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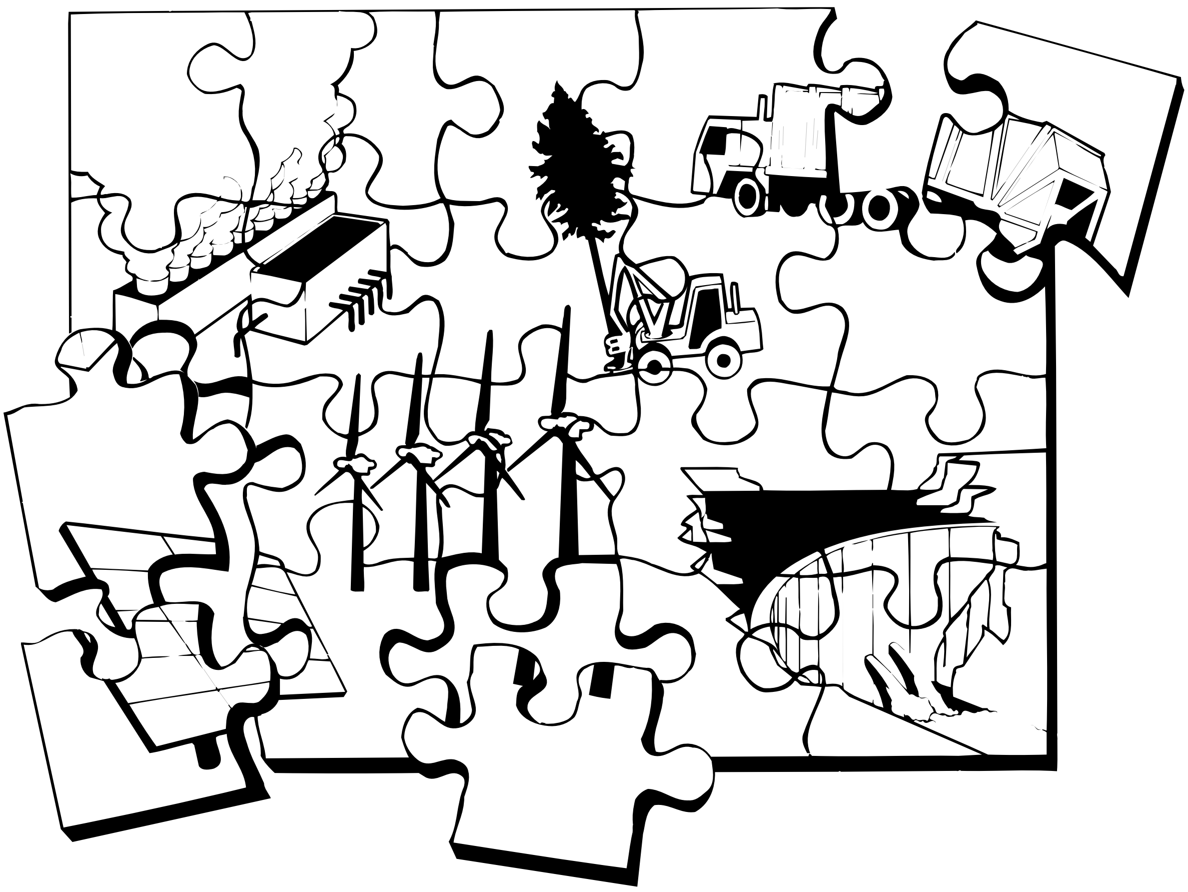
ENERGY EFFICIENCY AND RENEWABLE ENERGY CLEARINGHOUSE

Learning About Renewable Energy

FOR YOUNG SCHOLARS

Can you imagine life without television, cars, or computers? What if you had to cook your dinner over a fire or fetch water from a river? It might be fun for a camping trip, but you probably would not want to do it every day. But that's how life was before scientists and inventors discovered ways to use energy to make our lives easier.

Today, most of the energy we use comes from *fossil fuels*. Coal, oil, and natural gas are all fossil fuels. Over millions of years, the decay of plants, dinosaurs, and other animals was formed into fossil fuels. These fuels lie buried between layers of earth and rock. The only way to get them out is to drill or mine for them. While fossil fuels are still being created



The many renewable energy systems fit together to give us a complete picture of energy sources. From top left, the systems pictured are geothermal, biomass, municipal solid waste, photovoltaics, wind energy, and hydropower.

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today by underground heat and pressure, they are being consumed more rapidly than they are created. For that reason, fossil fuels are considered *nonrenewable;* that is, they are not replaced as soon as we use them. So, we could run out of them sometime in the future. Or, we might someday use so much fossil fuel that we won't be able to drill or mine fast enough to keep up with the demand.

Because our world depends so much on energy, we need to find sources of energy that will last a long time. What if there was a type of energy that never ran out? There is. It is called *renewable energy.*

In addition, because there are so many people on the earth using fossil fuels, we create a lot of pollution. So, we should also use energy sources that produce as little pollution as possible. While all energy sources cause some pollution in their creation or their consumption, renewable energy systems generally are less polluting than fossil fuel systems.

This wind farm uses many wind turbines to produce electricity.

What is renewable energy?

