POWER UP

Pre-Visit Activities

MARYLAND SCIENCE CENTER

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Handy Electricity

Objectives:

- To identify that electricity flows through wires.
- To describe that electricity requires a complete circuit.

Materials (for class):

- Toy that uses the body as a conductor. For example:

An energy stick
http://www.stevespanglerscience.com/energy-stick.html
Or energy ball
http://www.arborsci.com/energy-ball

Procedure:

Invite students to form a circle. Explain that you will make a model of what happens when current moves through a circuit. Have the students remain in their circle, extend their arms in front of them with their palms facing each other. To represent the charge moving through the circuit, have them bring their hands together and apart, clapping their own hands and bumping their neighbors' hands. Energy is passed from hand to hand. To create a switch, remove two students from the circle. The students to their left and right will not be able to reach each other's hands. When any neighboring hands in the circle can't bump each other, everyone must stop moving their hands. The switch is off, and the electricity cannot move. Put the students back in the circle to flip the switch on again, and have everyone go back to moving their hands.

Have all of the students join hands. Ask two students to separate their hands and have them each touch one of the energy toy contacts. The toy should light up and make noise. Select another two students to form a switch. When they let go of each other's hands, the light and noise will stop. Move the "switch" around the circle, giving pairs of students a chance to break the circuit one at a time.

Science Concepts:

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source to a load and back. When you use the electrical toy, the students form the circuit, the battery in the toy is the power source, and the light and buzzer are the load.

A **switch** is used to open or close a circuit. When a circuit is closed, all of the metal is touching and the current can move. When it is open, there is a gap where the metal is not touching and the electricity will not move through the circuit.

Current is the amount of electricity moving through a circuit. When you use the electrical toy, there is just a little bit of current because the battery does not produce much electricity. That is why you do not feel the current moving through your body and it is not dangerous. The current is very high in the electrical lines that bring power to us and in the electrical outlets in our homes. That is why that kind of electricity can be very dangerous and it is not safe to touch electrical wires our outlets.

Curriculum Connections:

Next Generation Science Standards

- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

Maryland State Science Curriculum Frameworks
Electricity and Magnetism

- Grade 4: Indicator 2. Investigate and provide evidence that electricity requires a closed loop in order to produce measurable effects.

Learning the Ropes with Electricity

(Adapted from an article with the same title, Science and Children, March 2013)

Objectives:

- To create a model of an electrical circut.
- To identify the function of a resistor in a circut.

Materials:

- 1 length of nylon rope long enough for all students to hold. Allow 2-3 feet per student. Tape the ends together to form a loop.
- Signs labeled battery, switch, bulb, and resistor (attach string or tape so students can wear the signs)
- At least 4 gloves or washclothes

For Extension
- 2 drinking glasses of the same size
- 1 bottle of clean water for drinking
- 2 straws: one thin (like a coffee stirrer) and one thick (like a drinking straw or milkshake straw). Cut these straws to the same length.
- 2 straws of the same diameter, one short and one long.

Procedure:

1. Have the students form a circle holding the rope. Explain that it represents a circuit. The rope isn't moving; we have no electrons flowing. Ask them what we need to add. We will need a power source.
2. Give the battery sign to one of the students, and have that student pull the rope while the other students allow it to pass through their hands.
3. Now the circuit needs to power something. Give one student the bulb sign. This student will open his or her eyes and mouth wide to represent a lit bulb. Adding the bulb also increases the resistance of the circuit. Gives this student gloves or a washcloth to hold the rope, and have him or her grip the rope more tightly, resisting its movement.
4. Next, give one student a resistor sign. Like the light, this student will grip the rope more tightly using gloves or a washcloth to slow its movement further. Now the light is receiving less electrical energy, so the student representing the light bulb should close his or her eyes and mouth slightly. The light is dimmer.
5. You can add additional batteries and resistors to the circuit to increase or decrease the flow of current.

Extension:

Ask for two student volunteers for a contest. Give each of them a glass with the same amount of water. State that whoever can drink the water faster wins. Begin a countdown, but stop at 2, explaining you "forgot" something. Hand one student the thick straw and the other student the thin straw (students will quickly figure out a winner) and start the count again. Discuss the results and compare the difference between the straws to the difference between narrow and wide electrical wires.
Start another race, giving one student a short straw and another student a long straw of the same diameter. This time, the student with the short straw will win. Use this result to predict whether adding more wire to a circuit increases or decreases the resistance.

