ELECTRICAL ENERGY

Energy from the flow of electrons

All matter is composed of fundamental building blocks called atoms. The outer shell of an atom contains negatively charged particles called electrons. The electrons are attracted to the positive charges found at the center of the atom (protons). The electrons surrounding an atom are in constant motion and can be “bumped” free of the atom by upsetting the attraction forces between the electrons and protons. One way to do this is to spin a magnet through a coil of copper wire. This will “bump” free the electrons surrounding the copper atoms in the wire and create a flow of electrons through the wire. Electricity is basically then the flow of electrons through a copper wire or any appropriate conductor. When we plug an appliance into a wall outlet we can use this available flow of electrons to conduct work. This form of energy can be used in systems designed to convert the electrical energy to mechanical energy (an electric motor) or to thermal energy (an electric iron) or to light energy (a light bulb).

Electricity is a very convenient form of energy and currently more than 35 percent of all energy consumed in the United States is used to generate electricity. Traditionally, electrical power is produced by converting other forms of energy to heat. This heat is then most often used to heat water into steam. The steam rapidly expands and can be used to force large turbine systems to rotate. A turbine contains magnetic coils and when they are rotated an electrical current can be generated. Typical approaches for creating electricity from other forms of energy are not very efficient. In most electrical generation systems only 30% of the thermal energy produced is actually converted to electricity. The rest of the heat generated is simply energy lost.

A distribution grid composed of a network of electrical lines and transformers is used to carry electricity to where it is needed. Electricity produced by the main power plant first enters a transmission substation where the voltage is increased using transformers. High voltage electricity is used to increase the efficiency of power delivery. A typical substation will push the electricity up to around 400,000 volts and can deliver this current over 300 miles. Once the electricity gets near its application its voltage is then reduced by another substation. The final voltage of the electricity entering a home is reduced again to 110 or 220 volts and passed through a utility meter to keep track of how much electrical power is consumed. Parts of this grid are often very visible with power lines running up and down a street delivering electricity to each home. In some cases the power lines are buried underground and are hidden from view.

Transporting electricity over long distances using power lines can result in an energy loss of 10 percent. A significant portion of the electricity produced is lost as thermal energy during generation. In Missouri twice as much energy is actually lost during electrical generation, transmission and distribution than is eventually utilized by customers (U.S. Department of Energy, 1999).

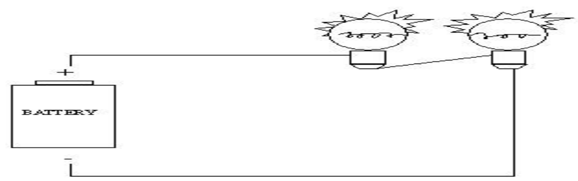
ELECTRICAL TERMS

<u>RESISTANCE</u>: Measures the opposition to an electrical current. Resistance can be thought of in terms of a garden hose that constricts how much water can pass through it. Although the water pressure can be increased to cause more flow, the rate of flow is still "resisted" by the small size of the garden hose. In electrical systems small wires can act like a small hose and resist the flow of electricity. Thicker heavy-duty wires allow more electrical charges to flow through. Resistance is measured in Ohms. Small wires with high resistance

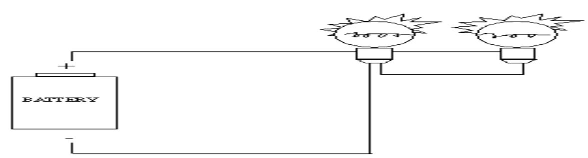
THE RELATIONSHIP BETWEEN VOLTAGE, CURRENT AND RESISTANCE:
The higher the voltage ("pressure") the more push there is to move electrons and this often results in a higher flow of electrons (current). However, the current (flow) is also influenced by the resistance of the material conducting the charge. Ohms law describes this relationship.

VOLTAGE=CURRENT X RESISTANCE

ELECTRICAL CIRCUITS:
Describe the path of electricity through a given application. Such paths can be very complex such as that of a computer. Circuits are divided into two basic types:



PARALLEL- The charges are split and travel through more than one path (the voltage remains the same for each light bulb).



ELECTRICAL POWER:
Is a measure of the rate of electrical energy used by a circuit. This is usually measured using a unit called a Watt (W). The electrical power required by an electrical appliance is related to the voltage ("pressure") used and the current ("flow of electrons") required.

POWER = CURRENT X VOLTAGE

The utility meter outside a home measures electricity consumed using units of kilowatt-hour (kWh) A kWh represents the electrical work done by a thousand (*kilo*) watts for one hour. The current average cost of electricity in the United States is around 7 to 10 cents per kWh.

will release energy in the form of heat and most homes are required to use a minimum size wiring to prevent potential fire risks.