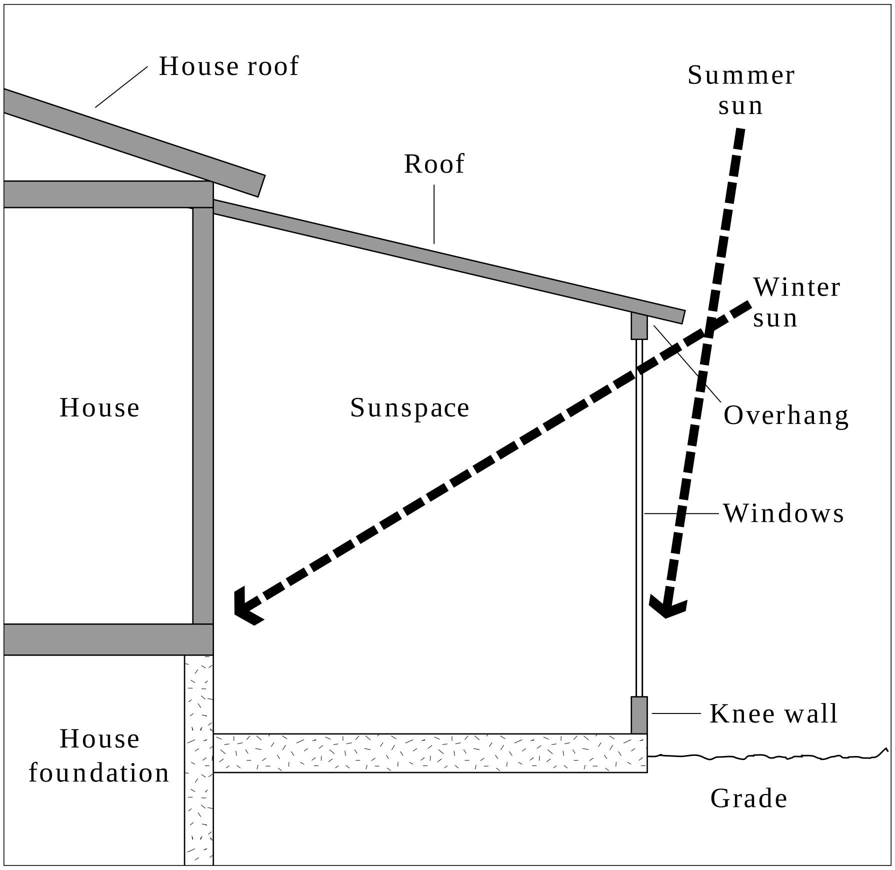
Renewable energy systems use resources that are constantly replaced and are usually less polluting. Examples of renewable energy systems include solar, wind, and geothermal energy (getting energy from the heat in the earth). We also get renewable energy from trees and plants, rivers, and even garbage.

Solar energy

We can use the energy in sunshine to warm and light our homes, heat our water, and provide electricity to power our lights, stoves, refrigerators, and other appliances. This energy comes from processes called *solar heating, solar water heating, photovoltaic energy* (converting sunlight directly into electricity), and *solar thermal electric power* (when the sun's energy is concentrated to heat water and produce steam, which is used to produce electricity).

Solar heating

Have you ever sat in a car that was closed up on a sunny day? Did you notice how hot it was in the car? This warmth is just one example of solar heating. We can use the sun to heat other things, including our homes. Today, more than 200,000 houses in the United States have been designed to use



Building a sunspace with an overhang over the south-facing windows can let the sun in during the winter and keep it out during the summer.

We can use the sun's energy to warm our homes, heat our water, and provide electricity.

features that take advantage of the sun's energy. These homes often use passive solar designs, which do not normally require pumps, fans, or other mechanical equipment to store and distribute the sun's energy. In contrast, active solar designs need additional mechanical components.

A passive solar home or building naturally collects the sun's heat through large, south-facing windows, which are just one aspect of passive design. Once the heat is inside, we need to capture and absorb it. Think about a sunny spot on the floor of your house on a cold day. That "sun spot" is nice and warm, right? It is warm because it holds the sun's heat, and we call such things *absorbers*.

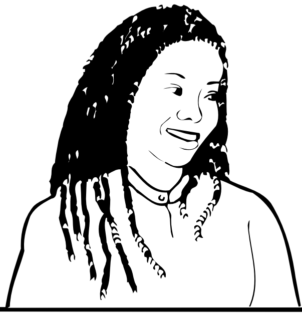
In solar buildings, *sunspaces* are built onto the south side of the structure and act as large absorbers. The floors of sunspaces are usually made of tiles or bricks that absorb heat throughout the day, then release heat. When the air is colder than the floor, the tiles or bricks release the heat to the air. For more information on sunspaces, contact the Energy Efficiency and Renewable Energy Clearinghouse (see the list of Resources at the end of this publication).

