Atoms to Electric Current

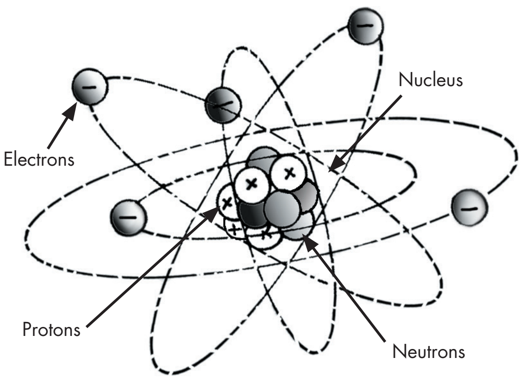
WHAT IS ELECTRICITY?

Electricity is a natural phenomenon and one of our most widely used forms of energy. A secondary energy source, electricity is generated from the conversion of primary sources of energy like coal, natural gas, oil, nuclear power, hydropower and other natural resources.

But, what is electricity? Where does it come from? How does it work? To get to the heart of the matter you must literally get to the heart of matter – the atom.

ATOMIC STRUCTURE OF MATTER

All matter is made up of atoms which are made up of smaller particles – ***protons***, ***neutrons*** and ***electrons***. The ***nucleus***, or center, of the atom contains the neutrons and protons and the electrons spin around the nucleus somewhat like the moon spins around earth. The electrons contain a negative charge, protons a positive charge and neutrons are neutral. They have neither a positive or a negative charge.

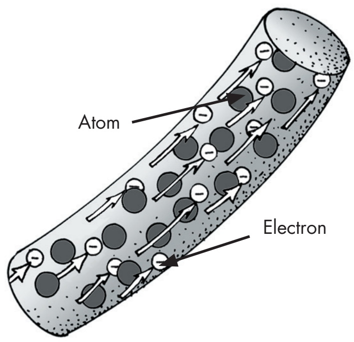


Atoms have specific numbers of electrons, protons and neutrons.

An ***ion*** is an atom that has become electrically unbalanced by the loss or gain of one or more electrons. An atom that loses electrons has more protons and so is positively charged and is called a ***cation***. An atom that gains electrons has fewer protons and so is negatively charged and is called an ***anion***. The process of producing ions is called ionization.

ELECTRONS, CONDUCTORS AND INSULATORS

Electrons can be made to move from one atom to another in a ***flow***. One electron is attached and another electron is lost. When those electrons move between the atoms, a current of electricity is created. In a piece of wire the electrons are passed from atom to atom, creating an ***electric current*** from one end to the other. Electrons are very, very small. A single copper penny contains more than 10,000,000,000,000,000,000,000 ($1x10^{22}$) electrons.



In a piece of wire, electrons have passed from atom to atom creating an electrical current.

Metallic materials – silver, copper, or aluminum contain numerous free electrons capable of carrying an electric current and are called ***conductors***. Nonmetallic materials – rubber, plastic, cloth, glass, and dry air, which contain few free electrons, are called ***insulators*** and have very high resistance. That is why rubber is used to cover the wires of an electric cord. The more free electrons a material contains, the better it will conduct electricity.

ELECTRIC CURRENT

Free electrons are ordinarily in a state of chaotic motion. However, when an electromotive force (or voltage) is applied, such as that provided by a battery or electric power plant generator, the free electrons in the conductor are guided in an orderly fashion, atom to atom, creating an electric current.

Electric current is measured in ***Amperes*** and is the amount of electrons passing a given point in one second. ***Voltage*** is a measure of potential difference, the electromotive force necessary to move electrons through conductors. The amount of electric current moved through a conductor by the voltage is influenced by the conductor's resistance.

Electric power, the work performed by moving electrons (electric current) is measured in ***Watts***, and is determined by multiplying the current by the voltage:

1 Watt = 1 Amp x 1 Volt

Because of the relationship between electric current and voltage to perform work, the same amount of work can be performed with either a high current and low voltage or a low current and high voltage.

