built. After all, more than 110 megawatts of new renewables capacity has been installed to serve green power customers, with about another 105 megawatts planned. For example, the Public Service Company of Colorado's green pricing program for wind energy,

Green power is transmitted by the electric grid, just like electricity from other power plants.



A Note About Electricity Terms

When describing electricity production, the terms electric power (or capacity) and electric energy (or electricity) are often used. “Power” is the ability to do work and “energy” is the actual performance of the work, or the use of that ability over a period of time. The distinction is like a person’s ability to lift weights and the actual lifting of the weights; although they have the capacity to lift the weights, until they actually lift them, they do not expend the energy.

The unit used in this text for electric power, or capacity, is the megawatt. The unit used for electric energy, or electricity, is the kilowatt-hour. It takes 60 watts of capacity to power a 60-watt lightbulb. To

light a 60-watt lightbulb for 1,000 hours requires 60,000 watt-hours of electricity, or 60 kilowatt-hours. To power 1 million 60-watt lightbulbs, 60 megawatts of capacity is required.



The distinction between capacity and electricity is important. A wind turbine, for instance, might have a 1-kilowatt capacity, but its electricity production per day in kilowatt-hours depends on how often and how strongly the wind blows. If a strong

wind blows for 24 hours, the wind turbine will produce 24 kilowatt-hours; if the wind only blows strongly for 8 hours and doesn’t blow at all the rest of the day, the wind turbine will produce 8 kilowatt-hours of electricity.

LADWP Green Power for a Green L.A. Green Pricing Program

With 20,000 customers electing to pay a slight premium for green power, the Los Angeles Department of Water and Power’s (LADWP’s) Green Power for a Green L.A. program is a success. This green pricing program has the highest number of subscribers in the country. The 20,000 subscribers, 1.5% of the utility’s customers, can purchase green power for 20% of their electricity needs—an average customer uses about 500 kilowatt-hours (kWh) each month—for \$3.00 per month. Customers will receive power from a newly constructed geothermal plant, and the utility is negotiating to purchase wind and biomass energy for the program.

When customers sign up for the program they receive two compact fluorescent light bulbs and a home energy survey on compact disk. By using the light bulbs, taking the survey, and then adopting its recommendations, cus-

tomers should be able to help reduce their electricity usage. Although the rate for new green power is 6% higher than for conventional electricity, the utility states that customers who use the light bulbs and reduce their energy use will see little or no increase (and perhaps a decrease) in their electricity bills. The utility hopes to sign up 200,000 customers in the next two or three years.



Green power marketers disclose the sources of the electricity they sell.

WindSource, has been so successful that the utility added more wind turbines to meet customer demand.

What is Green Power Marketing?

In some parts of the country, consumers can choose not only how their electricity is generated, but also who supplies it.

Utility deregulation has occurred in some states and consumers can choose an electricity supplier. Electricity markets are now open to competition in California, Massachusetts, New Jersey, Pennsylvania, and Rhode Island. A number of other states are phasing in competition, allowing some customers to choose their electrical supplier. Green power marketers, selling green products and services to residential, commercial, and wholesale customers, are active in

Power Content Label		
Energy Resources	Product A* (projected)	1998 CA Power Mix** (for comparison)
Eligible Renewable	55%	11%
- Biomass and Waste	-	2%
- Geothermal	-	5%
- Small Hydroelectric	-	2%
- Solar	-	<1%
- Wind	-	1%
Coal	10%	20%
Large Hydroelectric	11%	22%
Natural Gas	16%	31%
Nuclear	8%	16%
Other	<1%	<1%
TOTAL	100%	100%

* 50% of Product A is specifically purchased from individual suppliers.
 ** Percentages are estimated annually by the California Energy Commission based on the electricity sold to California consumers during the previous year.

For specific information about this electricity product, contact **COMPANY NAME**. For general information about the Content Label, contact the California Energy Commission at 1-800-555-7794 or www.energy.ca.gov/consumer

California and Pennsylvania, and green power products have also been introduced in New England.

Because of the way the electric grid works, the renewable energy that you buy is not necessarily delivered to your home. Instead, that power is delivered into the electrical grid, along with elec-

Green-e Renewable Electricity Certification Program: Protecting Green Power Consumers

The nonprofit Center for Resource Solutions established the Green-e Renewable Electricity Certification Program to ensure that consumers who purchase "green" power are getting exactly that. The Green-e logo on an electricity product means:

- At least 50% of the electricity supply for the product comes from renewable electricity resources.
- Any nonrenewable part of the product has lower air emissions than the traditional mix of electricity (for example, natural gas).
- The company offering the product agrees to abide by the Green-e Program's Code of Conduct, which requires that providers disclose the sources of the electricity they sell.
- The product does not contain any nuclear power.
- One year after deregulation, the product must contain at least 5% new renewable electricity. Green-e intends to increase the new renewables requirement each year.
- The company offering the product agrees to undergo a biannual review of advertising materials to ensure they are not making any false or misleading statements about their products.
- The company offering the product agrees to undergo an annual audit by a third party to ensure that they have purchased enough renewable power to satisfy what they sold to customers.

 rganizations as diverse as Episcopal churches, Kinko's, New Belgium Brewing Company, and the Pennsylvania Department of General Services (DGS) are running on green power. Although these organizations seem to have little in common, all are committed to using renewable energy to protect the environment.

The California Episcopal Diocesan Convention adopted a resolution instructing the State's 87 churches to buy renewable power to help cut greenhouse gas emissions. Each church that buys green power gets a \$250 donation from the green power marketer, which also donates \$20 to the church for each parishioner who signs up.

Kinko's, a provider of business services and document copying at its retail stores, is also buying green power in California and Pennsylvania. The company has also retrofitted more than 800 branches with energy-efficient lighting.

The New Belgium Brewing Company, a microbrewery in Fort Collins, Colorado, is

buying 100% wind energy from the local utility. To meet the ten-year agreement with New Belgium, a third turbine will be added to a wind energy project across the border in Wyoming. The company's 70 employees voted to purchase wind power even though it will reduce their bonuses. New Belgium had first looked at ways to recover CO₂ produced during fermentation, but concluded that displacing coal generation with wind energy to meet their energy needs would decrease CO₂ by more than six times that of a CO₂ recovery system.

The Pennsylvania DGS is purchasing green power for more than a dozen state accounts, representing about 5% of the DGS power purchase for 2000. Part of the energy will be supplied by a new ten-megawatt wind energy plant under construction in Garrett, Pennsylvania. Agencies receiving the power include the Pennsylvania Department of Corrections, capital buildings in Harrisburg, state office buildings, and 14 universities.

tricity from other power sources.

Depending upon the supply of renewable energy, on some days the green marketer may supply more green power and on some days, less. But by the end of the year, the green marketer must supply enough renewable energy to the grid to equal its green power commitments to consumers. To verify the claims of green marketers, the nonprofit Center for Resource Solutions started the Green-e program, which requires green marketers to include at least 50% renewables in their products and sets other criteria that green marketers must meet to bear the Green-e logo (see sidebar).

How Do Competitive Markets Work?

In competitive markets, electricity is still delivered to your home by the utility via existing transmission and distribution lines. Your utility bill will show distribution charges and generation charges separately. Distribution charges are paid to the utility, which is responsible for maintaining the distribution and transmission lines and delivering electricity to you. Generation charges are paid to the power supplier.

Today's Clean Energy Choices

The following briefly describes renewable energy technologies that might be offered in green pricing programs or competitive markets in your area.

If you do not currently have the option to choose your electricity supplier, contact your utility to find out what their plans are regarding utility deregulation and future power plant construction.



Hydropower produces 10% of the nation's electricity.

Hydropower

Hydropower is the most mature and largest source of renewable power, producing about 10% of the nation's electricity. Existing hydropower capacity is about 77,000 megawatts (enough electricity to meet the needs of 35 million households).

Hydropower plants convert the energy in flowing water into electricity. The most common form of hydropower uses dams on rivers to retain large reservoirs

of water. Water is released through turbines to generate power. Other hydropower plants, called "run of the river," do not dam up large amounts of water, but divert water from the river and direct it through a pipeline to a turbine.

Hydropower plants produce no air emissions, but can affect water quality and fish and wildlife habitats. To lessen these impacts, many hydropower projects are diverting a portion of the flow around the dams to mimic the natural flow of the river. Although this helps fish and wildlife, it also reduces the power plant's output. Fish ladders and other approaches are also being used to assist upstream migration of fish like salmon, and further measures such as improved turbines, offer the promise of reducing fish kills in downstream migration. In addition, low-impact hydropower plants have been designed and are operated to minimize impacts on the river.

Biomass

Biomass is already this country's leading non-hydro resource of renewable energy, accounting for more than 7,000 megawatts of installed capacity. Biomass fuels come from a variety of sources. The majority consist of waste from industrial processing—forestry and wood products, agriculture and food by-products, and other industries such as construction and transportation that must dispose of large quantities of unused biomass.

Geothermal energy originates deep within the Earth and produces minimal emissions.

For utilities and power generating companies with coal power plants, replacing some coal with biomass may represent one of the least costly renewable energy options. As much as 15% of the coal may be replaced with biomass without significant modifications to the existing plant. Biomass has less sulfur than coal; therefore, less sulfur dioxide is released into the air.

Gasification—converting the biomass to a gas and burning it in a gas turbine—is another way to generate electricity from biomass.