VOLTAGE: Is the measure of the "pressure" pushing electrical charges through a wire and is measured in volts (v). Voltage is actually a measure of *potential energy*. A standard battery separates positive and negative charges on metal plates creating potential energy. When the battery is connected, electrons flow from the negative terminal towards the positive terminal generating an electrical current. A 12-volt battery has more potential energy ("pressure") than a 1.5-volt battery. Higher voltage electrical currents such as in a home wall plug socket (typically 110 volts) can be quite dangerous because the "pressure" of the electrical flow is much higher than that of a flashlight battery.

CURRENT: Measures the flow of electrons through a conductor such as a copper wire. The more electrons that pass through, the higher the current. Current is measured using the units of amps (I).

ALTERNATING CURRENT(AC): This form of electricity is transmitted in reversing pulses called a sine wave. The electricity pulses back and forth at a rate of 60 cycles per second. AC current is used to deliver electricity to homes and businesses because the voltage can be increased or decreased as needed using transformers. A more efficient higher voltage is used during transmission over long distances with the voltage reduced for safety reasons prior to use in home or commercial applications.

SOME PRACTICAL CONSIDERATIONS FOR ELECTRICITY:

For safety reasons it is often recommended that multiple appliances should not be hooked up to one wall outlet. Each appliance will draw a current and by hooking up several appliances a large total current (amps) will be required. This will increase the flow of electrons through the wiring in the wall and can lead to the generation of heat producing a fire hazard. Similarly using thin wired extension cords can lead to heat build up and fire risks. An appliance or tool that requires lots of power (voltage and current) should be connected using a heavy-duty extension cord (thick wire...low resistance).

When a person is hurt by electricity it is actually the flow of electrons through their body (current) that causes the damage. The human body is actually a poor conductor of electricity and the resistance of tissue results in lots of heat production. Most damage from electrical contact is related to the current passing through the body and the resulting heat produced. High voltage lines (high "pressure") or materials that are good conductors of electrons, such as an aluminum ladder can pose safety risks. Fuses and breaker switches are often used in an effort to provide protection for electrical appliances and people. The fuse is designed to "trip" and interrupt an electrical circuit when an excessive flow of electricity occurs (current).

DIRECT CURRENT (DC): This form of electricity provides a continuous flow of electrons. Batteries are examples of such devices and provide a direct current in one direction from the negative terminal to the positive terminal.

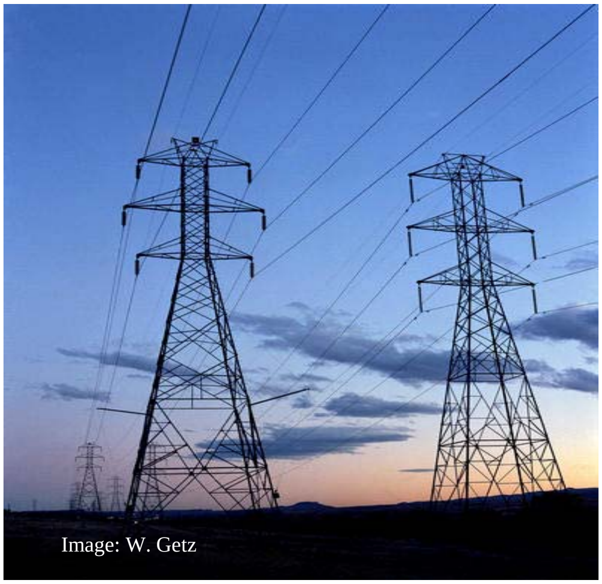
TRANSFORMERS: Use a system of copper coils to reduce or increase the voltage of an electrical current.

ELECTRICAL CONDUCTOR: Any substance that will allow the flow of electrons. Metals are in general excellent conductors and copper is most often used for electrical wiring purposes.

ELECTRICAL INSULATION: Any substance that does not conduct electricity very well. Examples are plastics, wood, paper, and fiberglass. These materials are often used to cover copper wires for safety reasons and prevent any unwanted delivery of electricity.

WHAT IS PEAK DEMAND?

This is a time period when many people want electricity at the same time. During the middle of night most people are asleep and businesses are closed so demand for electrical power is low. Power needs increase during the day and power companies must be ready to meet these spikes in demand. Seasonal factors also influence peak demand. During the summertime power needs are often significantly greater due to high demands for air conditioning. Utilities must design their facilities to be able to handle the changes in demand that occur over the course of a day and throughout the year.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