chapter 8

Electricity to Electronics

Sections

What You'll Learn

- **Define** electricity.
- **Identify** the three types of electricity and the differences between them.
- **List** uses for direct and alternating current.
- **Discuss** voltage, amperage, and resistance.
- **Use** Ohm's law to determine measurements in a circuit.
- **Tell** the purpose of an electric meter.
- **Explain** the difference between a conductor and an insulator.
- **Name** some uses for semiconductors and superconductors.
- **Describe** the two basic types of electrical circuits.
- **Summarize** the different types of electronic signal transmissions.
- **Tell** how fiber optic cables work.
- **Compare** analog and digital signals.

Explore the Photo

Strike One! A bolt of lightning carries a tremendous amount of electricity. *Why is it dangerous to walk through an open field during a thunderstorm?*

Launch the TECHNOLOGY LAB

Build a Simple Alarm System

At the end of this chapter, you will be asked to build a simple alarm system. Get a head start by using this checklist to prepare for the Technology Lab.

PROJECT CHECKLIST

- ✓ Review your classroom's safety rules and procedures.
- ✓ Ask your teacher how to properly use a wire stripper, metal punch, and drill.
- ✓ Brainstorm some possible uses for your alarm system.

Roger Ressmeyer/Corbis

section 8.1

Electricity Basics

Reading Guide

Before You Read **Connect** How are static electricity and lightning related?

Content Vocabulary

- atom
- electricity
- static electricity
- DC
- circuit
- AC
- frequency
- voltage
- transformer
- amperage
- resistance
- Ohm's law
- wattage

Academic Vocabulary

You will see these words in your reading and on your tests. Find their meanings at the back of this book.

- transmit
- vary

Graphic Organizer

Draw the section diagram. Use it to organize and write down information as you read.

Measuring Electricity

Term	Definition	Unit of Measure
Voltage		
Amperage		
Resistance		

Go to **glencoe.com** to this book's OLC for a downloadable graphic organizer and more.

TECHNOLOGY STANDARDS

STL 3 Relationships & Connections

STL 11 Design Process

STL 16 Energy & Power Technologies

ACADEMIC STANDARDS

Science

NSES Content Standard B Motion and forces

Mathematics

NCTM Algebra Represent and analyze mathematical situations and structures using algebraic symbols.

STL *National Standards for Technological Literacy*

NCTM *National Council of Teachers of Mathematics*

NCTE *National Council of Teachers of English*

NSES *National Science Education Standards*

NCSS *National Council for the Social Studies*

What Is Electricity?

Can static electricity be dangerous?

Have you ever touched a doorknob, and received a shock? In this chapter, you will learn why these shocks are only annoying and why lightning, which is another form of static electricity, is extremely dangerous. You will also learn why some devices require very little electricity while others require a lot. Every electric circuit contains voltage, amperage, and resistance. They determine what electricity can do and how dangerous it can be.

As You Read

Predict What is the purpose of an electric meter?

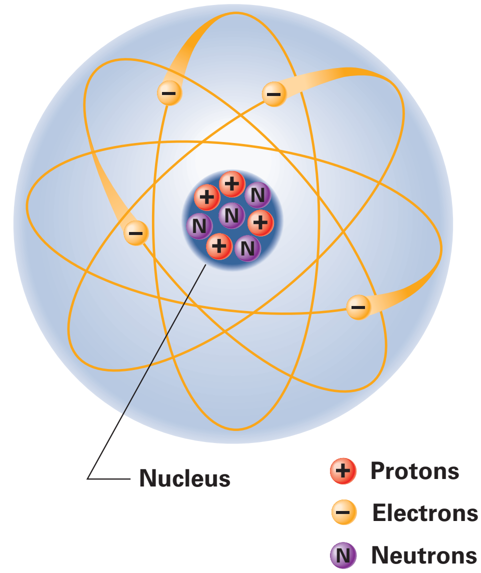
The Atom

To understand what electricity is and how it functions, you need to understand more about **atoms**. Atoms are the building blocks from which all things are made. They are made of several atomic particles:

- Protons
- Electrons
- Neutrons

Atoms contain an equal number of positively charged protons and negatively charged electrons. Most atoms also contain the atomic particles called neutrons, which have no charge at all. See **Figure 8.1**, The Atom.

Figure 8.1 The Atom



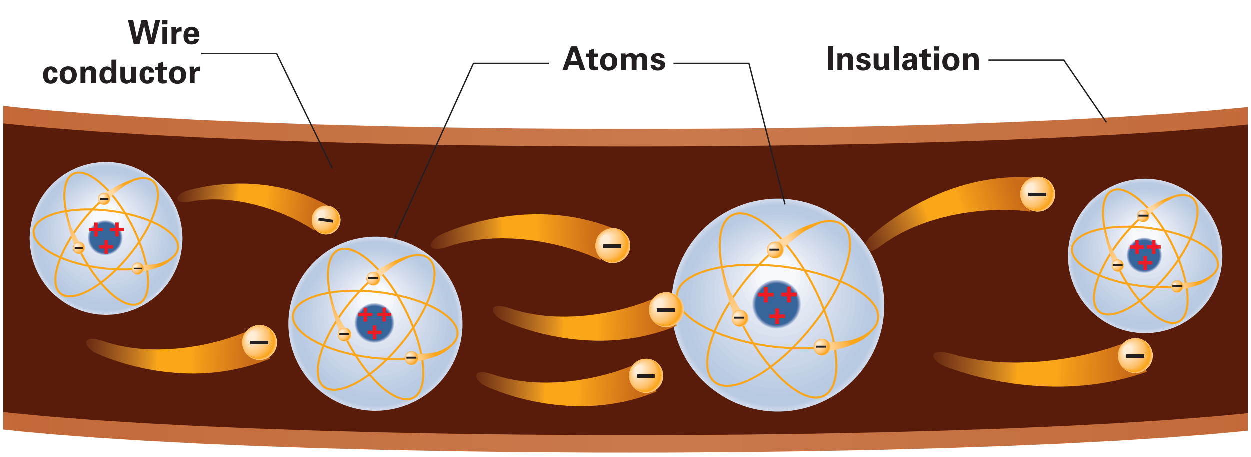
Inside the Atom Negatively charged electrons travel around the nucleus. The nucleus contains positively charged protons and neutral neutrons. *What happens when an atom has too many electrons?*

Electrons and Protons

An atom is in balance when it contains the same number of electrons and protons. Atoms obey the same rules of repulsion (pushing away) and attraction (moving together) as magnets. When an atom has too many or too few electrons, it pushes or pulls the extra electrons off to its neighboring atoms. This flow of electrons from one atom to another is called **electricity**. See **Figure 8.2**.