Electric Circuits

RESISTANCE

Electricity ***flows*** or moves through some materials better than others. The opposition to the flow of free electrons in a material is called ***resistance***.

Resistance in wire depends on how thick and how long it is and what it is made of. The size of wire is called its ***gauge***. The smaller the gauge number, the bigger around the wire. A gauge one wire is bigger around than a gauge 12 wire.

Different types of metal, used to make wire, have a different resistance. For example you can have gold, copper, aluminum, even steel wire. The lower the resistance of a wire the better it conducts electricity. Copper is used in many wires because its resistance is lower than most other metals. The wires in the walls of your house and inside lamps are probably copper.

A piece of metal can be made to act like a heater. When an electric current occurs, the resistance causes friction and the friction causes heat. The higher the resistance, the hotter it can get. So, a coiled wire high in resistance, like the wire in a hair dryer, electric heater or toaster can be very hot.

MAGNETISM AND ELECTRICITY

Magnetism and electricity are not two separate matters. In fact, whenever an electric current flows, a magnetic field is created, and whenever a magnet moves, an electric current is produced.

Electromagnetism is the way electric currents produce ***magnetic fields***. The magnetic field around a straight wire is weak. A stronger magnetic field is obtained by coiling wire into a spiraling loop, known as a ***solenoid***. An iron-cored solenoid, or electromagnet, has a strong magnetic field because the electrons in the iron align themselves with the magnetic field produced by the current. Electromagnets energize the fields of motors and generators, and are part of telephones, loudspeakers, buzzers, electric bells, telegraphs, relays, electric meters and many other devices.

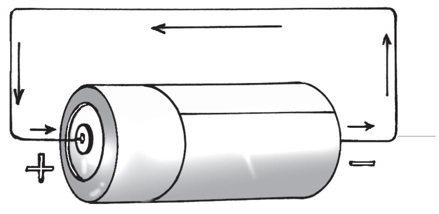
HOW DOES A CIRCUIT WORK?

An ***electric circuit*** is the system by which an electric current is directed, controlled, switched on or switched off. The primary requirement of a circuit is that it forms a complete path. Electrons must be able to flow through the whole system so that as many electrons pass back into the source of the current as leave it.

Current refers to the movement of charges. In an electric circuit – electrons move from the negative pole to the positive. If you connect the positive pole of a voltage source to the negative pole you create a circuit. This charge changes into electrical energy when the poles are connected in a circuit. This is similar to connecting the two poles on opposite ends of a battery.

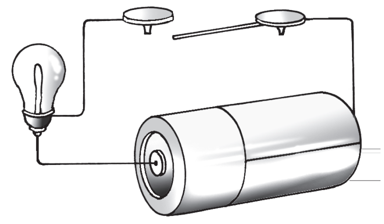
Along the circuit you can have a light bulb and an on - off switch. The light bulb changes the electrical energy into light and heat energy.

If the electricity is able to flow completely through the circuit, it is said to be a ***closed circuit***. If the electricity is unable to flow completely through the circuit, it is said to be an ***open circuit***.

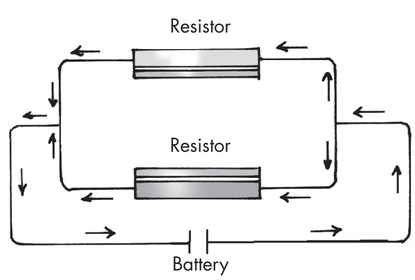


Simple Circuit

There are two basic circuits electricity flows through – series or parallel circuits. In ***series circuits*** all of the electrical components are connected to each other in a "series." Then the electric current has only one path to follow, and flows through each component.


Series Circuit

In ***parallel circuits***, the electrical components are connected individually to the main electrical circuit. Then the electric current has more than one path to follow. Parallel circuits allow for individual control of each electrical component. Buildings, most appliances, motors, etc., are wired in parallel circuits.



