2019 Version

Energy

Junior Science

GZ Science Resources

Energy makes things happen when it transfers between stores

Energy is not a substance or an object that you can touch or hold, but substances and objects can **possess energy.**

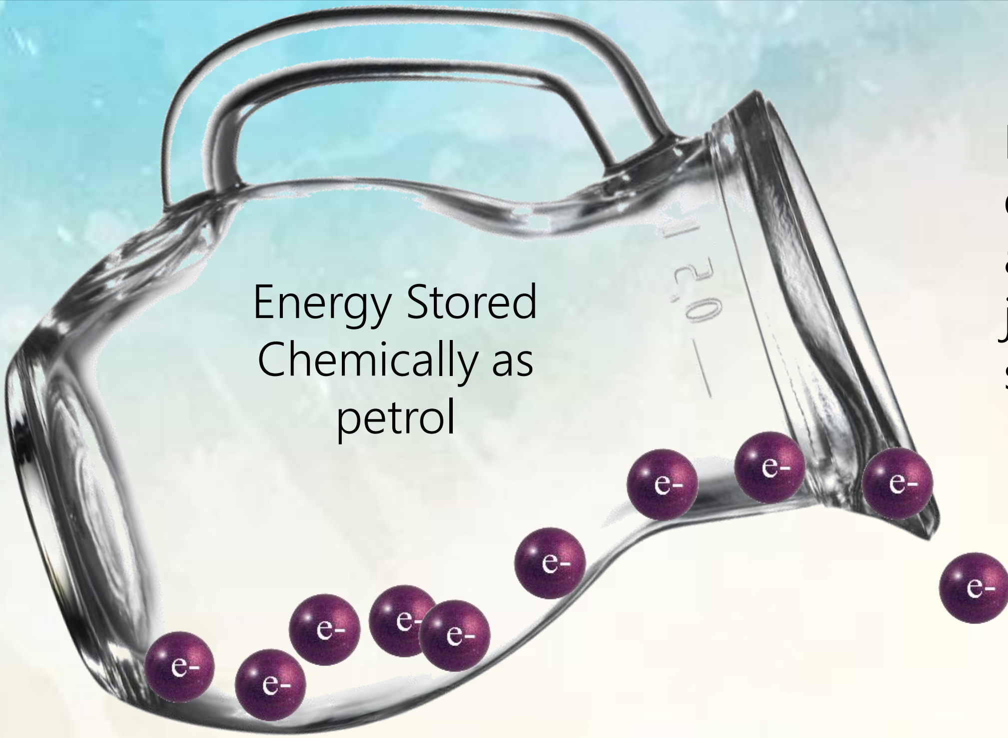
Energy is stored in different ways, and when it transfers (converts), objects can move or change their state.

Different ways in which energy can be stored include kinetic, heat (thermal), gravitational, elastic, and electromagnetic.

Some devices, such as motors or generators, change the way in which energy is being transferred, without storing any themselves.

Energy transfers between stores

This jug represents petrol, used by a car motor. The petrol stores energy (as a chemical potential store) As the petrol is used, containing the energy, the energy (e) converts / transfers into different stores.

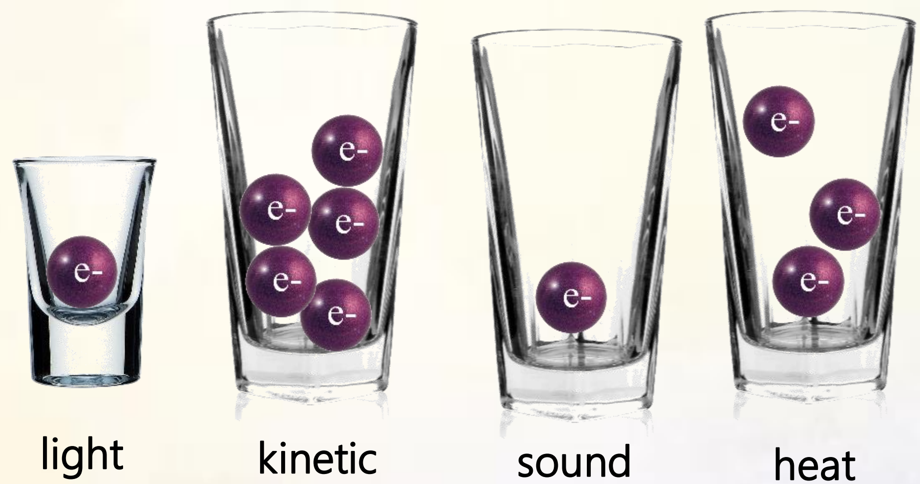


Energy is not created or destroyed – the TOTAL amount is conserved – just shifting from one store to another