Electricity can also be generated using landfill gas, produced by the decay of biomass in landfills. Landfill gas consists largely of methane, which can be burned in a boiler to produce steam for electricity generation or for industrial processes. Thus, this potentially harmful gas can be used in a beneficial way.

Biomass that would go to the landfill can be burned in a power plant instead.



Geothermal Energy

About 2800 megawatts of geothermal electric capacity are produced in the United States annually. Geothermal power plants utilize naturally occurring steam and hot water, which originate under the Earth's surface. All of the geothermal plants in the United States are in California, Hawaii, Nevada, and Utah. California already relies on geothermal energy to provide 6% of its electricity.

Geothermal power plants use steam to rotate a turbine, which powers an electric generator. Another growing use of geothermal energy is to heat buildings directly using the hot water. More than 500 megawatts of direct geothermal heating capacity are installed today.

Wind Energy

Currently, wind energy capacity amounts to 2500 megawatts in the United States. Although much of the nation's wind capacity—about 1600 megawatts—is in California, about half that much capacity

Wind turbines convert wind into electricity.

The photovoltaic cell is the basic unit in a PV system. The cell is made from semiconductor materials similar to those used in computer chips. Sunlight is absorbed by the materials, freeing electrons from their atoms, and allowing the electrons to flow through an external circuit to generate electricity. The greater the intensity of the sunlight, the more power generated in the cell.

Since photovoltaic systems use no moving parts to produce electricity, they are durable power systems with low maintenance, high reliability, and low environmental impacts. Because their basic building block, the module, is small, photovoltaic systems are suitable for both large and small electricity supply applications. For example, systems of several hundred kilowatts in size have been built in a number of locations.

Photovoltaic cells can produce electricity even on cloudy days.

was added in the Midwest and Great Plains during the last several years. Wind energy has been the fastest growing source of energy in the world since 1990, increasing at an average rate of 25% per year, a trend driven largely by dramatic improvements in wind technology.

Wind turbines operate on a simple principle. The energy in the wind is used to rotate blades around a hub. The hub is connected to the main shaft, which spins a generator. Utility-scale turbines range in size from 50 kilowatts to one or two megawatts. Small turbines, below 50 kilowatts, are used for homes, farms, ranches, telecommunications, or water pumping.

Photovoltaics

Photovoltaic (PV) cells—also called solar cells—produce electricity from sunlight. A small, but growing amount of PV generation is connected to the grid in 36 states.

Green Power: A Look Toward the Future

In the future, power lines might carry phone and Internet service to your home. Deregulation and competition in the electric power industry mean that most consumers will be able to choose not only green power, but possibly other services as well. Electric utilities may be split into separate generation and transmission/distribution companies. These companies will likely offer expanded service lines in addition to the usual electricity generation and transmission. So plugging into the Internet might mean literally plugging into your wall socket.



Green Power RESOURCES

Bioenergy Initiative

(U.S. Department of Energy)

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

DOE's Bioenergy Initiative seeks to develop a strong, integrated bioenergy industry to increase the production of bio-based fuels, chemicals, and power.

Green Power Network

<http://www.eren.doe.gov/greenpower/>

The Green Power Network provides news and up-to-date information on green power markets and green-pricing programs. On this site you will find information on green power providers, product offerings, and consumer issues and policies affecting green power markets.

Green-e Certification

(Center for Resource Solutions)

<http://www.green-e.org/>

The nonprofit Center for Resource Solutions established the Green-e Renewable Electricity Certification Program in order to ensure that consumers who purchase "green" power are getting what they pay for. Visit this site to learn more about certification, products, and providers.

SELF-GENERATION

Making Your Own Power

At first glance, generating your own electricity using renewable fuel sources seems like the ideal way to avoid monthly utility bills. For some homeowners, self-generation is a choice that makes sense for their circumstances and fits into their values. However, self-generation involves investing your money and your time doing research, comparing products, and maintaining your system. Depending upon your situation, you might not end up saving money, but homeowners who do choose to generate clean energy like being independent and knowing that they are minimizing their impacts on the environment.



A single wind turbine can power a home.

When is Self-Generation Appropriate?

Self-generation might be right for you if:

- A grid connection is not available in your area or can be made only through an expensive line extension. (The cost of running a power line to the utility grid at a remote site can be prohibitive, ranging from \$15,000 to more than \$50,000 per mile, depending upon the terrain.)
- You have an interest in gaining energy independence from your utility.
- You would like to reduce the environmental impact of electricity production.
- Your site has adequate renewable resources.
- You have a strategy for meeting your energy needs when renewable resources aren't available.
- Your state or utility provides for net metering, which allows you to interconnect your system with your utility and sell any excess generation to your utility.

In addition to considering the above, you should also:

- Research potential legal and environmental obstacles.
- Obtain cost and performance information from manufacturers.
- If cost-effectiveness is a key consideration, perform a complete economic analysis that accounts for a multitude of factors.

The Benefits of Net Metering

Net metering allows homeowners with self-generating systems to sell their excess power to the utility. Net metering can make self-generation economically attractive to you, depending on how it is implemented in your state. The best situation is when your meter turns backward and generation is fed into the utility



grid. This essentially allows you to bank your generation until you need it. You are selling your excess power to the utility at the same rate you pay for electricity, called the retail rate. In some states, a less attractive option is available, in which you sell your generation to the utility at the utility's avoided cost. This is the cost the utility would have to pay to purchase electricity on the wholesale market. The utility's avoided cost can be as much as ten cents per kWh less than the retail rate. Your utility will specify the interconnection requirements for net metering. Check with your utility before planning to take advantage of net metering.

the time, such as refrigerators, whereas others use electricity less often, like power tools. To determine your total energy consumption, multiply the wattage of the appliance by the number of hours it is used in a day. Some appliances do not give the wattage, so you may have to calculate the wattage by multiplying the amperes times the volts. (Information about wattage, amperage, and voltage can be found on a sticker or metal plate attached to the appliance itself or on a tag attached to the electric cord.) After adding the totals for each appliance, you can decide what power output you need for your renewable energy system.

- Understand the basics of small renewable energy systems.
- Review possibilities for combining your system with other energy sources, backups, and energy efficiency improvements.
- Plan for ongoing system maintenance.

Analyzing Your Loads

Performing a detailed load analysis is critical to sizing your renewable energy system. A load analysis is a measure of your daily energy needs. To conduct a load analysis, list all of your daily energy loads. A load includes anything that uses electricity from your power source, such as lights, heating and air conditioning, televisions, radios, and small and major appliances. Some loads use electricity all

Sample Load Analysis

Load	Daily Use (hrs)	x	Wattage	=	Total Energy Consumption
Radio	2		25		50
Lamp (fluorescent)	3		27		81
VCR	0.5		30		15
Television	6		150		900
Clothes Washer	1		500		500
Dishwasher	1		300		1300
Electric furnace (winter)	8		8500		68,000
Total Daily Energy Consumption					70,846 watt-hours

Note: This example shows a partial load analysis. You will need to include all items that require electricity to operate.

Analyzing Your Site and Sizing Your System

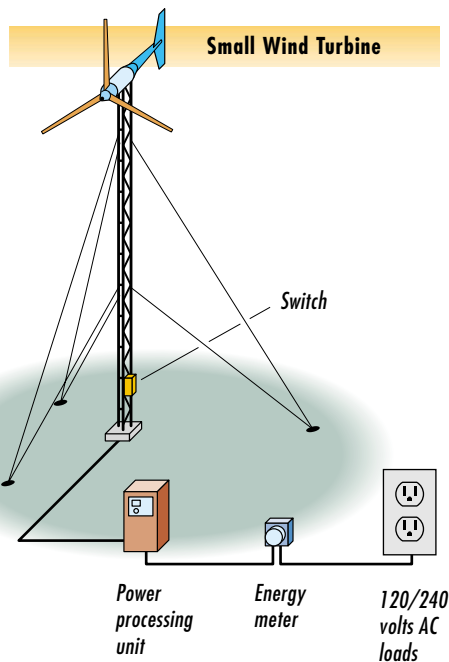
Your load analysis is a key component of sizing your renewable energy system. The renewable resource available at your site is the other key component.

Wind Energy Systems

All wind energy systems consist of a wind turbine, a tower, wiring, and the “balance of system” (BOS) components: controllers, inverters, and/or batteries.

Home wind turbines consist of a rotor, a generator mounted on a frame, and (usually) a tail. With 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 tail keeps the turbine facing into the wind.

A 1.5-kW wind turbine can meet the needs of a home requiring 300 kWh per month, for a location with a 14-mile-per-hour (6.26-meters-per-second) annual average wind speed. The manufacturer will provide you with the expected annual energy output of the turbine as a function of annual average wind speed and elevation at the site. The manufacturer will also provide information on the maximum wind speed in which the turbine is designed to operate safely. Most turbines have automatic speed-gov-



This system produces alternating current for home use.

erning 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 select the turbine size.

Because wind speeds increase with height in flat terrain, the turbine is mounted on a tower. Generally speaking, the higher the tower, the more energy 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 30 feet (9 meters) above any obstacle that is within 300 feet (90 meters) of the tower. An important consideration about tower height is zoning. Many local governments place limitations on the installation of structures taller than 30 to

35 feet. Because taller towers are almost always preferred, a review by the local zoning authority may be required. This is an especially important issue in urban and suburban areas.

