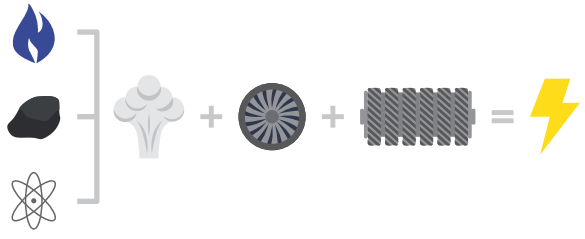
We Are Switched On

Did you use electricity today? Are you going to use electricity for the rest of your life?

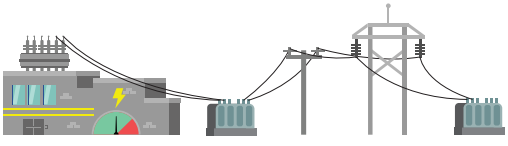
We use electricity every day to power our homes, schools, businesses and devices. In simplest terms, electricity is the flow of electrons through a conductor. When force is applied to a conductor by a battery or power plant generator, electrons are pushed through the conductor, which is usually a wire. Like dominos falling when pushed, an electric current is created.

Where do we get the power to generate electricity?

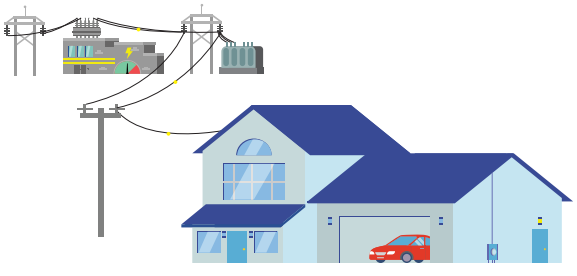
Electricity is generated from natural resources like natural gas, coal, uranium (nuclear) and renewables. Depending on the source, the process changes. Power plants use these resources to spin a turbine that converts mechanical energy into electric energy inside a generator.



Electricity travels long distances through transmission lines at almost the speed of light.



Distribution lines carry lower voltage electricity into your home to power devices that are plugged into an outlet with the flip of a switch.



War of Currents

Thomas Edison is the well-known inventor of the first incandescent light bulb. This light bulb ran on a direct electrical current (DC) where the electrons flow only in one direction. This became the standard for conducting electricity.

One of his employees, Nikola Tesla, built on Edison's idea by creating an alternating electrical current (AC) that changes the direction of the flow of electrons using a magnet. Edison was not impressed with Tesla's idea because it conflicted with Edison's business prospects for DC.

Tesla went ahead with his idea by filing a patent for his AC technology and began working with George Westinghouse. This sparked a fierce competition between the use of DC versus AC in the United States with Edison, Tesla and Westinghouse at the forefront.

Who won? We did! We still use both types. Most of the electricity we use in our homes is alternating electrical current, while direct electrical currents are typically used for batteries, computers, LEDs, solar cells and electric vehicles (EVs).

(Source: *energy.gov/edison-vs-tesla*, accessed February 2023)

Did You Know?

Benjamin Franklin suggested the use of lightning rods to redirect lightning away from buildings to keep them from burning down. The Centennial Light Bulb has been burning since 1901. It is maintained by the Livermore/Pleasanton Fire Department and is rarely turned off.

Flip the Switch

Electricity, or the flow of electric charge, needs a path to travel on, a circuit. An electric circuit is the system by which an electric current is directed, controlled, switched on or switched off. The circuit must form a complete path allowing energy to be changed from one form to another.

Three things are needed for electricity to flow: an energy source, a conductor to carry electrical energy and a load to use the energy. For example, a battery could be the energy source to power a light bulb. Batteries contain chemical energy that changes into electrical energy. In figure 2.1 the electrical energy moves through the wire, which is the conductor, and some of it is changed into heat energy due to resistance in the wire. The light bulb acts as the load to use the energy and changes the energy again, from electrical energy into light and more heat energy.

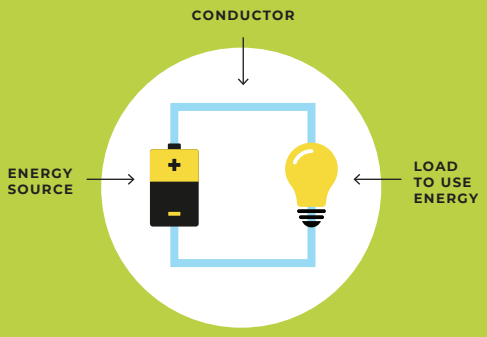
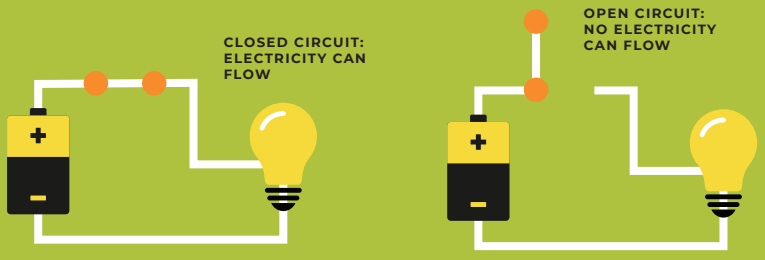