Parallel Circuit

Generators and Transformers

TURBINES AND GENERATORS

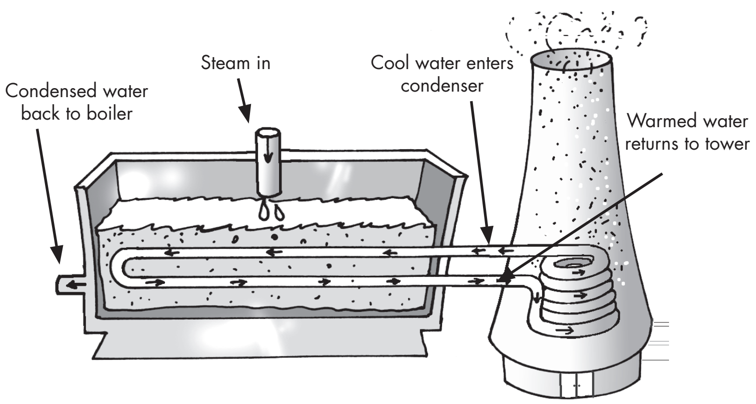
An electric utility power plant uses either a ***turbine***, an engine, a water wheel or other similar machine to drive a ***generator*** – a device that converts mechanical or chemical energy to electricity. Steam turbines, internal-combustion engines, gas combustion turbines, water turbines and wind turbines are the most common methods to generate electricity.

In North America most electricity is produced in steam turbines. The power plants:

- burn a fuel that produces heat
- the heat boils purified water
- the boiled water becomes steam
- the steam, under high pressure, spins a turbine
- the spinning turbine turns a shaft and rotor
- the shaft and rotor turn a magnet inside a generator

OR

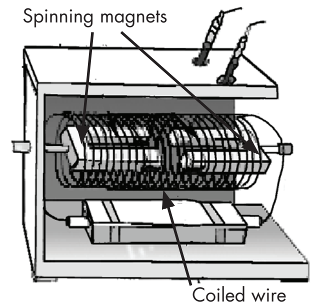
- the shaft and rotor turn coiled wires inside a magnet
- the ***magnet*** produces an electric current in the wire
- the wire in the generator converts mechanical, moving energy into electrical energy



The condenser and the cooling tower

After the steam spins the turbine, it is cooled and condensed back into water in a condenser. It is then circulated back to the boiler and the process repeats itself. The water used to cool the steam inside the condenser is from the power plant's cooling system. These systems can be either open- or closed-loop. In an open-loop system, water is piped in from a lake, river or other body of water; it cools the steam in the condenser and is piped back out. In a closed-loop system, the cooling water is reused. One type of closed-loop system uses a cooling tower. Cold water from the tower is piped through the condenser, back into the cooling tower where an evaporative process cools the water and it is piped back to the condenser. The evaporation that takes place inside the tower creates the huge, billowy, white steam clouds that some people mistake for smoke.

An electric ***generator*** is a device for converting mechanical energy into electrical energy. The large generators used by the electric utility industry have a ***stationary conductor***. A magnet attached to the end of a rotating shaft is positioned inside a stationary conducting ring that is wrapped with a long, continuous piece of wire. When the magnet rotates, it induces a small electric current in each section of wire as it passes. Each section of wire constitutes a small, separate electric conductor. All the small currents of individual sections add up to one current of considerable size that is used for electric power.

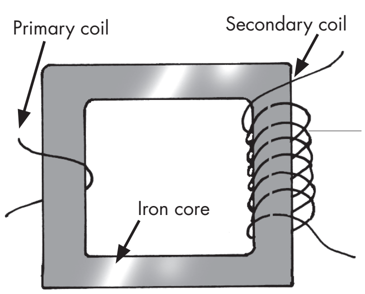


A simplified electric generator

All power plants have turbines and generators. Some turbines are turned by wind, some by water and some by steam.