Learning the Ropes with Electricity

(Adapted from an article with the same title, Science and Children, March 2013)

Science Concepts:

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source to a load and back. In our model, the battery is the power source and the light bulb is the load.

Current is the amount of electricity moving through a circuit. In the rope model, when the rope is moving faster, that represents a higher current. A light bulb receiving high current will light more brightly than a light bulb receiving low current. In the straw model, more water moving through the straw represents a higher current.

Voltage is the amount of pressure that makes electricity move. In the rope model, voltage can be increased by adding additional batteries.

Resistors increase the **resistance** of the circuit, or how much it opposes the current. In the rope model, adding resistors increases resistance and decreases the current; the rope moves more slowly. In the straw model, a straw that is narrower or longer has higher resistance and the water flows more slowly.

In **power transmission,** electricity must travel over long distances from power stations to consumers. In order to send power over such long distances, the power lines are wide so that they have lower resistance, and the voltage of the electricity is very high, so that there is enough pressure to keep it moving.

Curriculum Connections:

Next Generation Science Standards

- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

Maryland State Science Curriculum Frameworks
Physics: Electricity and Magnetism

- Grade 4: Indicator 2. Investigate and provide evidence that electricity requires a closed loop in order to produce measurable effects.
- Grade 6: Indicator 2. Cite evidence supporting that electrical energy can be produced from a variety of energy sources and can itself be transformed into almost any other form of energy.
- EXPECTATION 5.2 The student will know and apply the laws of electricity and magnetism and explain their significant role in nature and technology.
- INDICATOR 5.2.1 The student will describe the types of electric charges and the forces that exist between them.
- INDICATOR 5.2.2 The student will describe the sources and effects of electric and magnetic fields.

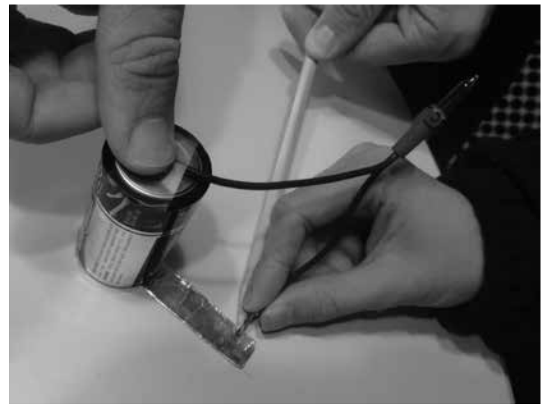
Carrier, S and T. Rex. 2013 *Learning the Ropes With Electricity.* Science & Children 50 (7) 36-39

Power Through a Pencil

Objectives:

Students will:

- Build and test a complete circuit.
- Identify materials as insulators or conductors.
- Use alternative materials to build a complete circuit.



Materials (for each group):

- Pencil, with intact eraser and sharpened tip
- Battery
- Bulb assembly (light bulb, light bulb holder and wires or pre-cut holiday light segments)
- Aluminum foil strip (approximately ½" x 2")
- Tape

Procedure:

It is much easier to complete this task if students work together to hold the materials properly and to make sure connections are secure. Direct pairs or teams of students to:

1. Tape aluminum foil strip to the flat negative contact of the battery.
2. Hold both wires of the bulb assembly. Touch one wire end of bulb to the positive battery contact and the other wire end to the aluminum foil strip. The bulb should light up. (If LED bulbs are being used, see TIPS below.)
3. After confirming that the bulb lights, tape the wire end to the battery contact.
4. Touch the metal ring of the pencil to the aluminum foil. Now carefully touch the wire to the top side of the metal ring, making sure the wire does not touch the foil. (The bulb should light.)
5. Test the other parts of the pencil (wood shaft, eraser, tip) in the same way, always making sure the wire does not directly contact the foil.
6. Have students identify materials as conductors or insulators. Also, have students describe the path that electricity takes as it flows through the circuit.

