

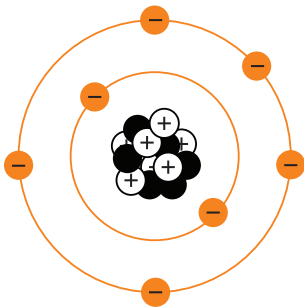
WHAT IS ELECTRICITY?

Background Information

To understand electricity, it is important to understand the atom, which is the building block of everything we know. Atoms are made of smaller particles: protons, neutrons and electrons. The center of the atom is called the nucleus. It contains the neutrons and protons. The much smaller electrons spin around the nucleus on paths called shells.

Neutrons have no electrical charge. Protons have a positive electrical charge and electrons have a negative electrical charge. These opposite charges attract each other, so an atom is balanced when it has an equal number of protons and electrons.

Because the force of attraction that holds electrons close to the nucleus is not always as strong in an atom's outer shells, electrons can be pushed out of their shells and away from the atom. These free electrons are electricity.



There are different forces that act to push free electrons. Friction between two items can cause free electrons to transfer from one item to the other, electrically charging both items. This is called static electricity. We see static electricity in nature.

When hair stands on end as it is brushed, or sparks fly as someone walks across the carpet, static electricity is at work. Lightning is also static electricity. It occurs when electrons move from a cloud to another area of the sky or ground.

An electromotive force, or voltage, can also push free electrons. It might come from a battery or an electric power plant generator. Free electrons pushed in this way can be guided in an orderly fashion that is useful to people. This motion is called an electric current. It is measured in Amperes (Amps) and represents the number of electrons passing a given point in 1 second.

An electric current that flows only in one direction is called a direct current (DC). Thomas Edison's first electric power plant and modern solar photovoltaic systems produce a DC current. An electric current that reverses the direction of its flow at regular intervals is called an alternating current (AC). Modern electric power plants deliver AC currents to light bulbs, televisions, air conditioners and other appliances in our homes and businesses.

TIPS FOR TEACHING

Younger elementary students should focus on forms of electricity that they observe and utilize in their lives. Ask young students to explore static electricity through friction with various objects. Brainstorm with them ways that electricity helps their families get work done more quickly. Older students can further explore the atom by making models. They can build simple circuits to investigate voltage, Amps and currents.

STUDENT ACTIVITY: STUCK ON YOU

All objects are composed of positively charged particles called protons and negatively charged particles called electrons. Normally the protons and electrons are evenly distributed in an object. Thus, the object is neutral or has no charge. When some objects are rubbed, their charged particles are redistributed. The object being rubbed picks up electrons from the object doing the rubbing. Thus, the object being rubbed becomes negatively charged and the object doing the rubbing becomes positively charged. Since unlike charges attract, the two objects will stick together.

Materials:

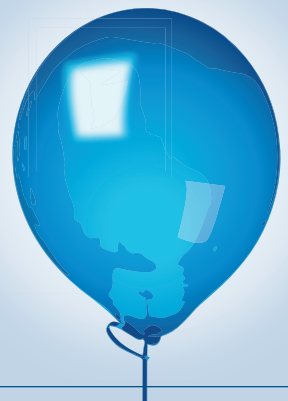
- 2 balloons
- 2 pieces of wool, fur or a sweater

Procedure:

1. Blow up a balloon and tie it.
2. Rub the balloon against a piece of wool, fur or a sweater.
3. Place the balloon against the wall; the balloon should stick to the wall.
4. Now blow up the other balloon and repeat step two. Place it next to the first balloon.

Questions:

1. What have you observed?
2. What type of electricity is illustrated?
3. What causes the balloon to stick to the wall?



HOW IS ELECTRICITY GENERATED?

Background Information

Electrical generation begins with a primary energy source. These can be nonrenewable like coal, natural gas or uranium (nuclear). Primary sources can also be renewable, like geothermal, water (hydro), wind or the sun (solar). Because electrical generation is dependent on another energy source, it is called a secondary energy source.