WHAT IS A TRANSFORMER?

One of the most essential electrical devices is the ***transformer***. It is used in power stations to boost voltages for transmission over power lines and at substations to reduce voltages to levels suitable for industrial or home use. Transformers contain two separate wire coils wrapped around an iron core. As electricity flows into the transformer through the first coil it produces a magnetic field in the iron core. The magnetic field then induces an electric current in the second coil which flows out of the transformer. Oil is circulated around the coils and iron core to insulate and cool the transformer. If the voltage is to be increased, the second coil contains more turns of the wire than the first coil. If the voltage is to be decreased, the second coil contains fewer turns of the wire than the first coil. Transformers are also used in many electrical appliances such as radios, televisions and battery chargers – wherever alternating voltage different from the supply is required.



A transformer

Transmission System

TRANSMISSION SYSTEM

Electricity moves through a complicated transmission system. Electricity is generated at a ***voltage*** of about 25,000 Volts. Because electricity can be transferred more efficiently at high voltages, the electricity goes to a ***transformer*** located in a step-up substation near the power plant that boosts the Voltage up to 69,000 to 765,000 Volts. The voltage depends on the distance the power will travel and the amount desired. A 765,000 Volt transmission line transports about as much electricity as five 345,000 Volt transmission lines, due to transmission loss of the lower voltage system.

The heavy cables running between high voltage towers are made of copper or aluminum because of that metal's low resistance. The high voltage ***transmission*** lines carry the electricity, at nearly the speed of light, long distances to a substation.

At the ***distribution substation***, step-down transformers change the high voltage electricity to lower levels so it can be carried on smaller cables or ***distribution lines***. In neighborhoods, another transformer mounted on a pole or in a utility box converts the power to even lower levels to be used by residential customers.

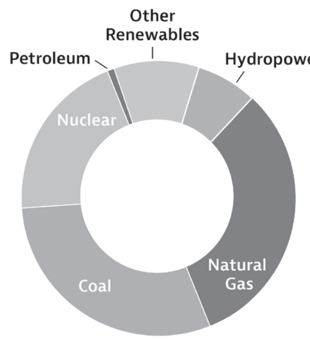
In many older areas of a city or town you will see wooden utility poles with power lines running to each house or business and the small transformer hanging on one of the power poles. However, in some areas of newer construction the distribution lines may be underground. Underground the power lines are protected from the weather, which can cause lines to break, and people are protected from the dangers of the overhead lines. It is important though, to remember to ask the electricity, natural gas and telephone utility companies to mark their underground lines before digging on your property.

When electricity enters your home it passes through a ***meter***. It reads how much electricity is used. Georgia Power customers have been upgraded to Smart Meters which read energy use remotely. They also show customers how their home is using electricity to help manage energy costs.

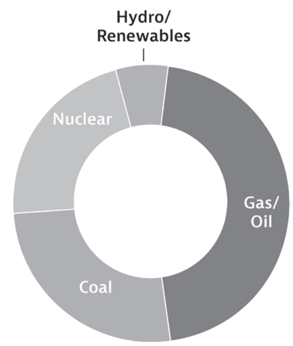
FUEL MIX

The combination of energy sources used to generate electricity is referred to as the ***generation*** or ***fuel mix***.

Several factors influence a utility's decision to use particular fuels to generate electricity. Chief among them are price, availability and reliability of supply. Government policies can also influence or dictate fuel choice. For example, in the late 1970s, in the midst of an energy crisis, new utility power plants were prohibited from burning natural gas or petroleum products. Today, many of the currently planned facilities are being designed to use natural gas. Future technology developments or concerns about supply and availability may lead to new changes in our fuel mix.



