Chapter 2 • Lesson 7

Objective: 8.P.2.1

Forms and Transformations of Energy

Key Words • energy • thermal energy • mechanical energy • electrical energy • chemical energy • electromagnetic energy • nuclear energy

Getting the Idea

Energy is a word you probably hear or use every day. You know that you need energy to climb stairs or carry your books. Energy cooks your food and heats your home. It powers cell phones, computers, and cars. You cannot see energy, but you can see its effects all around you.

What Is Energy?

Energy is the ability to make things move or change. Scientists define energy as the ability to do work. You need energy to cause change and get things done. For example, you must use energy if you want to pick up a box and carry it across a room. Energy has many different forms.

Forms of Energy

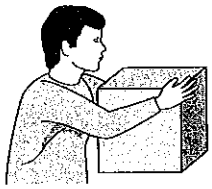
As you have learned, matter is made up of tiny particles called atoms and molecules. These particles are always moving. The energy of the moving particles is called **thermal energy**. A hot cup of cocoa, for example, has a lot of thermal energy. A glass of ice-cold lemonade has much less thermal energy.

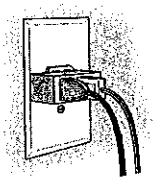
Mechanical energy is the energy of moving objects. A car moving down the street, a soccer ball rolling toward a goal, and a fish swimming in a lake all have mechanical energy. Water flowing over a waterfall and wind also have mechanical energy.

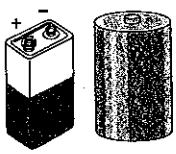
Electrical energy is the energy of moving electric charges. Electrical energy can move through wires. It powers devices you use every day. Lamps, toasters, and computers are just a few examples of devices that use electrical energy.

Chemical energy is energy stored in the bonds that hold atoms together in molecules. This energy is released when molecules undergo chemical reactions and form new substances. Food, fuels, and batteries all store chemical energy. Chemical reactions in your body release energy stored in the food you eat. In the same way, fuels, such as wood or gasoline, release energy when they are burned. The chemicals in a battery release energy when the battery is used to run an electrical device.

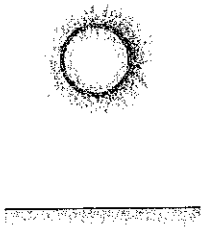
Electromagnetic energy is energy that travels as waves, through matter or through empty space. The energy Earth gets from the sun is electromagnetic energy. You can see this kind of energy as light and feel it as heat. Microwaves and radio waves are also kinds of electromagnetic energy.


Mechanical energy


Electrical energy



Chemical energy


Electromagnetic energy

Nuclear energy is energy stored in the nucleus of an atom. Recall that the nucleus of an atom is made up of protons and neutrons. These particles are held together by nuclear forces. Nuclear energy is released when these forces are overcome and particles are either removed from or added to the nucleus.

Transferring Energy

Energy can move from one place to another. For example, when a golfer swings a golf club, the moving club has mechanical energy. When the club hits a golf ball, some of the energy of the club is transferred to the ball, causing the ball to move.

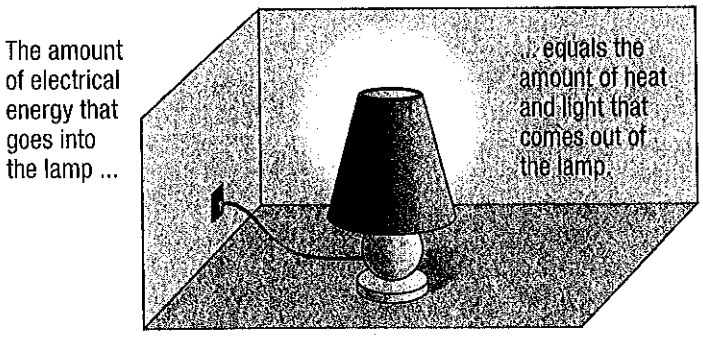
You can feel the transfer of thermal energy as heat. If you hold a warm cup of cocoa in your hands, your hands get warm. Your hands get warmer because some of the thermal energy in the hot cocoa is transferred to the cup. Thermal energy from the cup is transferred to your hands.