Extension/Variation:

- Take a pencil with the eraser end removed and sharpen it at both ends. Have students test to see if they can light their bulb by touching one tip to the foil strip and the other tip to the wire. If the graphite inside the bulb is intact, the bulb should light up. If students cannot get the bulb to light, have them hypothesize why not. (If the graphite inside the pencil is broken, the light bulb may not light.)

- Have a selection of commonly found items for students to test in their circuit. (possible items include: metal paper clips, plastic coated paper clips, binder clips, coins, washers, straws, toothpicks, erasers, rubber bands)

Power Through a Pencil

Tips for Circuit Building:

- Aluminum foil strips should not be long enough to reach both contacts of the battery or students may create a short circuit, which drains the battery and can get very hot!

- Ask for donations of old holiday/outdoor light strands, cut them up into individual bulbs and strip the insulation off the end of each wire. Bulbs from partially working strands are usually still functional when cut apart even if they were part of a non-functioning segment.

- Batteries: in order to light traditional incandescent bulbs, a 1.5 volt battery (any cylinder battery) is sufficient. For LED bulbs, 3 volts are needed: use two cylinder batteries stacked negative contact touching positive contact and taped together. 9 volt batteries may blow bulbs.)

- LED bulb assemblies will only work one direction. If bulb does not light, have students turn assembly around. It may help to mark one of the wires with a piece of tape.

- Aluminum foil strips can be used in place of wires, just be careful to avoid crossing strips and creating a short circuit.

Curriculum Connections:

Next Generation Science Standards
- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- 5-PS1-3 Make observations and measurements to identify materials based on their properties.

Maryland State Science Curriculum Frameworks
Electricity and Magnetism
- Grade 4: Indicator 2. Investigate and provide evidence that electricity requires a closed loop in order to produce measurable effects.
- Grade 6: Indicator 2. Cite evidence supporting that electrical energy can be produced from a variety of energy sources and can itself be transformed into almost any other form of energy.

Electrophorus and Leyden Jar

Objectives:

- To demonstrate the function of a capacitor.
- To describe the difference between static and current electricity.

Materials (for class):

- Two styrofoam plates
- Styrofoam Cup
- Aluminum foil
- Wool cloth or sweater
- Plastic cup

Set Up:

Electrophorus: Tape one Styrofoam plate to a table. Cover the bottom of the other plate with aluminum foil, and fold the foil over the rim. Tape the Styrofoam cup to the center of the foil-covered plate.

Leyden Jar: Entirely cover the inner surface of the plastic cup with two layers of aluminum foil. Fold over all the edges, leaving some foil protruding from the inner surface. Partially cover the outer surface of the cup with two layers of foil. Fold over the edges, leaving one half inch at the top of the cup uncovered.

Procedure:

(*see illustrations at end of document)*

Electrophorus:

1. Briskly rub the plate on the table with wool for one full minute. The plate now has a negative charge.
2. Holding only the Styrofoam cup, lay the second plate onto the charged plate, causing the electrons in the top plate to be repelled.
3. Invite a student to touch the foil to discharge it. They will feel a shock!
4. Lift the top plate one foot off the table. Invite another student to touch it again. This will ground the plate, and they will get another shock.
5. Repeatedly lift the top plate and touch the foil, and set it on the charged plate and touch the foil. There will be a shock every time.

Leyden Jar:

1. Hold the Styrofoam cup on the top Electrophorus plate with your right hand and set it on the charged bottom plate. Discharge the foil by touching it with your right pinky finger.
2. Hold the outer foil of the Leyden Jar with your left hand, keeping it one foot above the charged Electrophorus plate.
3. Lift the discharged Electrophorus top plate, holding only the insulating Styrofoam cup, and touch the foil on the plate to the inner foil of the Leyden Jar. Watch for a spark.
4. Repeat steps 1 to 3 several times.
5. Invite any students who are comfortable feeling a shock to form a circle and hold hands, leaving a break in the circle for you. Have the student on your right hold the outer foil, and the student to your left touch the inner foil. Everyone will feel a shock!

Electrophorus and Leyden Jar

Science Concepts:

The electricity in this demonstration is **static electricity.** Static electricity is when positive and negative charges are separated and not flowing. In a **static discharge,** like the shocks in the experiment, electrons jump suddenly from one material to another. This is different from **current electricity,** the kind of electricity we use to power electrical devices. Current electricity flows constantly instead of jumping all at once.

