ATOMS TO ELECTRIC CURRENT

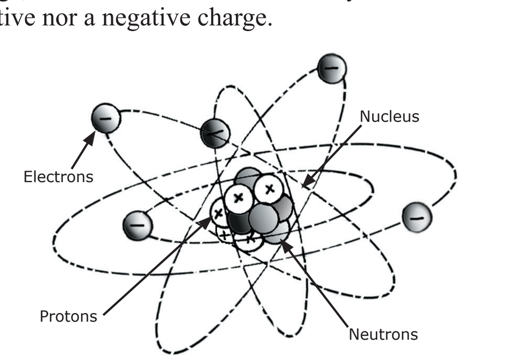
WHAT IS ELECTRICITY?

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 nor a negative charge.



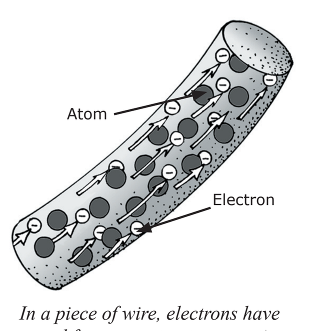
Atoms have specific numbers of electrons, protons and neutrons.

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***. Non-metallic 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 conductors 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's made of. The size of wire is called its ***gauge***. The smaller the gauge number, the bigger around the wire. A gauge 1 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 occurs, a magnetic field is created, and whenever a magnet moves, an electric current is produced.

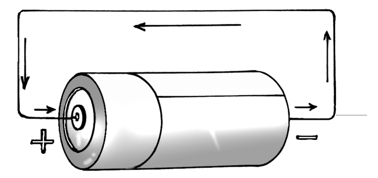
Electromagnetism is the way electric currents produce ***magnetic fields***. The magnetic field around a straight wire is weak. A stronger magnetic field is obtained by coiling wire into a spiraling loop, known as a ***solenoid***. An iron-cored solenoid, or electromagnet, has a strong magnetic field 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 form 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.

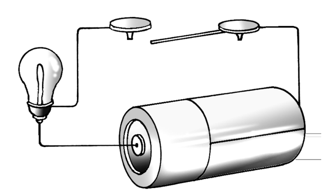
Current refers to the movement of charges. In an electric circuit—electrons move from the negative pole to the positive. If you connect the positive pole of a voltage source to the negative pole you create a circuit. This charge changes into electrical energy when the poles are connected in a circuit—similar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

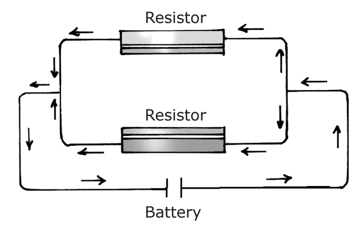

Simple Circuit

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***.

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" thus the electric current has only one path to follow, and flows through each component.


Series Circuit (use a flashlight bulb)

In ***parallel circuits***, the electrical components are connected individually to the main electrical circuit, thus 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.



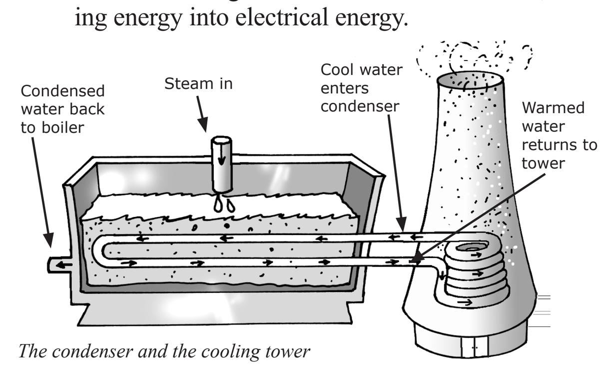
GENERATORS and TRANSFORMERS

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:

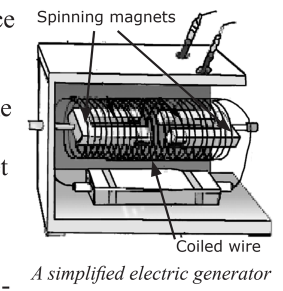
- burn a fuel that produces heat
- the heat boils purified water
- the boiled water becomes steam
- the steam under high pressure spins a turbine
- the spinning turbine turns a shaft and rotor
- the shaft and rotor turn a magnet inside a generator ***OR***
- the shaft and rotor turn coiled wires inside 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 never leaves the plant. 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's 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.

