section 3

Renewable Energy Sources

Reading Guide

What You'll Learn

- **Analyze** the need for alternate energy sources.
- **Describe** alternate methods for generating electricity.
- **Compare** the advantages and disadvantages of various alternate energy sources.

Why It's Important

The primary sources of energy in the United States are nonrenewable, so alternative energy sources need to be explored.

Review Vocabulary

radiant energy: the energy carried by an electromagnetic wave

New Vocabulary

- renewable resource
- photovoltaic cell
- hydroelectricity
- geothermal energy
- biomass

Energy Options

The demand for energy increases continually, but supplies of fossil fuels are decreasing. Using more nuclear reactors to produce electricity will produce more high-level nuclear waste that has to be disposed of safely. As a result, other sources of energy that can meet Earth's increasing energy demands are being developed. Some alternative energy sources are renewable resources. A **renewable resource** is an energy source that is replaced nearly as quickly as it is used.

Energy from the Sun

The average amount of solar energy that falls on the United States in one day is more than the total amount of energy used in the United States in one year. Because only about one billionth of the Sun's energy falls on Earth, and because the Sun is expected to continue producing energy for several billion years, solar energy cannot be used up. Solar energy is a renewable resource.

Many devices use solar energy for power including solar-powered calculators similar to the one in **Figure 19.** These devices use a **photovoltaic cell** that converts radiant energy from the Sun directly into electrical energy. Photovoltaic cells also are called solar cells.

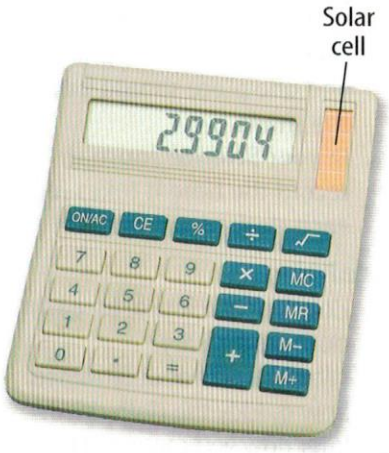


Figure 19 This calculator uses a solar cell to produce the electricity it needs to operate.

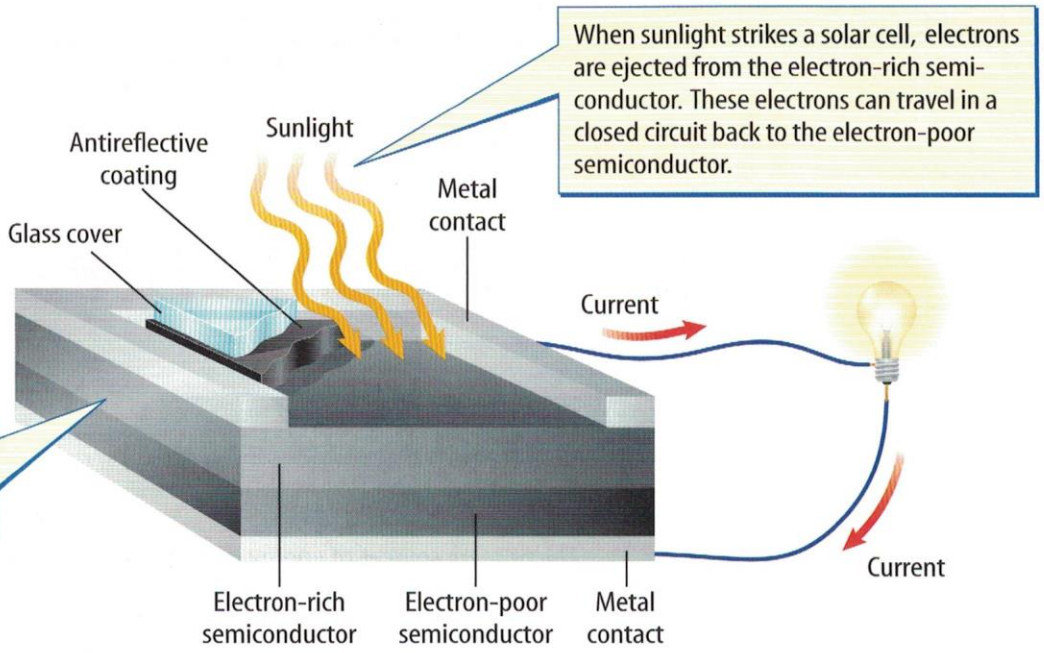


Figure 20 Solar cells convert radiant energy from the Sun to electricity. **Identify** *two devices that use solar cells for power.*