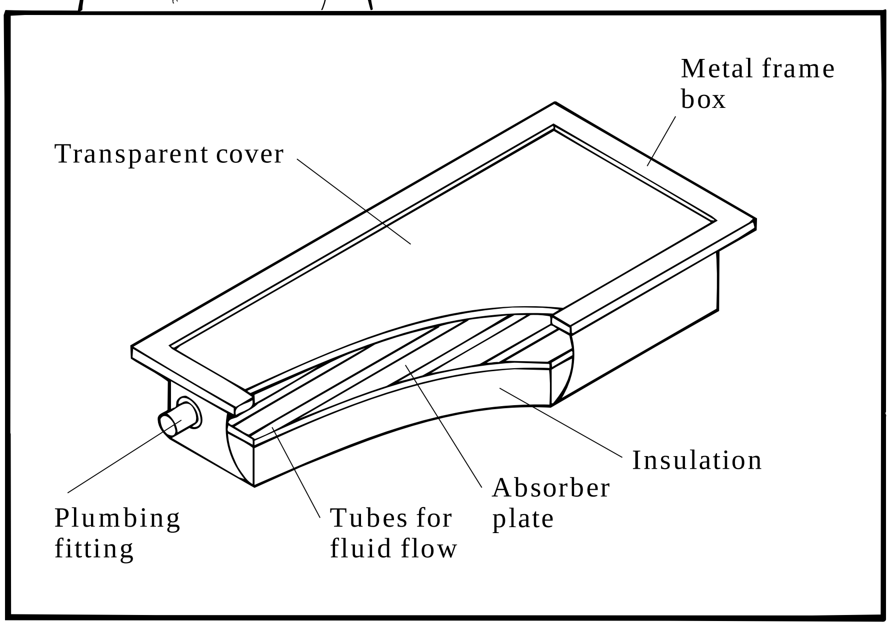
A challenge with solar heating is keeping the heat inside the house. One way to do this is to use special windows that reflect the heat back into the house. Another aspect of solar heating is that the house absorbs heat even during hot weather, when the last thing you need is more heat! So, passive solar homes need to be designed to let the heat in during cold months and block the sun in the hot months. How can you do this?

You can use deciduous trees or bushes in front of the south-facing windows. These plants lose their leaves in the winter and allow most of the sun in, while in the summer, the leaves will block out a lot of the sunshine and heat. Or, you can design your house to have overhangs above the south-facing windows. This will block out the summer sunshine when the sun is high in the sky but let it in when the sun is lower in the winter.

Solar water heating

The sun also can heat water for bathing and laundry. Most solar water-heating systems have two main parts: the solar *collector* and the *storage tank.* The collector heats the water, which then flows to the storage tank. The storage tank can be just a modified water heater, but ideally it should be a larger, well-insulated tank. The water stays in the storage tank until it is needed for something, say a shower or to run the dishwasher.





Flat-plate solar collectors capture the sun's energy and use it to heat water or other fluid that flows through the tubes.

A common collector is called a *flat-plate collector,* and is usually mounted on the roof. This collector is a rectangular box with a transparent cover that faces the sun. Small tubes run through the box, carrying the water or other fluid such as antifreeze to be heated. The tubes are mounted on a metal *absorber plate,* which is painted black to absorb the sun's heat. The back and sides of the box are insulated to hold in the heat. Heat builds up in the collector, and as the fluid passes through the tubes, it heats up.

Like solar-designed buildings, solar water-heating systems can be either active or passive. The most common systems are active, which means they use pumps to move the heated fluid from the collector and into the storage tank. For more information about heating water with the sun, contact the Energy Efficiency and Renewable Energy Clearinghouse.

While a solar water-heating system can work well, it can't heat water when the sun isn't shining—and we all know it can be cloudy for days at a time! For that reason, homes also have a conventional backup system that uses fossil fuels.

Photovoltaic energy

The sun's energy can also be made directly into electricity using *photovoltaic (PV) cells,* sometimes called *solar cells.* PV cells make electricity without moving, making noise, or polluting. They are used in calculators and watches. They also provide power to satellites, electric lights, and small electrical appliances such as radios. PV cells are even being used to provide electricity for homes, villages, and businesses. Some electric utility companies are building PV systems into their power supply networks.

Today, more than 200,000 houses in the United States have been designed and built to take advantage of the sun's energy.

Although the PV cells used in calculators and watches are tiny—less than a half inch (1.2 centimeters) in diameter—PV cells for larger power systems are about 4 inches (10 centimeters) in diameter. When more power is needed, PV cells can be wired together to form a *module.* A module of about 40 cells is often enough to power a small light bulb. For more power, PV modules are wired together into an *array.* PV arrays can produce enough power to meet the electrical needs of your house—or for even larger uses.