Reading Check **Define** What is electricity and how does it work?

Figure 8.2 The Flow of Electrons



Understanding Electricity Electrons in a circuit move from atom to atom. When an atom loses electrons, it becomes positively charged. When an atom gains electrons, it becomes negatively charged. *Why do scientists relate the behavior of magnets to the behavior of atoms?*

Types of Electricity

What are some different types of electricity?

Is the electricity that comes out of the wall outlets in your home the same as the electricity in batteries? Are static electricity and lightning different from the electricity that powers your home?

Static Electricity

Static electricity occurs when atoms have built up "extra" electrons. These extra electrons are ready to jump to new atoms. When super-charged atoms come close to an object that can conduct electricity, a spark occurs. When you receive a shock from ordinary static electricity, you are not hurt because the static charge lacks power. Static electricity can, however, destroy sensitive electronic circuits and ignite flammable liquids and gases.

Lightning is a very strong discharge of static electricity. If it hits a power line, the electricity surge can destroy electrical equipment in the area and cause blackouts.

Direct Current

DC, or direct current, is the flow of electrons in only one direction. At one time, all of the electricity used in the United States was direct current. Your local phone company still supplies DC current. Many people keep their original local phone service because the phones almost always work during a power failure.

Devices powered by batteries also use direct current. When plugged in, these devices convert the wall outlet electricity to direct current. Batteries contain stored electricity. When batteries are in use, electrons flow out from the negative terminal of the battery, and then back through the battery's positive terminal. A **circuit** is the pathway electricity takes. If a circuit is broken, electricity stops flowing, and the system stops working.

A String of Lights A series circuit provides a single path for current. *What happens if one of the bulbs burns out?*

Alternating Current

The wires that come into your home can be traced all the way back to a power generating station. The electrons that flow through these wires change direction 120 times per second. This is the reason that this electricity is called **AC**, or alternating current. Alternating current is easier to transmit and control than direct current.

Each back-and-forth motion is called a *cycle*. The electricity that powers your home is measured at 60 cycles per second. The number of cycles per second is the **frequency** of the alternating current. (In the metric system, cycles are called *hertz* or Hz.)

Reading Check **Summarize** What are types of electricity?

Electrical Flow

What are voltage, amperage, and resistance?

You cannot see electricity flowing through a circuit. However, its movement through a circuit is similar to that of water through a pipe. You need water pressure to push water through a pipe, and you need electrical pressure to push electricity through a wire.

The pressure and strength of the electric current as well as the opposition to the current are known as:

- Voltage
- Amperage
- Resistance

Voltage

Voltage is the pressure that pushes electricity through an electric circuit. Voltage pressure is measured in units called *volts*. A **transformer** is a device that can change alternating current from one voltage to another. Some equipment and appliances require less voltage than others require. High voltages can be sent over distances inexpensively.

Amperage

Amperage is the strength of the electrical current. It is measured in units called *amperes*. Amperage is measured in electrons per second. In cases of electric shock, it is the amount of current (amperage) that makes electricity dangerous enough to kill.

Resistance

Resistance is anything that opposes or slows the flow of electricity. It is measured in units called *ohms*. Resistance in a water pipe is determined by the diameter, length, bends, and kinks in the pipe. The resistance in an electric circuit is determined by the electric wire's diameter, length, and temperature. For example, the resistance of a wire *decreases* as the wire gets fatter. The resistance *increases* as the wire gets longer. If you add a component to the circuit, like an electrical appliance, resistance increases.

Reading Check **Identify** What do voltage, amperage, and resistance mean?

EcoTech

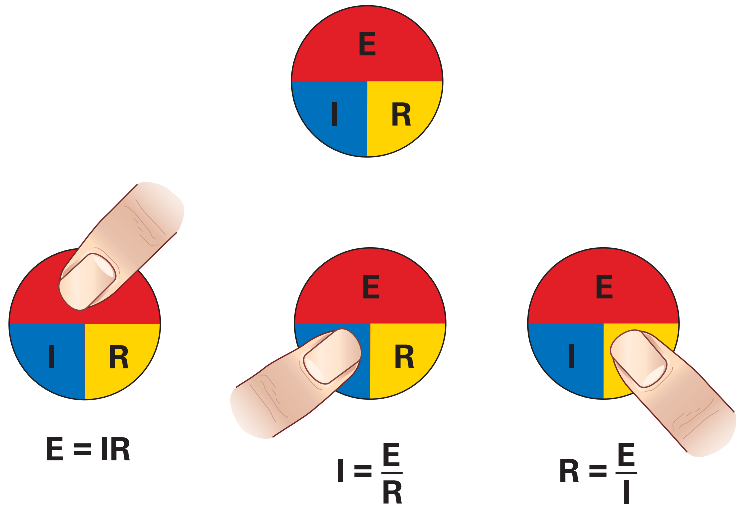
Hit the Lights

Traditional light switches can be forgotten and left on. Motion detectors and timed switches will automatically turn off unnecessary lighting. Controlled light switches allow for lower-level lighting, which uses less energy.

Try This Instead of lighting an entire room, use a small lamp at your desk or chair.

Figure 8.3 Ohm's Law

What Is Needed To use this Ohm's law diagram, put your finger over the value you want to find. This will give you the correct equation to use. *If the voltage is 120 and the resistance is 10, what is the amperage?*



Ohm's Law

What can you determine by using Ohm's law?

Building an electric device often means joining many different electrical systems together. These separate systems are all needed to fulfill the requirements of the device. The components must get the proper amount of electricity or the device will burn out, not function properly, or refuse to work. When you design an electric circuit, you must know the power needs of the components.

Ohm's law is a mathematical formula that is used to determine the voltage (E), amperage (I), or resistance (R) of an electric circuit. Ohm's law states:

$$\text{Voltage} = \text{Amperage} \times \text{Resistance or } E = I \times R$$

The law gives the electrical designer a way of determining exactly what the circuit will need to make it work efficiently. (See **Figure 8.3**.)

Reading Check **State** How can Ohm's law help you design electrical systems?

Academic Connections Social Studies

Neglected Metrics Many electric measurements are in metrics. Most of the world uses the metric system of measurement.

Apply Find out why the metric system has been slow to catch on in the United States. What social changes might make it more accepted?

The Electric Meter

What does an electric meter do?

Your local electric company keeps track of the electricity that your family uses. When you turn on an electric appliance in your home, the wheels of your electric meter turn. The moving wheels are measuring the electricity that is being consumed. The more appliances that you run, the faster the wheels turn, and the bigger your electric bill becomes.

Measuring Electricity

The electricity that your appliances use is measured in watts. Wattage (W) is a measurement of the electrical power an appliance will need to run. It is the voltage of the electric circuit multiplied by the amount of amperage needed to run the appliance *($W = E \times I$)*.