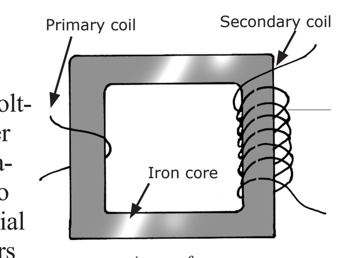


A simplified electric generator

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. Electricity flows into the transformer through the first coil. As the electricity flows 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. It 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.

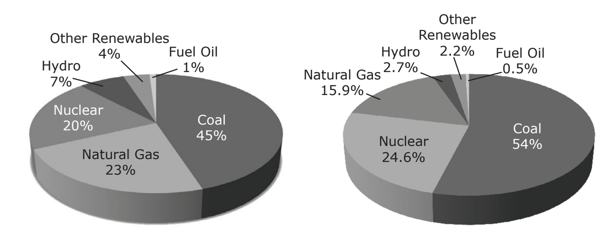
In many older areas of a city or town you will see wooden utility poles with power lines running to each house or business and the small transformer hanging on one of the power poles. However, in some areas of newer construction the distribution lines may be underground. Underground the power lines are protected from the weather, which can cause lines to break, and people are protected from the dangers of the over-head 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***. A utility company representative reads the meter periodically so the company will know how much electricity you used and can bill you for the cost.

FUEL MIX

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

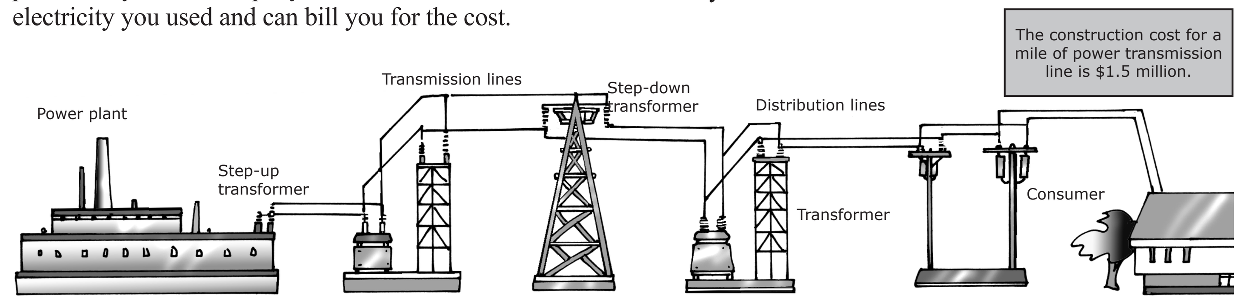
Several factors influence a utility's decision to use particular fuels to generate electricity. Chief among them are price, availability and reliability of supply. Government policies can also influence or dictate fuel choice. For example, in the late 1970s—in the midst of an energy crisis—new utility power plants were prohibited from burning natural gas or petroleum products. However, in the late '90s and the early 2000s the fuel of choice was natural gas. Today, many of the currently planned facilities are being designed to use natural gas, however, recent concerns about sufficient supply and availability may lead to other fuels.



Comparison of U.S. and Georgia Fuel Mixtures in 2009. Source: U.S. Dept. of Energy

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

GREEN POWER

Across North America green power partnerships have been developed to promote the use of renewable energy to generate electricity.

Green power is electricity that is generated from resources such as solar, wind, geothermal, biomass, and hydropower. Presently a high percentage of electricity is generated by burning fossil fuels. However, the increasing availability of green power allows customers the opportunity to purchase power that is environmentally friendly. As more green power sources are developed, the overall environmental impact associated with electrical generation will be reduced.