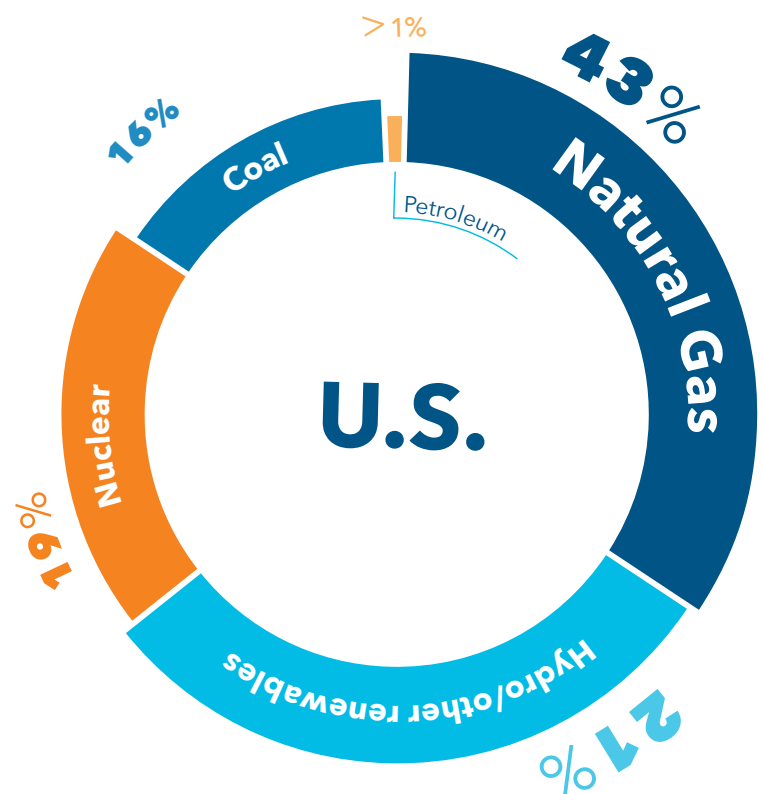
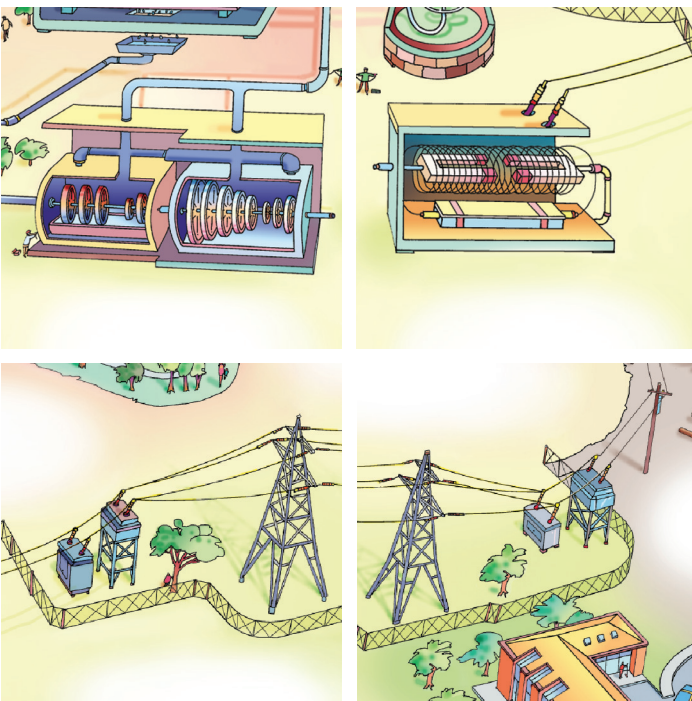
Electric utility power plants use primary energy sources to drive a turbine, engine or other machine. If the primary source is nonrenewable it produces heat, which turns water into steam, which drives the turbine. In North America, most electricity is produced using steam turbines. Renewable primary sources can drive the turbine in different ways, such as the force of falling water in a hydroelectric power plant.