Your electric meter measures kilowatt hours. Your lights and other appliances consume the equivalent of one kilowatt hour of electricity when they consume 1,000 watts of electricity.

Measuring Usage Electric companies use meters to keep track of the electricity that your family uses. When you turn on an electric appliance, the wheels of the meter turn. *What happens to the spin of the wheels on this meter if you turn off your appliances?*

Energy Efficiency

You can compare wattage efficiency of an appliance to gasoline efficiency in a car. The more efficient the car or electrical appliance, the less you will pay to keep it running.

Most electrical appliances, including light bulbs, indicate how much electricity (wattage) they will consume. You want to purchase the most energy efficient appliances possible. If you buy less efficient appliances, you will spend more on electricty over time. Look for Energy Star ratings on packages or labels and purchase the appliance or light bulb that is the most energy efficient.

Electric utility companies encourage people to use less electricity during high-demand periods. When the utility company cannot keep up with the demand, an electrical blackout is likely to occur.

section 8.1 assessment

After You Read Self-Check

1. Explain what causes atoms to become positively or negatively charged.
2. Define voltage and amperage.
3. Identify which unit is used for measuring voltage and amperage.

Think

4. Based on your understanding of atoms, explain what causes electricity to flow through a circuit.

Practice Academic Skills

STEM Science

5. Build a small DC electric motor. (Note: Your teacher must approve all experimental plans before you hook up any device to an electric current.)

STEM Mathematics

6. An electrical engineer is analyzing the power needs of a computer circuit she is designing. She knows that the voltage is 110 and the resistance is 11. What is the amperage of the computer circuit?

Math Concept **Using Formulas** Ohm's law states that Voltage (E) equals amperage (I) times resistance (R), or $E = I \times R$.

1. In a formula, quantities are represented by letters.
2. Plug known quantities into the formula, and then solve for the unknown.

For help, go to **glencoe.com** to this book's OLC and find the Math Handbook.

section 8.2

Controlling Electrical Flow

Reading Guide

Before You Read **Preview** How is electrical flow controlled?

Content Vocabulary

- conductor
- insulator
- semiconductor
- superconductor
- series circuit
- parallel circuit

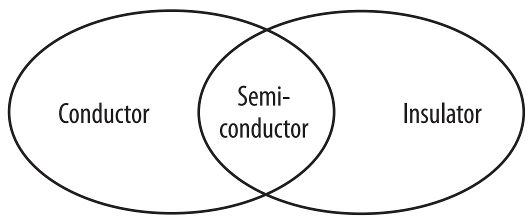
Academic Vocabulary

- generate
- series

Graphic Organizer

Draw the section diagram. Use it to organize and write down information as you read.

Controlling Electrical Flow



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TECHNOLOGY STANDARDS

STL 2 Core Concepts of Technology

STL 3 Relationships & Connections

STL 12 Use & Maintenance

STL 16 Energy & Power Technologies

ACADEMIC STANDARDS

Science

NSES Content Standard B Structure and properties of matter

Mathematics

NCTM Geometry Use visualization, spatial reasoning, and geometric modeling to solve problems.

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NCTM *National Council of Teachers of Mathematics*

NCTE *National Council of Teachers of English*

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Conductors and Insulators

How is the flow of electricity controlled?

Conductors are materials that contain atoms that have a very weak hold on their electrons. Copper, aluminum, gold, and silver are excellent conductors of electricity. Think of electrical conductors as highways on which electricity travels.

Insulators are materials that contain atoms that have a very tight grip on their electrons. Rubber, plastic, and ceramics make good insulators. Insulation prevents the electrons from leaving their intended path.

As You Read

Connect How do circuit breakers protect your home and school?

Semiconductors and Superconductors

What are semiconductors and superconductors?

Semiconductors are materials that can act as either conductors or insulators. Most semiconductors are made using the silicon found in ordinary sand. Manufacturers add different ingredients to the silicon to control their electrical conducting properties.

Semiconductors are found in most electrical and electronic devices. Without them, your TV, computer, MP3 player, and digital camera would not exist.

Superconductors have no measurable resistance to electricity. They make it possible to **generate** more productive and efficient electrical power. Superconductor technology is built into new electric generators and transformers. They also play a critical role in magnetic resonance imaging (MRI) machines, new super-efficient industrial motors, and magnetic levitation trains.

Reading Check **Recall** What are some uses for semiconductors and superconductors?

Tech Stars

Charles F. Brush

Wind Energy Pioneer

In 1888, Charles F. Brush introduced the world to the wind turbine, an automatic windmill used to generate electricity. As one of the founders of the American electrical industry, Brush invented the electrical DC system used in the public electric grid, as well as the first commercial electrical arc light, and an efficient method for manufacturing lead-acid batteries. His wind turbine was huge with a rotor diameter of 50 feet. Its 144 rotor blades were made of cedar wood. The Brush windmill ran for 20 years and charged the batteries in the cellar of his mansion.

The principles of Brush's windmill did not change much over the years, until about 1980 when computers took control of the turbines. But his insightful use of a natural, renewable resource has proved successful over the long term. In Denmark, wind-powered generators produce about 20 percent of the country's electricity use.

A Legacy Brush's company, Brush Electric, was based in Cleveland, Ohio. He sold it in 1889. By 1892, the company merged with Edison General Electric Company under the name of General Electric Company (GE). More than 100 years have passed, and GE is one of the world's leading wind turbine suppliers.

English Language Arts/Writing Describe in a few paragraphs how you feel wind power can benefit the earth.

Go to **glencoe.com** to this book's OLC to learn about young innovators in technology.

Ethics in Action

The Three Gorges Dam

The Three Gorges Dam in Hubei province, China, is the largest hydroelectric river dam in the world. It provides electricity for nine provinces and two cities. It also controls flooding, which is a major problem on the Yangtze River.

Progress at a Price However, the dam has caused more than a million people to leave their homes because of rising waters. In addition, many ancient sites and artifacts have been lost. The dam has permanently altered the ecosystem in Hubei province.

English Language Arts/Writing

Trading Places Imagine that you live in a small village in China. The government is building a huge new dam. It will bring electricity to the region, but your village will be destroyed. You will have to leave your home.

1. Write a letter to an American student.
2. Describe how the situation makes you feel.
3. Explain what you would want the government to do.

Electrical Circuits

What makes up an electrical circuit?

An electrical circuit begins at a power source and ends back at that same power source. The circuit must have at least one device that consumes electricity, such as a buzzer or light bulb.