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. Most towers have just three earth anchors. Guyed towers with four earth anchors 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

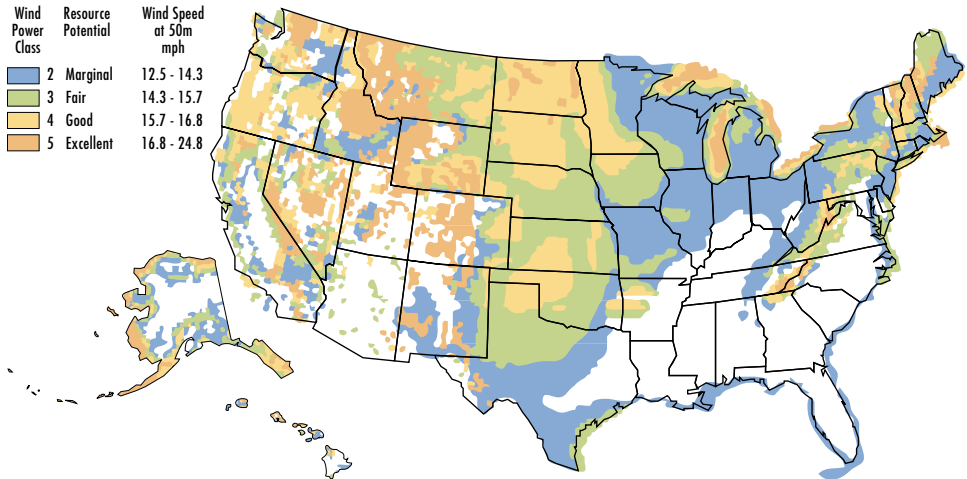
should be avoided.

Wind turbine warranties vary between one and five years depending on the manufacturer.

Estimating Wind Resources at Your Site

Wind can be a difficult resource to estimate. For one thing, wind resources are extremely site dependent. The U.S. Department of Energy has compiled wind resource maps that are available from the American Wind Energy Association and the National Technical Information Service. These maps are excellent sources for regional information and can show whether wind speeds in your area are generally strong enough to justify further investigations. Checking with your local airport or weather bureau will help give you an idea of the wind speeds in your area, but your site may experience higher or lower average wind

Average Annual Wind Power Resource

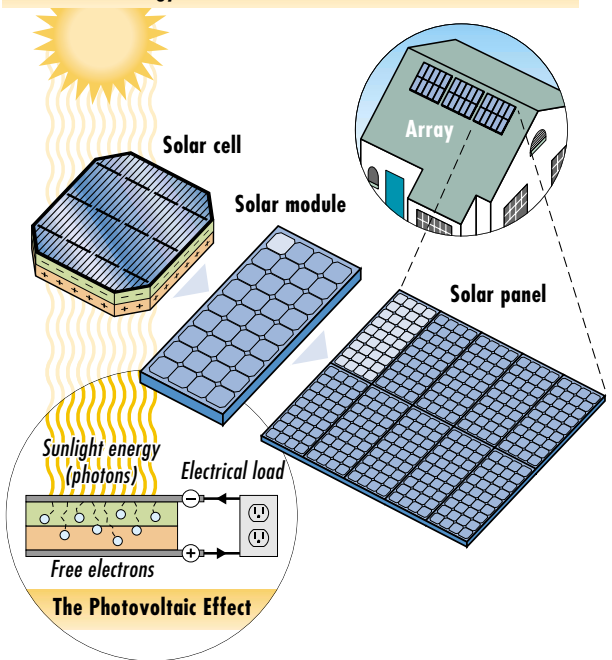


speeds. Your site should have *average* wind speeds of at least nine miles per hour or more.

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 site for a year. You can do this with a recording anemometer. The most accurate readings are taken at “hub height” (the elevation at the top of the tower where you will install the wind turbine).

The standard wind sensor height used to obtain data for the DOE maps is 33 feet (ten meters). Because a small wind turbine can be purchased for about the same price as an anemometer, another option is to install a small turbine and measure its performance for a year. A dealer can then predict the performance of a larger machine sized to meet your loads.

You can have varied wind resources within the same property. If you live in hilly 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 winds 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 buildings, which could block the wind.



Solar Energy (PV) Systems

Photovoltaic cells produce direct-current (DC) electricity. About 40 cells are joined together in enclosed, protective casings called modules. About ten of these modules are mounted in one PV panel. These flat-plate PV panels can be mounted facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day. About ten to 20 PV panels can provide enough power for a household; for large electric utility or industrial applications, hundreds of arrays can be interconnected to form a single, large PV system.

Two primary types of PV technologies available commercially are crystalline silicon and thin film. In crystalline-silicon technologies, individual PV cells are cut

from ingots of crystalline silicon. In thin-film PV technologies, the PV material is deposited on glass or thin metal that mechanically supports the module.

Thin-film-based modules are produced in sheets that are sized for specified electrical outputs.

Several companies have started integrating PV products into building materials. For example, PV shingles look like traditional asphalt shingles and can be installed by roofers. Other similar technologies are standing-seam metal roofs incorporating PV and modules that look like slate roofing materials. Soon to be widely available is glass for windows and skylights that generates electricity. The benefit of these technologies is that they replace building materials that you would buy anyway.

The cost over 20 years will amount to between 20 and 40 cents per kilowatt-hour. However, costs will vary quite a bit depending on your location, solar resources, and available subsidies.

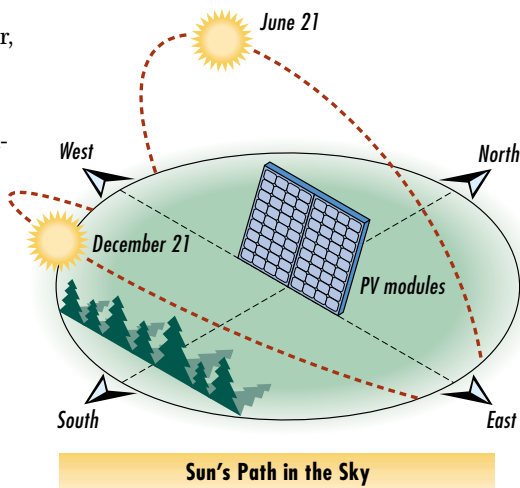
In addition to PV modules, the components needed to complete a PV system may include a battery charge controller, batteries, an inverter or power control unit (for alternating-current loads), safety disconnects and fuses, a grounding circuit, and wiring.

Estimating Solar Resources at Your Site

There are three factors to consider when determining whether your site is appropriate for photovoltaics.

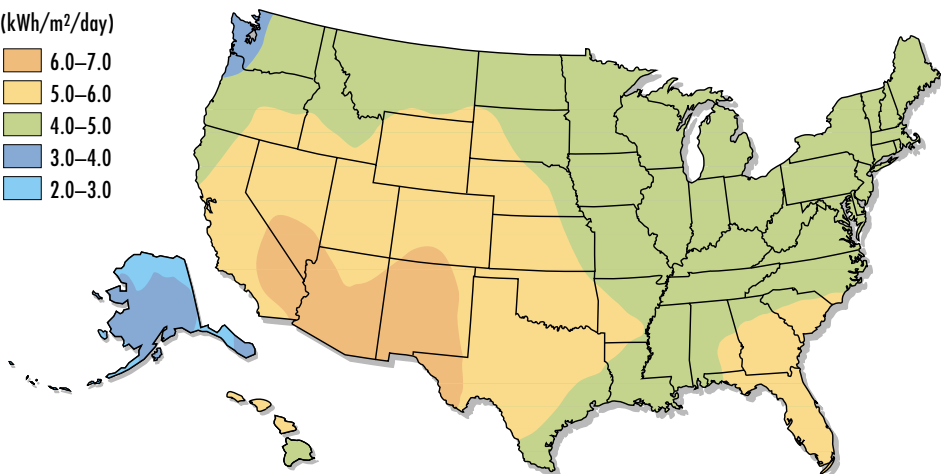
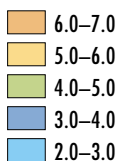
1. Systems installed in the Northern Hemisphere must have southern exposure. For maximum daily power output, PV modules should be exposed to the sun for as much of the day as possible, especially during the peak sun hours of 10 a.m. to 3 p.m.
2. The southern exposure must be free of obstructions such as trees, mountains, and buildings that might shade the modules. Consider both summer and winter paths of the sun, as well as the growth of trees and future construction that may cause shading problems.
3. The unobstructed southern exposure must also have appropriate terrain and sufficient space to install the PV system.

Unlike utility power plants, which produce electricity constantly despite the time of day and year or the weather, the output of PV modules is directly



Average Annual Solar Energy Resource

(kWh/m²/day)



related to time and weather. Where you live will affect the number of PV modules you will need for power, because different geographic regions experience different weather patterns. However, PV systems still produce electricity in bad weather. On cloudy days, they can produce up to 80% of their potential energy delivery; on hazy, humid days, about 50%; and on extremely overcast days, they still produce up to 30%. Seasonal variations affect the amount of sunlight available to power a PV system.

When designing a PV system, be sure your installer obtains data specific to your area. The National Oceanic and Atmospheric Administration began collecting solar data nearly 20 years ago. The National Renewable Energy Laboratory's (NREL's) Renewable Resource Data Center can provide solar resource information, as can the Energy Efficiency and Renewable Energy Clearinghouse. Some state energy offices also have solar data-collection programs to assist solar designers. Finally, books are

available that contain solar data on most major cities in the United States.