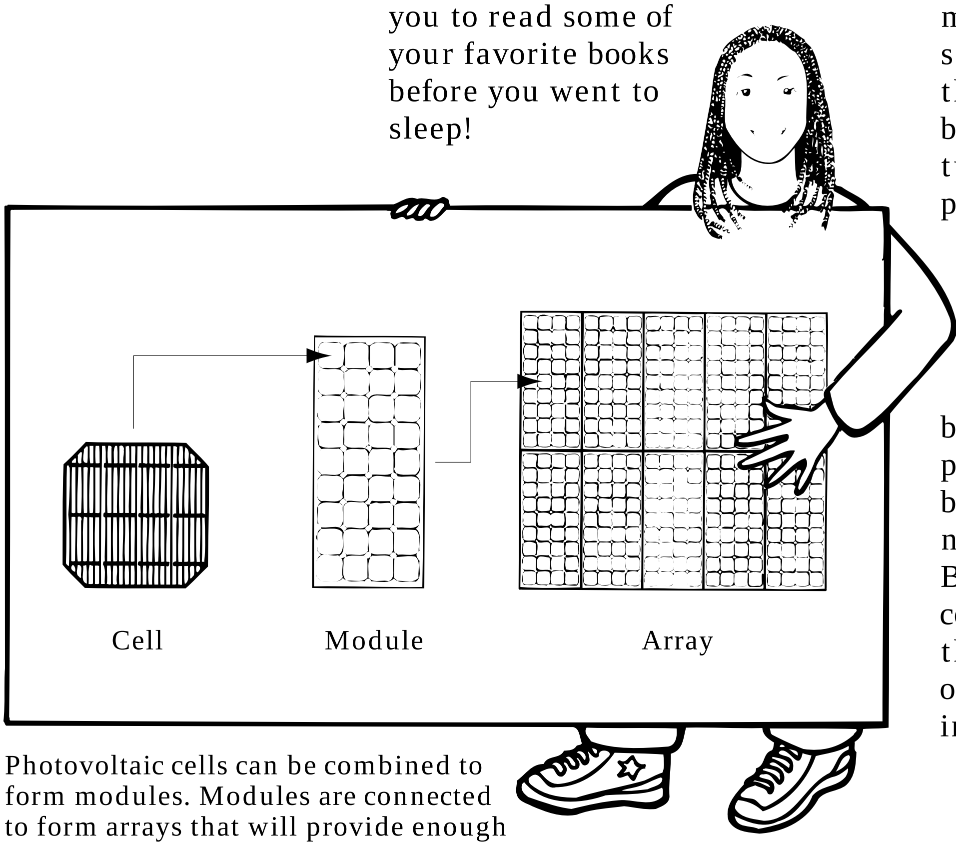
Today, PV systems are mostly used for water pumping, highway lighting, weather stations, and other electrical systems located away from power lines. For example, if you had a cabin on a mountain top, a PV system would allow you to read some of your favorite books before you went to sleep!

Because PV systems can be expensive, they are not used in areas that have electricity nearby. But if someone needs electricity in a remote place, PV can be quite economical. Another aspect of PV power is "intermittency," which means that if the sun isn't shining, the system can't make electricity. Because PV systems only produce electricity when the sun is shining, these remote systems need batteries to store the electricity.

Solar thermal electric power

Solar thermal systems can also change sunlight into electricity, but not in the same way as PV cells. In most cases, solar thermal systems concentrate (focus) sunlight to produce heat. This heat boils water to make steam. The steam rotates a *turbine,* which is made of several rows of blades mounted on a large shaft. The steam's pressure flows through the turbine, pushes against the blades, and causes the shaft to turn, much like you can make a pinwheel spin by blowing on it. The turbine is attached to a generator that makes electricity.

Like electricity from PV systems, solar thermal power can be intermittent. To avoid this problem, many systems use a backup system that relies on natural gas to heat the water. Because solar thermal systems concentrate the sun's energy, they need to be located in areas of the world that receive a lot of intense sunshine.



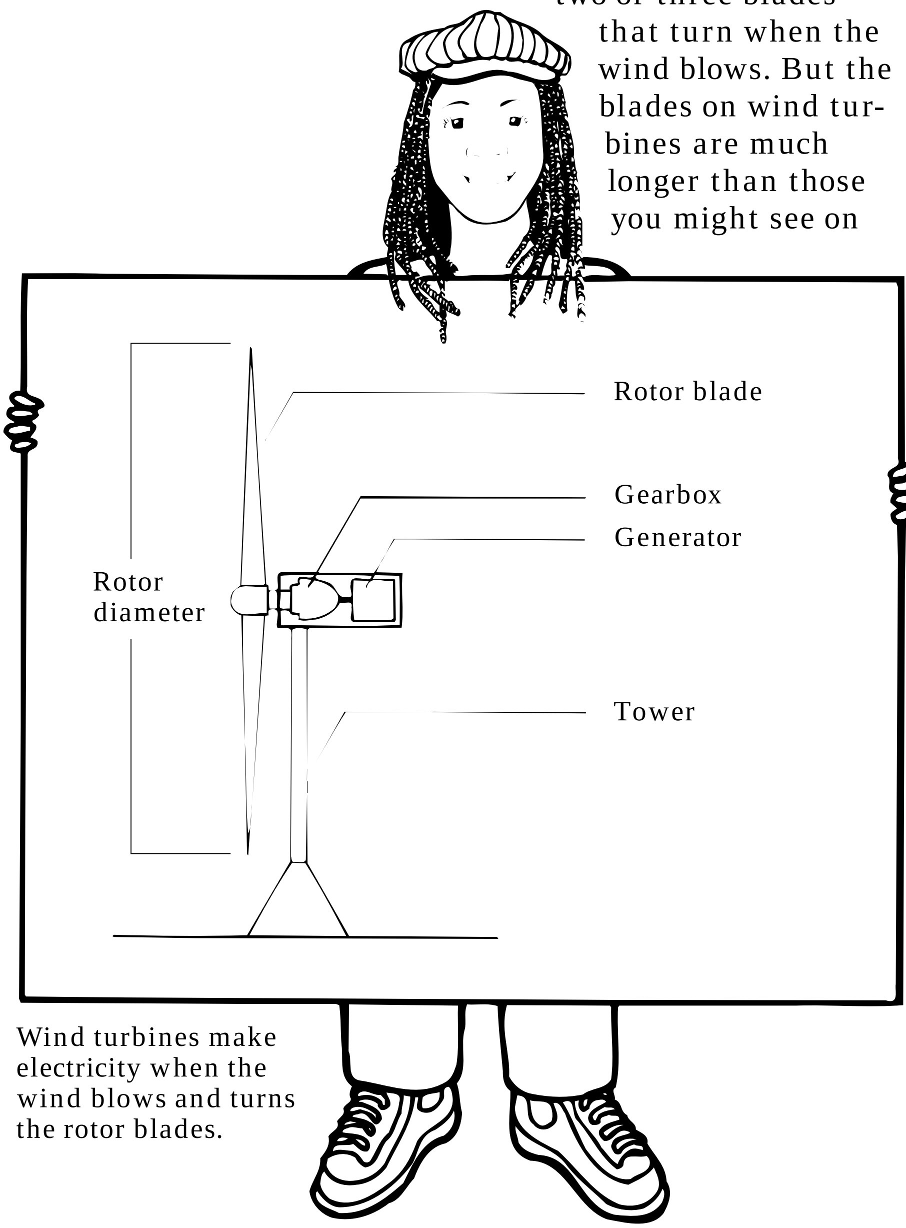
Photovoltaic cells can be combined to form modules. Modules are connected to form arrays that will provide enough electricity for any need.