Energy Transformations

Energy can change from one form to another. A change from one form of energy to another is called an energy transformation. All forms of energy can be transformed into other forms. Energy transformations let us use energy in different ways. Examples of energy transformations are listed below.

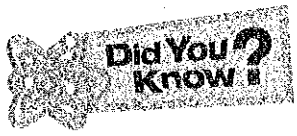
- Green plants transform electromagnetic energy in the form of sunlight into food. The food is stored chemical energy.
- A car engine changes chemical energy stored in gasoline into thermal energy and then into mechanical energy.
- A candle and a match contain stored chemical energy. When you burn them, their chemical energy changes to light and heat.
- A fan changes electrical energy into mechanical energy.
- A flashlight changes chemical energy stored in a battery into electrical energy and then into light and heat.
- A hot plate changes electrical energy into thermal energy.

As you can see, energy changes form all the time. However, energy can never be destroyed. The amount of energy before and after an energy transfer or transformation will always be the same. The diagram shows electrical energy going into a lamp. The energy comes out as light and heat. The amount of energy that goes in always equals the amount that goes out.



When a lightbulb is lit, the energy released as heat is not useful. It is sometimes described as "lost" energy, but it is not really lost. It is transferred to the air around the lightbulb.

Whenever energy is transformed or transferred, some energy moves into the environment, most often in the form of heat. The ways we get and use energy also have other effects on the environment, as you will learn in the next lesson.



Sound is another form of energy. When you use a digital music player, it changes chemical energy in the battery into electricity and then into sound.

Discussion Question

What are some of the forms of energy you used today? Explain how you used each one.

Lesson Review

1. Which form of energy does a battery store?

   A. nuclear energy

   B. thermal energy

   C. chemical energy

   D. electrical energy

2. When moving air strikes the blades of a windmill, it causes the blades to turn. What form of energy do the moving blades have?

   A. mechanical

   B. chemical

   C. electrical

   D. electromagnetic

3. Which of these changes happens when you run?

   A. Mechanical energy is changed to chemical energy.

   B. Chemical energy is changed to mechanical energy.

   C. Energy is used up and lost.

   D. Your body makes new energy.

4. Which of the following energy changes happens in an electric lamp?

   A. Electrical energy turns into chemical energy.

   B. Thermal energy turns into electrical energy.

   C. Electrical energy turns into mechanical energy.

   D. Electrical energy turns into electromagnetic energy.

Objectives: 8.P.2.1; 8.P.2.2

Energy Resources and Their Environmental Impact

Key Words • environment • nonrenewable energy resource • renewable energy resource • fossil fuel • pollution • solar energy • photovoltaic cell • solar battery • solar reflector • wind energy • hydropower • biomass • geothermal energy

Getting the Idea

Humans use large amounts of energy to power cars, heat homes, and produce electricity. That energy comes from resources found in nature. Humans' choices and use of energy resources affect the **environment**, or surroundings, of all living things.

Types of Energy Resources

Energy resources can be classified as either nonrenewable or renewable. A **nonrenewable energy resource** is used much faster than it can be replaced. A **renewable energy resource** either can be replaced as it is used or cannot be used up. People must consider the advantages and disadvantages of each energy resource when deciding which types to use.

Nonrenewable Energy Resources

Most of the energy used in the United States comes from fossil fuels. A **fossil fuel** is an energy resource that formed over millions of years from the decayed remains of ancient plants and animals.

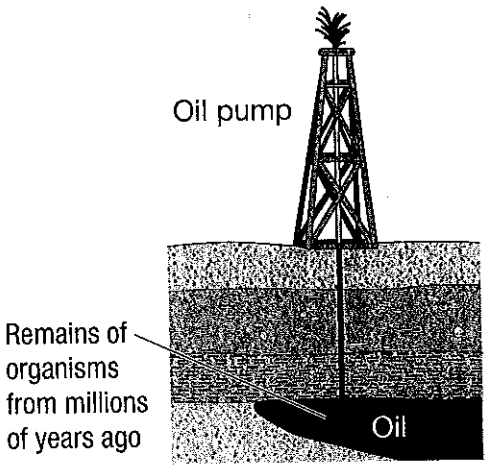
Coal is a solid fossil fuel that formed from decayed plants that lived millions of years ago. Coal is burned in many power plants. The heat it releases is used to boil water. The steam that is produced expands and causes a turbine to spin. A turbine looks like a huge fan. The spinning turbine turns a generator, which changes mechanical energy to electrical energy. The electrical energy is distributed along wires that make up the power grid.