Mini LAB

Using Solar Power at Home

Procedure

1. Cut a piece of **cloth** into four equal sized pieces.
2. Wet the pieces and wring them out so they are the same dampness.
3. Spread the pieces out to dry—two pieces inside and two pieces outdoors. One piece of each set should be in direct sunlight and one piece should be in the shade.
4. In your **Science Journal,** record the time it takes for each cloth piece to dry.

Analysis

1. How long did it take for each cloth piece to dry?
2. What conditions determined how quickly the cloth dried?
3. Infer how you can use solar energy in your home to conserve electricity.

Try at Home

How Solar Cells Work Solar cells are made of two layers of semiconductor materials sandwiched between two layers of conducting metal, as shown in **Figure 20.** One layer of semiconductor is rich in electrons, while the other layer is electron poor. When sunlight strikes the surface of the solar cell, electrons flow through an electrical circuit from the electron-rich semiconductor to the electron-poor material. This process of converting radiant energy from the Sun directly to electrical energy is only about 7 percent to 11 percent efficient.

Using Solar Energy Producing large amounts of electrical energy using solar cells is more expensive than producing electrical energy using fossil fuels. However, in remote areas where electric distribution lines are not available, the use of solar cells is a practical way of providing electrical power.

Currently, the most promising solar technologies are those that concentrate the solar power into a receiver. One such system is called the parabolic trough. The trough focuses the sunlight on a tube that contains a heat-absorbing fluid such as synthetic oil or liquid salt. The heated fluid is circulated through a boiler where it generates steam to turn a turbine, generating electricity.

The worlds' largest concentrating solar power plant is located in the Mojave Desert in California. This facility consists of nine units that generate over 350 megawatts of power. These nine units can generate enough electrical power to meet the needs of approximately 500,000 people. These units use natural gas as a backup power source for generating electricity at night and on cloudy days when solar energy is unavailable.

Energy from Water

Just as the expansion of steam can turn an electric generator, rapidly moving water can as well. The gravitational potential energy of the water can be increased if the water is retained by a high dam. This potential energy is released when the water flows through tunnels near the base of the dam. **Figure 21** shows how the rushing water spins a turbine, which rotates the shaft of an electric generator to produce electricity. Dams built for this purpose are called hydroelectric dams.

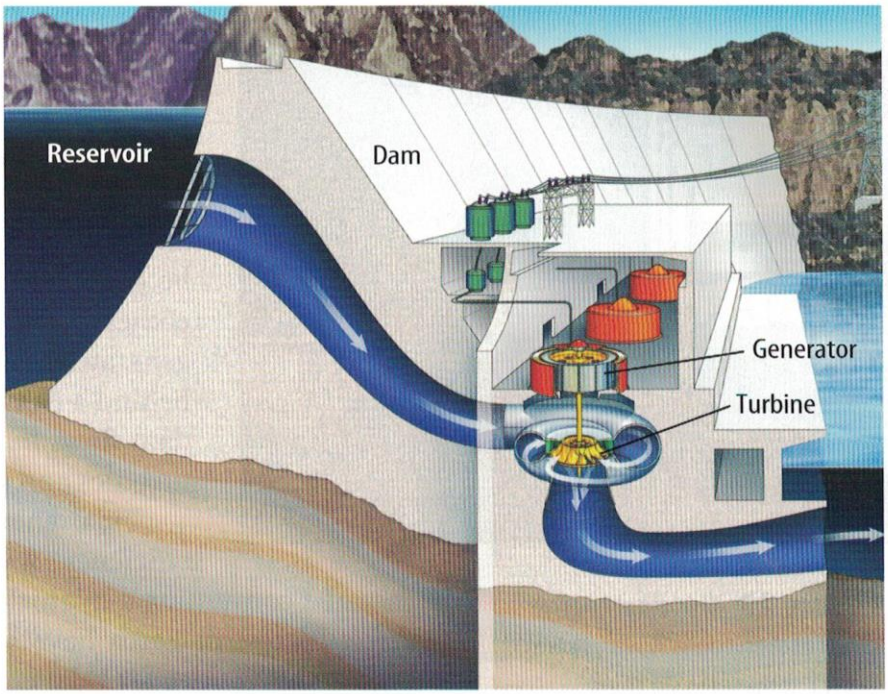


Figure 21 The potential energy in water stored behind the dam is converted to electrical energy in a hydroelectric power plant.
Diagram *the energy conversions that occur as a hydroelectric dam produces electrical energy.*

