ELECTRICITY

Electricity is the most versatile energy source that we have; it is also one of the newest: homes and businesses have been using it for not much more than a hundred years. Electricity has played a vital part of our past. But it could play a different role in our future, with many more buildings generating their own renewable electric power using solar cells and wind turbines.

What is electricity?

Electricity is a type of energy that can build up in one place or flow from one place to another.

Current electricity

When electrons move, they carry electrical energy from one place to another. This is called **current electricity** or an **electric current**. Electric currents are also involved in powering all the electrical appliances that you use, from washing machines to flashlights and from telephones to MP3 players. These electric currents last much longer.

Electric circuits

All electric circuits generally have:

(1) a voltage source, such as a battery or generator,
(2) connecting wires, and
(3) an electric device (such as a light bulb or electric motor) that has resistance R.

For an electric current to happen, there must be a **circuit**. A circuit is a closed path or loop around which an electric current flows. A circuit is usually made by linking electrical components together with pieces of wire cable.

Thus, in a flashlight, there is a simple circuit with a switch, a lamp, and a battery linked together by a few short pieces of copper wire. When you turn the switch on, electricity flows around the circuit. If there is a break anywhere in the circuit, electricity cannot flow. If one of the wires is broken, for example, the lamp will not light. Similarly, if the switch is turned off, no electricity can flow. This is why a switch is sometimes called a circuit breaker.

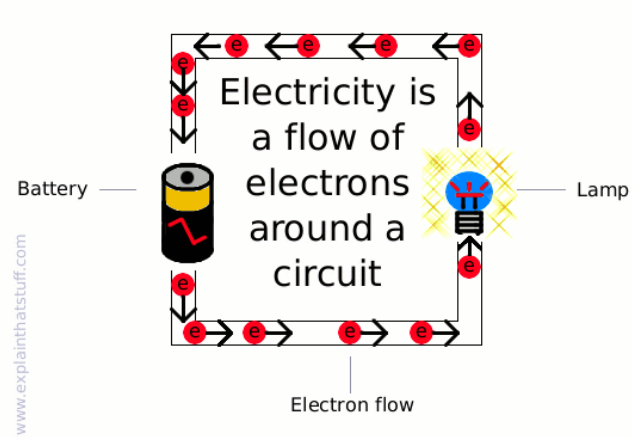
Electricity travels in closed loops, or circuits (from the word circle). It must have a complete path before the electrons can move. If a circuit is open, the electrons cannot flow. When we flip on a light switch, we close a circuit. The electricity flows from the electric wire through the light and back into the wire. When we flip the switch off, we open the circuit. No electricity flows to the light. When we turn a light switch on, electricity flows through a tiny wire in the bulb. The wire gets very hot. It makes the gas in the bulb glow. When the bulb burns out, the tiny wire has broken. The path through the bulb is gone. When we turn on the TV, electricity flows through wires inside the set,

producing pictures and sound. Sometimes electricity runs motors—in washers or mixers. Electricity does a lot of work for us. We use it many times each day.

How electricity moves

Materials such as copper metal that conduct electricity (allow it to flow freely) are called **conductors**. Materials that don't allow electricity to pass through them so readily, such as rubber and plastic, are called **insulators**. What makes copper a conductor and rubber an insulator?

A current of electricity is a steady flow of electrons. When electrons move from one place to another, round a circuit, they carry electrical energy from place to place like marching ants carrying leaves. Instead of carrying leaves, electrons carry a tiny amount of electric charge.



Series and parallel circuits.

Parts (or components) of an electric circuit can be arranged in *series* or in *parallel*.

In a **series** circuit, the parts of the circuit (such as the battery, a switch, and the electric device) are connected one after another (in series) in a single closed loop. You can trace the pathway that the current takes around the circuit with your finger, passing through the devices in series, as shown below. Thus, the electrons that flow in this circuit leave the negative terminal of the battery, pass through the resistance of each electric device, and return to the positive terminal of the battery.

In a series circuit, there is only **one path** for the same current that passes through the resistances of the electric devices (light bulbs). If one device (e.g. bulb) in series burns out, the circuit is broken and there is no other path for the flow of charges. The consequence is that the other devices no longer work.

