LESSON 1

Biomass and Geothermal Energy

Guiding Question: How can we use biomass energy and geothermal energy?

Knowledge and Skills

- Explain the benefits and current status of renewable energy resources.
- Define biomass energy and explain how it is used.
- Describe how geothermal energy is harnessed and used.

Reading Strategy and Vocabulary

Reading Strategy As you read, make a two-column table. In the left column, write the blue and green lesson headings. In the right column, write notes that summarize the information in the text that follows each heading.

Vocabulary biomass energy, biofuel, biopower, geothermal energy, ground source heat pump

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18.1 LESSON PLAN PREVIEW

Real World Students discuss how they use or could use alternative energy sources in their daily lives.

Differentiated Instruction English language learners apply the meaning of a prefix to understand lesson vocabulary.

Inquiry Students model how the ground changes temperature to understand geothermal energy.

18.1 RESOURCES

In Your Neighborhood Activity, *Regional Renewable Energy* • Paper and Pencil Activity, *Compare Biofuels* • Bellringer Video, *Autos—The Nation That Runs on Ethanol* • Real Data Online • Real Data Math Worksheet • Lesson 18.1 Worksheets • Lesson 18.1 Assessment • Chapter 18 Overview Presentation

FOCUS Have students watch the ABC News video **Autos—The Nation That Runs on Ethanol,** which describes the use of ethanol-powered vehicles in Brazil and identifies the factors that would need to change to allow ethanol to become as popular a fuel choice in the United States as it is in Brazil.

RENEWABLE ENERGY RESOURCES are sometimes called *alternative energy resources,* because they are an alternative to fossil fuels and nuclear energy. Why is it important to provide an alternative? Fossil fuels will not last forever. In addition, their use causes pollution, including greenhouse gas emissions. Nuclear power is a relatively pollution-free alternative to fossil fuels, but it has its own problems, including waste disposal and the possibility of accidents.

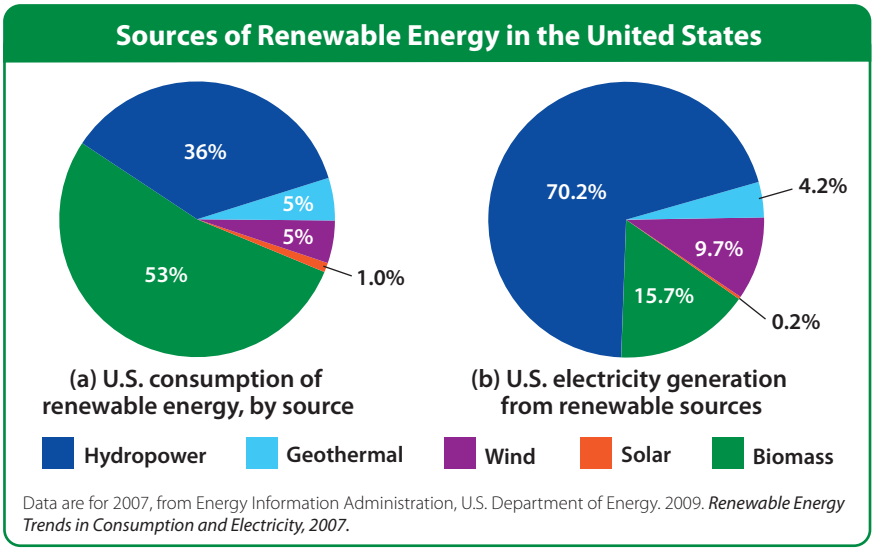
The Reasons for Alternative Energy

Alternative energy resources are needed to replace fossil fuels, reduce air pollution, and reduce the emission of greenhouse gases.

You are familiar with some kinds of renewable energy. When you see a sailboat gliding across a bay, you are observing wind energy in action. Since ancient times, people have harnessed wind and moving water to do work. Hundreds of years ago, in Europe, America, and other parts of the world, windmills and water wheels turned machinery that ground grain into flour. And long before that, people burned wood to cook food and keep warm.

Today wind, water, and wood still provide people with energy. In addition, if you have seen solar panels on roofs, you know that people have found ways to capture energy from the sun. Scientists are looking into new ways of using renewable resources to fill modern energy needs.