Petroleum is a liquid fossil fuel that is also known as crude oil. It formed from ancient sea organisms. The gasoline burned in car engines is made from oil. Propane, which is often burned to heat homes or cook food, is also made from oil.

Natural gas is a fossil fuel found along with petroleum. Natural gas is used in stoves, furnaces, water heaters, clothes dryers, and other appliances. Like coal, natural gas and petroleum can be burned in power plants to generate electrical energy.

The main advantage of fossil fuels is that they produce large amounts of energy when they are burned. However, fossil fuel use can cause **pollution**, the release of unwanted materials into the environment. Burning fossil fuels causes air pollution. Coal mining can damage land and pollute nearby water supplies.

Oil is obtained by drilling deep into Earth's crust. Drilling for oil may disturb habitats—the places where plants and animals live. Sometimes oil is spilled at a drilling site or from a ship carrying oil. Such accidents can severely damage habitats.



Burning fossil fuels releases carbon dioxide. Scientists have observed that carbon dioxide in the atmosphere has increased during the last few hundred years. This is about the same amount of time that people have been building and using machines powered by fossil fuels. Many scientists believe that extra carbon dioxide from burning fossil fuels is causing or adding to global warming and climate change. *Global warming* is a trend of rising average temperatures around the world.

Another source of electricity used in the United States is nuclear energy. Recall that nuclear energy is energy stored in the nucleus of an atom. Nuclear power plants produce electrical energy by breaking apart atoms to release this stored energy. Most nuclear power plants use the element uranium, a nonrenewable resource, as fuel.

An advantage of using nuclear energy is that it does not cause air pollution. A disadvantage is the possibility of an accident that could release radioactive materials into the environment. Radiation from such materials can be very harmful to humans and other living things. Nuclear power plants also produce radioactive wastes. These must be stored safely for a very long time.

Renewable Energy Resources

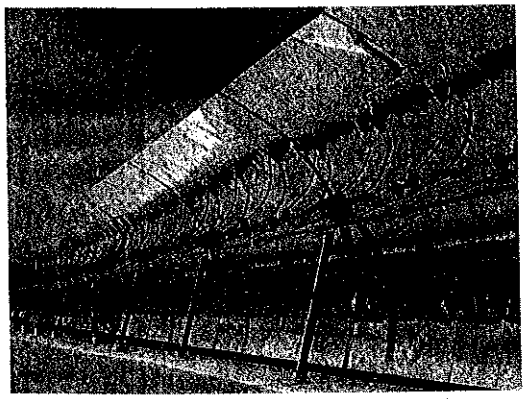
Humans have used energy from wind and moving water for thousands of years. Today, these resources are used to produce electricity. Other renewable resources are also used as sources of energy.

Solar energy is energy from the sun. The sun gives off huge amounts of energy. People have learned to collect this energy to produce heat and electricity. You may have seen houses with solar panels on the roof. One kind of solar panel uses solar energy to heat water for use in the home.

Another kind of solar panel is used to produce electricity. A device called a **photovoltaic cell**, or solar cell, can change light energy into electricity. When light strikes atoms in the cell, the light causes electrons to move. If the solar cell is part of an electric circuit, an electric current flows through the circuit. A single cell produces only a small amount of electricity, but many cells together can produce enough electricity to provide power for an entire building.

Because photovoltaic cells require sunlight, they cannot produce electricity at night. Buildings that use solar energy can be connected to the power company grid. They obtain electricity at night from that system. Some buildings have **solar batteries** to store electrical energy produced by solar cells. The energy is used at night, when the solar cells are not supplying electricity.

Solar energy can be used in power plants. In one kind of solar power plant, many solar panels are placed in an open area that receives sunlight throughout the day. The electricity the panels produce flows into the power company grid. Another kind of power plant uses solar reflectors. A **solar reflector** reflects and focuses sunlight onto a fluid-filled pipe. The fluid in the pipe becomes heated, and the thermal energy is used to turn water into steam. The steam turns a turbine, just as it would in a fossil-fuel power plant. The photo below shows an array of solar reflectors.