For centuries, windmills have been used to grind grain and pump water. Now, people use the wind to generate electricity.

Wind power

Did you know that wind is considered an indirect form of solar energy? This is because the wind is driven mainly by temperature differences on the surface of the earth that are caused by sunshine.

For centuries, the wind has been used to sail ships, grind grain, and pump water. Now, people use the wind to generate electricity. The windmills built long ago had many blades, but today's *wind turbines* usually have just two or three blades that turn when the wind blows. But the blades on wind turbines are much longer than those you might see on a windmill. In fact, wind turbine blades can be up to 82 feet (25 meters) long!



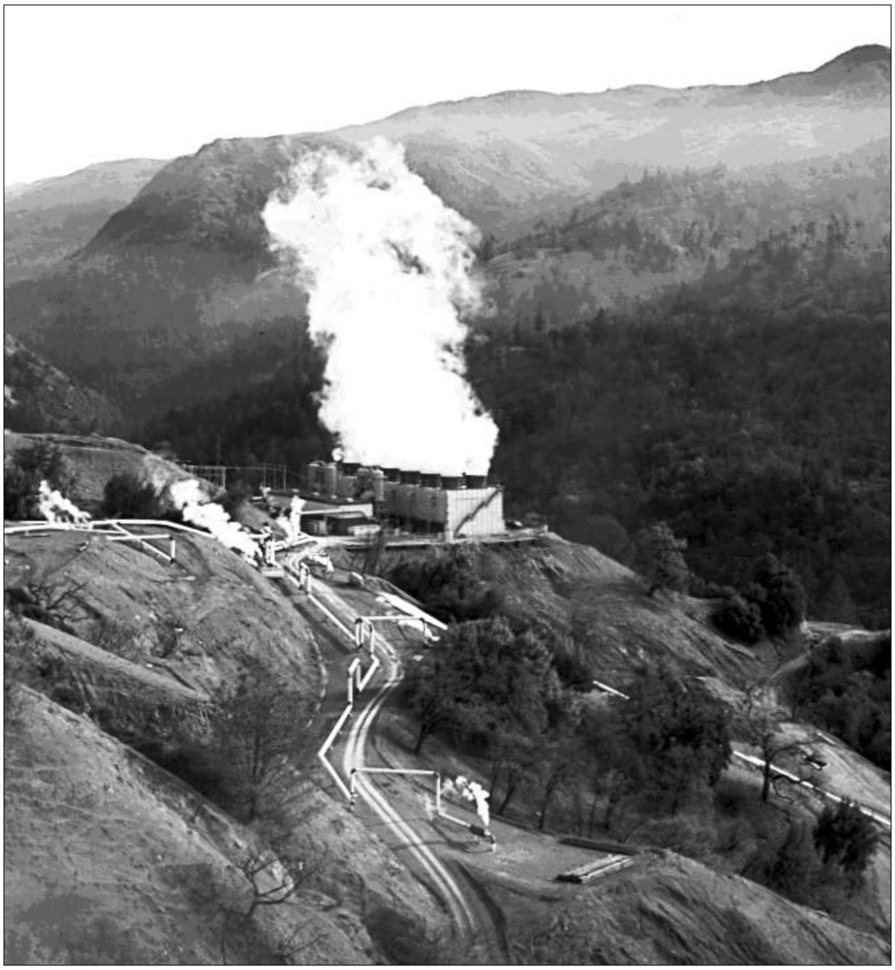
Wind turbines make electricity when the wind blows and turns the rotor blades.

The blades drive a generator that produces electricity, much like steam turbines. The longer the blades and the faster the wind speed, the more electricity the turbine generates. Wind turbines are placed on towers because the wind blows harder and more steadily above the ground.