U.S. Fuel Mix 2017

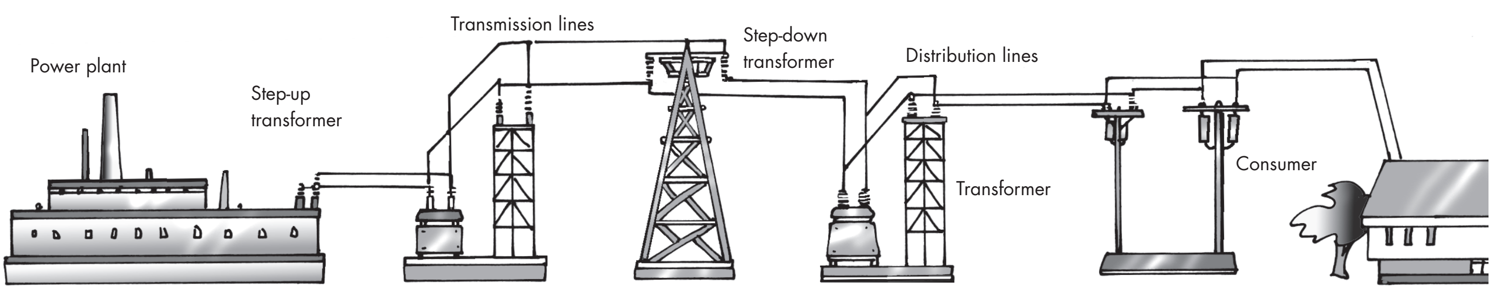


Georgia Power Fuel Mix 2017

(Sources: U.S. Energy Information Administration and Georgia Power, accessed September 2018)

The fuel choice also depends on whether the unit will be used continuously or only during peak usage times, its environmental impact and necessary environmental controls.

Most utilities rely on a variety of fuels to generate electricity. A varied fuel mix protects the electric company and its customers from unforeseen events such as fuel unavailability, price fluctuations, and changes in regulatory practices. It also helps ensure stability and reliability in electricity supply and strengthens national security.



Using Renewable Energy Sources

RENEWABLE ENERGY

Georgia Power and Southern Company are paving the way in making Georgia a national leader in renewable energy. Energy is considered "renewable," when it is produced by resources such as hydro, biomass, landfill gas, wind and solar. Usually, for each kW of renewable energy that is produced, the owner of that resource receives a "renewable energy credit" (REC).

During the past 10 years, more and more electricity is sourced from these types of generators. Georgia Power's customers benefit from the development of renewable energy because it can be low cost, it adds variety to our fuel mix and it produces low or no carbon, which means it's good for the environment too. Currently, Georgia Power has more than 2,600 megawatts (MW) of renewable generation. This means that about 12 percent of power plants that serve Georgia Power customers are renewables. We expect this number to continue to grow each year and by 2023, the Company expects to have greater than 4,200 MW of renewable generation.

Georgia Power offers a variety of renewable energy programs for both residential and business customers that want to install, procure or promote the development of additional renewable resources. Visit georgiapower.com/solar to find out more.

Biomass

Biomass facilities usually produce energy by low-grade wood waste like woodchips, wood pellets and tree limbs resulting from tree-thinning activities. Agricultural crops, crop residues and farm animal wastes are also forms of biomass that can be converted to energy. Currently, Georgia Power has more than 330 MW of power purchase agreements with various Biomass Proxy Qualified Facilities, some under contract for more than 30 years.

Landfill Gas

Landfill gas is a type of biomass energy categorized as "waste energy." The process of decomposition — when organic material is broken down by microorganisms — generates methane gas, a greenhouse gas that can be hazardous. Georgia Power has contracts with landfill gas projects totaling approximately 25 MW.

Hydro

Flowing water, referred to as hydropower, is the most widely used renewable energy source in the world. Many people are surprised to learn that since Georgia Power was founded it has relied heavily upon this renewable energy resource, which is still providing low-cost, clean renewable energy to customers today! The Company currently operates approximately 1,100 MW of hydroelectric generating facilities.