The **leyden jar** is the earliest type of **capacitor.** Capacitors are similar to batteries, but they store power from an outside source. In this experiment, the **electrophorus** was our power source and the leyden jar was our capacitor. In electronics, capacitors are charged by current electricity from a battery or outlet.

Curriculum Connections:

Next Generation Science Standards

- 3-PS2-3 Ask questions to determine cause and effect relationships of electrical or magnetic interactions between two objects not in contact with each other.
- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- 5-PS1-3 Make observations and measurements to identify materials based on their properties.

Maryland State Science Curriculum Frameworks
Physics: Electricity and Magnetism

- Grade 4: Indicator 1 Recognize and describe the effects of static electric charges.
- EXPECTATION 5.2 The student will know and apply the laws of electricity and magnetism and explain their significant role in nature and technology.
- INDICATOR 5.2.1 The student will describe the types of electric charges and the forces that exist between them.
- INDICATOR 5.2.2 The student will describe the sources and effects of electric and magnetic fields.

Electrophorus and Leyden Jar

Electrophorus

Leyden Jar

Musical Greeting Card Challenge

Objectives:

- To identify components of a circuit.
- To modify a circuit to create a music box.

Materials (for each student or group):

- Musical greeting card
- Music box template (printed on card stock)
- Scissors
- Tape
- Glue

Set Up:

Prepare one card as a model to show students where to find the circuitry. Remove the cover from the inside of the card to find the circuit. Cut and fold one music box template to demonstrate assembly.

Procedure:

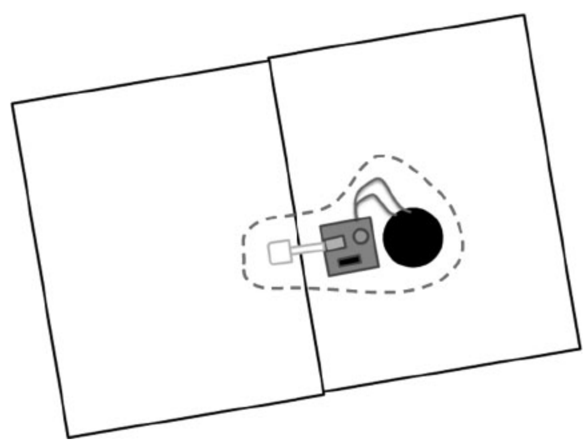
Direct students to:

1. Remove the inside cover on the greeting card to expose the circuit.
2. Cut the circuit out of the card. Make sure to keep the part of the tab that is on the left side of the card (see diagram).
3. Identify the components of the circuit. They should find the power source, switch, integrated circuit, and speaker.
4. On the box template, cut on the solid lines and fold on the dotted lines. Match the numbered flaps to the box sides, and glue them down.
5. Line up the hinge of the box with the hinge from the greeting card. Tape the circuitry to the top of the box, and the pull tab to the side. The music will play when the box is opened.

Extension/Variation:

The switch component can be modified. You can tie a string to the pull tab and attach it to something, or remove the pull tab and bend the top of the switch up to create a pressure switch. Invite students to design their own way to attach a greeting card circuit to objects around the classroom or at home.

Recordable greeting cards are more expensive, but have additional circuit components to investigate and add another opportunity for design.



Musical Greeting Card Challenge

Science Concepts:

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source to a load and back. In the greeting card circuit, the load consists of the integrated circuit and speaker.

A **switch** is used to open or close a circuit. When a circuit is closed, all of the metal is touching and the current can move. When it is open, there is a gap where the metal is not touching and the electricity will not move through the circuit. When the plastic pull tab is in the way, the metal in the card's switch is not touching, so the circuit is open and the music will not play.

A **speaker** is a device that uses electrical energy to make sound.

An integrated circuit, or chip, is a very complicated electrical circuit inside a plastic case. It has many more components than rest of the simple greeting card circuit. The integrated circuit in the greeting card contains all the information needed to make the speaker play the song.