To produce the most electricity, wind turbines need to be located in areas where the wind blows at a constant speed, which it does not do in all parts of the world. Wind speed is described by seven "classes." For example, Class 7 winds are extremely strong, while Class 2 winds are mild breezes. Generally, Class 4 winds and above are considered adequate for a wind turbine to produce electricity.

Large groups of wind turbines, called wind farms or wind plants, are connected to electric utility power lines and provide electricity to many people. New turbine designs now take advantage of less windy areas by using better blades, more electronic controls, and other improvements. Some new turbines can also operate efficiently over a wide range of wind speeds.

An advantage of wind turbines over some forms of renewable energy is that they can produce electricity whenever the wind blows (at night and also during the day). In theory, wind systems can produce electricity 24 hours every day, unlike PV systems that can't make power at night. However, even in the windiest places, the wind does not blow all the time. So, while wind farms don't need batteries for backup storage of electricity, small wind systems do need backup batteries. And, we're still learning about local wind patterns and how they affect wind turbines and blades.



Pacific Gas and Electric

Since 1960, Pacific Gas and Electric Company has been producing electricity from geothermal steam at its plant in California called The Geysers.

Geothermal energy

We can also get energy directly from the heat in the earth. This is known as *geothermal energy*, from "geo" for earth and "thermal" for heat. Geothermal energy starts with hot, molten rock (called *magma*) miles below the earth's surface that heats a section of the earth's crust. The heat rising from the magma warms underground pools of water known as *geothermal reservoirs*. Sometimes the water can even boil to produce steam. If there is an opening through the rock to the surface, the hot underground water may seep out to form hot springs, or it may boil to form geysers. One such geyser that you may have seen is Old Faithful in Yellowstone National Park.

For thousands of years, people have been using hot springs for bathing and for cooking food. With today's technology, we do not have to wait for the hot water to come to the earth's surface. Instead, we can drill wells deep below the surface of the earth to tap into geothermal reservoirs. This is called *direct use* of geothermal energy, and it provides a steady stream of hot water that is pumped to the earth's surface so its heat can be used.

Geothermal energy also is used to produce electricity. Similar to solar thermal electricity, steam—either pulled directly from the geothermal reservoir or from water heated to make steam—is piped to the power plant. There, it rotates a turbine that generates electricity.

One source of geothermal power is The Geysers geothermal field located in northern California. This power plant is the largest source of geothermal energy in the world and produces as much power as two large coal or nuclear power plants.

While geothermal energy is a good source of power, we could run out of it by drawing so much energy out of the reservoir that it is not able to replenish itself at the rate we're using it. In addition, water from geothermal reservoirs often contains minerals that are corrosive and polluting.

Imagine a new type of farm where energy crops, such as fast-growing trees or grasses, might be grown and harvested for their energy content!

Biomass energy

When you burn a log in your fireplace or in a campfire, you are using *biomass energy.* Because plants and trees depend on sunlight to grow, biomass energy is a form of stored solar energy. Although wood is the largest source of biomass energy, we also use corn, sugarcane wastes, and other farming by-products.

There are three ways to use biomass. It can be burned to produce heat and electricity, changed to a gas-like fuel such as methane, or changed to a liquid fuel. Liquid fuels, also called *biofuels,* include two forms of alcohol: *ethanol* and *methanol.* Because biomass can be changed directly into a liquid fuel, it could someday supply much of our transportation fuel needs for cars, trucks, buses, airplanes, and trains. This is very important because nearly one-third of our nation's energy is now used for transportation.

Diesel fuel can also be replaced by *biodiesel* made from vegetable oils! In the United States, this fuel is now being produced from soybean oil. However, any vegetable oil—corn, cottonseed, peanut, sunflower, or canola—could be used to produce biodiesel. Researchers are also developing algae that produce oils, which can be converted to biodiesel.

The most commonly used biofuel in the United States is ethanol, which is produced from corn and other grains. A blend of gasoline and ethanol is already used in cities with high air pollution. However, ethanol made from corn is currently more expensive than gasoline on a gallon-for-gallon basis. And even if we took all the corn that could possibly be grown in the United States and used it to produce ethanol, it would not make enough ethanol to power all our cars. So, it is very important for scientists to find less expensive ways to produce ethanol from other biomass crops.

The water in rivers and streams can be captured and turned into hydropower, also called hydroelectric power.

Today, we have found new ways to produce ethanol from grasses, trees, bark, sawdust, paper, and farming wastes. These processes could greatly increase the use of biomass energy in the United States. Imagine a new type of farm where *energy crops*, such as fast-growing trees or grasses, might be grown and harvested for their energy content!