Benefits of Renewable Energy Renewable energy resources provide several benefits. For one thing, most of them are unlikely to run out. Also, if renewable energy resources replace fossil fuels, they will help decrease air pollution and greenhouse gas emissions. And if our nation develops renewable energy resources, we will be less dependent on other nations to supply us with fuel. Finally, the development of renewable energy will create jobs for people to design, build, and maintain the needed technology. Maybe you will one day have a career in a renewable-energy industry.



Connect to the Central Case

FIGURE 1 Renewable Energy in the United States The graphs show **(a)** U.S. consumption of renewable energy and **(b)** U.S. generation of electricity from renewable energy sources. **Compare and Contrast** About 7 percent of the energy in the United States comes from renewable sources. How does this compare with Germany's goal for 2020?

ANSWERS

Figure 1 Germany's goal for 2020 is 10%, so the U.S. is at 70% of that goal.

Renewable Energy Today Today the world is powered mainly by fossil fuels. Oil, coal, and natural gas supply 80 percent of our energy. These three fuels also generate two thirds of the world's electricity. However, use of renewable energy sources is generally growing much faster than use of nonrenewable energy. The leader in growth is wind power, which has grown nearly 50 percent each year since the 1970s.

Renewable energy will probably keep growing rapidly. That will happen because the world population will keep increasing and—along with it—the need for energy. In addition, reserves of fossil fuels are decreasing. Furthermore, citizens want a cleaner environment. In spite of growth, though, it will take renewable energy sources some time to catch up. At present, even though renewable-energy technology is rapidly improving, renewables cannot yet produce enough power to replace fossil fuels and nuclear energy.

Biomass Energy

Energy derived from biomass is used for cooking, heating, powering motor vehicles, and generating electricity.

Biomass is material that makes up living organisms or comes from organisms. Wood, manure, and grain are all examples of biomass. **Biomass energy** is energy that is produced from this material. Recall that fossil fuels, too, come from living things. However, unlike energy from fossil fuels, biomass energy is renewable.

Using Biomass as an Energy Source There are many ways of using biomass to produce energy. More than 1 billion people still burn wood from trees as their main energy source. In developing nations, families gather wood to burn in their homes for heating, cooking, and lighting. Wood, charcoal, and manure account for 35 percent of energy use in developing nations. In the poorest nations, these forms of biomass supply up to 90 percent of energy. Industrialized nations are developing new ways to use biomass as a source of energy. Biomass energy can now power motor vehicles and generate electricity.

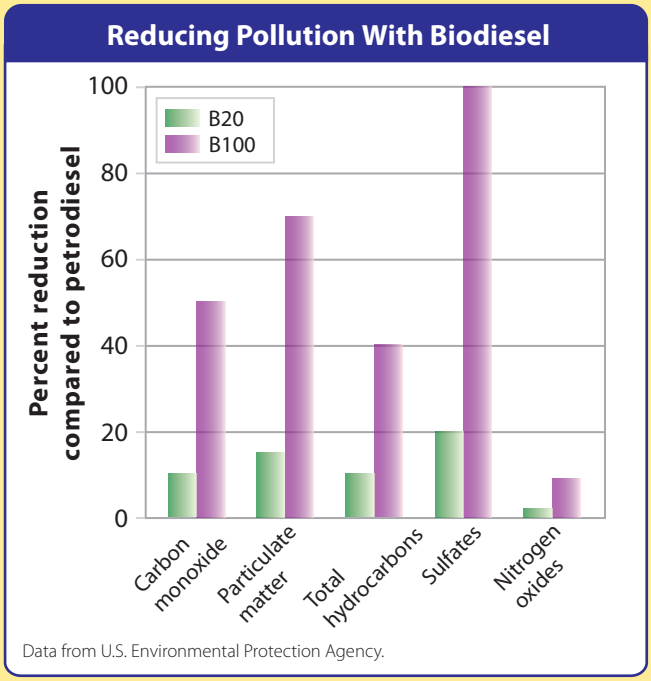
FIGURE 2 Biomass for Fuel Women in Mozambique, Africa, collect wood to use as fuel.

Real Data

Biodiesel

The graph shows the percentage reductions in several major automotive pollutants when two kinds of diesel fuel are burned. One kind, B20, is a mixture that consists of 20 percent biodiesel and 80 percent conventional, petroleum-based diesel. The other, B100, is 100 percent biodiesel.