Solar

Georgia Power currently has about 970 MW of solar resources online, creating one of the largest voluntary solar portfolios of an investor-owned utility operating without a renewable portfolio standard. Most of Georgia Power's solar resources are procured, which means that the Company purchases the energy produced by a solar facility owned by someone else, through a long-term power purchase agreement (PPA). Most of these PPAs happen through a competitive bidding process, or at contracted prices designed to prevent upward pressure on rates.

Also as part of Georgia Power's solar portfolio, the Company owns a fleet of solar generating facilities either online or under construction across the state. By the end of 2020, the Company will have 19 solar generating facilities delivering energy to Georgians. This includes energy from research and demonstration facilities, where the Company is studying different types of solar technologies and applications. The knowledge gained from these projects will inform the Company as it plans for how it will meet customers' future energy needs.

In addition to the Company's solar procurement and generation, Georgia Power has a variety of on-site installation guidance and renewable energy purchasing programs for customers.

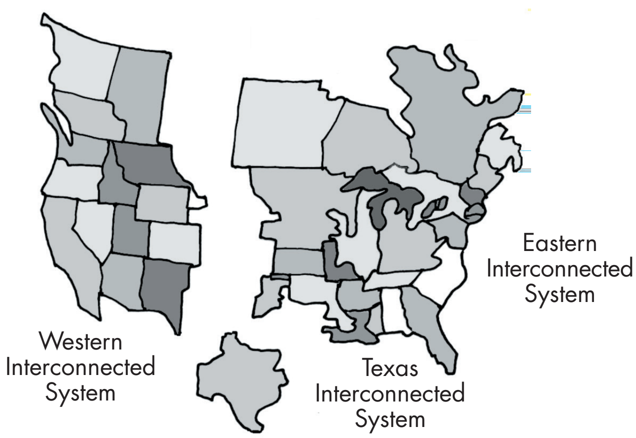
Wind

Georgia Power purchases energy sourced from 250 MW of Oklahoma-based Blue Canyon wind farms. Also, Georgia Power continues to partner with Southern Company to better understand if enough energy can be generated from wind off the coast of Georgia, or at different altitudes and with different wind turbine sizes to overcome the higher costs of this generation type. Currently, Georgia Power is engaged in both Small Wind and High Wind research projects to study feasibility, costs and long-term viability for these types of wind technologies in Georgia.

Distribution and Management

GEOGRAPHIC DISTRIBUTION

Since electricity cannot be stored or easily transported over long distances, the geographic distribution of power plants is very important. The bulk power system is composed of three major networks, or ***power grids***, that extend through the U.S. into Canada and Mexico: the *Eastern Interconnected System*, the *Western Interconnected System* and the *Texas Interconnected System*. These networks provide electric utilities with alternative power paths in emergencies and allow them to buy and sell power from each other and from other power suppliers.



The structure of the grid makes reliability possible. But what makes it a reality is the coordination in operations of the electric companies that make up this network. For the electric power grid to work smoothly and without disruption, a transmission operation must be aware of more than the power flowing over its own system created by its own generators and the electricity demand of its customers. It must also be aware of the transfers of power between other systems and how those transfers might flow through its own system.

To coordinate power flow, control areas have been formed. Control areas, consisting of one or several transmission operators, ensure that there is always a balance between electrical generation and the amount of electricity needed at any given moment to meet demand. Operators use computerized systems to exercise minute-by-minute control over the network and ensure that power transfers occur during specified times in pre-arranged amounts.

Providing oversight for these transfers are seven regional groups that form the ***North American Electric Reliability Council*** (NERC) whose members include electric utilities and market participants from all segments of the industry across the U.S., Canada and the northern portion of Mexico. NERC helps utilities work together to comply with standards and guidelines for system-wide reliability.