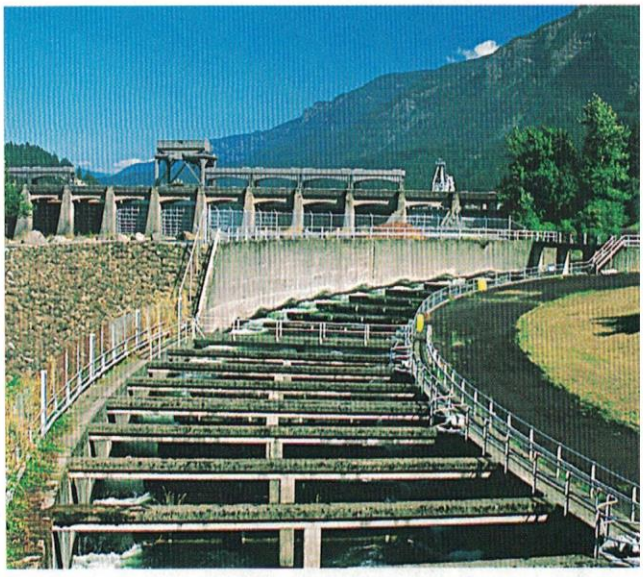
Using Hydroelectricity Electricity produced from the energy of moving water is called **hydroelectricity.** Currently about 8 percent of the electrical energy used in the United States is produced by hydroelectric power plants. Hydroelectric power plants are an efficient way to produce electricity with almost no pollution. Because no exchange of heat is involved in producing steam to spin a turbine, hydroelectric power plants are almost twice as efficient as fossil fuel or nuclear power plants.

Reading Check ***Why are hydroelectric power plants more efficient than fossil fuel power plants?***

Another advantage is that the bodies of water held back by dams can form lakes that can provide water for drinking and crop irrigation. These lakes also can be used for boating and swimming. Also, after the initial cost of building a dam and a power plant, the electricity is relatively cheap.

However, artificial dams can disturb the balance of natural ecosystems. Some species of fish that live in the ocean migrate back to the rivers in which they were hatched to breed. This migration can be blocked by dams, which causes a decline in the fish population. Fish ladders, such as those shown in **Figure 22,** have been designed to enable fish to migrate upstream past some dams. Also, some water sources suitable for a hydroelectric power plant are located far from the regions needing power.

Figure 22 Fish ladders enable fish to migrate upstream past dams.



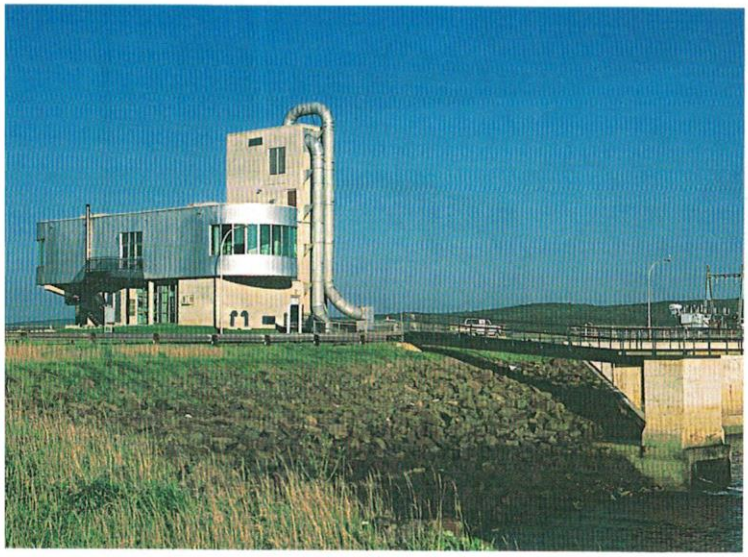


Figure 23 This tidal energy plant at Annapolis Royal, Nova Scotia, generates 20 megawatts of electric power.