Note: Heat tends to spread out so is not often available for further transfer

Amount of energy →

Energy Stores →

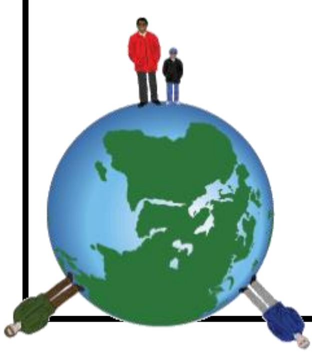


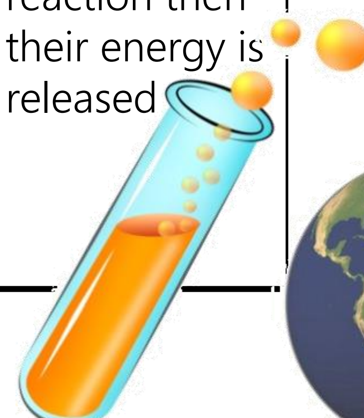
Kinetic energy can be stored in different ways

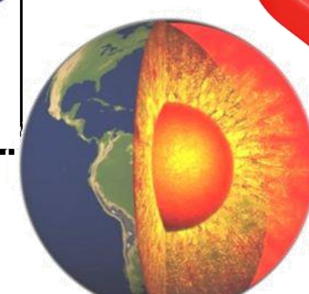
Light (radiant) Energy	Sound Energy	Mechanical kinetic Energy	Heat (thermal) Energy	Electrical Energy
Energy traveling in waves, with wavelengths that can be seen by humans.	Sound travels in waves of different pressure. This causes movement of particles. Sound cannot travel in a vacuum.	Movement energy. This can be seen when matter changes its position in space	The kinetic energy that atoms contain. The more they move the more heat they contain. Measured by temperature	Energy contained in electrons. This can either be static like lightning or current electricity that moves in a circuit.

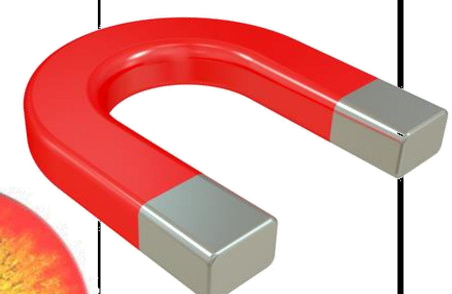
Potential energy can be stored in different ways

Gravitational Energy	Elastic Energy	Nuclear Energy	Chemical Energy	Geothermal Energy	Magnetic Energy
This is the energy contained by an object which pulls it back to Earth. The further up from the ground the more it contains.	Found in springs, rubber bands etc. The more they are compressed the more energy they contain to make them change back to their original shape	The energy contained by the nucleus of an atom which holds the neutrons and protons together. A lot of energy is released when these are separated in a nuclear reaction	The energy contained in the bonds of chemical molecules – i.e.food or battery acid. When these bonds are broken in a chemical reaction then their energy is released	Energy produced by geological processes of the Earth which causes heat and pressure to rise to the surface.	Energy contained by a magnet to either attract or repel other magnetic objects. It can also cause electrical currents.