A Web site is available that will walk you through calculating your loads and sizing your PV system to meet your needs. See <http://www.nrel.gov/buildings/pv/>.

Microhydropower Systems

If you are fortunate enough to have a stream running through your property, you might be able to generate hydropower. Microhydropower is a term used to describe very small hydropower systems. The definition of microhydropower varies, but is generally below 300 kilowatts. At this size, the system can be operated as a “run of the river” installation, without the need for significantly altering the site with dams for water storage.

Microhydropower systems use water pressure to move a mechanical device (the turbine), which then drives a generator to produce electricity or performs work directly. The advantages of micro-

hydropower systems are that they run continuously and the energy produced is predictable. However, river flows vary across the seasons, and year-to-year, so accurately determining the resource is very important.

The key determinates of the available resource are head and flow. Head is the vertical distance the water falls. Flow is the volume of the water. The power generated by a hydropower system is the product of the head, the flow, and the efficiency of the equipment.

The major components of a typical microhydropower system include the intake from the river, the penstock, the turbine, and the generator. The penstock delivers the water to the turbine, which rotates and powers the generator. Batteries may be used for storage. Most microhydropower systems use a DC generator to charge a battery bank. An inverter may be used to produce AC electricity.

Estimating Microhydropower Resources at Your Site

A dealer will want to know the head and flow at your site. You can hire someone to assess your site resources or do it yourself.

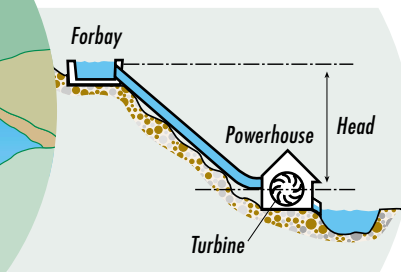
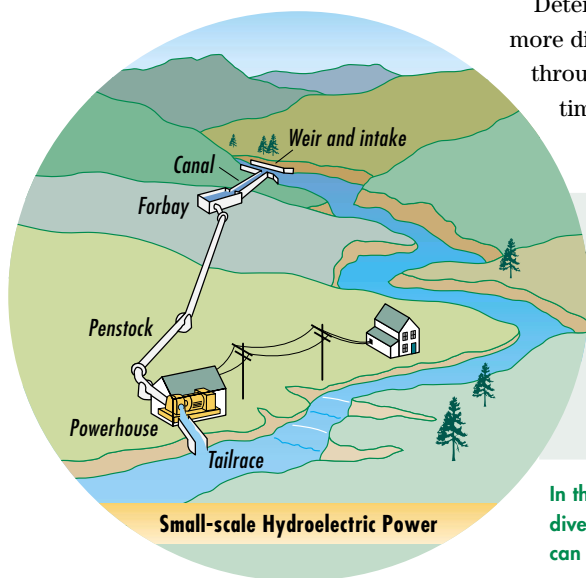
Measuring Head

You'll need to know the vertical distance from the water intake to the turbine. If you do the assessment yourself, you will need to make some decisions about where to locate the water intake and turbine. If you hire a dealer, they will determine the system location and measure the head for you.

There are a number of ways to measure head, using surveying techniques, altimeters, or a simple water-filled tube and pressure gauge. Whichever method is used, three separate measurements should be taken at your site to verify accuracy.

Determining Flow

Determining flow at a site is much more difficult to measure. Flow varies throughout the year; therefore, a one-time measurement is not very



In this microhydropower system, water is diverted into the penstock. Some generators can be placed directly into the stream.

useful. Ideally, a hydrological study should be performed, which involves checking records of regional rainfall and water flows.

Hybrid Power Systems

According to many renewable energy experts, a stand-alone “hybrid” system that combines generation sources, such as wind and PV, offers several advantages over a single generation 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 PV 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 PV modules 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 PV modules and batteries in the system. Keep in mind that the storage capability must be large enough to supply electrical needs during noncharging periods. Battery banks are typically sized for one to three days of operation.

A general rule is to design the renewable energy system to provide 80% of the energy and use fossil fuels for the remaining 20%.



Energy stored in backup batteries can provide power when renewable resources are not available (at night or when the wind isn't blowing).

Balance-of-System (BOS) Equipment

In addition to wind turbines, PV modules, or a microhydropower generator, you must purchase BOS equipment. This may include battery charge controllers, batteries, inverters, wires, conduit, a grounding circuit, fuses, safety disconnects, outlets, metal structures for supporting the PV modules, and any additional components that are part of the system.

In very small systems, 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 electric-



Solar energy systems make sense for some homeowners.

ity 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 home buyers. We'll discuss BOS configurations first for loads requiring direct current, then for loads needing alternating current.

In grid-connected systems, the only additional equipment needed is an inverter that makes the turbine output electrically compatible with the utility grid. No batteries are needed. Work with the manufacturer and your local utility on this process.

When examining the costs of wind turbines, PV modules, or microhydropower generators, remember that these costs do not include the cost of BOS equipment.

Direct-Current System Equipment

Battery. In off-grid systems, the battery stores electricity for use at night or for meeting loads during the day when the generation source (wind turbines, PV, or microhydropower) is not generating sufficient power to meet load

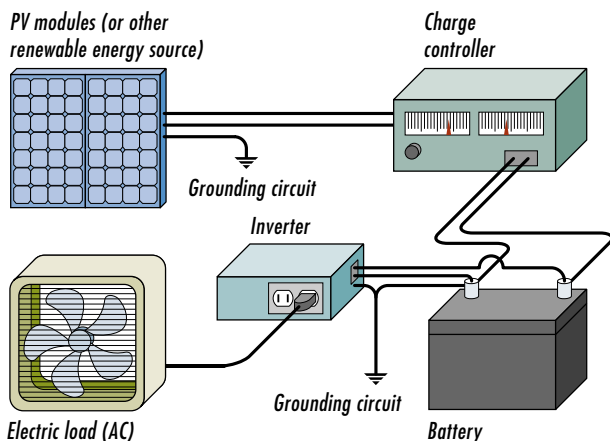
requirements. To provide electricity over long periods, renewable systems require deep-cycle batteries. These batteries, usually lead-acid, are designed to gradually discharge and recharge 80% of their capacity hundreds of times. Automotive batteries are shallow-cycle batteries and should not be used in renewable systems because they are designed to discharge only about 20% of their capacity. If drawn much below 20% capacity more than a few dozen times, the battery will be damaged and will no longer be able to take a charge.

The cost of deep-cycle batteries depends on the type, capacity (ampere-hours), the climatic conditions in which it will operate, how frequently it will receive maintenance, and the types of chemicals it uses to store and release electricity. An off-grid PV or wind system may have to be sized to store a sufficient amount of power in the batteries to meet power demand during several days of cloudy weather or low winds. This is known as "days of autonomy." Consult your dealer before selecting batteries for your system.

Most types of batteries contain toxic materials that may pose serious health and safety problems. The National Electric Code, battery companies, and renewable system designers recommend that lead-acid and wet-cell batteries, which give off explosive hydrogen gas when recharging, be located in a well-ventilated space isolated from the other electrical components of the system and away from living spaces. Also, allow enough space for easy access during maintenance, repair, and replacement. Most importantly, maintain the battery according to the manufacturer's instructions, and recycle the batteries properly when they wear out.

Charge Controller. The charge controller regulates the flow of electricity from the generation source to the battery and the load. The controller keeps the battery fully charged without overcharging it. When the load is drawing power, the controller allows the charge to flow from the generation source into the battery, the load, or both. When the controller senses that the battery is fully charged, it stops the flow of the charge from the generation source. Many controllers will also sense when loads have taken too much electricity from batteries and will stop the flow until sufficient charge is restored to the batteries. This last feature can greatly extend the battery's lifetime.

The cost of controllers generally



depends on the ampere capacity at which your renewable system will operate and the monitoring features you want.

Alternating-Current System Equipment

Inverter. Alternating-current (AC) systems also require an inverter, which changes the DC electricity produced by renewable systems and stored in batteries into AC electricity. Different types of inverters produce a different “quality” of electricity. For example, lights, televisions, and power tools can operate on lower-quality electricity, but computers and other sophisticated electronic equipment require the highest-quality electricity. So, you must match the power quality required by your loads with the power quality produced by the inverter.

Inverters for most stand-alone applications (i.e., those systems not connected to the utility grid) cost less than \$1 per rated output watt. The cost is affected by several factors, including the quality of the electricity it needs to produce; whether the incoming DC voltage

is 12, 24, 36, or 48 volts; the number of AC watts your loads require when they are operating normally; the amount of extra surge power your AC loads need for short periods; and whether the inverter has any additional features such as meters and indicator lights.

Tell your dealer if you plan to add additional AC loads in the future. If you are considering building another room onto your house or adding electrical loads, consider purchasing an inverter with a larger input and output rating than you currently need. This may be less costly than replacing it with a larger one later.

For more about sizing an inverter, see <http://www.nrel.gov/buildings/pv/>.

Selecting a Dealer

Your dealer can help you analyze your loads and size your system correctly. The dealer will install your equipment,

making sure that it runs properly. Dealers will also have contacts at the local utility if you are connecting your system to the utility grid.