The turbine is connected to a generator, which is a device that converts mechanical energy into electrical energy. Most generators at electric power plants use an electromagnet attached to the end of a rotating shaft, which is inside a stationary ring wrapped with wire. When the magnet rotates, it induces an electric current in each coil of wire that it passes. These currents together produce a stronger current.

Transporting electricity to the consumer is not a simple task for an electric utility. In many cases the electricity will have to travel great distances. To make this possible, voltage must be increased with a step-up transformer. High voltage electricity must travel on transmission lines, which are wires or cables that are capable of handling the voltage. A step-down transformer at the distribution substation decreases voltage of electricity that is carried on distribution lines into neighborhoods. Another step-down transformer further decreases voltage closer to the consumer so that it is safe for use.

TIPS FOR TEACHING

Increase younger elementary students' understanding of renewable and nonrenewable energy sources by discussing the familiar: wind, water and sun. Explore how these resources return repeatedly in nature. Have older students make predictions about the future of renewable and nonrenewable energy sources. Lead them in drawing, acting out or explaining the generation process.



U.S. Electrical Generation Sources

(Source: eia.gov/tools/faqs/faq.php?id=427&t=3, accessed March 2024)

HOW IS ELECTRICITY GENERATED AND TRANSMITTED?

Background Information

The electricity produced by a generator travels along cables to a transformer, which changes electricity from low voltage to high voltage, as much as 765,000 Volts. Electricity can be moved long distances more efficiently using high voltage. Transmission lines are used to carry the electricity to a substation. Substations have transformers that decrease the voltage to 5,000 to 35,000 Volts (12,000 Volts being most common). From the substation, distribution lines carry the electricity to a transformer on a pole or on the ground that steps it down once again to 120 to 220 Volts, then on to homes, offices and factories, which require low voltage electricity.

Transformers are also used in many electrical appliances, such as radios, televisions and battery chargers, wherever a different voltage from the supply is required. If the transformer is raising the voltage it is called a step-up transformer. If it is lowering the voltage it is called a step-down transformer. Each transformer has two coils of wire inside that create two electric circuits with different voltages.

Visit eia.gov/kids to learn more about electricity and how it is made and transmitted.

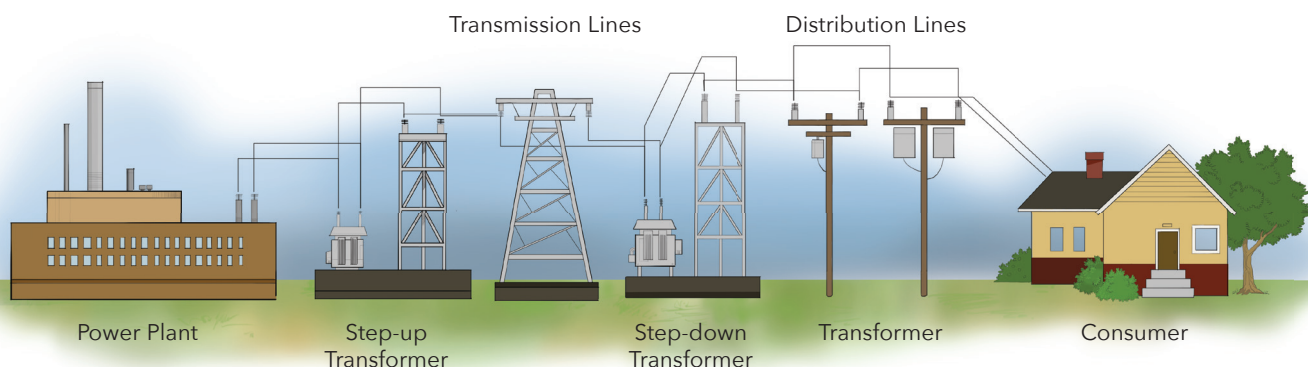
TIPS FOR TEACHING

Early elementary students should understand that electricity is flowing to their homes through several circuits and that energy is being transferred from place to place by electric currents.

