

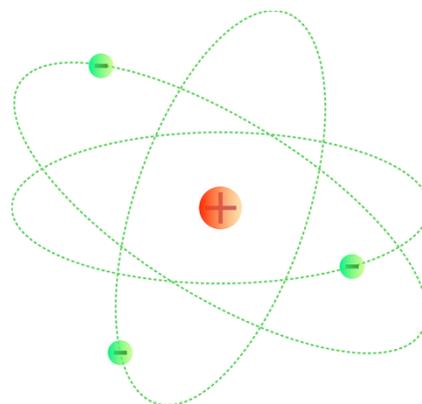
# Electricity

## Introduction

Electricity is crucial to how we live our lives today. Most of the technologies that generate light, heat, sound or movement are powered by electricity. Can you think of some of these? There are plenty of them! So what is electricity, where does it come from and how is it measured? Read on to find out the answers to these questions, as well as lots of other information!

## What is electricity?

Electricity is a type of energy. Energy gives things the power to work; for example, the energy that animals get from food allows them to move. Everything around us is made from matter. Matter is made from tiny atoms, which are so small that over a thousand billion of them could fit on the point of a pin. Incredibly, these atoms are made up of even tinier particles called neutrons, protons and electrons. Protons have a positive charge, while electrons contain a negative charge; therefore a substance containing more protons than electrons is positively charged, whereas a substance with more electrons than protons is negatively charged. However, substances naturally want to have an equal balance of protons and electrons. Electrons can move from one atom to another atom. When electrons move from negatively charged matter to positively charged matter, this movement generates electricity!



An atom: the negative electrons travel around the positive nucleus

## How is electricity generated naturally?

Electricity can be generated naturally (without people doing anything deliberately to generate it). Have you ever received a small shock when you touch something or someone else? This is caused by static electricity. Static electricity is generated by two things rubbing against each other, which transfers electrons from one thing to the other. This can lead to electricity occurring when the electrons move from the negatively charged thing to the positively charged thing. In a thunderstorm, ice crystals in the clouds rub together, leaving the bottom of the cloud negatively

charged. A lightning bolt occurs when electrons move from the bottom of the cloud to the positively charged ground! Animals also generate electricity (find out why they do this later in the text).

### How do two positively charged things interact?

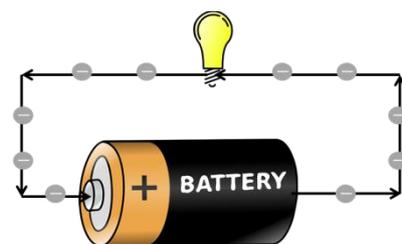
Static electricity is generated when electrons move from a negatively charged thing to a positively charged thing. In other words, positively charged things attract negatively charged things. Can you remember where else in science we see opposites attract? We see something similar with magnets, when unlike poles attract. Can you remember what happens when the north pole of a magnet is moved close to the north pole of another magnet, or the south pole of a magnet is moved close to the south pole of another magnet? They repel each other. This is the same with positively charged and negatively charged things. In the picture, the boy's positively charged hairs are repelling each other, making them stand up! So remember, like charges repel, whereas unlike charges attract.



The boy's positively charged hairs repel each other

### How is electricity generated for us to use?

Naturally occurring electricity is not what we use to power the technologies that we use in our lives. There are two main sources of electricity for this: mains electricity and batteries. Mains electricity is what comes from plug sockets in the wall, whereas batteries are portable (they can be carried around). Power stations generate heat energy from a fuel; the heat energy is used to create steam; the steam is used to turn a turbine and a generator converts the movement energy into electricity. This electricity is then brought to our homes along cables. These cables can be underground, in the air supported by pylons or in walls. Batteries store chemical energy, which they then convert to electrical energy. The electrons flow from the negative side of the battery to the positive side. A battery has gone 'flat' when all of this chemical energy has been converted. Rechargeable batteries can be plugged into the mains, so that they can be used again. Some people have microgeneration systems that produce electricity, such as solar panels or wind-turbines on their roofs.



Electrons travelling from a battery and around a circuit

## Why is electricity useful?

Electricity from the mains and from batteries is useful for us because it can be easily changed into other forms of energy, such as light, heat, sound and movement. For example, electricity is converted into light in a light bulb, into heat in a radiator, into sound in a radio and into movement in a robot. The human body also uses electrical signals that move along nerves to carry messages to and from the brain. Some animals use electricity to navigate or communicate; others, like the electric eel and the electric catfish, use electricity as a weapon!



Elephantnose fish use electrolocation to find their way in murky water

## What are sources and consumers of energy and electricity?

Items that require electricity in order to work, like mobile phones and lights, are consumers of electricity and energy. Batteries and power stations are sources of electricity. These sources of electricity need their own energy sources to work. There are many sources of energy that we convert into electrical energy, including the chemical energy in batteries, fossil fuels (gas, coal and oil), nuclear energy, solar power, wind power, wave power, geothermal energy (from the Earth's inner heat) and hydroelectric power (from dams and waterfalls).