With any major purchase, you must have confidence in the dealer's products and services. Becoming an informed consumer will help you feel more confident in your choices. With the growth of the renewable energy industry, the number of regional dealers, mail-order and e-commerce businesses, and local distributors has rapidly expanded. Many telephone directories contain listings for dealers under the "solar" heading. After you identify dealers, you will want to do some research to learn more about them.

Professional credentials are one indication of a dealer's knowledge and qualifications. Ask dealers about their training, certifications, and licenses. A second consideration is the dealer's experience in the field. How long has the

A Self-Generation Success Story

When the Eppersons of Norman, Oklahoma, purchased this home in 1992, one of the features they liked about it was the wind turbine out back. The original owner had installed a Bergey Windpower 10-kilowatt turbine in 1984. Since the local utility, Oklahoma Electric Cooperative, allowed net metering, any excess production from the wind turbine was credited against the homeowners' electric consumption on the next billing period. Thus, the home had unusually low electric bills.

The wind turbine sits about 250 feet behind the home on a guyed-lattice tower. Other than some electronics problems



from a malfunctioning circuit breaker and one lightning strike, the system has worked reliably since installation. At this point, the wind energy system has paid for itself and the Eppersons receive more than half of their electricity for free.

company been in business? Your local Better Business Bureau can advise you whether any customers have registered complaints about the dealer. You should also ask the dealer how many systems like yours he or she has designed and installed. Ask for references, and to speak with owners of systems similar to the one you want to purchase.

A third consideration in selecting a system installer is the variety and quality of products offered for each component of the system. Because PV systems are often designed for a specific site, one company's products may not be appropriate for all applications. Competent dealers will stock components manufactured by several companies. A variety of product options will help ensure that the most appropriate components are available for your system. When a dealer recommends a product, ask what the recommendation is based on, whether there are consumer or independent

testing facility reports you can read, and whether the products are listed with Underwriters Laboratories.

Also, consider the service agreements and performance guarantees the dealer provides and the warranties given by the product manufacturers. No system is maintenance-free, nor will all components function flawlessly forever. When problems emerge with your system, what services will the dealer provide? What warranties do the manufacturers provide? What costs should you expect to pay, and which costs will be assumed by the dealer and/or the manufacturer?

Finally, you should compare prices from different dealers. Because distribution channels and dealer networks have expanded dramatically, the opportunity to "shop around" is much greater today. If possible, approach more than one dealer about a draft design and cost estimate for your system.

Fuel Cells: A Look Toward the Future

What if your home heating system and your electricity were all powered by a fuel that produces no emissions but water vapor?

An unrealistic pipe dream? Not at all. The fuel is hydrogen, and the primary technology that will allow you to use it—the fuel cell—is advancing by leaps and bounds.

Researchers see the potential to use green power sources—such as wind power or solar photovoltaic electricity—to produce hydrogen by applying an electric current to two electrodes immersed in water.

In the foreseeable future, hydrogen is likely to come from natural gas or methanol. For your home, this could mean that your natural gas supply is fed through a fuel processor to make hydrogen, which feeds a fuel cell. The fuel cell provides all the electricity and heat you need. Prototypes of this technology are being tested now, with plans for full-scale production only a few years away.

Self-Generation RESOURCES

American Wind Energy Association (AWEA)

202-383-2500

<http://www.awea.org>

AWEA represents wind power plant developers, wind turbine manufacturers, insurers, financiers, and others involved in the wind energy business. Call AWEA or visit their Web site to access a list of wind energy system manufacturers and providers.

Financing Solutions Web site: Homeowners

<http://www.eren.doe.gov/financing/homeowners.html>

The homeowners section of this Web site provides links to several resources on renewable energy financing.

Interconnection

<http://www.irecusa.org/connect.htm>

If you're interested in connecting a home power system to your utility's electric grid, a vast amount of information is posted on the Interconnection page on the Interstate Renewable Energy Council's Web site.

Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes

A detailed guide to microhydropower, written for development workers, but useful for the motivated do-it-yourselfer. It is filled with illustrations, equations, and examples. Written by Adam Harvey and published by Intermediate Technology Publications, London, 1993.

Micro-Hydro Power: A Guide for Development Workers

Although written for development workers, this book will be helpful to anyone with an interest in microhydropower and some general technical experience. It covers stream analysis, design concepts and equipment, cost and economics, implementation, and maintenance. Separate chapters are devoted to each system component. Written by P. Fraenkel and others and published by Intermediate Technology Publications, London, 1991.

Microhydropower Handbook

This handbook contains detailed information on system design, construction, operations, economics, and legal and environmental issues. Published by E&G Idaho, Inc., for the U.S. Department of Energy, 1983. Available from the National Technical Information Service, 1-800-553-6847. Order no. DE83006698.

National Renewable Energy Laboratory (NREL)

<http://www.nrel.gov>

NREL is the U.S. Department of Energy's premier laboratory for renewable energy and energy efficiency research, development, and deployment. The NREL Web site offers extensive information on wind energy, photovoltaics, geothermal energy, bioenergy, and alternative fuels. You can also access renewable resource maps and solar radiation data.

National Technical Information Service (NTIS)

<http://www.ntis.gov>

703-605-6050

NTIS is the federal government's central source for the sale of engineering, scientific, technical, and related business information.

Net Metering (Green Power Network)

<http://www.eren.doe.gov/greenpower/net-metering/index.shtml>

The Green Power Network provides extensive information on net metering and net metering programs around the country. Visit their Web site to learn more about this important incentive for consumer investment in renewable energy generation.

Solar Energy Industries Association (SEIA)

703-248-0702

<http://www.seia.org/>

SEIA is the trade association for solar energy manufacturers, dealers, distributors, contractors, and installers. Contact SEIA to learn more about how you can use solar energy in your home. Their membership list will help you find providers in your area that can assist you in choosing and installing a system.

RENEWABLE ENERGY AT HOME

Clean Choices for Heating, Cooling, and Lighting

Heating and cooling uses more energy and drains more energy dollars than any other system in your home. Typically, 44% of your utility bill goes for heating and cooling. What's more, heating and cooling systems in the United States together emit more than a half-billion tons of carbon dioxide into the atmosphere each year, adding to global warming. They also generate about 24% of the nation's sulfur dioxide and 12% of the nitrogen oxides, the chief ingredients in acid rain.

Using solar energy and geothermal heat pumps can help heat and cool your home while drastically cutting your utility bills and helping the environment. Solar energy and geothermal heat pumps can also heat your water, and solar energy can help light your home. This chapter suggests ways for you to accomplish all these things.



Geothermal heat pumps deliver at least three times more energy than they consume.

Using the Sun for Heat and Light

The sun is the cleanest energy source for heating and lighting. Everyone uses solar energy to some extent: just opening your drapes during the day and turning off your lights is one way of using the abundant energy of the sun. Today, new technologies can help you use more



A sunspace is a useful and attractive addition to the home.

solar energy in your home while creating a more comfortable living space.

The ancient Anasazi tribe of the American Southwest knew about solar energy, and they built their homes on south-facing cliffs that would receive plenty of sunshine in the winter. The sun's low arc across the southern sky heated their mud-and-sandstone homes effectively. In the summer, the sun's higher arc in the sky allowed the cliff overhangs to shade their homes from the sun's hot rays, keeping them cool.

Today, you can use this same wisdom to take advantage of solar energy for your home. South-facing windows designed to let in the sun's heat will help lower your energy bills, while overhangs above those windows can prevent the high summer sun from heating your home in the summer.

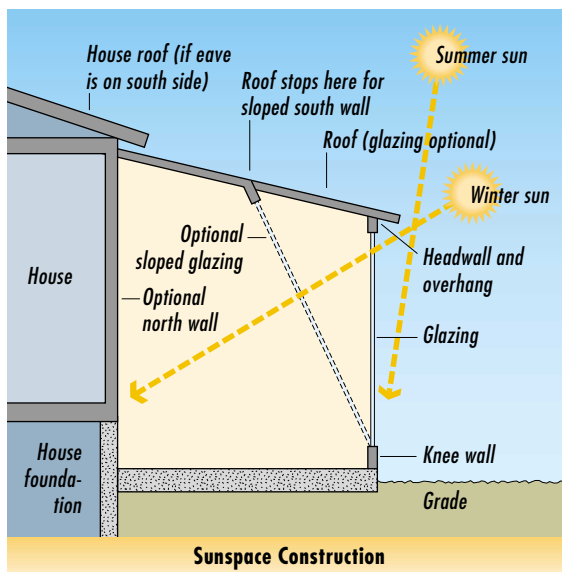
Shading windows with overhangs and landscaping

Ironically, one of the most important aspects of using solar energy in your home is assuring that you don't let too much solar energy into your home during the summer. This is most critical on your south-facing windows. Like the ancient Anasazi, you need to use overhangs to keep out the summer sun while letting in the winter sun.

In Hawaii, Guam, Puerto Rico, and southern Florida, you'll want to keep out the sun's heat year-round. You can use large overhangs, but the simpler approach would be to shade your south-facing windows with shrubs or trees.

The opposite is true in Alaska, where you want no overhang or shading at all—you need all the solar heat you can get!

Alaska and other cold climates are also the only locations where you would want to leave your east- and west-facing windows unshaded. The summer sun, which actually rises in the northeast and sets in the northwest, blasts solar energy into the east and west sides of your home. This is especially noticeable near sunset, after your home has grown warm throughout the long summer day.