An electric switch is used to open and close the circuit to turn things on and off. There are two types of electrical circuits:

- Series circuit
- Parallel circuit

Series Circuits

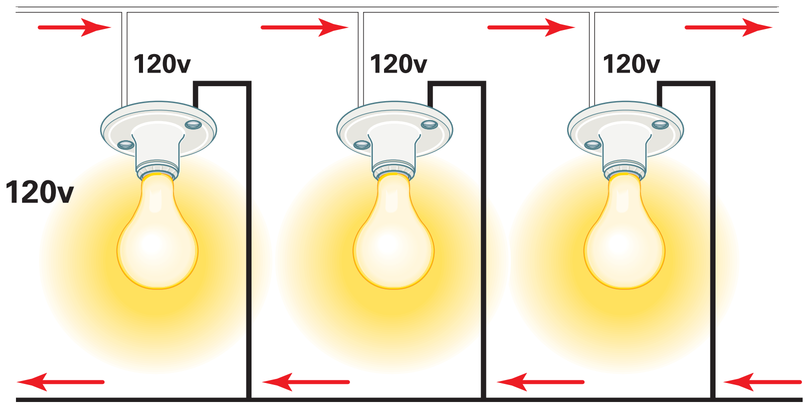
In a **series circuit**, the electricity takes one path through multiple electrical devices. A major disadvantage of series wiring is that if one device burns out, all the devices in the circuit stop working. Devices cannot operate independently.

When batteries are connected in a series, each one increases the voltage (pressure) in the circuit. When you place three 1.5-volt batteries together in a series, the circuit is powered by 4.5 volts. Do you understand why?

Light bulbs and other electrical devices can also be wired together in a series. In this type of circuit, the electricity must pass through each device on its way to the next. Again, if any item in the circuit breaks down, power is lost to the entire circuit. Most of the circuits in your home are not series circuits.

Reading Check **Identify** What are the two basic types of electrical circuits?

Figure 8.4 **Parallel Circuit**



Multiple Pathways A parallel circuit provides individual electrical pathways for the current to flow to each energy-consuming device. *How can you tell if a string of lights is wired into a parallel or a series circuit?*

Parallel Circuits

In a **parallel circuit**, electricity flows along separate paths to each individual energy-using device in the circuit. See **Figure 8.4**. If one device burns out, the electricity does not stop flowing to the other devices in the circuit.

Most of the circuits in your home are parallel circuits. All the electric outlets in your home are connected to a fuse box or circuit-breaker panel. These safety devices shut off the electricity in case of a power overload. A power overload can superheat electrical wires and start a fire.

section 8.2 assessment

After You Read Self-Check

1. Compare and contrast electrical insulators and electrical conductors.
2. Describe a semiconductor.
3. Define superconductors and how they are used.

Think

4. Name some possible causes for a blown fuse.

Practice Academic Skills

STEM Science

5. With your teacher's help, wire low-voltage, DC light bulbs together in a series circuit and a parallel circuit. Remove a bulb from each circuit. What happens?

STEM Mathematics

6. Jorge wanted to find out how many 9-volt batteries connected in a series are required to create a 120-volt circuit. So, he divided 120 by 9 and concluded that he needed $13\frac{1}{3}$. Write a sentence explaining Jorge's mistake, and tell the correct answer.

Math Concept **Discrete Quantities** Sometimes a fraction or decimal solution to a problem does not make sense.

1. Think about the question asked in the problem.
2. Be sure your answer makes sense given the situation described in the problem.

For help, go to **glencoe.com** to this book's OLC and find the Math Handbook.

section 8.3

Electronics

Reading Guide

Before You Read **Connect** What is an electronic device?

Content Vocabulary

- electronic device
- electromagnetic wave
- transmitter
- fiber optic cable
- laser
- analog signal
- digital signal
- transistor
- integrated circuit

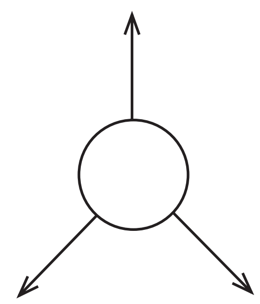
Academic Vocabulary

- network
- compare

Graphic Organizer

Draw the section diagram. Use it to organize and write down information as you read.

Types of Signal Transmissions



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TECHNOLOGY STANDARDS

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STL 12 Use & Maintenance

STL 16 Energy & Power Technologies

ACADEMIC STANDARDS

Science

NSES Content Standard E Abilities of Technological Design

English Language Arts

NCTE 12 Use language to accomplish individual purposes.

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Electronic Devices

What is an electronic device?

The words *electric* and *electronic* are often used interchangeably. To keep things simple, electric devices generate and utilize electricity as a source of power. The electricity lights electric bulbs and rings door bells. An **electronic device** can change one form of energy, such as sound or light, into an electrical signal to be used in the device or transmitted.

As You Read

Predict What is a fiber optic cable?

Electronic devices allow for information to be processed and transmitted. This processing takes place in self-contained electronic games and in complex robotic systems. Your telephone, TV, radio, and computer are all electronic devices.

Reading Check **Describe** What is the difference between an electric device and an electronic device?

Signal Transmission

How can electronic signals be sent?

Electronic signals can be sent along a wire, through the air on electromagnetic waves, or as pulses of laser light through fiber optic cables.

Wire Transmission

Wire transmission includes all communication that takes place over wires. Telephones, cable TV, computer-to-printers, and even computer-to-monitors all use wire transmission.

To transmit a signal along a wire, the signal must be converted into a series of electric pulses. Alexander Graham Bell's 1876 telephone changed the sound of the speaker's voice into a varying electric current. Wires carried these electric pulses to the receiving phone. The electric pulses were then converted back into varying vibrations that replicated the sound of the sender's speech.

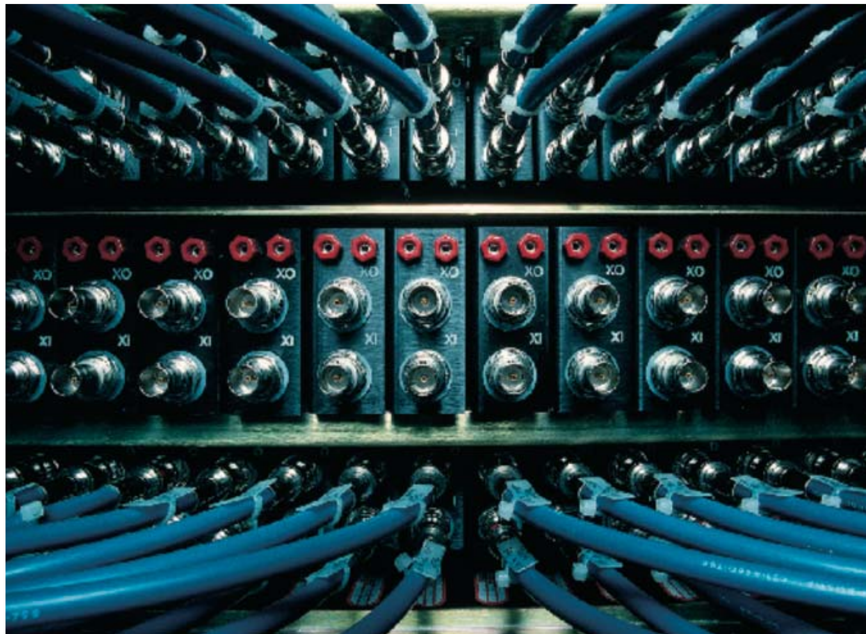
Today's land-line telephones have been modified and improved many times, but they still use the transmission principle developed by Bell more than 100 years ago. Your call is transmitted through a cable. Your phone signal reaches a computer exchange **network**, where it is directed to the proper receiver.