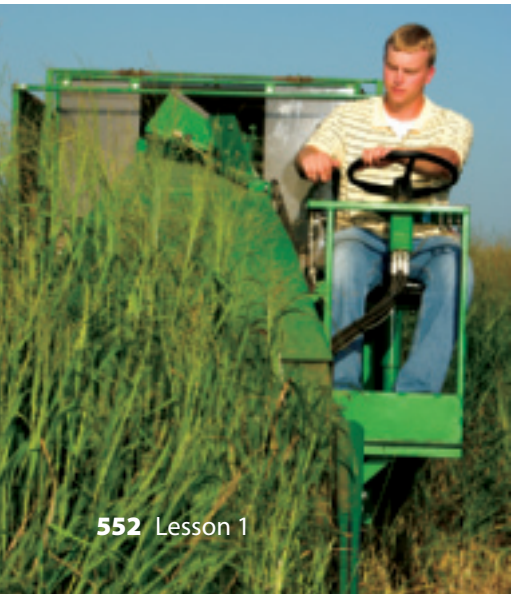
1. **Interpret Graphs** In the graph, what do the percentages refer to? (*Hint:* Look at the label for the vertical axis and think about what both fuels are being compared to.)
2. **Interpret Graphs** If B20 is used, by what percentage are carbon monoxide emissions reduced?
3. **Compare and Contrast** Of the two fuels shown on the graph, which reduces pollution most?
4. **Interpret Graphs** Can you use this graph to determine the actual amount of each pollutant released when the fuels are burned? Explain your answer.



ANSWERS

Real Data For answers to the Real Data Activity, see page A–29 at the back of the book.

FIGURE 3 Electricity From Switchgrass Fast-growing switchgrass, shown here, may one day be a source of biopower.



Biofuels Liquid fuels from biomass sources, known as **biofuels,** are helping to power millions of vehicles on today's roads. The two primary biofuels are *ethanol,* which is used in gasoline engines, and *biodiesel,* which runs diesel engines.

▶ ***Ethanol*** Ethanol is produced by the fermentation of starches or sugars. The result of this type of fermentation is pure alcohol. Ethanol can be used either by itself or as a supplement to gasoline to power cars. The ethanol that is used as an energy source in the United States is produced mainly from corn. A blend of gasoline and alcohol called *gasohol* is widely used in the United States because it releases smaller amounts of many pollutants, such as carbon monoxide and particulate matter, than does pure gasoline.

▶ ***Biodiesel*** Biodiesel is produced from vegetable oil, such as soybean oil. Although biodiesel can be used in its pure form, it is usually mixed with conventional petroleum-based diesel fuel. Biodiesel cuts down on emissions compared with conventional diesel fuel.

Biopower Electricity that is generated by the combustion of biomass is called **biopower.** Many of the sources used for biopower are the waste products of existing industries or processes. For instance, the timber industry generates sawdust and other woody debris. Cornstalks, corn husks, and biomass waste from landfills can also be burned to generate electricity. Besides using waste, we also grow crops to produce biopower. These crops include fast-growing trees and grasses, such as the switchgrass in **Figure 3.**

The decomposition of biomass by microorganisms produces gas that can be used to generate electricity. The breakdown of waste in landfills produces methane. This "landfill gas" is being captured at many landfills and sold as fuel. Power plants that burn methane and other kinds of biomass operate similarly to those powered by fossil fuels. The combustion heats water, creating steam to turn turbines that power generators.

Benefits of Biomass Energy Because biomass is a valuable energy resource, the German government has established a research center to explore and promote its use. There are many benefits to biomass energy. For one thing, the carbon produced by the combustion of biomass is the same amount of carbon that was removed from the atmosphere by photosynthesis to make the biomass in the first place. Therefore, the combustion of biomass releases no net carbon into the atmosphere. Biomass energy can also benefit nations economically. Unlike oil and other fossil fuels, biomass is distributed worldwide. Therefore, it should help reduce many nations' dependence on imported fuels.

Costs of Biomass Energy Biomass energy has disadvantages, too. Biofuel crops take up land that might be used for growing food or left in its natural condition. Deforestation, soil erosion, and desertification can result if wood is cut down too rapidly for fuel. In reality, biomass is not renewable if it is used up faster than it is produced. Biomass is not an efficient source of energy, and its use can cause indoor air pollution.

▶ ***Inefficiency*** Growing corn for ethanol requires a substantial input of energy, partly because farmers use fossil fuels to run farm equipment. Corn ethanol provides only a small amount more energy than the energy needed to produce it. It takes 1 unit of input energy to gain 1.5 units of energy from ethanol.