By law of conservation of energy, the energy provided by the battery is equal to the sum of the energies transferred to the resistance of each of the devices in the circuit. Therefore, when the circuit has more than one resistance device, the **total resistance** (or the series equivalent resistance) is equal to the **sum of the resistances** of each device in

the circuit. As more light bulbs (devices) are added to the series circuit, the overall resistance increases and the current decreases. So, with more bulbs in the series circuit, there is reduced current and the bulbs become dimmer.

By applying **Ohm's law**, the total current in the series circuit is numerically equal to the voltage supplied by the source divided by the total (series) resistance in the circuit.

In a **parallel** circuit, all the devices share a common connection to the high-potential terminal of the voltage source and also a common connection to the low-potential terminal of the voltage source. In parallel circuits, different devices are on separate "parallel" branches. Therefore, there are different paths for currents such that a break in the flow of charges in one path (as shown in the diagram below by the light bulb that is not lit due to the open switch) does not interrupt the flow along other paths.

In a parallel circuit, at least one branch of the circuit creates **different paths** (or branches) for charge flow. The voltage is the same across each branch because the ends of a device in each branch are connected the same two points of the circuit. So, each branch has its own path from one terminal of the voltage source to the other terminal.

By the law of conservation of charge, the total current in a parallel circuit is equal to the **sum of all the branch currents**. The branch with the lowest resistance draws the most current.

Increasing the number of parallel branches provides additional paths for current. The additional current passes along the new parallel branch without altering the current in the original branches. This results in the increase of the total current because the overall resistance (or parallel equivalent resistance) has decreased. So, the **parallel equivalent resistance is smaller** than the resistance of any one of the branches. With more branches to a parallel circuit, the brightness of the light bulbs does not change since the current in each branch remains the same at the same voltage.

Measuring electricity

We can measure electricity in a number of different ways, but a few measurements are particularly important.

Voltage

The voltage is a kind of electrical force that makes electricity move through a wire and we measure it in volts. The bigger the voltage, the more electricity will tend to flow. So a 12-volt car battery will generally produce more electricity than a 1.5-volt flashlight battery.

Current

Voltage does not, itself, go anywhere: it's quite wrong to talk about voltage "flowing through" things. What moves through the wire in a circuit is electrical current: a steady flow of electrons, measured in amperes (or amps).

Power

Together, voltage and current give you electrical power. The bigger the voltage and the bigger the current, the more electrical power you have. We measure electric power in units called watts. Something that uses 1 watt uses 1 joule of energy each second.

The electric power in a circuit is equal to the voltage × the current (in other words: watts = volts × amps). So if you have a 100-watt (100 W) light and you know your electricity supply is rated as 120 volts (typical household voltage in the United States), the current flowing must be 100/110 = 0.90 amps. If you're in the UK you're household voltage is 240 volts. So if you use the same 100-watt light, the current flowing is 100/240 = 0.42 amps.

Electricity is measured in units of power called watts. It was named to honor James Watt, the inventor of the steam engine. One watt is a very small amount of power. It would require nearly 750 watts to equal one horsepower. A kilowatt represents 1,000 watts. A kilowatthour (kWh) is equal to the energy of 1,000 watts working for one hour. The amount of electricity a power plant generates or a customer uses over a period of time is measured in kilowatthours (kWh). Kilowatthours are determined by multiplying the number of kW's required by the number of hours of use. For example, if you use a 40-watt light bulb 5 hours a day, you have used 200 watthours, or 0.2 kilowatthours, of electrical energy.

Energy

Power is a measurement of how much energy you're using each second. To find out the total amount of energy an electric appliance uses, you have to multiply the power it uses per second by the total number of seconds you use it for. The result you get is measured in units of power × time, often converted into a standard unit called the kilowatt hour (kWh). If you used an electric toaster rated at 1000 watts (1 kilowatt) for a whole hour, you'd use 1 kilowatt hour of energy; you'd use the same amount of energy burning a 2000 watt toaster for 0.5 hours or a 100-watt lamp for 10 hours. See how it works?