Atmospheric Transmission

The magnetic field created when electricity flows through a wire can also carry a message through the air. This very weak magnetic field is converted into **electromagnetic waves** by passing through a strong magnetic field. The electromagnetic wave that is produced carries the original signal off into the atmosphere.

Remote Control These students are participating in a robotics competition that involves many schools. They use electronic communication systems to communicate with robots they have built. *Are the robots the senders or the receivers?*

Whose Line Is It? Thousands of phone conversations can go through each of these fiber optic phone lines at the same time. *If you send multiple messages through the same cable at the same time, what keeps them from scrambling together?*



The device used to send the electromagnetic wave that carries the signal into the atmosphere is called a **transmitter**. The transmitters in cell phones and personal remote controls are very small, so their signals must be picked up reasonably close to the location where they are sent.

Fiber Optic Transmission

Fiber optic cables are made from very pure glass. The term *optic* is used to describe something related to light. Each glass strand in a cable can be thinner than half the thickness of a human hair.

The glass strands have an outer glass coating with different reflective characteristics. This causes the rays of light traveling at the core to stay inside in spite of twists and turns. These cables can carry a signal for very long distances. If necessary, the sender can easily boost the power so messages will not be lost.

The signals that are sent along fiber optic cables are powered by lasers. **Lasers** are very powerful, very narrow beams of highly focused light. All of these light rays have exactly the same wavelength. The beam that is made by a laser can be visible light or invisible infrared light.

By transmitting signal beams that are on different wavelengths, engineers can send many messages along the same fiber optic strand at the same time. When they reach their destination, the different wavelengths are separated.

Reading Check **List** What are the basic types of electronic signal transmissions?

SuperStock

Analog and Digital Signals

Which signal is faster—analog or digital?

Electric **analog signals** change continuously, and they are used in all kinds of systems. Alexander Graham Bell learned how to turn electricity into analog signals. The current in his telephone circuit varied with the intensity of the person's speech. If your watch has hands that rotate smoothly, it is an analog watch. The second hand on an analog watch never stops moving.

A **digital signal** is analog information that has been converted into digital information. The changing analog information is sampled frequently and turned into distinct, separate values. Your digital watch represents the seconds as exact numbers. It starts and stops continuously. The time is never "between" one second and the next.

Because digital signals can be compressed to take up less space in storage, sent faster, and stored longer than analog signals, they are preferred for electronics. For example, when you speak into a phone, your voice, which is analog information, is changed into a digital signal. However, this does not mean that digital signals are more accurate than analog signals.

Reading Check **Contrast** How are analog and digital signals different?

Imagine This...

Smaller Is Better

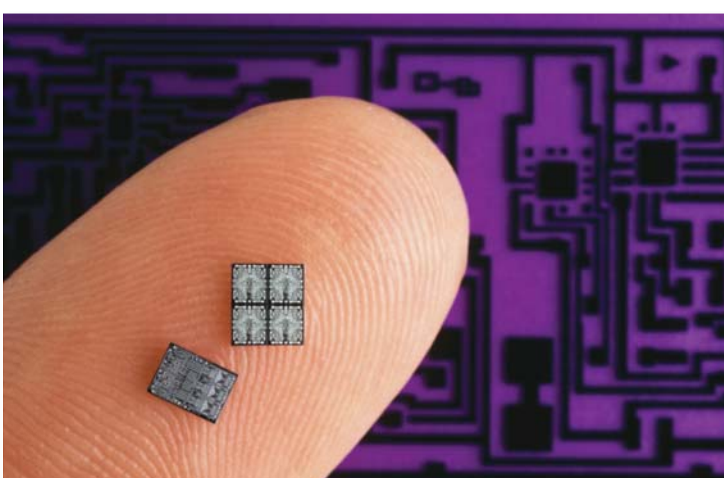
Imagine if electronic devices were embedded in roadways and could automatically send out traffic reports. Engineers are testing new wireless sensors no bigger than a coin for a variety of uses. They are also monitoring energy use in supermarkets and the movement of enemy troops on battlefields. *How could small, wireless sensors be used in your school or home?*

Go to **glencoe.com** to this book's OLC for answers and to learn more about different wireless sensors.

Size and Speed

Will electronic devices continue to shrink in size?

Each new improvement in electronics is built on past knowledge. In the 1940s, vacuum tubes became the first electric "switch" in electronic equipment. They resembled light bulbs, used a lot of electricity, and gave off a lot of heat.



Smaller and Smaller Microchips may be incredibly small, but they can process huge amounts of information. *Do you think this trend of shrinking electronics will continue for the foreseeable future? Why or why not?*

Compact Storage Microchips process a lot of information. *What material is used to make chips?*

1950s

Starting in the 1950s, vacuum tubes were replaced by the **transistor**, a small, cool running device that could also act as an electric switch. The transistor was tiny **compared** to a vacuum tube. However, thousands of hand-soldered connections were needed to join transistors and other components into completed circuits.

1960s

The next size reduction took place in the 1960s. The first **integrated circuit** contained one transistor and two other electric components on a single chip of silicon. Very tiny passageways in the silicon connected the tiny components together.

1970s to the Present

By the 1970s, technologists were placing thousands of integrated circuit components on to a single chip. Today these tiny microchips contain millions of components.

section 8.3 assessment

After You Read Self-Check

1. Describe the ways in which electronic signals can be transmitted.
2. Explain how Alexander Graham Bell's original telephone worked.
3. Compare and contrast an integrated circuit and a vacuum tube.

Think

4. Mika is singing a song. State whether her song is analog or digital information and explain why.

Practice Academic Skills

English Language Arts/Writing

5. Look up the meaning of the prefixes *trans*- and *tele*-. Write two sentences about the origin and meaning of each prefix and give one examples of words that use them.