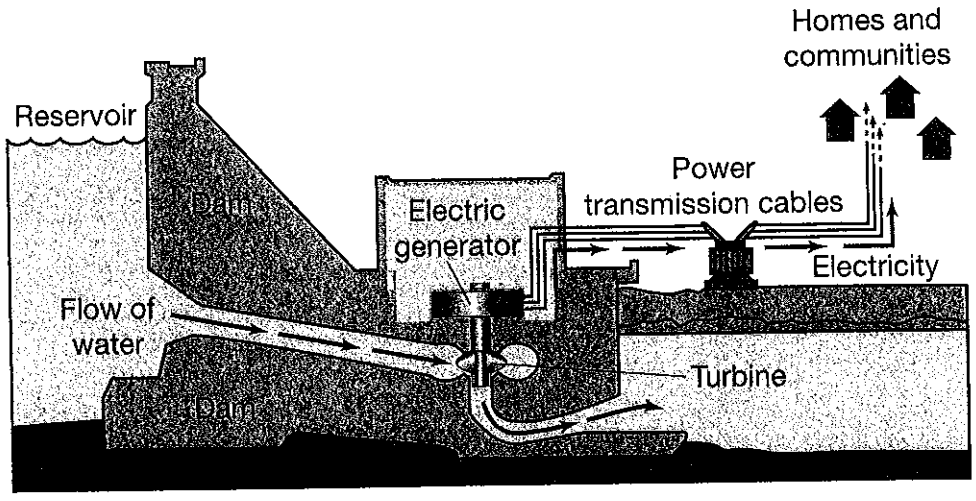
Solar energy has many advantages. Producing electricity from sunlight does not cause pollution or use nonrenewable fuels. The sun provides much more energy than people need, so solar energy will not run out. Solar panels are expensive. But the cost of electricity produced from fossil fuels is increasing. At the same time, new technologies are lowering the cost of solar panels.

Wind energy is the energy of moving air. It can be used to turn the blades of windmills or wind turbines. In a wind turbine, the blades are attached to a shaft that turns an electric generator, which produces electricity. Wind farms are areas that use a large number of wind turbines to produce electrical energy. Wind farms must be constructed where winds blow rather steadily most of the year. In the United States, many of the largest wind farms are in the Great Plains and Midwest regions, but large wind farms are being built in other areas and offshore.

A benefit of wind energy is that it does not cause pollution or contribute to global warming. However, wind energy does have some disadvantages. People who live near wind farms say that the turbines are noisy. Birds and bats have been struck and killed by the turning blades.

Hydropower is the energy of moving water. Hydroelectric power plants, which use hydropower to produce electricity, have been built on many rivers in the United States and around the world. At a hydroelectric power plant, the moving river water turns the blades of turbines. The turbines move the parts of electric generators, producing electricity. A natural waterfall is a good location for a hydroelectric power plant because of the large amount of energy in falling water. In other places, a dam must be built.

Hydroelectric Dam

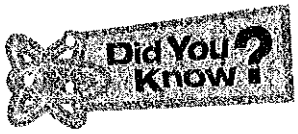


Like wind energy, hydropower does not cause pollution. But it cannot be used everywhere. Hydroelectric energy is available only where there is a fairly large river. Also, constructing a dam often involves the creation of an artificial lake called a reservoir. This floods nearby land and destroys the habitats of many organisms.

Biomass is any material from living things that can be used as an energy source. Examples of using biomass for energy include burning wood and burning discarded plant material. A biomass fuel called ethanol can be made by fermenting crops such as corn. The ethanol can be added to gasoline to be burned in car, truck, and bus engines. This reduces the amount of gasoline that is used.

One disadvantage of burning biomass and biomass fuel is that it releases carbon dioxide. Another concern about using ethanol as a fuel is that it is made from crops that are also food sources for people and farm animals. Using these crops to produce fuel could affect how much food is available.

Geothermal energy is heat energy from inside Earth that can be used to heat buildings and produce electricity. Geothermal energy also produces natural hot springs and geysers. Using geothermal energy requires a location that is over volcanically active ground. One country that has many places like this is Iceland. Much of Iceland relies on geothermal energy.