▶ ***Indoor Air Pollution*** Indoor air pollution can result if wood and other biomass fuels are burned inside buildings. In developing nations, the burning of biomass indoors is a major threat to health. It increases the risk of respiratory system problems such as lung cancer and infections.

Reading Checkpoint *How can biomass energy cause indoor pollution?*

Geothermal Energy

Steam and hot water produced by geothermal energy can be used for generating electricity and for heating.

Deep beneath the surface of Earth, high pressure combined with the breakdown of radioactive elements produces heat. This heat is geothermal energy, which heats rocks below Earth's surface, sometimes melting them to form liquid rock called magma. In some places, heated rocks or magma in turn heat underground water. Hot water and steam may spurt from beneath the ground to the surface, as shown in **Figure 4.** Hot springs and geysers are the result of geothermal energy.

Your World, Your Turn

WHAT DO YOU THINK?

Corn and other crop plants can be used to produce ethanol for fuel. This means that the land on which the crops are grown cannot be used to grow crops that feed people. Do you think that the use of crops and land to produce ethanol is justified? Would you attach any conditions to this use?

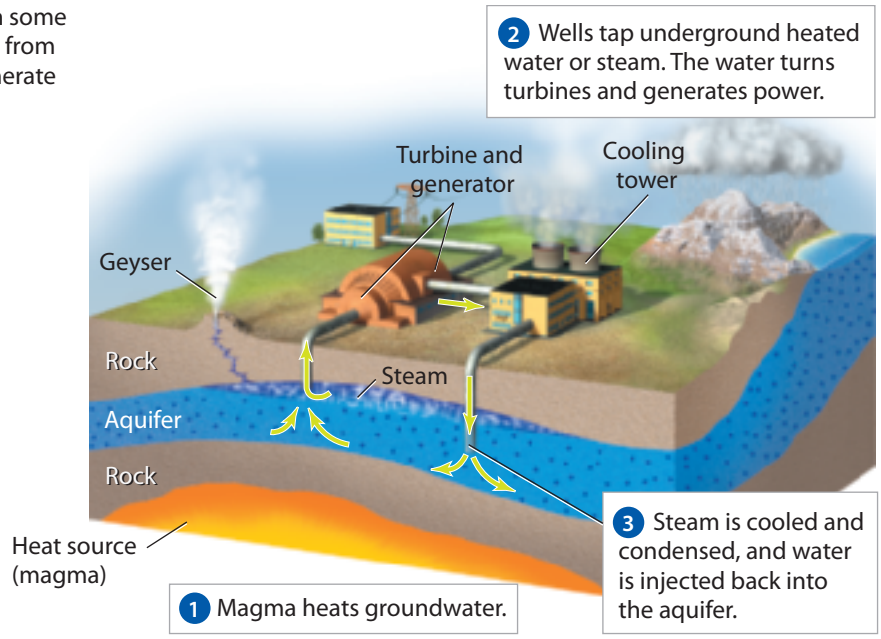
ANSWERS

What Do You Think? Students' opinions will vary but should be well supported.

Reading Checkpoint Indoor air pollution can build up if wood or other biomass fuels are burned inside buildings.

FIGURE 4 Geyser Eruptions of geysers such as this one in Yellowstone National Park are the result of geothermal energy.

FIGURE 5 A Geothermal Power Plant In some locations, magma heats groundwater. Steam from that heated groundwater can be used to generate electricity.



BIG QUESTION

What are the potential uses and limitations of renewable energy sources?

Explanation Have students discuss the costs and benefits of geothermal energy. Then, have students imagine that local officials have proposed a geothermal plant for their area. Have students decide whether or not they would support the idea, based on their discussion. Have each student write a paragraph that states and supports his or her opinion.

Harnessing Geothermal Energy

Geothermal energy can be harnessed to produce electricity in two basic ways. In some cases, steam from geysers at the surface is used to supply energy. Usually, however, wells must be drilled down hundreds or thousands of meters toward heated rocks and water. For example, Germany does not have many locations where magma comes close to the surface. In Germany, therefore, deep drilling is the main method of getting access to geothermal energy.

Generating Electricity

Figure 5 shows how geothermal energy can be used to generate electricity. In this illustration, a geothermal power plant taps into steam below ground. The steam turns the blades of a turbine, which makes a generator produce electricity. After being used, the steam is often cooled and condenses into liquid water. The water is then returned to the aquifer from which it came.