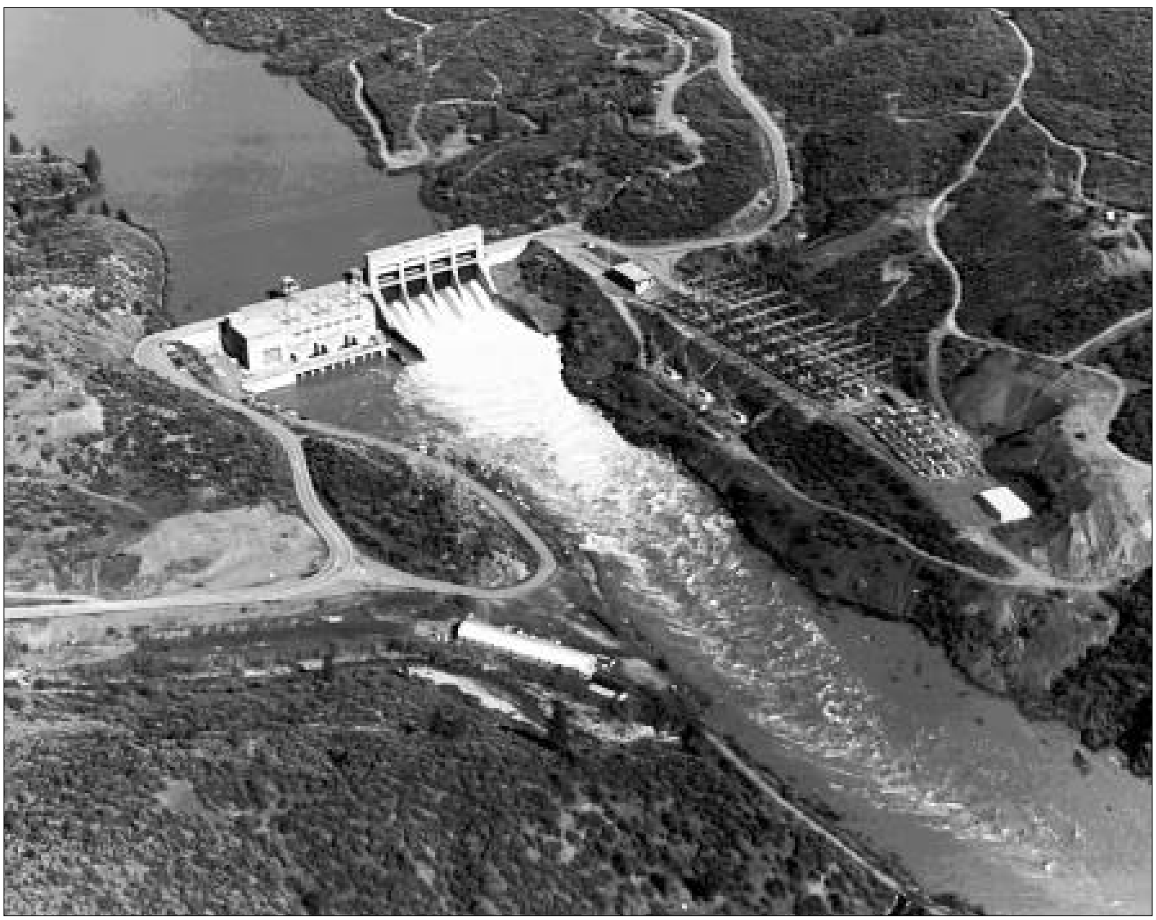
Of course, like many resources, we need to manage our use of biomass or we might consume it faster than we produce it. Also, like any fuel, biomass creates some pollutants when it is burned or converted into energy.

Hydropower

The water in rivers and streams can be captured and turned into *hydropower,* also called *hydroelectric power.* The most common form of hydropower uses dams on rivers to create large reservoirs of water.

Water released from the reservoirs flows through turbines, causing them to spin. The turbines are connected to generators that produce electricity.

Hydroelectric power plants in the United States generate enough electricity to power whole towns, cities, and even entire regions of the country. Hydropower currently is one of the largest sources of renewable power, generating about 10 percent of the United States' electricity.



This hydropower plant is located at the Keswick Dam on the Sacramento River north of Redding, California.

What you may throw out in your garbage today just might become fuel for someone else. That's right, trash has the potential to be a large energy source.

Hydropower is also inexpensive, and like many other renewable energy sources, it does not produce air pollution.

However, the drawback to hydropower is that damming rivers can change the ecology of the region. For example, the water below the dam is often colder than what would normally flow down the river, so fish sometimes die. The water level of the river below the dam can be higher or lower than its natural state, which affects the plants that grow along the riverbanks.

Energy from trash

What you may throw out in your garbage today just might become fuel for someone else. That's right, whether you call it trash or garbage, this *municipal solid waste* has the potential to be a large energy source.

In 1993, the Environmental Protection Agency estimated that the United States generated 207 million tons (188 million metric tons) of trash. Out of all that trash, however, only 32 million tons (29 million metric tons) were converted to energy.

Garbage is also an inexpensive energy resource. Unlike most other energy resources, someone will collect garbage, deliver it to the power plant, and pay to get rid of it. This helps cover the cost of turning the garbage into energy. Garbage is also a unique resource because we all contribute to it.

Municipal solid waste can be burned in large power plants to generate electric power. Municipal waste-to-energy plants currently generate about 2500 megawatts of electricity—the equivalent of several large coal plants.

There is also a way to use the energy trapped in landfill garbage. When food scraps and other wastes decay, a gas called *methane* is produced. Methane is the main ingredient in natural gas. We can drill wells into landfills to release this gas. Pipes from each well carry the methane gas to a central point where it is cleaned. The gas can then be burned to produce steam in a boiler, or it can be used to power generators to produce electricity.