Ask students to trace the energy they use to light their homes from the light bulb back to the power plant. Ask what natural resources could be used to make the electric current that comes from the power plant.

FIRST BATTERY INVENTED: 1800

The unit used to measure electric force or pressure is called a Volt, after the Italian physicist Alessandro Volta. He invented a simple electric cell that used chemicals to make electricity. By connecting many cells, Volta built a "voltaic pile" or battery. The voltaic battery provided a continuous source of electricity that scientists could use in their experiments.



WHO ARE ELECTRICITY CONSUMERS?

Background Information

Electricity is essential to our daily lives. Electricity powers our businesses and industries; it is used in schools and other public institutions; it allows us to surf the internet or watch our favorite television shows at home. Billions of dollars are spent on electricity in American homes, businesses and industries each year. Electricity in the U.S. can cost the average family hundreds of dollars each year.

According to the U.S. Energy Information Administration, in 2022, residential consumption of electricity accounted for 39 percent, commercial for 35 percent and industrial for 26 percent. Power companies must project what these different types of consumers expect from their electricity supplier and the companies must strive to meet the varied demands. (Source: [eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php](https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php), accessed June 2024)

The personal and professional lifestyles of citizens are growing increasingly complex. Technological advances contribute to our comfort and efficiency but demand more electricity. For example, today's business practices rely increasingly on the internet, electronics, computers, email and cell phones, all services that depend on the reliable delivery of electricity.

Meeting our growing demand for electricity, while maintaining our commitment to protect the environment, is one of the most complex issues facing today's policy makers. Some people argue that as we move further into the 21st century we will be forced to choose between reliable electricity, affordable electricity and a clean environment. This is not necessarily true.

Electric utilities need to answer four questions about the needs of their consumers when making plans for the future. What are the consumers' demands to fit their lifestyles? What are the economic and regional characteristics of the consumers? What are the consumers' views on environmental issues? What political views or agendas do the consumers represent?

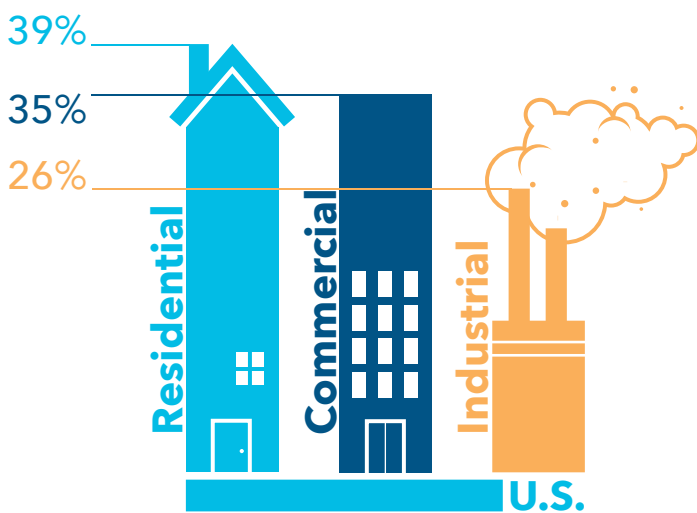
Data collected by the U.S. Environmental Protection Agency and other government sources, clearly shows that over the past few decades the supply of affordable and reliable electricity has expanded, while progress in improving environmental quality has been made. The U.S. and Canada have plentiful domestic resources to generate electricity.

Emerging technologies are allowing us to meet the growing demand for electricity more efficiently and with fewer emissions.

Visit the website [eia.gov/energyexplained](https://www.eia.gov/energyexplained) to learn more about how we make and use electricity.