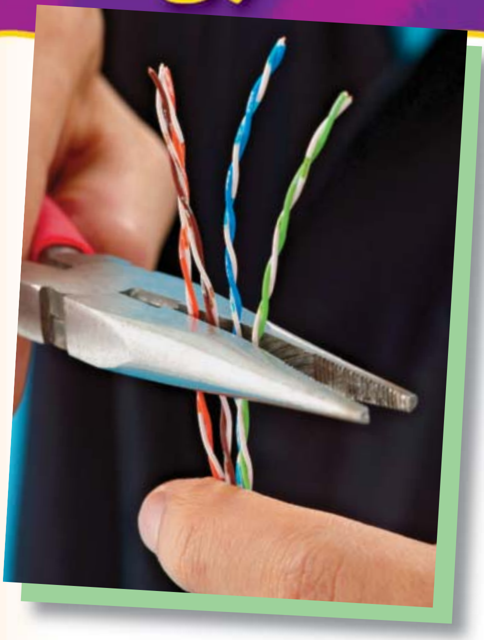
STEM Science

6. With your teacher's help, use a low-power laser to send sound signals through a fiber optic cable. Describe and summarize the experiment in a one-paragraph essay.

Exploring Careers in Technology

Stephanie Martin

ELECTRICAL ENGINEER



Q: *What do you do?*

A: I work in the field of electronic warfare, which is preserving the electromagnetic spectrum for friendly use while denying its use to the enemy. By jamming an enemy radar or communication system, you can prevent them from attacking friendly forces. On a typical day, I might research a target system, model a scenario to estimate effectiveness, conduct a field test, brief a group that will be using jammers, communicate with war fighters, or write a report. I also travel extensively for field testing and conferences.

Q: *What kind of training and education did you need to get this job?*

A: I studied electrical engineering with an emphasis on communications systems. I also worked as an intern during college. Most of my training has been on the job. I have attended classes on electronic warfare, and I am currently working on my master's degree in electrical engineering by taking evening classes through Johns Hopkins University.

Q: *What do you like most about your job?*

A: I like the people I work with and traveling to new places. By far the greatest thing about my job is being able to see something I have worked on help protect people and save lives.

English Language Arts/Writing

Specialization There are many kinds of engineers. Most engineers specialize in one particular field, such as aerospace, biomedical, chemical, nuclear, or civil engineering.

1. Research a particular field of engineering and write about it in a one-page report.
2. Remember your audience: Write a description that will make your classmates interested.
3. Make it exciting. Include details about what people do in the field, what a typical day is like, and why this field of engineering is important.

Go to **glencoe.com** to this book's OLC to learn more about this career.

Real-World Skills

Listening and speaking, problem solving, troubleshooting

Academics and Education

Mathematics, science, engineering English language arts

Career Outlook

Growth as fast as average for the next ten years

Source: *Occupational Outlook Handbook*

chapter 8 Review and Assessment

Chapter Summary

Section 8.1 Electricity is the movement of electrons from atom to atom. Electricity is forced through wires by its voltage. A wire's resistance is determined by its thickness, length, and its ability to conduct electricity.

Section 8.2 Insulators cover conductors because they resist the flow of electricity. Superconductors have no electrical resistance. In a series circuit, electricity must pass through each device. If one device burns out, the electricity stops flowing. Parallel circuits have separate pathways.

Section 8.3 We use electromagnetic waves and fiber optic cables to carry messages. By transmitting signal beams on different wavelengths, we can send many messages on the same fiber optic strand at the same time.

Review Content Vocabulary and Academic Vocabulary

1. On a sheet of paper, use each of these terms and words in a written sentence.

Content Vocabulary

- atom
- electricity
- static electricity
- DC
- circuit
- AC
- frequency
- voltage
- transformer
- amperage
- resistance
- Ohm's law
- wattage
- conductor
- insulator
- semiconductor
- superconductor
- series circuit
- parallel circuit
- electronic device
- electromagnetic wave
- transmitter
- fiber optic cable
- laser
- analog signal
- digital signal
- transistor
- integrated circuit

Academic Vocabulary

- transmit
- vary
- generate
- series
- network
- compare

Review Key Concepts

2. **Compare** the three types of electricity.
3. **Define** voltage, amperage, and resistance.
4. **Describe** the purpose of an electric meter.
5. **Tell** the difference between an insulator and a conductor.
6. **List** some uses for semiconductors and superconductors.
7. **Identify** the basic types of electrical circuits.
8. **Discuss** the different types of electronic signal transmissions.
9. **Explain** how fiber optic cables work.
10. **Describe** the difference between analog and digital signals.

Real-World Skills

11. Safety and Electricity Communicate electrical safety concepts to young children. Research childhood accidents related to electricity, where most of them occur, and why. What are the most important concepts that should be explained to young children? Design a poster or public service ad for TV.

STEM **Technology Skill**

12. Test for Conductivity Create a simple circuit using a battery, wire, and a light bulb. Use it to test the conductivity of materials you find at home or at school.

a. Test items such as paper clips, cloth, metal objects, and water.

b. Chart your results by listing the name of the object, what it is made from, and whether it conducts.

Academic Skills

Social Studies

13. Write a one-page report about the history of electricity. You might research an inventor, such as Benjamin Franklin, Thomas Edison, or Nicola Tesla, and his or her role in developing the technology of electricity.

STEM **Mathematics**

14. What is the amperage to run a 120-volt hair dryer that draws 2,400 Watts?

Math Concept **Using Formulas** The two formulas that relate to how electricity works are: $E = I \times R$ and $W = E \times I$. E is voltage, or the pressure that pushes electricity through a circuit; I is amperage, or the flow of current; R is resistance to that flow; and W is wattage, or the power an appliance uses.

TSA WINNING EVENTS

Electrical Engineer

Situation Design an electrical device that provides light, sounds an alarm, or serves some other purpose.

Activity Brainstorm ideas with a teammate. Sketch your ideas; make a schematic diagram of your best idea. Then build your device and present it to your classmates.

Evaluation You will be evaluated on how well you meet the following criteria:

- Proposal—good idea
- Schematic—clear and technically correct
- Device—does what it is supposed to do
- Complexity—evident

Go to **glencoe.com** to this book's OLC for information about TSA events.

Standardized Test Practice

Directions Choose the letter of the best answer. Write the letter on a separate piece of paper.

1. Which statement is true about lightning?

A Lightning is a form of static electricity.

B Lightning occurs when atoms lose most of their electrons.

C Lightning is a form of alternating current.

D Lightning only hits metal objects that are good conductors.