FIG. 2.1

A circuit controls the flow of electricity and can be open or closed. If the circuit is open, the path is broken and no electricity can flow. This is how a light switch works. It opens and closes the circuit. When the switch is off the electrical pathway is not complete so no electricity can flow. When you flip the switch you close the circuit which allows the light to turn on.



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 and more.

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 store chemical energy that can be released during a chemical reaction and converted to electrical energy. 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
- Copies of the "A Bright Idea!" student sheet. Download the student sheet at *nef1.org/electricgeneration-poster*.

Activity:

Using one battery and one light, make the holiday lights or light bulbs light up.

Congratulations, you have made an electrical circuit! Have students use the materials provided to experiment with simple circuits by following the guided inquiry activity on the student sheet.

1. What did you have to do to get the light to come on and complete the circuit? How was it touching the battery?
2. What did you have to do to make the light bulb turn off, then back on?
3. What type and form of energy is in the battery?
4. What other forms of energy was the battery's energy transformed into?

Don't Be Cruel, Preserve Your Fuel

Electricity is a secondary energy source. It is generated from a primary source, the sun (solar), oil, coal, natural gas, uranium (nuclear), water or wind. Energy comes from natural resources that are either renewable or nonrenewable. Nonrenewable energy resources are replaced very slowly or not replaced at all. Fossil fuels are nonrenewable resources and include coal, crude oil, natural gas and uranium. Renewable energy resources can be replaced through natural and/or human processes in a relatively short amount of time. Examples are:

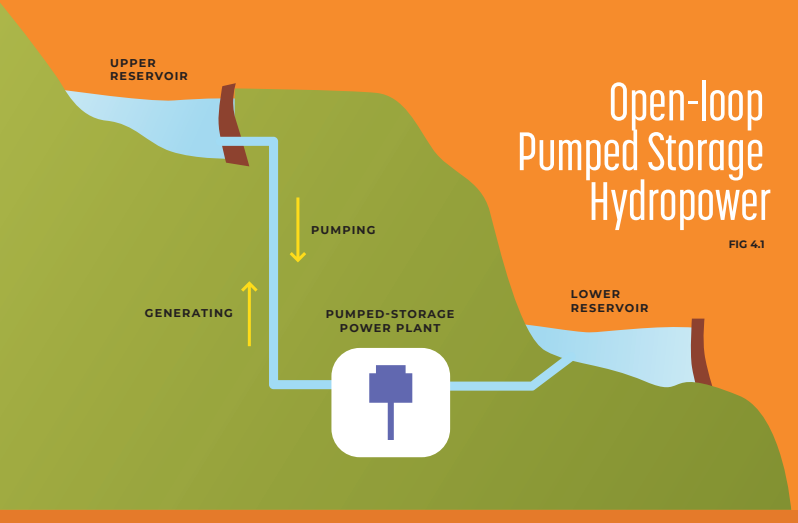
Solar
Energy from the sun

Wind
Energy caused by the sun's uneven heating of the earth's surface

Hydropower
Energy from moving water: ocean waves, tides & temperatures

Biomass
Energy from plants & animals

Geothermal
Energy from heat within the earth



Open-loop Pumped Storage Hydropower

FIG 4.1

Renewable energy helps the environment by reducing human caused greenhouse gas emissions that are produced from burning fossil fuels. Renewable energy has the potential to reduce the use of nonrenewable resources.

Using renewable energy can require certain conditions, like a strong wind or a sunny day. Energy storage techniques make it possible to balance generation of electricity with the demand needed at different times of the day. For example, solar energy can be generated during a bright, sunny day and stored for later use when electricity is in peak demand.

Storage Options

Pumped Storage Hydropower (Fig. 4.1)
Water is stored in an upper reservoir. When electricity is needed, it is released to flow down to a lower reservoir through a turbine to begin the electric generation process.

Compressed Air Energy Storage
When electricity is off-peak (not in demand) it can be used to compress air. The air is stored underground or above ground in pipes. When electricity is needed, the pressurized air is released to generate electricity.

Thermal Storage
Thermal systems use heating and cooling methods to store and release energy. For example, molten salt can store heat from the sun for later use. Other systems use chilled water or water heaters to store excess energy.

Batteries
Batteries can store electricity for devices in your home. Did you know that many types of batteries can store electricity on a large scale for the grid? One example, the lithium-ion battery was initially developed for consumers.