Curriculum Connections:

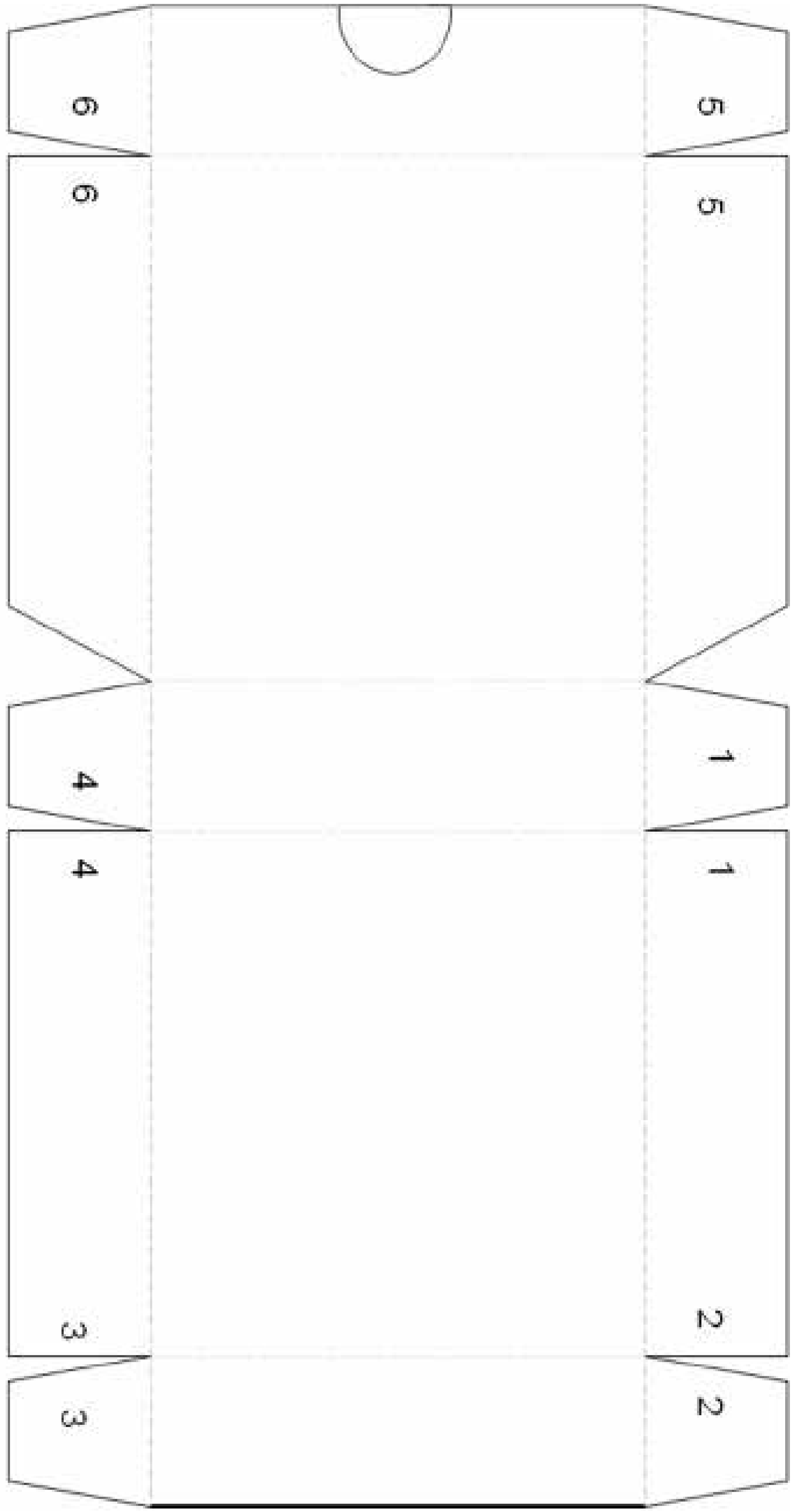
Next Generation Science Standards

- 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- 5-PS1-3 Make observations and measurements to identify materials based on their properties.
- 4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time or cost.
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Maryland State Science Curriculum Frameworks
Electricity and Magnetism

- Grade 4: Indicator 2. Investigate and provide evidence that electricity requires a closed loop in order to produce measurable effects.
- Grade 6: Indicator 2. Cite evidence supporting that electrical energy can be produced from a variety of energy sources and can itself be transformed into almost any other form of energy.