TIPS FOR TEACHING

Have students create a graph of the different sectors using electricity. Ask them to interpret the graph. Which group used the most electricity? The least? Visit the EIA website to get state data and compare the graphs for your state and the nation.



Electricity Consumption

(Source: [eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php](https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php), accessed June 2024)

ELECTRICITY SCAVENGER HUNT

Student Activity

We use electricity to keep us cool, to prepare food and to run video games. Take a look at all the ways your family uses electricity. Take a tour of your home, placing a tally mark next to each item you have that uses electricity. If there is more than one of something, such as more than one light bulb, put a mark for each one. If you have something that is not listed below in your home, write it in the space marked "OTHER." Be sure to get permission before entering bedrooms or bathrooms that are not your own.

Outside Your Home

- light bulbs, including patio lights, garage lights
- air conditioner*
- automatic sprinklers
- motion detectors
- OTHER

Garage/Basement

- light bulbs
- air compressor*
- electric trimmer/edger
- electric mower
- freezer*
- garage door opener
- music player (radio, MP3 player)
- power tools
- refrigerator
- sump pump*
- water heater*
- water softener/filtration unit
- utility timer
- OTHER

Living Room/Family Room

- light bulbs
- cable/satellite TV box
- DVD player/DVR
- electric space heater*
- game system
- humidifier
- massager
- music player (radio, MP3 player)
- powered exercise equipment
- sewing machine
- television
- OTHER

Kitchen

- light bulbs
- automatic bread maker
- blender
- clock
- slow cooker
- deep fryer
- dishwasher
- electric can opener
- electric knife
- electric fry pan
- electric grill/griddle
- electric range (stove top)*
- electric wok
- food processor
- garbage disposal
- microwave oven
- mixer
- music player (radio, MP3 player)
- popcorn popper
- refrigerator*
- television
- toaster
- waffle iron
- warming tray
- OTHER

Bathrooms

- light bulbs
- electric razor
- electric toothbrush
- exhaust fans
- electric dental care system
- curling iron
- hair dryer
- heated curler set
- jetted tub*
- towel warmer
- OTHER

Bedrooms

- light bulbs
- aquarium/terrarium
- clock
- dehumidifier
- electric space heater*
- music player (radio, MP3 player)
- television
- electric blanket
- OTHER

Home Office/Den

- light bulbs
- battery charger*
- ceiling fan
- clock
- computer
- computer printer
- electric space heater*
- copier
- dehumidifier
- music player (radio, MP3 player)
- television
- electric pencil sharpener
- OTHER

Laundry Room

- light bulbs
- electric clothes dryer*
- iron
- electric heating pad
- washer
- steamer
- vacuum
- OTHER

Total number of things using electricity in my home

WHAT ARE CONDUCTORS, INSULATORS AND CIRCUITS?

Background Information

Electric current or electricity travels through wires from generation plants to places that use it: industrial and commercial buildings and our homes. Conductors, insulators and circuits are needed to make this happen. Conductors are materials that allow an electric current to pass through them. For example, most metals conduct an electric current. That is why wires are made of metals. Insulators, on the other hand, resist the flow of an electric current. Rubber, plastics and other insulators do not allow electricity to pass through them easily.

Electricity moves through a circuit, which is a pathway for an electric current to follow. Usually copper wire that is surrounded by insulation of different colors comprises the wiring in most homes and businesses. This will ensure that the electricity cannot escape. However, if for some reason a conductor that has electricity running through it does not have insulation around it or the insulation is damaged, it can pass the electricity to another conductor. This is called a short circuit.

An open circuit is a pathway that has an opening, which does not allow an electric current to flow. A switch that is in the off position makes its circuit an open circuit. A closed circuit is where an electric current is allowed to flow. For example, when a switch is in the on position the pathway is complete and a current can flow through it.