Purchasing green power does not mean the electricity entering your home is the exact electricity produced by the renewable energy source. It means a utility purchases a portion of its power from a renewable source and offers its customers the opportunity to support their purchase of green power.

Customers can install their own renewable energy generating equipment at their facility. ***On-site renewable generation*** can increase power reliability, provide stable electricity costs and help manage waste streams. In many areas, excess green power generated on-site can be returned to the electric grid, allowing customers to obtain credit from their utility.
For more information log onto:
www.epa.gov/greenpower or www.mb.ec.gc.ca

As of 2011, Georgia Power has more than 1,100 megawatts (MW) of renewable generation (mostly hydro), representing about 7 percent of its generating capacity and is working to add additional capacity from renewable generation sources.

Customers can sign up for green energy.
Visit www.georgiapower.com/green to find out more.

Hydro
In its early years, Georgia Power depended heavily on hydroelectric plants, which are still providing low-cost, clean renewable energy to our customers. There are few, if any, new large-scale hydroelectric sites available in the Southeast, and there are large demands for water resources in Georgia's growing communities.

Biomass
Biomass (crops or wood waste) is the highest potential renewable source in the Southeast. Georgia Power has contracts with seven qualified biomass/renewable facilities that will generate 136 MW of capacity (enough renewable energy to power more than 34,000 homes). Georgia Power also buys energy from eight other renewable sources when available.

Landfill Gas
Georgia Power offers customers the opportunity to purchase Green Energy from two landfill gas facilities in Georgia. Landfill gas is about one-half methane, which has 20 times the global warming potential of CO_2. This gas typically escapes from municipal landfills into the atmosphere and can create a hazard. Therefore, landfills have begun to burn the gas in reciprocating engines to produce power.

Solar
Georgia Power has installed seven photovoltaic (PV) technologies on the roof of Georgia Power's corporate headquarters. Each test technology will be capable of producing approximately 4 KW. Throughout the demonstration, the company will evaluate the performance and cost-effectiveness of each technology.

Wind
Southern Company and Georgia Tech has studied the feasibility of generating electricity from wind off the coast of Georgia. The study found average wind speeds of 16-17 mph about five miles off the Georgia coast. Comparable winds have been used in other areas of the country for land-based wind farms but offshore wind resources typically must be stronger to overcome higher construction and operational costs.

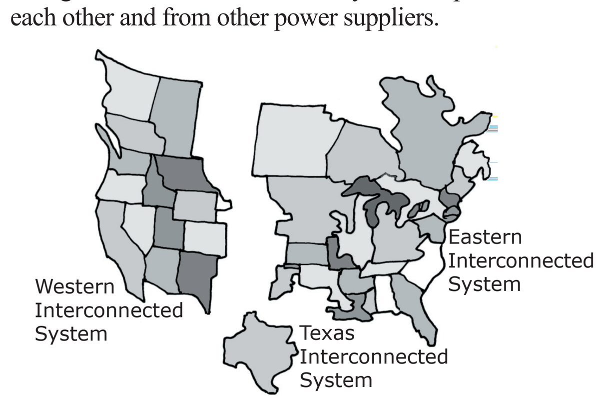
Southern Company will continue to pursue feasible wind energy generation in coastal areas. The advent of lower-speed and more hurricane-tolerant wind turbine designs may overcome economic and technological hurdles. With community support, wind energy may yet someday contribute to the energy needs of the Southeast.

Georgia Power and Southern Company continue to explore renewable energy technologies, such as wind, solar, landfill gas and biomass.

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 bulk power system is composed of three major power grids made up of the ten regional groups listed at right

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 operator must be aware not only of the power flowing over its own system created by its own generators and the electricity demand of its customers, but 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 ten 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.

A ECAR - East Central Area Reliability Coordination Agreement
B ERCOT - Electric Reliability Council of Texas
C FRCC - Florida Reliability Coordinating Council
D MAAC - Mid-Atlantic Area Council
E MAIN - Mid-American Interconnect Network
F MAPP - Mid-Continent Area Power Pool (U.S.)
G NPCC - Northeast Power Coordinating Council (U.S.)
H SERC - Southeastern Electric Reliability Council
I SPP - Southwest Power Pool
J 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 brown outs 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-based, hydro, or nuclear 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. And 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.