Choosing windows for solar heating and lighting

Once your windows are properly shaded, you'll want to choose windows that will maximize your use of sunlight while minimizing energy leaks. The U. S. Department of Energy (DOE) and the Environmental Protection Agency (EPA)

have developed an Energy Star® designation for products meeting certain energy performance criteria. The energy efficient performance of windows, doors, and skylights varies by climate zones. Look for new high-efficiency Energy Star® windows that can let in the sun's rays while insulating against the outside cold. In addition to the Energy Star® label, look for the label provided by the National Fenestration Rating Council (NFRC). The NFRC label includes the U-factor—an indication of how well the window insulates—and the solar heat gain coefficient (SHGC), which indicates how well a window admits solar heat.

Of course, another aspect of sunlight is the light itself, which can supplement electric lighting while creating a brighter, more inviting living space. Because the sun's visible light is actually a separate component of solar energy than the sun's heat—which is actually nonvisible infrared light—the two aspects of sunlight can be handled differently by windows. For instance, a window with a low SHGC—designed to reject the sun's heat—can still allow in most of the sunlight. The recent innovation of “spectrally selective” coatings allow windows to reject heat without the dark tinting that was common on older heat-rejecting films.

Storing solar energy

Letting solar radiation into your home is only half the story of using solar energy; the other half is storing the solar

energy for later use. It's coldest at night, so the best use of solar energy is to absorb it with heat-retaining materials during the day, then allow those materials to keep the house warm at night. One choice is heavy tile flooring; anyone who has a tile floor knows how it can still feel warm hours after the sun has set. Brick and other masonry are also great materials; these can be used both in sun-exposed floors and in walls.



In a new home or a small remodeling project, south-facing windows admit heat and light.

Some designers have even incorporated water into walls to help store solar energy.

The idea of using heat-retaining materials has led to other solar energy innovations. For instance, Trombe walls actually incorporate heat-storing materi-



Armory Park Street Scene

Builders, utility executives, and government officials broke ground in late 1999 on Armory Park del Sol, a sustainable, affordable housing development in Tucson, Arizona. When completed in 2002, Armory Park del Sol will consist of 99 single-family homes on 14 acres, priced from \$90,000 to \$200,000 and higher for custom homes, all incorporating cutting-edge solar technologies.

The development is a national demonstration project of the Partnership for Advancing Technology in Housing (PATH), a presidential industry-government initiative led by the Department

of Housing and Urban Development (HUD) and DOE. Armory Park del Sol is a cooperative venture of John Wesley Miller Companies, Global Solar Energies, and Tucson Electric Power Company.

The homes will also maximize solar heating through dual-pane windows and thermal mass storage in the exterior walls. Ultra-efficient surround insulation will help save energy, and the latest water-saving technologies will cut water use by about 65% compared to typical Tucson homes.

als, such as masonry, in south-facing walls. A layer of glass or plastic glazing is mounted on the outside of this wall, leaving a small airspace between the glazing and the wall. This helps the wall absorb and retain heat. Trombe walls absorb the sun's heat during the day, then radiate that heat from the inside of the wall into your home during the night.

Climate-Responsive Architecture

So-called "climate-responsive" architecture is based on designing homes to use the smallest amount of energy for the climate they are in. Admitting or rejecting solar heat based on your climate is the simplest example of this philosophy.

Climate-responsive architecture is based in part on making homes as efficient as possible. In a poorly insulated

home that uses a lot of energy for heating, the effects of solar heating may be insignificant. But some super-insulated homes can use solar heating as their main heating source. For information on how to make your home more energy efficient, see the companion to this brochure, *Energy Savers: Tips on Saving Energy & Money at Home*.

Using More Solar Energy in Your Existing Home

In an existing home, any renovation or window replacement project is an opportunity to improve your home's energy performance. Most existing homes have poorly insulated, leaky windows that would be cost effective to replace. When replacing windows,

consider increasing the windows on the south side of your home and decreasing the windows on the north, east, and west sides.

Also, look for opportunities to increase the use of natural sunlight in your home, because this reduces your energy costs for lighting. Although windows are one part of natural lighting,

energy, you might even consider adding a sunspace.

Although many of the choices for enhancing the solar energy performance of your home are straightforward, based on the concepts presented here, sometimes the correct approach is not so obvious. For instance, if you live in a climate that's both hot in the summer and cold in the winter—as is most of the United States—and you're not able to add overhangs to your south-facing windows, would it be better for them to admit or reject solar energy? Or if you're totally renovating the south side of your home, what would be the ideal amount of windows?

For questions such as these, there are many computer programs available, from the very simple to the extremely complex. The U.S. Department of Energy

An architect can design an addition that is attractive and saves energy.

you might also consider eliminating unnecessary internal walls to create a more open space in your home. This allows the sunlight to penetrate deeper into your home, creating a brighter, more comfortable living space. Dividing walls that don't reach to the ceiling can be used to provide some structure while still maintaining an open environment. The use of light-colored paints with a matte finish will help reflect and diffuse the sunlight throughout your home.

Renovations offer options to not only improve windows and lighting, but also to add heat-storing materials in areas warmed by the winter sun. In homes where it's difficult to make use of solar



developed one of the easier programs to use, called RESFEN, which is available free of charge. The program helps you examine the energy performance of windows in your home.

Using Solar Energy in a New Home, or When Extensively Renovating an Old One

An architect can examine the energy performance of your house in terms of how each of the components—the insulation, windows, heating and cooling system, ventilation, and lighting— all work together. This approach, called “whole-house” design, allows the architect to optimize each of these components for your location to achieve the best energy performance at an economical price.

When using a whole-house design for



This home was built to take advantage of southern exposure.

a new house, solar energy features can be incorporated at little or no additional cost. The only key requirement is for the house to have an orientation to the south to take full advantage of the winter sunlight.

A typical benefit of a whole-house design is that your heating system can often be downsized because of the use of insulation, high-efficiency windows, and solar energy. Not only does this save you money up-front on the heating system, but it also allows the heating system to operate more efficiently, because most systems perform best when they're used at or near their full capacity.

Geothermal Heat Pumps

One of the most energy-efficient options for heating and cooling your home draws on another form of renewable energy—geothermal energy, or heat from the earth. This is not the hot steam and heat that comes from deep underground



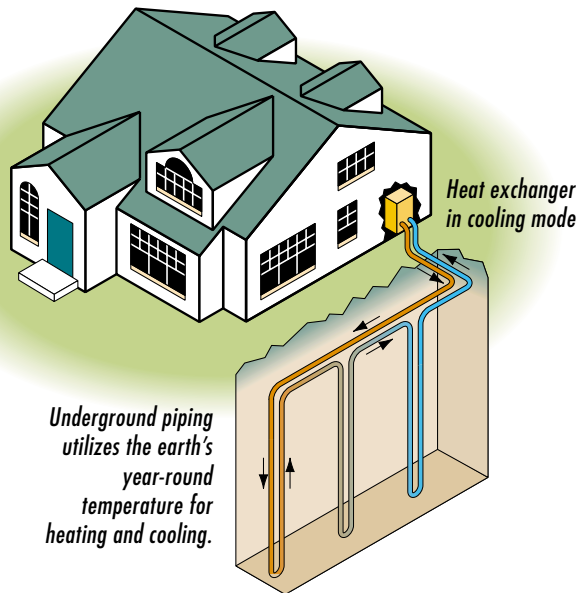
(discussed on page 11). Rather, geothermal heat pumps draw on the relatively stable temperatures of the ground surrounding your home as a source of heat in the winter and cooling in the summer.

Geothermal heat pumps are usually installed when a house is built, because they require the installation of a large loop of tubing at least several feet under the surface. For some systems, narrow trenches are dug to install the tubing; other systems use vertical loops that can be installed much like drilling a well—a simpler process for retrofits to existing homes.

Some models also use geothermal energy to heat water for your home. These so-called “hydronic” systems save you money by eliminating the need for a separate water heater and save energy by heating water efficiently.

Just as a refrigerator uses electricity to keep the inside cool, while releasing heat into your kitchen, a geothermal heat pump can keep the inside of your home cool while releasing heat into the cool earth. In the winter, this process is reversed, so the geothermal heat pump draws heat from the earth and releases it into your home.

Because geothermal heat pumps actually move heat between your home and the earth, rather than creating heat by burning fuels, they operate very cleanly



and efficiently. In fact, geothermal heat pumps are at least three times more efficient than the most energy efficient furnaces on the market today.

The relatively stable temperatures of the ground allow geothermal heat pumps to operate more efficiently than conventional air-source heat pumps, which exchange heat from the home with the outside air rather than the ground. During hot summer days, it's much easier to release heat into the cool earth than into the hot air. Likewise, during frigid winter days, it's easier to draw heat from the ground than from the much colder air. For these reasons, geothermal heat pumps operate efficiently even in harsh climates.

Other Energy Sources

Air-source heat pumps and high-efficiency gas furnaces can heat homes efficiently while minimizing air

pollution. These options are often twice as efficient, and much cleaner, than older boilers and furnaces.

Look for the Energy Star® label when buying new heating and cooling equipment, and also check the EnergyGuide label. Although the minimum furnace efficiency is set at 78% by U.S. law, some models can achieve efficiencies as high as 95%.

There is another abundant source of renewable energy that might work for your home: wood heat. Today's modern wood stoves can generate heat efficiently from wood with low emissions.