Flywheels
A flywheel is a very heavy wheel that stores a great deal of kinetic, mechanical energy when it spins fast. Flywheels store mechanical energy like a battery stores chemical energy.

Future Storage Methods
Storage technologies make electricity generated by these sources available when we need it. Increased use of renewable energy has helped to push the development of storage technologies.

Harness the Power of Natural Resources

A natural resource is something that exists without humankind and comes from the earth or the sun. Some examples are wind, natural gas, the sun and water. Natural resources are used in many ways. Solar energy is harnessed through solar panels and wind energy by wind turbines for electricity. Electricity can be generated by the heat generated from natural gas.

Natural resources are not only used for electric generation, however. Natural gas, coal or wood can be burned to produce heat. Historically, water was used to turn water wheels in pumps and mills to produce mechanical energy, wind was used to power ships across oceans and coal was burned to power the first steam engines.

Not all natural resources are easily replaced. Natural gas and crude oil are found in the earth, but take millions of years to form. Therefore we call them nonrenewable. Resources such as sunlight and wind are easily replaced, and we call them renewable. The use of nonrenewable and renewable resources are essential to heating our homes, cooking our food and generating electricity.

Natural resources are amazing. They...

- ***Power*** spacecraft, cellular phone towers and weather stations
- ***Supply electricity*** in places where power lines do not exist
- Are placed in ***beneficial areas***, like solar installations in fields, amongst grazing cows or on pontoons that float on water to reduce evaporation and undesirable algae growth
- Can use technology to ***turn their waste products into something useful***, such as heat from burning coal being used to generate electricity
- Will be innovated for future use. ***An example is hydrogen*** being a clean energy carrier that can store, move and deliver energy produced from other natural resources

Student Activity: What's Your Energy Resource?

Have students research various fuel sources of energy: coal, oil, natural gas, uranium, solar, wind or water. Students can then work together to develop a creative delivery method of teaching the class about their chosen energy source. Ideas include...

Make an edible replica of a fuel source.

Rewrite song lyrics to reflect information about an alternative or renewable fuel source.

Develop a board game with informational cards and decision-making questions.

Write a Haiku for each alternative and renewable fuel source.

Save Energy, Money & the Planet

Energy efficiency means using less energy to accomplish the same amount of work. We can be energy efficient in one of two ways:

1 Efficient technologies

2 Wise behaviors

Combined efforts will help preserve our natural resources and save money. Because residential appliances, lighting and electronics consume roughly one-half of the electricity we use in our homes, improving the energy efficiency of appliances is an important step toward conserving resources.

Student Activity: Decoding Efficiency

Solve the picture puzzles to discover 12 energy saving tips.

1. Take quick +s instead of +hs.
2. off +s that U do not +d.
3. Put on when coo+ .
4. Turn the +v when no+ 1 is +ing.
5. Re+ lea+ +s.
6. Do not OPEN door while it is on.
7. Wash in water.
8. In the winter open when the is shining.
9. when they R dir+ .
10. U +se re+ +able +s 2 save energy.
11. , and .
12. U +se a 2 wash the .

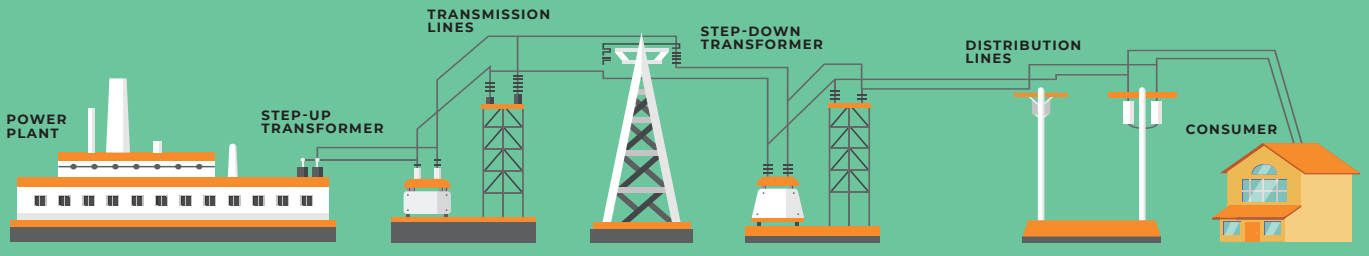
Intelligent Power Networks

Smart grid technology allows multiple paths of communication between electric utility companies, their customers and energy production sites. This communication can help avoid a disruption during events such as intense weather or a downed power line. It helps the utility switch between available sources used to generate electricity and adjust the amount of power feeding into the grid based on customer needs. This advanced system uses smart meters to measure electricity usage more frequently. It provides reports that help families understand how to save electricity and show when electricity is cheapest.

Smart meters allow you to view your energy use and control the impact of appliances and electric products right from your computer or handheld device. You can change settings that allow you to control when appliances are turned on and off, including during peak hours which may result in energy and financial savings.