2. When an atom loses electrons, it becomes positively charged.

T **F**

Test-Taking Tip When studying for a test, write important ideas, definitions, and formulas on flash cards. Use them for quick reviews.

chapter 8

TECHNOLOGY LAB

Build a Simple Alarm System

All alarm systems include a circuit, a switch, and some kind of ringer. In an alarm clock, the switch is connected to a clock, and the ringer might be a radio that wakes you up. A modern security alarm system may include sensors that react to physical movement or changes in temperature.

Tools and Materials

- ✓ Clothespin
- ✓ 6 inches of #20 bell wire
- ✓ Wire stripper
- ✓ Metal punch
- ✓ Drill
- ✓ 9/64 drill bit
- ✓ 3½ × 4½ × ¾ -inch wood base
- ✓ 9-volt battery
- ✓ 9-volt battery snap
- ✓ Piezoelectric buzzer
- ✓ Two 16/32-inch machine bolts
- ✓ Four 6/32-inch nuts
- ✓ Six small washers
- ✓ Four ½-inch #6 wood screws
- ✓ One 1-inch #7 wood screw
- ✓ Electrical tape
- ✓ Wooden tongue depressor
- ✓ String
- ✓ 3½ × ¾ inch tin plate strip

SAFETY

Electrical Safety

When using tools, machines, and wiring, be sure to always follow appropriate safety procedures and rules.

Set Your Goal

For this activity, you will build the alarm shown in the illustration. When your alarm is completed, try to find a serious or funny way to use it.

Know the Criteria and Constraints

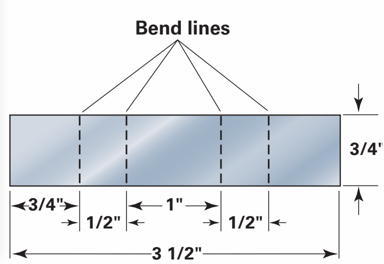
In this lab, you will:

1. Build and test your alarm to be sure it works.
2. Find a creative use for the alarm.
3. Demonstrate your alarm to the class. You can use visual aids.

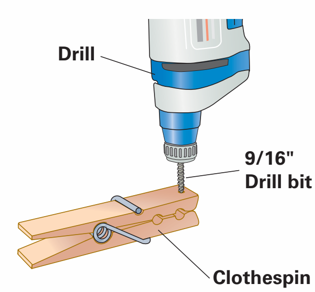
Design Your Project

Follow these steps to build your alarm and complete this lab.

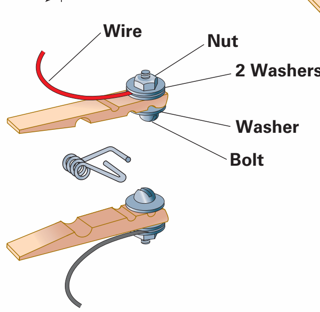
1. Create the base. Cut and bend the metal strip that holds the battery.
2. Cut holes in the battery holder with the metal punch.



BATTERY HOLDER

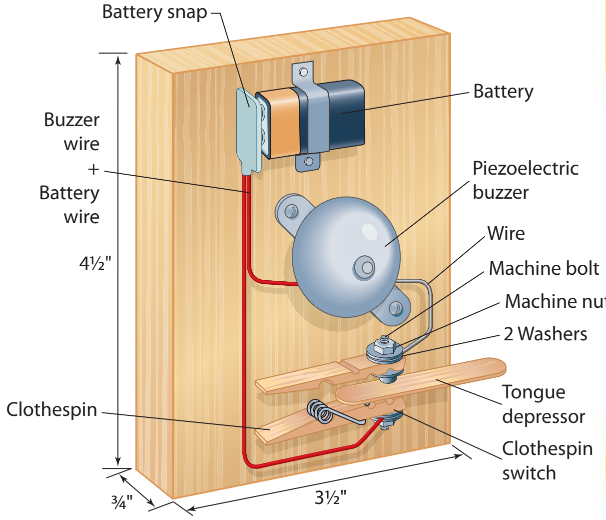


DRILLING CLOTHESPIN



ASSEMBLING THE CONTACTS ON THE CLOTHESPIN

3. Use #6 wood screws to attach the holder and buzzer to the base.
4. Build the switch using the clothespin.
   - Drill a 9/64-inch hole through the two closed ends of the clothespin.
   - Slip a bolt and washer through each hole. Secure each bolt with a nut.
   - Strip ½ inch of insulation from wire ends and slip two washers onto the bolts' ends. Hook one end of the bell wire between washers and secure in place with a nut.
   - Repeat procedure to hook the buzzer's black wire to the other side.
5. Secure the clothespin by screwing the #7 wood screw through the spring.
6. Splice the buzzer's red wire to the battery snap's red wire. Splice the free end of the bell wire to the black wire of the battery snap. Tape your connections with electrical tape.
7. Place a tongue depressor between the clothespin contacts. Connect the battery snap.
8. Test the alarm by pulling out the tongue depressor.
9. Adapt your alarm to work where you plan to install it.
10. Create a video or other visual aid of your demonstration.



THE SIMPLE ALARM SYSTEM

Evaluate Your Results

After you complete this lab, answer these questions on a separate piece of paper.

1. Why does the buzzer ring after you pull the tongue depressor?
2. Can a larger model of this alarm protect your home? Why or why not?
3. What is the relationship of the battery's voltage and the buzzer size?

Academic Skills Required to Complete Lab				
Tasks	**English Language Arts**	**Math**	**Science**	**Social Studies**
Research ways to use an alarm.	✓			✓
Build the alarm.		✓	✓	
Write presentation content.	✓		✓	
Create presentation of how student will use the alarm.	✓			✓
Present to the class.	✓		✓	

Technology Time Machine

The Essence of Energy

Play the Game This time machine will travel to the past to show how experiments in energy and electricity led to today's technological achievements. To operate the time machine, you must know the secret code word. To discover the code, read the clues, and then answer the questions.

Clue 1

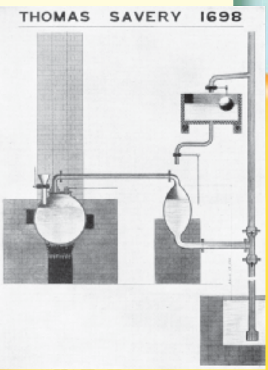
200 B.C.E. Greek inventor Hero of Alexandria invented the pump originally to bring water up from wells more than 2,000 years ago. He could never have imagined its many uses today. The automobile might never have been possible without the pump.

Clue 2

600s Wind power for ships goes back thousands of years. In the Middle Ages, windmills were designed to manufacture, grind grain, and operate water pumps by converting kinetic energy. Windmills may have originated in Persia, now Iran.

Clue 3

1698 For many years pumps were used to drain water from flooded mines, but they were not very powerful. Thomas Savery of England invented the steam engine to add power to the pumps and drain the mines.