Series and parallel circuits are types of circuits that are used to wire homes and businesses. A series circuit is where there is one pathway for an electric current to follow. Various devices are connected in such a way the electric current flows through each device. In a parallel circuit, there are multiple pathways for an electric current to flow through the devices on the circuit.

TIP FOR TEACHING

Ask students about different examples at home or school that are similar to open or closed circuits. Closed circuit: turn the faucet handle or lever for water to flow; a green traffic light that allows traffic to flow; school crossing guard that allows students to cross the street. Open circuit: a bridge that is out or destroyed over a river so that no one can cross; computer mouse that is not connected to a computer; a red light at an intersection that does not allow traffic to flow.

Open circuit:
No electricity
can flow.



Closed circuit:
Electricity
can flow.



STUDENT ACTIVITY: A BRIGHT IDEA!

Electric circuits conduct an electric current from the power source through wires to a load (a device that uses electric current). Power sources can be many different things from batteries to generators, solar panels to wind turbines.

Alessandro Volta, an Italian physicist, made the first battery in 1800. Volta placed two different metal electrodes in an electrolyte solution (a chemical mixture which will conduct an electric current). The chemical reaction caused an electromotive force. A common misconception is that batteries store electrical energy. This is not really true. Batteries convert chemical energy to electrical energy. They store chemical energy that can be released during a chemical reaction. By using metals or carbons that have different chemical properties and an acid or base that will allow the movement of electrical charges, an electric current can be produced.

Materials:

- Several general purpose C-cell batteries
- A string of holiday lights, cut apart and stripped at the ends OR small bulbs and sockets with wires
- Copies of the "A Bright Idea!" student sheet

Activity:

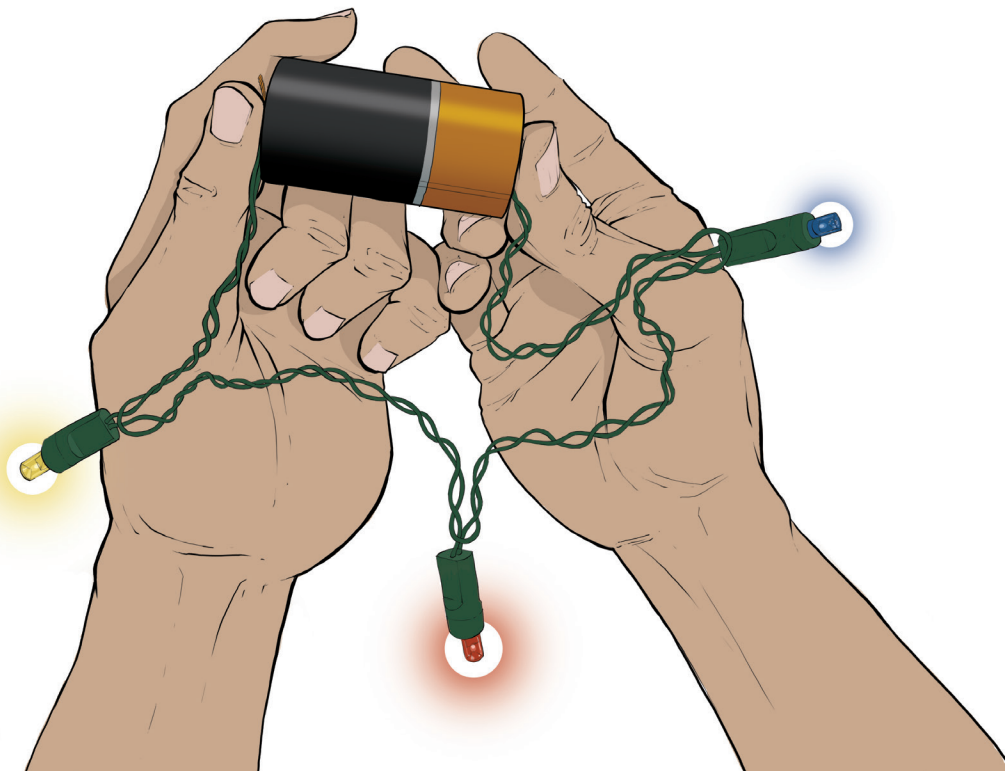
Have students use the materials provided to experiment with simple circuits by following the guided inquiry activity on the student sheet. As the students do the activity, have them note the light and heat energy given off.