In Iceland, nearly 90 percent of homes are heated with geothermal energy. Geothermal energy is also used to heat some roads and sidewalks, keeping them free of ice and snow.

Discussion Question

Suppose a wind farm was proposed for an area near where you live. Would you support this idea? Give reasons for your response.

Lesson Review

1. Which of the following is a nonrenewable energy resource?

   A. coal

   B. wood

   C. wind

   D. biomass

2. Which source of energy depends on moving water?

   A. geothermal energy

   B. hydropower

   C. solar energy

   D. biomass

3. Which of the following does **not** release carbon dioxide when it is used as an energy resource?

   A. petroleum

   B. ethanol

   C. coal

   D. wind

4. Why is the use of geothermal energy limited?

   A. It can be used only in areas that have volcanic activity, and these areas are limited.

   B. It can be used only in areas that receive a great deal of sunlight, and these areas are limited.

   C. It destroys habitats, so it cannot be used in areas where there is a lot of wildlife.

   D. It pollutes the water, so it cannot be used in areas where people live.

Objectives: 8.P.2.1; 8.P.2.2

Chapter 2 • Lesson 9

Using and Conserving Energy Resources

Key Words • conservation • data table • circle graph

Getting the Idea

You have seen that some energy sources are nonrenewable. Unfortunately, these are the resources that are used most. In the last 50 years, worldwide use of fossil fuels has more than doubled to meet the needs of a growing world population. These fuels will not last forever. In this lesson, you will learn some of the ways people can manage their use of energy wisely.

Using Energy

People have always needed and used energy resources. For much of human history, the only way to keep warm and cook was to burn wood and other biomass fuels. To travel, people used their feet, animals, or boats pushed by the wind.

For centuries, work was performed with hand tools or simple machines powered by the efforts of humans or animals. Over time, people developed windmills and watermills, which use the energy of moving air and water to power machines. Water-powered mills were used to saw wood, grind grain, and weave cloth. How much work could be done depended on the energy that could be obtained from the moving water.

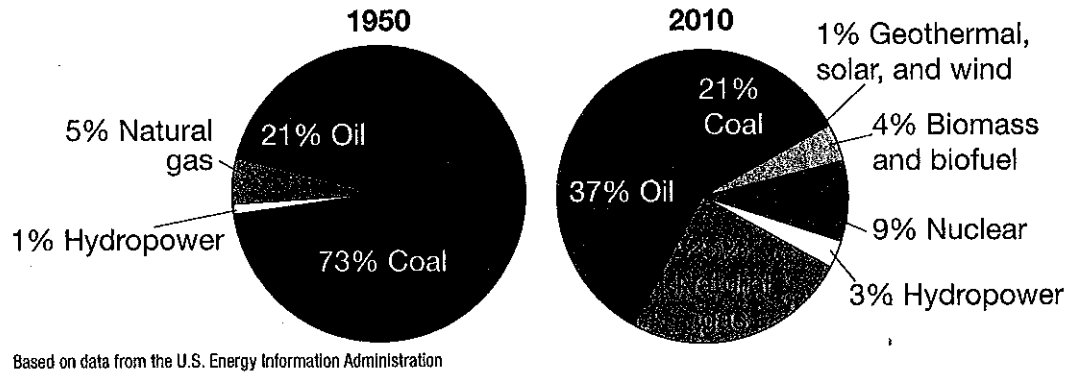
The invention of the steam engine gave humans a new energy source for manufacturing and other processes. In the 1700s and 1800s, during a period called the Industrial Revolution, many large factories were built. These factories could turn out products faster and cheaper than ever before. But there was a new cost. The steam engine required fuel. Coal, a fossil fuel, was burned to boil water to make the steam that powered the engine. Burning coal released smoke. In areas where there were many factories, the air became polluted. Soot, a thin layer of carbon, covered buildings near factories. The dependence of humans on fossil fuels had begun.

Steamships and steam-powered railroads became the main forms of transportation. These new machines had boilers that ran on burning coal. In the 1880s, people started burning coal to produce electricity. Soon cars that burned gasoline became common. From that time to today, humans' need for energy has increased quickly. Most of that energy has come from fossil fuels.