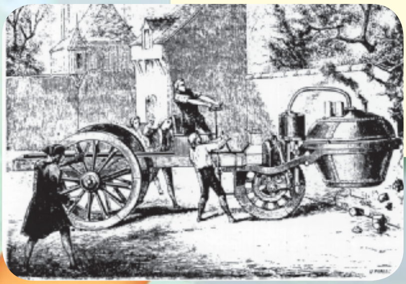
Clue 4

1700s The development of steam-powered engines progressed quickly in Europe. One steam engine could supply the power needed to run all the machines in a factory. Steam locomotives hauled heavy loads to far-off places. Steamships provided safe, fast, dependable transportation. It was the very beginning of the Industrial Age.

SuperStock, TimeLife Pictures/Getty Images

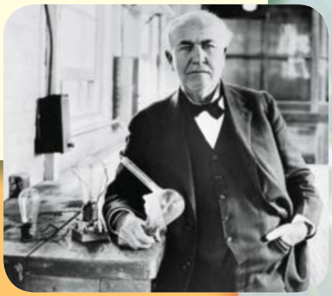
Clue 5

1769 Nicolas-Joseph Cugnot, a French military engineer, built the first self-propelled road vehicle by attaching a steam engine to a "horseless" carriage. The automobile was born.



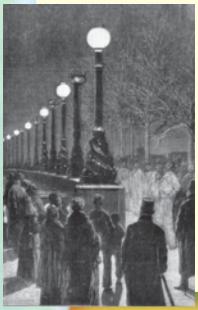
Clue 6

1878 Inventor Thomas Edison began his research on electric lighting. He learned that a carbon arc light produced an extremely bright light by sending electricity across a gap between two carbon terminals. With his associates, Edison developed an incandescent lamp that produced a glow by passing electricity through a filament or wire.



Clue 8

1904 Electricity was a hot new product. Demand for streetlights soared. Some materials were in short supply. An inventor named Leo Baekeland developed a synthetic material to insulate electrical coils so the technology became more available.



Clue 7

1879 Edison and his associates discovered a carbon filament made from burned sewing thread. This produced the first incandescent light bulb for use in people's homes. A year later, Edison realized that bamboo filaments increased the life of the bulbs.

Crack the Code

On a piece of paper, write the answers to these questions:

1. What did Cugnot attach a steam engine to when he built a self-propelled vehicle?
2. What is essential to technology?
3. Where did Greek inventor Hero come from?
4. What inventor was most responsible for bringing electric light into our homes?

Now write down the first letter of each answer. Put them together to discover the secret code word!

Hint Solar collectors can trap this and save money on bills for its use.

Unit 2 Thematic Project

Designing Alternative Power Plants

Energy and Power In Unit 2, you learned about different forms of energy. The power you receive by flipping a switch may seem automatic. But your electric company can convert energy from many sources—hydro, solar, wind, nuclear, or coal—to create the power to run our homes and businesses.

Voltage Inventory Most homes in the United States are wired with 120 volts of electricity. This means a standard plug can supply that amount of power. Look around your house. Count sockets, wall plugs, extension cords, and power strips. Multiply that number by 120 to find the potential voltage.

One Step Forward We can conserve energy to help our planet. If we all do just one thing each day, the task will not seem so overwhelming. Turn off a light in an empty room or use compact fluorescent bulbs.

This Project In this project, you will design an alternative power plant.

Your Project

- Choose an alternative energy source.
- Choose and complete one task:
  1. Write a proposal. State why your source is possible, efficient, cost-effective, and Earth-friendly.
  2. Create a two-dimensional model of a power plant. Use freehand drawing or CAD. Label your model.
  3. Create a 1-minute commercial.
- Write a report.
- Create a presentation with posters, video, or presentation software.
- Present your findings to the class.

Tools and Materials

- ✓ Computer
- ✓ Internet access
- ✓ Trade magazines
- ✓ Word-processing software
- ✓ Presentation software
- ✓ Posterboard
- ✓ Colored markers

The Academic Skills You'll Use

- Communicate effectively.
- Speak clearly and concisely.
- Use correct spelling and grammar in a written report.
- Conduct research using a variety of resources.
- Incorporate reading, writing, and speaking with viewing, representing, and listening.

English Language Arts

NCTE 4 Use written language to communicate effectively.

NCTE 8 Use information resources to gather information and create and communicate knowledge.

Science

NSES Content Standard F Science and technology in society

Big Cheese Photo/Jupiter Images

Step 1 Choose Your Topic

You can choose any energy source for your project. Examples include:

- Hydroelectric
- Wind
- Solar
- Clean coal
- Atomic
- Geothermal
- Natural gas
- Biodiesel
- Biomass
- Biofuels

Tip! *Explore all energy sources to see which is most interesting!*

Step 2 Do Your Research

Research your project. Your fact finding may include a combination of sources. Write answers to these questions:

- How was the energy source used in the past?
- What do old and new articles in libraries and online sites say about your topic?
- What are the blueprints or specifications of similar systems?
- How would someone who does CAD or drafting do a sketch?

Tip! *Keep your design as simple as possible!*

Step 3 Explore Your Community

Tour the local electric company. Ask about the future of power in your community. Ask for feedback on your design.

Tip! *Research the company before you go.*

Step 4 Create Your Project

Your project should include:

- 1 research project (proposal, design, blueprint, model, or video)
- 1 report
- 1 presentation

Project Checklist

	Objectives for Your Project
Visual	✓ Make a poster, blueprint, model, video, or slide presentation to illustrate your project.
Presentation	✓ Make a presentation to your class.
	✓ Discuss what you have learned.
	✓ Turn in research and names from your interview to your teacher.

Step 5 Evaluate Your Presentation

In your report and/or presentation, did you remember to:

- Demonstrate your research and preparation?
- Engage your audience?
- Back up statements with facts, details, and evidence?
- Use visuals effectively?
- Speak slowly and enunciate clearly?

Rubrics Go to **glencoe.com** to the book's OLC for a printable evaluation form and your academic assessment form.

GLOBAL TECHNOLOGY

A Sunny Source of Power

In the past Portugal depended on fossil fuels for energy. But the country is one of Europe's sunniest areas, and so a company called Catavento built a solar power plant in Serpa, Portugal. It is the first large solar installation there with 52,000 photovoltaic modules (solar panels). Located among olive trees on hillside pastures, the plant produces electricity for 8,000 homes. It also reduces greenhouse gas emissions, required by the European Union.

Critical Thinking *What other countries might be able produce solar energy? Why?*

Portuguese

hello	hallo
goodbye	adeus
How are you?	Como é vai?
thank you	obrigado
You're welcome	Nãoha de qué

Go to **glencoe.com** to the book's OLC to learn more and to find resources from **The Discovery Channel.**