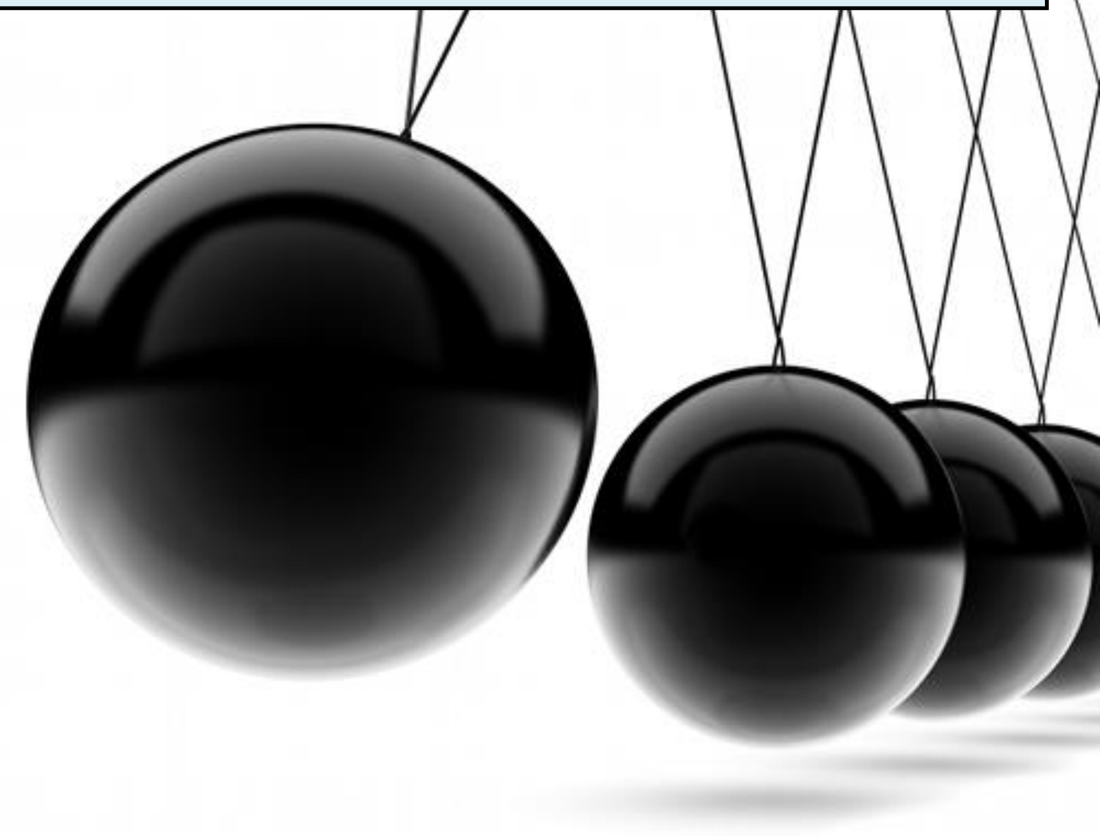




Energy is always conserved.

Energy can not be created or destroyed, it can only be converted from one store ("type") to another.

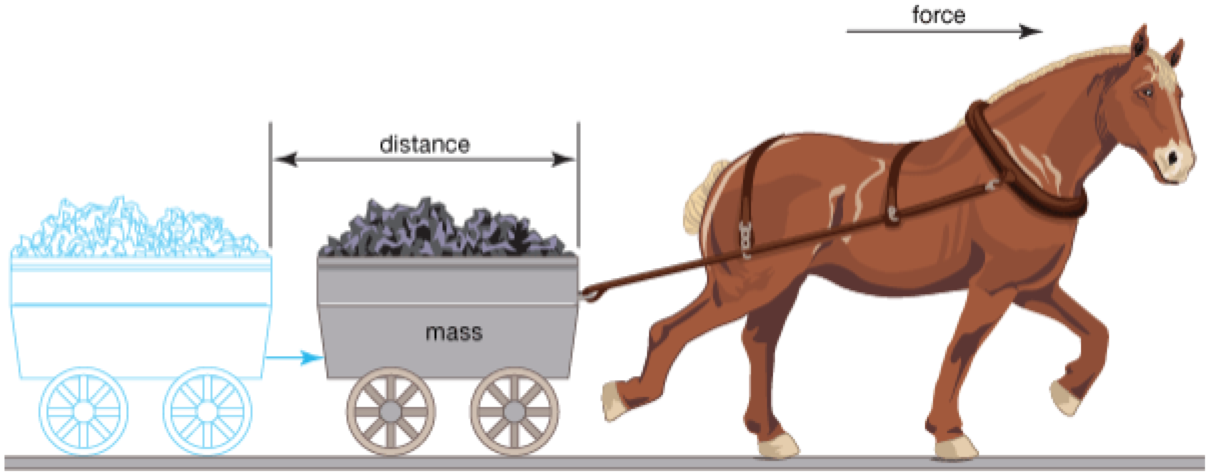
The total amount of energy never changes. Energy is able to convert from one store ("type") to another. Energy stored as potential energy must be converted into kinetic stores in order for **work** to be done.