The smart grid is a group of transmission lines, distribution lines, substations and transformers.

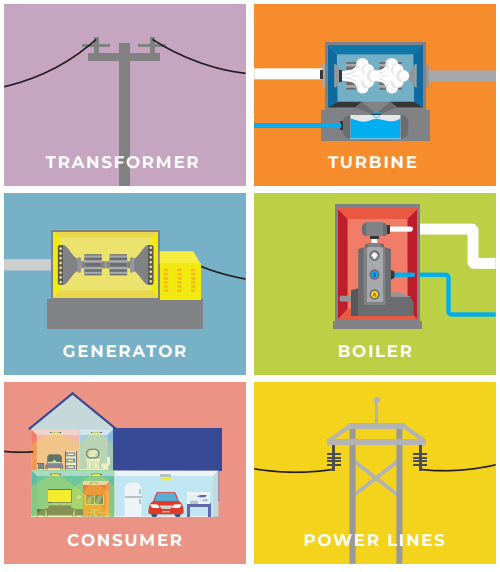
Transformers are used to change the voltage of electricity traveling through the grid. Step-up transformers take the electricity generated by the power plant and boost the voltage. Higher voltages can travel over transmission lines faster with less resistance because they are made of copper or aluminum wires. Electricity then travels to the step-down transformer at the destination so it can be converted to a lower voltage and distributed to customers. In some residential neighborhoods there is an additional transformer mounted on a pole that lowers the voltage even further to be used in your home.



Student Activity

Create a visual model of the electric generation and transmission process.

1. Download the "Electric Generation Puzzle Cards" at *nef1.org/electricgeneration-poster*.
2. Pass out the cards and give students a few minutes to put the pieces in process order individually or in small groups.
3. Go through each step of the process asking students the type of energy going in and coming out of each step.
4. Ask students how the process of generating electricity with alternative energy sources would vary from the fossil fuel power plant shown in the puzzle. Which pieces would be different or removed if you were using wind power? Hydropower? Solar power? Nuclear power?



To Know and Do More

Students, design your own virtual renewable energy system at *pbs.org/wgbh/nova/labs/lab/energy/*.

Did You Know?

Your electric vehicle (EV) can be used to store electricity for your home. The battery works as a microgrid, storing energy that can be redistributed inside your home using a smart meter.

Electrical Safety Is No Accident

Electricity, when used properly, is a safe and convenient form of energy. When used improperly, electricity can cause fires, shocks, injuries and even death. The following safety tips will help you avoid electrical accidents.

1. Unplug appliances using the ***rubber plug***, not the cord.
2. Never stick anything in an outlet except a ***plug***.
3. ***Never overload*** outlets.
4. ***Do not mix*** water and electricity.
5. ***Go inside*** when there is a storm.
6. ***Stay away*** from downed power lines and anything they may be touching.
7. ***Stay away*** from electrical equipment.
8. ***Keep things away from space heaters*** because they can cause a fire.
9. Do not fly drones or climb trees near ***power lines***.

Student Activity: Full of Hot Air

Years ago your great-grandparent would take one day each week to do the laundry. All the dirty laundry would be washed and hung on a clothesline in the fresh air to dry. Many people still like to hang some of their laundry outside because of the fresh smell it has when they bring it inside and fold it. Hanging laundry on a clothesline is the most energy-efficient way to dry clothes.

Today there are three types of clothes dryers; you can discover what they are by solving the puzzle below.

The first number in the pair is the column down, the second number is the row across. For example, 2-4 is the letter D, determined by going down 2 rows and across 4 rows.

	1	2	3	4	5
1	C	E	U	A	O
2	S	G	H	D	T
3	N	L	R	M	I

1-1 3-2 1-5 2-5 2-3 1-2 2-1 3-2 3-5 3-1 1-2

1-2 3-2 1-2 1-1 2-5 3-3 3-5 1-1

3-1 1-4 2-5 1-3 3-3 1-4 3-2 2-2 1-4 2-1

The Ideal Career

New technology increases the efficiency of electrical generation. More career paths will open to keep up with the demand for electricity in our communities. Some options currently available are:

Line Workers
Build, repair and maintain the grid

Electrical Technicians
Ensure power is flowing correctly between the power plant and cities

Sustainability Specialists
Help companies work to become more eco-friendly

Energy Engineers
Increase energy efficiency of buildings and manufacturing processes

Conservation Scientists
Manage and protect natural resources from human made threats such as pollution, construction and overuse

For more information, visit *eia.gov/kids/for-teachers/career-corner/*.

National Energy Foundation

About NEF

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. Energyutilities and organizations partner with NEF to address critical topics such as efficiency, safety and electric transportation. NEFrecognizes the importance of education in making informed energy decisions.

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