Musical Greeting Card Challenge



Power Up Vocabulary

As you prepare for your trip to the Power Up exhibit, it may be useful to introduce some of the following terms to your students. Familiarity with some of these concepts will help prepare your students for a more meaningful experience in the exhibit.

Grades K-2

Key Terms

Electricity is a kind of energy that moves through a circuit. We use electricity to make things light up, move, make sound, and heat up.

A **switch** is used to open or close a circuit. When a circuit is closed (on), all of the metal is touching and the current can move. When it is open (off), there is a gap where the metal is not touching and the electricity will not move through the circuit.

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source (like a battery) to a load (like a light bulb) and back.

Current is the amount of electricity moving through a circuit. Sometimes there is a lot, like in the power lines that bring electricity to our houses, and sometimes there is just a little, like in the circuit inside a flashlight.

Advanced Terms

A **power station** is a place where electricity is produced.

Load is the amount of electricity something needs to work.

A **grid** is the network of power lines that connects places where electricity is produced to places where electricity is used.

Grades 3-5

Key Terms

Electricity is a kind of energy. It is the flow of electrons through a circuit.

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source to a load and back.

Current is the amount of electricity moving through a circuit.

A **switch** is used to open or close a circuit. When a circuit is closed, all of the metal is touching and the current can move. When it is open, there is a gap where the metal is not touching and the electricity will not move through the circuit.

Mechanical energy is the energy of something that is moving.

A **motor** transforms electrical energy into mechanical energy. For example, the motor in a toy car uses the electrical energy from a battery to make a wheel spin.

A **generator** transforms mechanical energy into electrical energy. For example, in a power plant steam spins a turbine that is connected to a generator. The generator transforms the spinning energy of the turbine into electrical energy.

Power Up Vocabulary

Advanced Terms

Electricity generation is how the electricity that we use is produced. Some ways that the electricity we use in our homes is generated include coal power, nuclear power, wind power, and solar power.

Electricity distribution is how the electricity that we use is moved from one place to another. Electricity travels from the places it is made, like power plants and wind farms, to the places it is used, like homes and schools.

A **grid** is the network of power lines that connects places where electricity is produced to places where electricity is used.

Voltage is the amount of pressure that makes electricity move.

A **transformer** changes the voltage of electricity. One kind of transformer increases the voltage when electricity is transported a long distance, and another kind decreases the voltage when electricity is distributed to homes.

Grades 6-8

Key Terms

Electricity is a kind of energy. It is the flow of electrons through a circuit.

A **circuit** is a path that electricity moves through. Circuits are usually made of metal wire that connects a power source to a load and back.

Current is the amount of electricity moving through a circuit.

Voltage is the amount of pressure that makes electricity move.

Electricity generation is how the electricity that we use is produced. Some ways that the electricity we use in our homes is generated include coal power, nuclear power, wind power, and solar power.

Electricity distribution is how the electricity that we use is moved from one place to another. Electricity needs to be moved from the power stations where it is produced to the consumers who use it.

A **grid** is the network of power lines that connects power stations and electricity consumers.

A **motor** transforms electrical energy into mechanical energy. For example, the motor in a toy car uses the electrical energy from a battery to make a wheel spin.

A **generator** transforms mechanical energy into electrical energy. For example, in a power plant steam spins a turbine that is connected to a generator. The generator transforms the spinning energy of the turbine into electrical energy.

Power Up Vocabulary

Advanced Terms

Demand is the amount of energy needed by consumers in the grid.

Capacity is the maximum amount of energy that can be produced by power stations.

AC, or alternating current, is a type of electricity where the direction of the current reverses many times per second.

DC, or direct current, is a type of electricity where the direction of the current is always the same.

A **transformer** changes the voltage of electricity. One kind of transformer increases the voltage when electricity is transported a long distance, and another kind decreases the voltage when electricity is distributed to homes.

Resistors increase the resistance of the circuit, or how much it resists the current.

Rheostats are variable resistors. They can increase and decrease the resistance of the circuit, which lets you control the amount of current moving through the circuit.

Voltmeters are tools that measure voltage.

Ammeters are tools that measure the amount and direction of current.

Capacitors store energy that comes from another power source.