Energy is the ability to do Work

Any change in speed, size, shape or temperature in an object requires energy to move between stores.
Energy is the ability to do work.
Work is applying force to an object and making it move in distance.

Energy is measured in a unit called a joule (J).



A **joule**, unit of work or energy, is equal to the work done by a force of one **Newton** acting through **one metre**. This unit is named in honour of the English physicist James Prescott Joule.

W (work) = F (force) x d (distance)

Power is measured in a unit called a watt (W).

extra info

Power is a measure of energy use. Power is how quickly energy is being used, which is called the rate of energy use.

Power is the amount of energy used in a period of time and the units are called **watts**.

1 joule of energy for 1 second = 1 watt of power

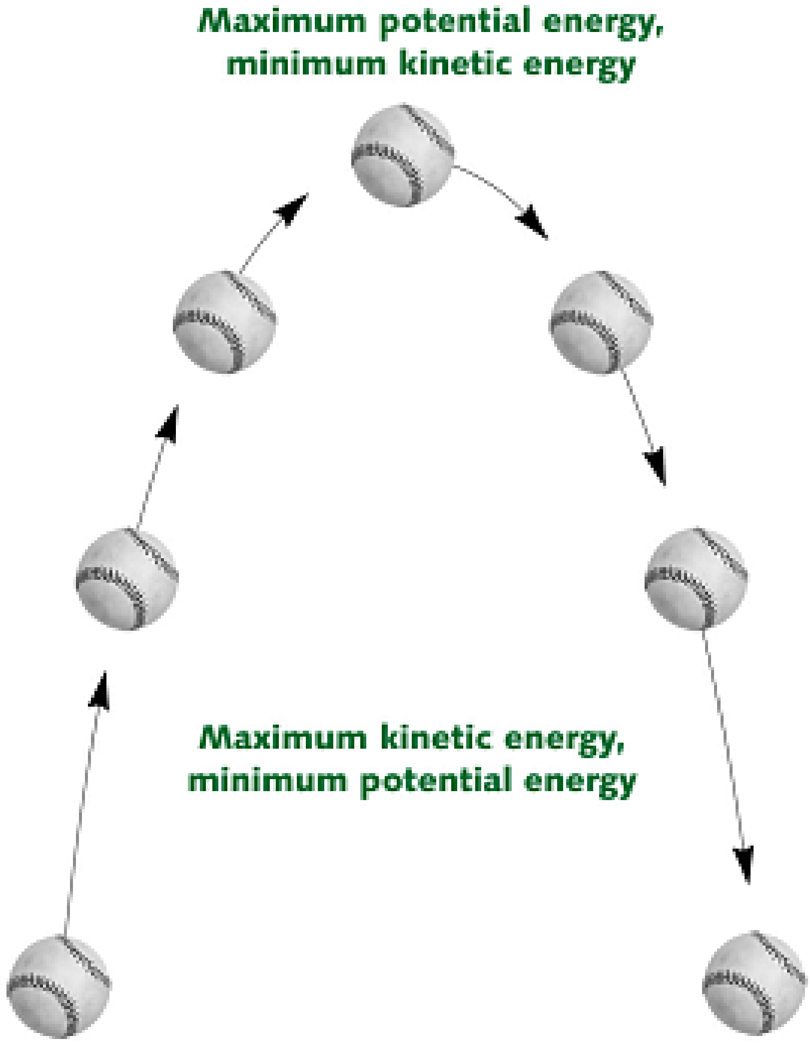
1 watt of power for 1 second = 1 joule of energy

Energy can be found in Potential or Kinetic Energy stores

Energy can move between kinetic (E_k) and potential (E_p) stores.