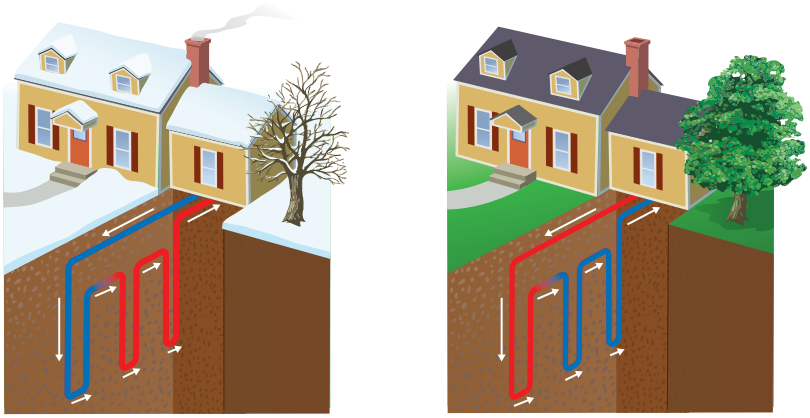
Some geothermal power plants actually create the steam that is used to generate electricity. Cold water from the surface is pumped deep underground, where it reaches heated rocks. Heat from the rocks converts the water to steam. The steam then rises to the power plant, where it turns the blades of a turbine.

Using Heat Directly

Hot groundwater can be used directly for heating homes, offices, and greenhouses. Hot water is piped from its source into buildings. Therefore, heating with groundwater is practical only where geothermal energy sources are nearby.

Ground Source Heat Pumps

Geothermal energy can be used even in areas without heated underground rocks. A **ground source heat pump** takes advantage of the fact that the temperature of soil a few feet underground stays about the same all year, even though the air temperature changes with the seasons. This steady underground temperature is what enables a ground source heat pump to work.



Winter
In winter, the soil deep underground is warmer than the air at the surface. Water flowing through the pipe transfers heat from the ground to the house. This warms the house.

Summer
In summer, the soil underground is cooler than the air above the ground. Water in the pipe cools the house by transferring heat from the house to the ground.

FIGURE 6 Ground Source Heat Pump A ground source heat pump takes advantage of the fact that the temperature of soil far below the ground remains about the same in winter and summer.

In a ground source heat pump, water circulates through underground pipes, as shown in **Figure 6**. In the winter, the water picks up heat from the ground and transfers it to a building. The opposite happens in the summer. Water transfers heat from a building to the ground, cooling the building in the process. More than 600,000 ground source heat pumps are already used to heat homes in the United States.

Benefits and Costs of Geothermal Energy The use of geothermal energy can help replace the use of fossil fuels. Like other renewable sources, geothermal power causes far less air pollution than fossil fuel combustion. And geothermal power releases a much smaller quantity of greenhouse gases than does the burning of fossil fuels.

On the negative side, geothermal sources may not always be truly sustainable. If a geothermal power plant uses heated water more quickly than groundwater is replaced, the plant will eventually run out of water. In addition, the water of many hot springs contains chemicals that damage equipment and add to pollution. Some geothermal energy projects may trigger earthquakes. Moreover, geothermal power plants are generally limited to areas where heated groundwater can be tapped fairly easily. Most of the world's nations, including Germany, have few such areas.

ANSWERS

Lesson 1 Assessment

1. The world population is increasing; supplies of fossil fuels are limited; pollution needs to be reduced.
2. Biomass energy is energy produced from the materials of which living things are composed. Some examples include wood, manure, and grain.
3. Steam produced below ground rises to the surface, where it turns the blades of a turbine and produces electricity. The steam cools and condenses, and the liquid water returns underground.
4. Answers will vary but should reflect knowledge of geothermal resources.

LESSON 1 Assessment

1. **Relate Cause and Effect** Why will the use of renewable energy probably keep increasing?
2. **Explain** What is biomass energy? Give an example.
3. **Sequence** Describe how geothermal energy is used to generate electricity from steam that is produced naturally underground. Include what often happens to steam after it is used to produce electricity.
4. Explore the BIGQUESTION Suppose you are a planner who is working for the German government. You and other planners must decide how to use tax money to develop renewable resources. Would you spend tax money on developing sources of geothermal energy? Why or why not?