Energy from the Tides

The gravity of the Moon and Sun causes bulges in Earth's oceans. As Earth rotates, the two bulges of ocean water move westward. Each day, the level of the ocean on a coast rises and falls continually. Hydroelectric power can be generated by these ocean tides. As the tide comes in, the moving water spins a turbine that generates electricity. The water is then trapped behind a dam. At low tide the water behind the dam flows back out to the ocean, spinning the turbines and generating electric power.

Tidal energy is nearly pollution free. The efficiency of a tidal power plant is similar to that of a conventional hydroelectric power plant. However, only a few places on Earth have large enough differences between high and low tides for tidal energy to be a useful energy source. The only tidal power station in use in North America is at Annapolis Royal, Nova Scotia, shown in **Figure 23.** Tidal energy probably will be a limited source of energy in the future.

Harnessing the Wind

You might have seen a windmill on a farm or pictures of windmills in a book. These windmills use the energy of the wind to pump water. Windmills also can use the energy of the wind to generate electricity. Wind spins a propeller that is connected to an electric generator. Windmill farms, like the one shown in **Figure 24,** may contain several hundred windmills.

Figure 24 Wind energy is converted to electricity as the spinning propeller turns a generator.

However, only a few places on Earth consistently have enough wind to rely on wind power to meet energy needs. Also, windmills are only about 20 percent efficient on average. Research is underway to improve the design of wind generators and increase their efficiency. Other disadvantages of wind energy are that windmills can be noisy and change the appearance of a landscape. Also, they can disrupt the migration patterns of some birds. However, wind generators do not consume any nonrenewable natural resources, and they do not pollute the atmosphere or water.

Energy from Inside Earth

Earth is not completely solid. Heat is generated within Earth by the decay of radioactive elements. This heat is called geothermal heat. Geothermal heat causes the rock beneath Earth's crust to soften and melt. This hot molten rock is called magma. The thermal energy that is contained in hot magma is called **geothermal energy.**

In some places, Earth's crust has cracks or thin spots that allow magma to rise near the surface. Active volcanoes, for example, permit hot gases and magma from deep within Earth to escape. Perhaps you have seen a geyser, like Old Faithful in Yellowstone National Park, shooting steam and hot water. The water that shoots from the geyser is heated by magma close to Earth's surface. In some areas, this hot water can be pumped into houses to provide heat.

Reading Check ***What two natural phenomena are caused by geothermal heat?***

Geothermal Power Plants

Geothermal energy also can be used to generate electricity, as shown in **Figure 25.** Where magma is close to the surface, the surrounding rocks are also hot. A well is drilled and water is pumped into the ground, where it makes contact with the hot rock and changes into steam. The steam then returns to the surface, where it is used to rotate turbines that spin electric generators.

The efficiency of geothermal power plants is about 16 percent. Although geothermal power plants can release some gases containing sulfur compounds, pumping the water created by the condensed steam back into Earth can help reduce this pollution. However, the use of geothermal energy is limited to areas where magma is relatively close to the surface.

Science Online

Topic: Geothermal Energy

Visit gpscience.com for Web links to information about geothermal energy.

Activity Using the information that you find write a paragraph describing why current facilities are located where they are.