Heating Water with Solar Energy

Another way to use renewable energy in your home is to use solar energy for water heating. Today's systems carry a rating that tells you how well they'll meet your hot water needs. And they provide a clean, reliable, and cost-effective source of hot water.

Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat transfer fluid; a passive system has no pump.

Most systems use a roof-mounted solar collector, so you'll need a south-facing roof with good solar exposure. A typical solar water heating system circulates water or an antifreeze solution through this solar collector, where the sun's heat warms the liquid.

If water is used, the system circulates the water between the solar collector and a storage tank in your house, and the storage tank serves as your source of hot

water. If an antifreeze solution is used, the system will also circulate it between the solar collector and a storage tank, but water is circulated through coils in the tank to provide your hot water. In some cases, an additional tank is then used to store the hot water.

If you're currently using an electric water heater, solar water heating is a cost-effective alternative. In fact, a study by the Florida Solar Energy Center



Today's solar water heaters are efficient, reliable, and attractive.

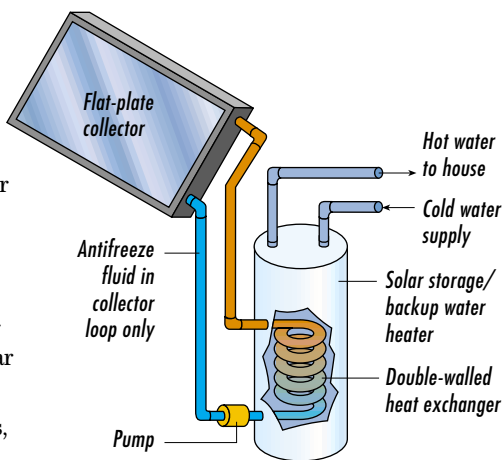
showed solar water-heater owners saved as much as 50% to 85% annually on their utility bills as compared to electric water heating. If you're building a new home, the cost of the system can be spread over the term of your mortgage. The only pollution generated by solar water heating is the pollution produced in generating electricity to power the pumps and controls. Some systems even operate without pumps, reducing the environmental effects to a negligible amount and helps

reduce greenhouse gases. When a solar water heater replaces an electric water heater, the electricity displaced over 20 years represents more than 50 tons of avoided carbon dioxide (a greenhouse gas) emissions alone.

Take the same care in choosing a solar water heater that you would in purchasing any major appliance. Your best protection is to consider only certified and labeled systems. The Solar Rating and Certification Corporation (SRCC), a nonprofit, independent third-party organization formed by the solar industry, state energy officials, and consumer advocates certifies and rates solar water heaters.

As with all renewable energy systems, you should check to see if any special rebates or financing deals are provided in your state. Rebates are often offered

through your local electric utility. Consult with your state energy office, or see the resources listed at the end of this chapter for other information sources.



Active, Closed-Loop Solar Water Heater

Renewable Energy at Home: A Look Toward the Future

Today, most new home buyers get to choose their carpets, countertops, flooring, and other decorative options. Soon, the choices might include adding a solar water heater, a geothermal heat pump, or heat-storing Trombe walls. Builders are beginning to offer green homes that save energy and water while increasing comfort. Climate-responsive architecture along with whole-house design principles will drastically reduce home energy use. And lower utility bills mean homeowners will have more money to spend turning that house into a home.

Renewables for Heating and Lighting RESOURCES

American Council for an Energy Efficient Economy (ACEEE)

202-429-0063

<http://www.aceee.org>

ACEEE is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. ACEEE provides publications and guides on making your home more energy efficient.

Alliance to Save Energy

202-857-0666

<http://www.ase.org>

The alliance to Save Energy is a nonprofit coalition of business, government, environmental, and consumer leaders who promote the efficient and clean use of energy. Contact the alliance for information and publications on energy efficiency.

Renewables for Heating and Lighting RESOURCES

Efficient Windows Collaborative

<http://www.efficientwindows.org/>

Access helpful guidelines on window selection from this site.

Energy Star®

<http://www.energystar.gov>

This site provides information on how to select Energy Star® windows, boilers, furnaces, heat pumps, and other Energy Star® appliances and products.

Financing Solutions Web Site:

Homeowners

<http://www.eren.doe.gov/financing/homeowners.html>

The homeowners section of this Web site provides links to several resources on renewable energy financing.

Geo-Heat Center

<http://www.oit.edu/~geoheat>

541-885-1750

The Geo-Heat Center provides technical/economic analysis for those actively involved in geothermal development. Technical material on resources, direct use equipment, design schemes, and software are also available.

Geothermal Heat Pump Consortium (GHPC)

<http://www.ghpc.org/>

1-888-ALL-4-GEO (255-4436)

The Geothermal Heat Pump Consortium provides extensive information on the use of geothermal heat pumps.

Home Energy Saver

<http://hes.lbl.gov/HES>

This site, hosted by the Lawrence Berkeley National Laboratory, is designed to help consumers identify the best ways to save energy in their homes and access many “how to” resources. You can use an online calculator to compute your home’s energy use and plug in energy efficiency improvements to see how much savings you can realize.

RESFEN Windows Software

<http://windows.lbl.gov/software/resfen/resfen.html>

This software package from the U.S. Department of Energy helps you evaluate windows. To obtain a copy of RESFEN, fax your request, with your mailing address, to Software Request at: 510-486-4089.

Or mail your request to:

Software Request

Windows & Daylighting Group

MS 90-3111

Lawrence Berkeley National Laboratory

Berkeley, CA 94720

Solar Benefits Model

<http://www.eren.doe.gov/solarbuildings/sbm.html>

This Web site allows you to calculate the benefits of including a solar water heating system in your new home.

Solar Rating and Certification Corporation (SRCC)

<http://www.solar-rating.org/about.htm>

407-638-1537

SRCC publishes the thermal-performance ratings of solar energy equipment. They also offer a directory of certified solar systems and collectors as well as a document (OG-300-91) that details the operating guidelines and minimum standards for certifying solar hot-water systems.

The Sustainable Buildings Industry Council (SBIC)

<http://www.sbicouncil.org/>

The SBIC Web site provides design software and other resources for saving energy in buildings and effectively using solar energy.

THE CLEAN ENERGY CHOICE IN TRANSPORTATION

Clean Fuels and Vehicles

One of the more challenging ways to use clean energy is in fueling our cars. Advanced transportation technologies—including fuel cells, electric motors, advanced engines, improved materials, and other technologies—aim to reduce pollution and minimize petroleum fuel use in cars, trucks, buses, fleet vehicles, and public transportation. Compared to current commercial vehicles, advanced vehicles achieve higher fuel economies and make greater use of alternative fuels. The most common alternative fuels in use are biodiesel, ethanol, hydrogen, methanol and natural gas.

Alternative Fuels: Ethanol

Ethanol is the primary U.S. fuel made from renewable energy sources. Ethanol produced from corn is used as a gasoline additive to provide additional oxygenation in cities that have trouble meeting

air quality standards for ozone. Corn—like other plants, trees, and organic materials—is considered a “biomass” energy source.

To make greater use of ethanol, “flex-fuel” vehicles are now available that can be fueled with either gasoline or E85—a mixture of 85% ethanol and 15% gasoline. This flexibility allows you to use E85 where it’s available, but still fuel your car with gasoline in areas where E85 is not available.

One issue with producing ethanol from corn is its limited ability to meet our transportation energy needs. All the corn produced in the country would not generate enough ethanol to fuel our vehicles. To address this issue, new technologies are being developed to convert other biomass sources into ethanol. For instance, the ability to convert not only corn, but also crop residues such as cornstalks and cobs into ethanol, will

Corn and other types of biomass produce ethanol fuel.



Ethanol and methanol are becoming more common at service stations across the country.



duced from biomass sources.

More renewable fuels are being developed and will be available in increasing quantities in the coming years. For diesel engines, biodiesel fuels have been developed from vegetable oils and animal fats. These renewable-source fuels have the benefit of burning cleaner and with less soot than regular diesel fuel.

Fuel Cells

The fuel cell is a device that converts the chemical energy of a fuel directly into usable electricity and heat without combustion. Fuel cells are similar to batteries in that both produce a DC current by means of an electrochemical process. Unlike batteries, however, fuel cells use reactants that are stored externally and operate continuously as long as they are supplied with fuel. Any hydrogen-rich material can theoretically serve as a source of hydrogen for fuel cells. These currently include natural gas and petroleum distillates, as well as renewable fuels such as methanol, ethanol, or hydrogen.

Fuel cell vehicles have the potential to reduce harmful emissions and consumption of nonrenewable energy sources because they are clean and efficient. Fuel cells are a technology that could change our future – a device that could power automobiles with little or no tailpipe emissions, provide energy to homes and factories with virtually no smokestack pollution — and use renewable, domestic energy at high efficiency while creating thousands of jobs.

Fuel cells are one of the three power

greatly expand the production of ethanol from corn, and also improve its economics. In the future, there will be dedicated energy crops that will supply our nation's vehicles with ethanol.

Researchers have also developed the technology to convert other forms of biomass—such as wood chips, food waste, grass, or even trash—into ethanol.

Other Alternative Fuels

In addition to ethanol, a wide variety of energy sources other than gasoline or petroleum diesel fuel can be used to fuel vehicles—these are clean fuels, but most of them are not renewable.

Natural gas vehicles are ideal urban commuter cars, because many cities now offer a number of natural gas refueling stations. The vehicles operate efficiently, with very low tailpipe emissions. Natural gas is also ideal for public transportation, such as buses, taxis, limousines, or shuttles.