Residential appliances consume roughly one-third of the electricity produced. Refrigerators alone utilize the electrical output of about 26 large power plants, nearly 7% of total consumption. Improving the energy efficiency of appliances is, therefore, an important step toward conserving fuel 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.

GEORGIA POWER EARTHCENTS PROGRAM

What is EarthCents?
EarthCents is Georgia Power's portfolio of energy efficiency programs created to help our customers save money and energy while helping to protect the environment.

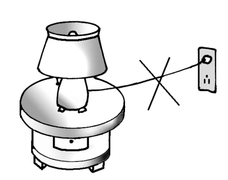
Why has Georgia Power launched EarthCents?
EarthCents aligns under one name the programs and resources Georgia Power has available to help residential and business customers become more energy efficient. This will make it easy for customers to easily identify the ways Georgia Power can help them save money and energy.

Which programs are part of EarthCents?
EarthCents programs include: Home Energy Improvement Program, Lighting and Appliance Program, Refrigerator Recycling Program, New Home Program, Water Heating Program, Home Audit, and Commercial Energy Efficiency. Green Energy will also fall under this umbrella.

Visit the EarthCents website at www.georgiapower.com/earthcents to find out more.

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: don't place cords where people will trip over them or where they will receive excessive wear; keep cords away from heat and water; don't pull on cords to disconnect them, pull on the plug; and don't 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.
- In case of electric shock, do not touch victim until electricity is turned off. If victim is in contact with electric power lines, the only safe procedure is to call the power company. If victim is in contact with low voltage cord, use a dry rope or stick to remove victim. If victim is in shock, raise his/her feet.
- 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.

ELECTRICAL GENERATION

RESOURCES

American Coal Council
(202) 756-4540
www.americancoalcouncil.org

American Coal Foundation
1-800-325-8677 www.acf-coal.org

American Gas Association
(202) 824-7000 www.aga.org

The American Hydrogen Association
(602) 328-4238 www.clean-air.org

American Petroleum Institute
(202) 682-8000 www.api.org

America Wind Energy Association
(202) 383-2500 www.awea.org

American Solar Energy Society
(303) 443-3130 www.ases.org

American Water Works Association
(303) 794-7711 www.waterwiser.org

The Alliance to Save Energy
(202) 857-0666 www.ase.org

Canadian Centre for Energy Information
1-877-606-4636 www.centreforenergy.com

Edison Electric Institute
(202) 508-5000 www.eei.org

Energy Information Administration
(202) 586-8800 www.eia.doe.gov

Energy Quest California Energy Commission
(916) 654-4989 www.energyquest.ca.gov

Federal Energy Regulatory Commission
1-866-208-3372 www.ferc.gov

Geothermal Resources Council
(530) 758-2839 www.geothermal.org

APPrO, Association of Power Producers of Ontario, (416) 322-6549 www.appro.org

National Hydropower Association
(202) 682-1700 www.hydro.org

National Mining Association
(202) 463-2600 www.nma.org

National Propane Gas Association
(202) 466-7200 www.npga.org

National Renewable Energy Laboratory
(303) 275-3000 www.nrel.gov

Natural Resources Defense Council
(202) 727-2700 www.nrdc.org

North American Electric Reliability Council
(NERC) (609) 452-8060 www.nerc.com

Nuclear Energy Institute
(202) 739-8000 www.nei.org

Office of Energy Efficiency Natural Resources Canada
(613) 995-0947 www.oee.nrcan.gc.ca

Renewable Energy Policy Project
(202) 293-2898 www.repp.org

Solar Energy Industries Association
(202) 682-0556 www.seia.org

Solar Energy Society of Canada Inc.
(613) 686-4474 www.sesci.ca

Sustainable Energy Coalition
www.sustainableenergycoalition.org

U.S. Department of Energy
1-800-dial-DOE www.energy.gov

United States Energy Association
(202) 312-1230 www.usea.org

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