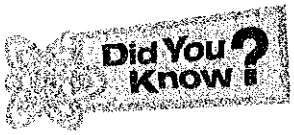
Today, people use more devices and machines than ever before. As a result, our energy needs have grown. We use hair driers, vacuum cleaners, and clothes washers and driers to save ourselves time and effort. We watch TV and talk on phones. We use furnaces to heat our homes in cold weather and air conditioners to cool our homes in hot weather. We use computers to find information and communicate. We travel by car, bus, train, plane, and even spacecraft. Each of these devices uses energy, which we get from a variety of sources.

In 1950, the main source of energy in the United States was coal. Hydropower supplied a small amount of energy, but people did not use other renewable energy sources. Since then, our energy use has changed. Today, we use more oil and natural gas than coal. We also use nuclear power. And we use more renewable energy sources.

U.S. Energy Use by Source



Based on data from the U.S. Energy Information Administration



The energy of water flowing through hydroelectric power plants produces almost 20 percent of the world's electric power.

Conserving Energy

In the 1950s, the United States' energy consumption, or use, was about the same as its energy production. In other words, we used about the same amount of energy as we got from our own energy sources. Since then our energy production has increased, but so has our energy use. It has grown so much that it now far exceeds our production. We rely on other countries' energy resources to make up the difference.

As our country's population increases, so does our need for energy. Imagine that something unexpected happened to our energy sources. What if we could no longer get the energy we needed from other countries? Or suppose our own energy production decreased. We might run out of a nonrenewable energy resource. Then there would be a shortage of energy.

Some areas could lose their supply of electricity for short or long periods. Fuel could become very expensive or not be available at all. Some people might not have fuel to heat their homes or drive their vehicles. Companies might not be able to transport their products, such as food and clothing, to places that needed them. An energy shortage could change the way many people live.

Our energy needs are great while many energy resources are limited. There may not always be enough energy for all the people who need or want it. There are two ways to keep this from happening. One is to use renewable resources. In Lesson 8, you learned about many of these resources, such as solar energy and wind energy. By using solar panels or building wind farms, people can increase their use of renewable energy sources and decrease the need for fossil fuels.

The other way to avoid energy shortages is to use energy wisely. **Conservation** is the careful use and management of resources. Ways to conserve energy resources include adding insulation to walls and roofs to cut down on heat loss. Keeping the thermostat at a low temperature in winter saves fuel. During summer, using air conditioning less or keeping the thermostat at a higher temperature conserves resources by using less electricity. Even something as simple as turning off the lights when you leave a room saves energy.

People can conserve fossil fuels by buying fuel-efficient cars. These are cars that can travel more miles per gallon of gas. Hybrid electric cars, which use rechargeable batteries in addition to gasoline, are extremely efficient. Taking public transportation, such as a bus or a train, also saves fuel. A bus full of people uses less gas per person than a car full of people. Walking or riding a bicycle is a good way to save fuel when traveling short distances.

Recycling helps conserve energy. Metal cans made of aluminum can be recycled to make new aluminum products. It takes less energy to recycle aluminum than to obtain it from bauxite, the mineral in which aluminum is found.

Focus on Inquiry

There are many ways to organize and display numerical information. Numbers can be organized in a **data table**, which is a chart made up of rows and columns. Using a graph is another way to display information. A **circle graph**, or pie chart, shows parts of a whole. It, looks like a pie cut into different-size slices. Each slice represents a part of a whole. All the slices together equal the whole, or 100 percent.

Circle graphs, like the ones shown on page 53, help you quickly compare parts of a whole just by looking at the graph. To make a similar comparison using a data table, you would need to read all the numbers in the table.

Lesson Review

1. Most of the energy used in the United States comes from

   A. oil and natural gas.

   B. coal and nuclear energy.

   C. natural gas and biomass.

   D. hydropower and oil.

2. Which of the following is the **most** reliable prediction about the future of some nonrenewable energy sources?

   A. Enough new coal and oil will form to meet our needs in the near future.

   B. In the near future, people will no longer need to conserve fossil fuels.

   C. Fossil fuel supplies will decrease, and the cost of fossil fuels will increase.

   D. Coal will be in short supply, but oil will still be widely available for our use.

3. The wise use of natural resources is called

   A. production.

   B. conservation.

   C. biomass.

   D. restoration.