A BRIGHT IDEA!

A Bright Idea! Student Sheet

Electrons moving in a wire are called an electric current or electricity.

1. Using one battery and one light make the bulb light up. Congratulations, you have made an electrical circuit!
2. What did you have to do to get the light to come on and complete the circuit? How was it touching the battery?
3. What do you have to do to make the light bulb turn off, then back on?
4. What do you think the electrical terms open circuit and closed circuit mean?
5. How do you think a light switch works?
6. What type and form of energy is in the battery?
7. Into what forms of energy did you transform the battery's energy?
8. Using one battery, try to light up two lights.
9. Sketch how the wires are connected to the battery when you light two lights.
10. Are the lights the same brightness as when you lit only one or are they dimmer?
11. Compare your methods and results for numbers 8 to 10 with other students. Is there more than one way to light multiple lights using only one battery?
12. A series circuit has only one path that electrons can follow as they are pushed from one side of the battery to the other. A parallel circuit has more than one path and the electrons can go more than one way to get from one end of the battery to the other. Which type of circuit did you make and draw in number nine?
13. Experiment with multiple batteries connected together, placing the positive end of one battery touching the negative end of another battery. What effect does the number of batteries have on the brightness of the bulbs?
14. If you leave the battery connected to a bulb long enough, you will feel the wire and the ends of the battery getting warm. What do you think is causing this?
15. Can that heat be useful? Can it be dangerous? Give an example to prove your point.



CAREER CONNECTIONS

Have you ever considered a career in energy? There are many jobs in the electricity industry. There are electricians, electrical engineers, line workers, transmission and distributions technicians, power plant operators, power plant technicians, accountants, IT personnel and many more. Check out the Get into Energy website for more information on electricity industry careers getintoenergy.com.

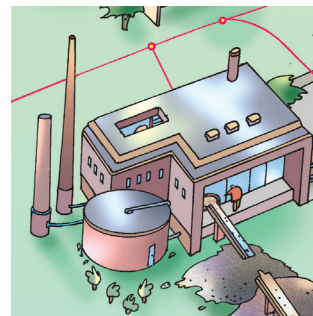
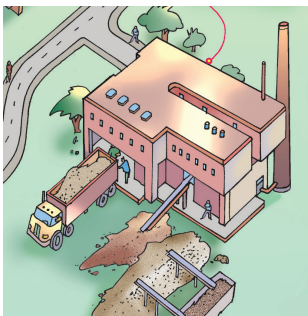


How to Use This Poster

Before displaying the poster, make copies of the back for use with your students.

STEM Connections

STEM education is an approach to teaching and learning that integrates content and skills of science, technology, engineering and mathematics. These skills include: problem-solving, innovation, invention, inquiry, logical reasoning, critical thinking, technological literacy, design and modeling, data analysis and probability, collaboration and real world connection. Information and activities on the poster address several of the STEM content areas and skills.



National Energy Foundation

The National Energy Foundation (NEF) has empowered millions of students and families to make energy wise choices for over four decades through its nonprofit mission to cultivate and promote an energy literate society. A community of volunteer classroom teachers and staff educators brings unique educational integrity to NEF's K - 12 energy education programs, with many programs resulting in national recognition like the award winning energy efficiency program, Think! Energy. Energy utilities and organizations partner with NEF to address critical topics such as efficiency, safety and electric transportation. NEF recognizes the importance of education in making informed energy decisions.

Acknowledgements

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