However, as with burning any type of fuel, municipal solid wastes can produce air pollution when they are burned and turned into energy.

Renewable energy in your future

One day, all your home's energy may come from the sun or the wind. You may not think twice about filling your car's gas tank with biofuel. And your garbage might contribute to your city's energy supply. As scientists push the limits of renewable energy technologies and improve the efficiencies and costs of today's systems, we will soon be to the point when we may no longer rely mostly on fossil fuel energy.

Glossary

Biomass energy: Changing farming wastes, grasses, trees, bark, sawdust, and other things into energy by burning it, changing it to a gas, or converting it to a liquid fuel.

Energy crops: Crops grown specifically for their fuel value, including food crops such as corn and sugarcane, and non-food crops such as poplar trees and switchgrass.

Fossil fuels: Energy sources formed by the decay of plants, dinosaurs, and other animals over millions of years; coal, oil, and natural gas are fossil fuels.

Geothermal energy: Using the heat from the earth to produce power.

Hydropower: Using the energy in flowing water to make electricity.

Municipal solid waste: Using trash or garbage to produce energy by burning it or by capturing the gasses it gives off and using them as fuel.

Nonrenewable fuels: Fuels that cannot be easily made or “renewed.” We can use up nonrenewable fuels. Oil, natural gas, and coal are nonrenewable fuels.

Passive solar heater: A solar water-heating or space-heating system that moves heated air or water without using pumps or fans.

Passive solar home: A house that uses a room or another part of the building as a solar collector.

Photovoltaic energy: A type of solar energy that converts sunshine into electricity.

Renewable energy: Types of energy that are “renewed” as we use them; solar, wind, and geothermal energy are forms of renewable energy.

Solar collectors: Boxes, frames, or rooms that trap the sun’s rays to produce heat.

Solar energy: Energy from the sun. The heat that builds up in your car when it is parked in the sun is an example of solar energy.

Solar heating: Using the sun’s energy to heat our homes and water.

Sunspace: A room that faces south, or a small structure attached to the south side of a house.

Wind power: Using the wind to produce electricity by turning blades on a wind turbine.

Wind power plant: A group of wind turbines interconnected to a common utility system.

Resources

Helpful Groups

This publication gives you some information on different forms of renewable energy. If you want more information, check out the groups listed here.

For You

The Energy Efficiency and Renewable Energy Clearinghouse
P.O. Box 3048
Merrifield, VA 22116
(800) DOE-EREC (363-3732)
Fax: (703) 893-0400

This free service has information on renewable energy and saving energy. It is funded by the U.S. Department of Energy.

National Renewable Energy Laboratory
Center for Science Education
1617 Cole Boulevard
Golden, CO 80401
(800) NEW-ENGY (639-3649)

This center has student and teacher information and videos on renewable energy.

Renew America
1400 16th Street, NW, Suite 710
Washington, DC 20036
(202) 232-2252

This group offers information on renewable energy and the environment.

For Your Teacher

Bull Frog Films
P.O. Box 149
Oley, PA 19547
(800) 543-3764

This group has films and videos on energy. Ask for its free catalog.

National Energy Education Development Project
1920 Association Drive, Suite 414
Reston, VA 22091
(800) 875-5029

This group offers energy education program materials for grades 4 to 12.

National Energy Information Center
Energy Information Administration
1000 Independence Avenue, SW, Room 1F-048
Washington, DC 20585
(202) 586-8800

This group offers energy information for a wide range of audiences.

Books

These books have more information on energy. This list does not cover all the books available on energy, nor does any mention of a book mean that we recommend it. To get these books, go to your public or school library or local bookstore. Ask the bookstore how much the book costs before you order it.

For You

Alternative Sources of Energy, by Warren Brown, Chelsea House Publishers, 1994.

Energy Alternatives, by Barbara Keeler, Lucient Books, 1990.

Energy Resources: Toward a Renewable Future, by D.J. Herda, F. Watts Publisher, 1991.

Experimenting with Energy, by Alan Ward, Chelsea House Publishers, 1994.

Facts on Future Energy Possibilities, by Hugh Johnstone, F. Watts Publisher, 1990.

Facts on Water, Wind, and Solar Power, by Guy Arnold, F. Watts Publisher, 1990.

Fueling the Future, by Janet Pack, Childrens Press, 1992.

Rads, Ergs, & Cheeseburgers: The Kid's Guide to Energy & the Environment, by Bill Yanda, J. Muir Publications, 1991.

Renewable Energy: A Concise Guide to Green Alternatives, by Jennifer Carless, Walker and Co., 1993.

For Your Teacher

Science Projects in Renewable Energy and Energy Efficiency, American Solar Energy Society, National Energy Foundation, 5160 Wiley Post Way, Suite 200, Salt Lake City, UT 84116, (801) 539-1406, 1990.

Teach with Energy! Fundamental Energy, Electricity and Science Lessons for Grades K–3, National Energy Foundation, 5160 Wiley Post Way, Suite 200, Salt Lake City, UT 84116, (801) 539-1406, 1990.

Teach with Energy! Fundamental Energy, Electricity and Science Lessons for Grades 4–6, National Energy Foundation, 5160 Wiley Post Way, Suite 200, Salt Lake City, UT 84116, (801) 539-1406, 1992.