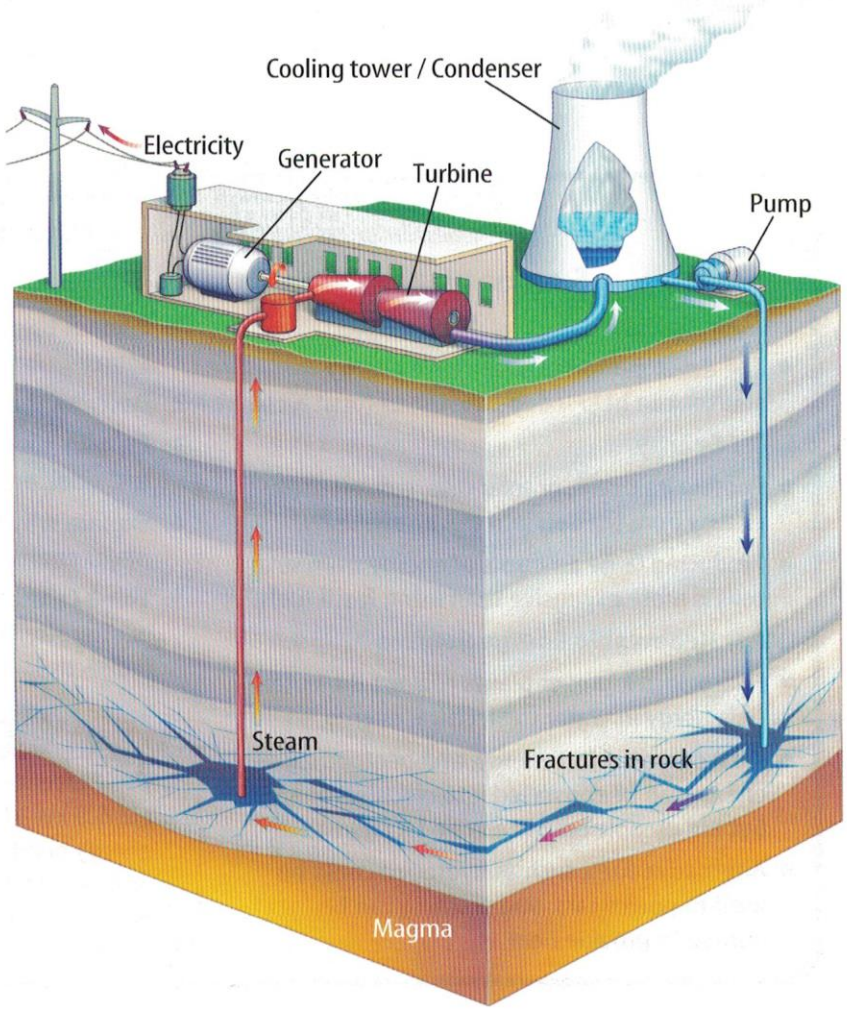


Figure 25 A geothermal power plant converts geothermal energy to electrical energy. Water is changed to steam by the hot rock. The steam is pumped to the surface where it turns a turbine attached to an electric generator.

Figure 26 Hydrogen may one day replace gasoline as a fuel for automobiles. Burning hydrogen produces water vapor, instead of carbon dioxide.

Alternative Fuels

The use of fossil fuels would be greatly reduced if cars could run on other fuels or sources of energy. For example, cars have been developed that use electrical energy supplied by batteries as a power source. Hybrid cars use both electric motors and gasoline engines. Hydrogen gas is another possible alternative fuel. It produces only water vapor when it burns and creates no pollution. **Figure 26** shows a car that is equipped to use hydrogen as fuel.

Biomass Fuels Could any other materials be used to heat water and produce electricity like fossil fuels and nuclear fission? Biomass can be burned in the presence of oxygen to convert the stored chemical energy to thermal energy. **Biomass** is renewable organic matter, such as wood, sugarcane fibers, rice hulls, and animal manure. Converting biomass is probably the oldest use of natural resources for meeting human energy needs.

section 3 review

Summary

Energy Options

- The development of alternative energy sources can help reduce the use of fossil fuels.

Solar Energy

- Photovoltaic cells, or solar cells, convert radiant energy from the Sun into electrical energy.
- Producing large amounts of energy from solar cells is more expensive than using fossil fuels.

Other Renewable Energy Sources

- Hydroelectric power plants convert the potential energy in water to electrical energy.
- Tidal energy, wind energy, and geothermal energy can be converted into electrical energy, but are useable only in certain locations.
- Alternative fuels such as hydrogen could be used to power cars, and biomass can be burned to provide heat.

Self Check

1. **Explain** the need to develop and use alternative energy sources.
2. **Describe** three ways that solar energy can be used.
3. **Explain** how the generation of electricity by hydroelectric, tidal, and wind sources are similar to each other.
4. **Explain** why geothermal energy is unlikely to become a major energy source.
5. **Think Critically** What single energy source do most energy alternatives depend on, either directly or indirectly?

Applying Math

6. **Use Percentages** A house uses solar cells that generate 6.0 kW of electrical power to supply some of its energy needs. If the solar panels supply the house with 40 percent of the power it needs, how much power does the house use?