Methanol is another alternative fuel, and like ethanol, it is usually mixed with 15% gasoline to form a fuel called M85. Methanol is currently produced from natural gas, although it can also be pro-

system technologies currently being considered for an 80-miles-per-gallon vehicle under the Partnership for a New Generation of Vehicles (see box on page 42).

Many of the major automakers have demonstrated direct hydrogen fuel cell systems that should have the potential to be competitive with internal combustion engine propulsion systems.

Electricity as a Fuel

Electricity is considered an alternative fuel when it is used to charge an electric vehicle. Today, electric vehicles are available from most major automakers. Ford Motor Company, for instance, recently received an order from the U.S. Postal Service for 500 electric vehicles—the largest U.S. order for electric vehicles in history.

The real question for electric cars is, where does the electricity come from?

It's possible for the electricity to come from renewable energy sources, making the electric car a clean car in every way. The simplest way is to purchase 100% green power to recharge the car. Some cities have also installed recharging stations with roofs to shelter the cars as they refuel. These roofs are covered with photovoltaic solar panels, so that they actually generate the electricity to refuel the cars.

Hybrid Vehicles

As we move toward vehicles that run on renewable fuels, it's also important to reduce the amount of fuel used by vehicles. While saving energy, fuel-efficient cars also produce less air pollution.

One approach to increasing automotive efficiency is the hybrid electric vehicle. These vehicles are powered by both an engine and an electric motor, and include a battery pack large enough to continue providing power to the electric motor under most normal driving conditions. The electricity needed to maintain the charge of the batteries is generated by the engine, so unlike elec-



DaimlerChrysler and Toyota are among automakers developing hybrid electric vehicles.



Advanced vehicles of the future will provide much better fuel economy and emissions savings than today's conventional vehicles. However, there are only a few alternative fuel vehicles available for sale today. Until you are able and ready to buy a clean and efficient alternative fuel vehicle, here are some things you can do today to drive "greener" with your current vehicles.

 Maintain your car responsibly by keeping it tuned, the tires properly inflated and wheels aligned. Have your oil changed at an oil/lube station which recycles every drop of oil. And keep the air and fuel filters clean. You'll get better gas mileage, pollute less, and extend engine and tire life.

 Work and study at home when possible. If everyone would stay at home one extra day a week, we'd save over 10% of the gasoline that cars use and the pollution they create.

 Don't overfill the tank of your car, and use the fuel with the lowest recommended octane number. Each gallon of spilled or evaporated gas puts as much hydrocarbon in the air as 7500 miles worth of going out the tailpipe of a car.

 Reduce driving to work and on errands, and carpool when you can. By choosing to live closer to your job and shopping near home, you'll save time, gas, and pollution. Combine trips when you can to save gas and reduce by more than half the air pollution from cars caused by cold starts.

 Avoid warming up your car in the winter. It doesn't need it, and a car idling in the driveway wastes gas and pollutes the air.

For more tips on driving green, visit http://www.ott.doe.gov/consumer/drive_greener.html.

tric vehicles, hybrid electric vehicles do not need to be plugged in.

The year 2000 marked a turning point for hybrid electric vehicles in the United States, with the first sale of hybrid electric cars by Honda. The Honda Insight, initially released as a two-seat vehicle, combines a three-cylinder gasoline engine with an electric motor that provides an extra boost while accelerating and climbing hills. The Insight achieves a remarkable 70 miles to the gallon on the highway, according to U.S. Environmental Protection Agency mileage estimates.

The Toyota Prius, a four-door sedan, combines a four-cylinder gasoline engine with an electric motor, working in tandem to save energy. DaimlerChrysler, Ford, and General Motors are expected to

follow suit with their own hybrid electric cars in the near future.

One key to the high efficiency of hybrid electric vehicles is the fact that although a lot of power is needed to accelerate a car, a relatively small amount is needed to keep it rolling at a constant speed. Standard gasoline or diesel cars need a large, powerful engine for acceleration, but suffer an efficiency penalty when that same large engine is used to cruise at highway speeds. A hybrid electric vehicle uses just a small engine for cruising, but boosts its power with the electric motor during acceleration.

Another key to high efficiency in these vehicles is power management, which is really the tricky part. The motor and engine must be switched on and off as

DOE and six other federal agencies are working with the major U.S.-based automakers in the Partnership for a New Generation of Vehicles (PNGV) to make automobiles more efficient and less polluting. This government/industry partnership leads the development of fuel-cell and hybrid electric vehicles, advancing technologies such as compression-ignition, direct-injection engines, high-efficiency electric motors, high-power batteries, and lightweight materials. PNGV has the goal of creating a full-size car that achieves 80 miles per gallon by 2004, without sacrificing safety, affordability, or other features Americans expect in their cars.

they are needed, and enough energy must be drawn from the engine to keep the batteries charged over the course of a day's drive. To help keep the batteries charged, especially in stop-and-go city driving, "regenerative" braking actually generates electricity while braking the car.

All of the hybrid electric cars planned or in production now include either a gasoline or diesel engine, but there's no technical reason why a hybrid electric vehicle couldn't someday make use of

renewable energy sources by fueling up with ethanol or methanol. And the diesel models that Ford and General Motors are developing could potentially be fueled from cleaner-burning biodiesel fuels. So someday soon, you may be driving a clean, efficient car powered by renewable fuels.

Renewable Transportation RESOURCES

Center for Transportation Technologies and Systems (Fuel Cells)

<http://www.ctts.nrel.gov>

The National Renewable Energy Laboratory's Center for Transportation Technologies and Systems Web site provides information on fuel cell technology.

Clean Cities

<http://www.cities.doe.gov>

Clean Cities, a program sponsored by the U.S. Department of Energy, is designed to encourage the use of alternative fuel vehicles and their supporting infrastructure throughout the nation.

Fuel Economy Guide

<http://www.fueleconomy.gov>

This site, jointly developed by the U.S. Department of Energy and the U.S. Environmental Protection Agency, allows you to find and compare fuel economy for 1985–2000 model year cars and trucks.

Hydrogen Information Network

<http://www.eren.doe.gov/hydrogen/>

Learn more about how hydrogen is already being used in many industries, and what the future holds for hydrogen as a clean energy source and transportation fuel.

U.S. Department of Energy, Office of Transportation Technologies (OTT)

<http://www.ott.doe.gov>

OTT works with the transportation and energy supply industries, and research and development organizations to develop and promote advanced transportation vehicles and alternative-fuel technologies that will reduce oil import requirements, emissions, and greenhouse gases. Through the OTT Web site you can access extensive information on alternative-fuel and hybrid vehicles, alternative fuels such as ethanol, methanol, and biodiesel, and other transportation technologies such as fuel cells.

A LOOK TOWARD THE FUTURE OF RENEWABLE ENERGY

The future is bright for renewable energy, and new initiatives and industry advances are bringing innovative technologies that will affect your business, your home, and your car. These key technologies will change the way energy is produced, distributed, and stored in this country. New bioenergy products will appear in all aspects of our lives. At the same time, the availability of hydrogen-powered fuel cells will allow our cars and homes to meet their future energy needs while producing almost no harmful emissions.

Throughout this booklet we've shared information and ideas about how you can begin to use renewable energy in your home today. In many states you can choose to have your electricity come from renewable energy choices. Every day more states are opening up competitive markets and green pricing programs, and if you don't already have this choice,

you may very soon. Self-generation isn't a choice for everyone, but you may find that it works for your situation. Whether you generate your power through wind, photovoltaics, microhydropower, or a combination of these technologies, the information we've provided will get you started. There are a number of ways to incorporate renewable energy into your home for heating and lighting such as solar water heating, geothermal heat pumps, and sunspaces. The information and resources listed should help you determine what makes sense for your home. And finally, we've shown you choices in renewable transportation. We will continue to see many advances in alternative fuels and in alternative fuel and hybrid vehicles, but today you can choose ethanol and other clean fuels such as natural gas and electricity to power your car.

Using renewable and clean energy technologies will ensure a secure and prosperous energy future, and a healthy environment for generations to come.



Although this booklet has suggested many ways for you to use renewable energy today, it has also pointed toward many technologies that are likely to dramatically change our world in the coming years.

Many sources, including the Department of Energy's Energy Information Administration foresee increases in the use of renewables for electricity, fuels, and other uses well into the 21st Century. If fuel cells and bioenergy become commonplace, it's possible that the use of renewable energy could grow much faster than anyone has predicted. But even taking current energy scenarios at face value, renewable energy will grow to provide a large fraction of the world's energy use within the next 60 years. We will see renewable energy grow during our lifetimes, and children born today will live to see a cleaner, brighter renewable energy future.

Renewable Future RESOURCES

Energy Information Administration (EIA)

<http://www.eia.gov>

EIA, a statistical agency of the U.S. Department of Energy, is responsible for researching and reporting energy usage from all energy resources and determining future trends.

Shell Group

<http://www.shell.com>

For a perspective on future renewable energy scenarios, visit the Shell Group Web site.

World Resources Institute

<http://www.wri.org>

202-729-7600

The World Resources Institute provides information, ideas, and solutions to global environmental problems.

Helping children learn about clean energy technologies is an investment in a brighter energy future.



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For more information on renewable energy
and energy efficiency, visit DOE's Energy
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(EREN) at **<http://www.eren.doe.gov>**.



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