MRO - Midwest Reliability Organization

FRCC - Florida Reliability Coordinating Council

NPCC - Northeast Power Coordinating Council (U.S)

RF - ReliabilityFirst

SERC - Southeastern Electric Reliability Council

TRE - Texas Reliability Entity

WECC - Western Electricity Coordinating Council (U.S.)

LOAD MANAGEMENT

Load management is the balancing of electricity supply and demand, and involves the control of electrical consumption. Because electric power cannot be stored easily or economically, utilities and other electricity suppliers must have enough generation facilities available to meet the maximum demand on their systems, whenever that occurs. Otherwise power shortages or brownouts occur.

Demand for electricity usually peaks on summer weekday afternoons, when air conditioners are in high use. In the winter, mornings and evenings are peak demand periods as lights and furnaces are switched on. Throughout all seasons, weekends tend to have the lowest demand for electricity as factories and business offices are closed. The variation in demand constitutes a ***load*** or ***demand curve***.

To ensure that there is enough electricity available to meet customer demand, some plants work around the clock, allowing utilities and other power providers to generate a steady supply of electricity equal to the demand of their customers. Typically, companies use coal, natural gas, hydro, or nuclear based plants to provide this continuous service because they are cheaper to run for prolonged periods.

Pumped storage hydro, gas or oil based and renewable (wind and solar) units are usually the units of choice for providing service for the hours of the day when demand hits its highest levels or peak. These units may be started and stopped quickly, unlike coal and nuclear based plants. When used to meet peak demand, higher fuel costs do not have such a great impact because the plants are used for only a few hours at a time.

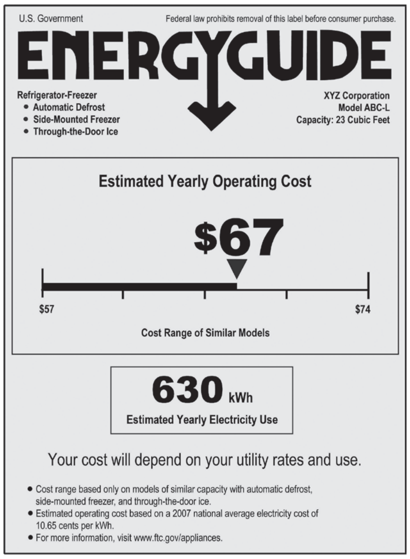
Efficiency and Safety

ENERGY EFFICIENCY AND USE

For over 100 years, electricity has made our homes more comfortable and enjoyable, and our industries more productive. Today, electricity is powering a new world of electronics – computers, TVs, CDs, DVDs, video games. To generate this electricity, the nation's power plants rely on finite natural resources such as coal and natural gas, as well as renewable energy sources such as water and wind. Using these energy sources does have an impact on the environment. It is important, therefore, to use electricity as efficiently as possible. This will help to protect our environment and preserve our natural resources. Using electricity wisely will also help you save money in your home and business, and it will keep our nation's electricity supply more reliable.

Appliances and lighting consume roughly half of the electricity produced in the United States. An older refrigerator alone can cost $300 per year to run. Improving the energy efficiency of appliances is an important step toward conserving resources.

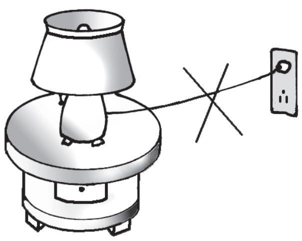
When buying home appliances, it is important to check the energy efficiency rating. Purchase the right size appliance for your needs. Oversized appliances consume more electricity and undersized appliances will have to work harder and thus, consume more electricity. Compare the wattage of appliances. Wattage will inform you how much electricity the appliance will consume. Also be sure to turn off lights and other electrical appliances when you are not using them.