## Which source of energy for electricity is best?

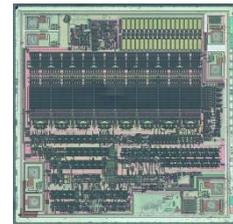
Different sources of energy have different strengths and weaknesses. For instance, gas, coal and oil can be used all year around, but most scientists believe that they cause global warming. Nuclear energy can be used all year around too and does not cause global warming, however it does produce highly toxic waste that is expensive and dangerous to store. Renewable sources of energy do not have the problems of nuclear power or burning fossil fuels, yet they are not as reliable, are not an option in all places and can cause other problems. For example, people often think that wind farms spoil scenery and dams often need to flood land where people live and work.



Nuclear waste

## What are circuits and how do they work?

A circuit is made up of a power source and an unbroken pathway of a conducting material. In the circuit on page 2, the power source is the battery and the conducting material is electrical wire. The type of electricity in a circuit is called current. Current electricity flows from one place to another, such as from the negative side of the battery to the positive side. (Static electricity does not have current, as the electrons jump instead of flowing). Conductors are substances that allow electricity to flow through them easily, whereas insulators are substances that do not allow electricity to flow through them easily. Most metals are good conductors, while most non-metals like rubber and plastic are insulators. A switch can be used in a circuit to stop or allow the current to flow. If the switch is used to break the pathway, the current will stop flowing. On / off switches on plug sockets and devices work in the same way - by completing or breaking a circuit. Bulbs, buzzers and many other devices can be added to circuits. Such devices are known as components and they convert the electrical energy into heat, sound or light. Modern computers contain millions of tiny circuits called microchips.



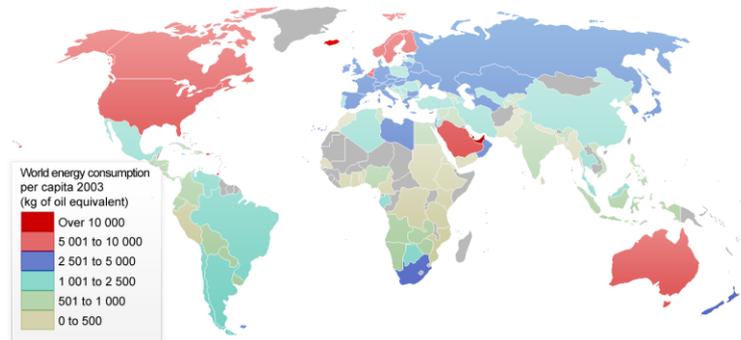
Microchips are tiny circuits

## What units of measurement are used for electricity?

The reason that current flows is because of the 'potential difference' between the positive charge at one point and the negative charge at the other point. The size of this difference is measured in volts (V) and is called voltage. The bigger the voltage is, the stronger the current will be. Current is measured in amperes (amps). Different devices need different levels of current. For example, an iron might need 5 amps, while an electric heater might need 10 amps. The amount of electrical energy that a device uses is measured in Watts (W). The other main unit of measurement related to electricity is resistance, which is measured in ohms ( $\Omega$ ). Resistance is the ability of a substance to restrict the flow of electricity. Insulators will have a higher level of resistance than conductors, although there will also be differences in the level of resistance between different conductors. For example, copper provides lower resistance than iron, so copper is better as a conductor. Using a metal with greater resistance to electricity in a circuit means that more energy is lost as heat and / or light than would be lost if a metal with lower resistance was used. Thicker wires also provide less resistance than thinner wires; similarly, shorter wires provide less resistance than longer wires.

## What social problems are there related to electricity?

Eventually fossil fuels will run out, so we need to start planning for this before it happens. Every person can help reduce the amount of electrical energy that is needed by not wasting it; for instance, by not leaving lights on when they're not needed, by not leaving devices on standby and by using energy-efficient light bulbs. Scientists and engineers are constantly trying to make devices more energy-efficient and trying to find new ways of generating electricity. There are also still more than 1.5 billion people on Earth that still do not have access to electricity. Can you imagine having to live without it? Think of all of the things that you would no longer be able to use!



Global energy use per person – red is high, blue is medium and grey is low

## Summary

Electricity is an incredibly useful type of energy for us, as it can be converted into heat, sound, light and movement energy. It occurs when electrons move from one atom to another. With static electricity, which is the cause of lightning, the electrons jump. With current electricity, which is the type of electricity that we make use of, the electrons flow. Current electricity comes to us through mains electricity or it comes from batteries. Animals use electricity to send messages from their brains and through their nervous systems, while some animals use electricity to find their way around or as a weapon. In order for us to have electrical energy, we need a source of another form of energy which can then be converted to electrical energy. There are a number of such energy sources, but none of them are perfect. Once electrical energy is generated, it is brought to our homes through a circuit. For a circuit to carry current, it needs a power source and an unbroken pathway made from a conducting material. There are several units of measurement related to electricity: potential difference is measured in volts (V), current is measured in amperes (amps), the amount of energy that a device uses is measured in Watts (W) and levels of resistance are measured in Ohms ( $\Omega$ ). Society also faces a number of electricity-related challenges for the future, such as sustainability and providing access to electricity for everyone in the world.

## References

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