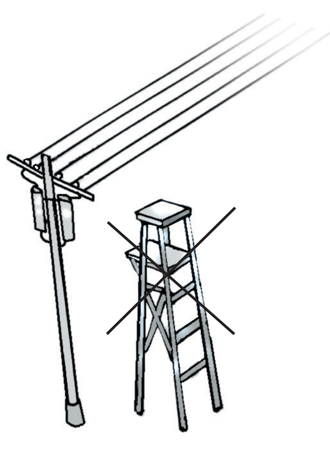
EnergyGuide Label

ELECTRIC SAFETY

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



- Be careful with electrical cords – do not place cords where people will trip over them or where they will receive excessive wear; keep cords away from heat and water; do not pull on cords to disconnect them, pull on the plug; and do not twist, kink or crush cords.
- Never use an appliance while standing in water or when wet.
- Keep combustible materials away from lamps or heating devices.
- Disconnect appliances before cleaning.
- Keep ladders away from electric power lines.
- Turn off circuits when changing light bulbs.
- In case of an electrical fire, call the fire department; unplug appliance if safe; use fire extinguisher or baking soda, never use water.
- Never touch broken electric lines. Call police and the electric company immediately.
- Never attempt to remove a kite from an electric power line and be aware of the location of electric power lines when flying kites.
- When climbing trees, be sure that electric power lines don't touch the tree; if they do, DO NOT climb the tree.



Careers in Energy

Electrical Line Worker: Assist with construction and maintenance activities associated with overhead and underground power distribution systems, including operating all equipment. This position works outdoors year-round, in all types of weather and requires climbing tall concrete, steel, and wood structures.

Engineering: Opportunities at Georgia Power exist at our power generating plants, distribution and transmission units and our corporate offices. At our generating plants, engineers are involved in the maintenance, operation and design of fossil fuel, hydro or nuclear plants. Distribution and transmission cover all power lines and substations between the power generating plant and your home or business. Here, engineers study and design the expansion of our line and substation system to meet future demand. They also consult with customers on our products and services and propose solutions that best serve them. Our corporate engineers work at corporate offices, in the field and/or on construction sites and support projects at our business units, depending on our needs. Some examples are retrofitting plants with modern environmental controls and planning and design for the construction of new nuclear plants.

Engineering Representative/ Technician: Day-to-day engineering activities related to new service delivery throughout the service territory assigned. Be a champion of our safety vision. The primary responsibility in this position will be managing multiple projects for residential, commercial, and industrial new business customers. Candidate must be able to prepare and schedule construction of jobs to meet committed service dates. The engineering representative is expected to balance the customer's needs against company goals and produce designs that effectively meet both. The engineering representative must also be an exceptional communicator and use those skills to help ensure customer satisfaction.

Maintenance Technical Skilled personnel are specialists on the mechanical, electrical and instrument and controls systems in the plant. They are responsible for all the equipment in the plant. They plan and document daily work assignments for preventative maintenance, perform troubleshooting and repair the systems.

For more information, visit georgiapower.com/company/careers/cool-jobs-in-industry/cool-careers.html.

ABOUT NATIONAL ENERGY FOUNDATION

The National Energy Foundation (NEF) is a unique 501(c)(3) nonprofit educational organization dedicated to the development, dissemination and implementation of supplementary educational materials and programs relating to energy.

Georgia Power

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ABOUT GEORGIA POWER

Georgia Power is the largest electric subsidiary of Southern Company (NYSE: SO), America's premier energy company. Value, Reliability, Customer Service and Stewardship are the cornerstones of the company's promise to 2.5 million customers in all but four of Georgia's 159 counties. Committed to delivering clean, safe, reliable and affordable energy at rates below the national average, Georgia Power maintains a diverse, innovative generation mix that includes nuclear, coal and natural gas, as well as renewables such as solar, hydroelectric and wind. Georgia Power focuses on delivering world-class service to its customers every day and the company is consistently recognized by J.D. Power and Associates as an industry leader in customer satisfaction. For more information, visit georgiapower.com and connect with the company on Facebook (facebook.com/georgiapower, Twitter (twitter.com/georgiapower) and Instagram (instagram.com/ga_power).