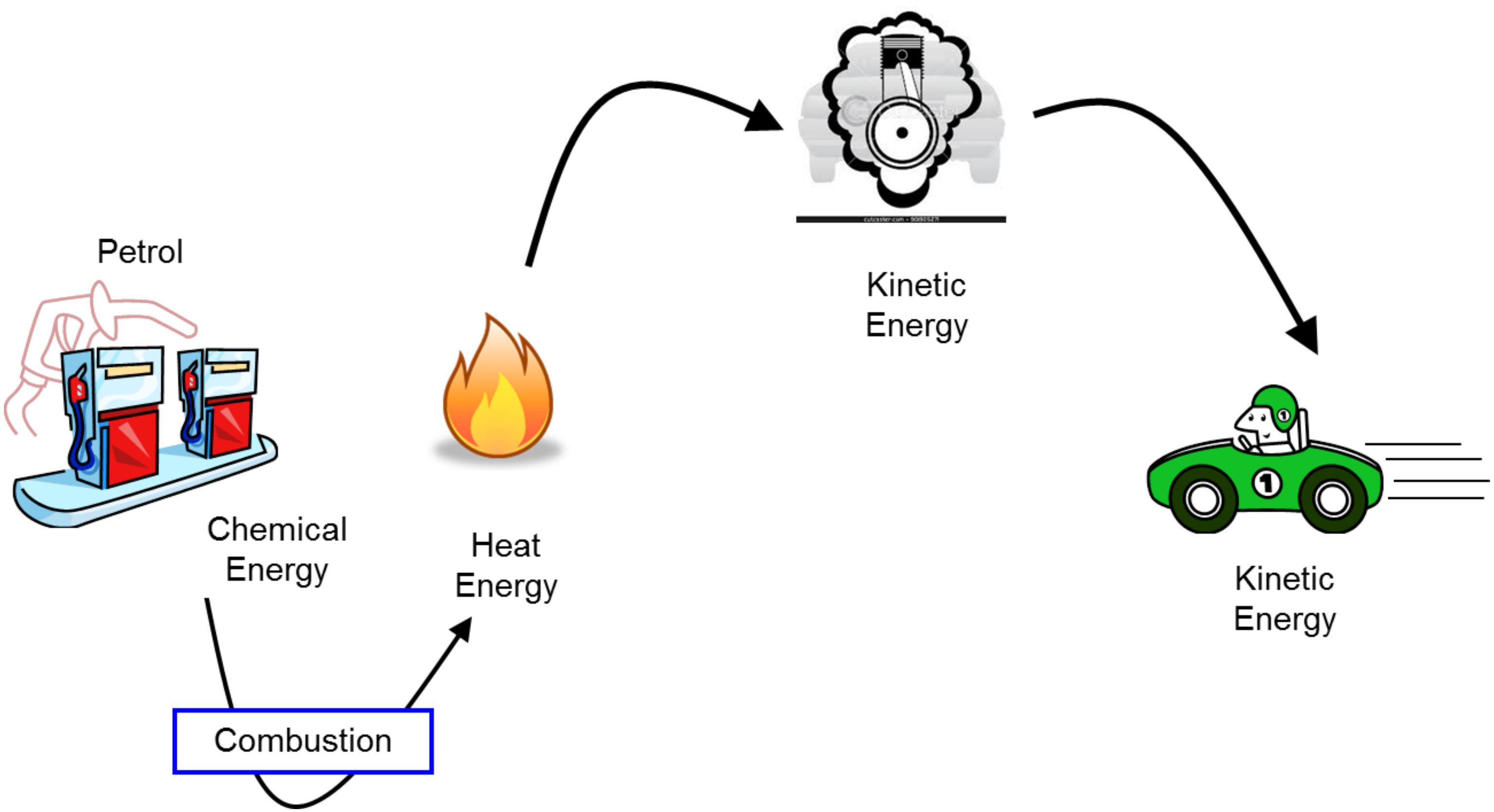
Kinetic energy is seen when particles, waves or objects move.

The effects that **potential energy** has on matter can be seen as it transfers into active energy stores, such as the energy contained in the ball due to its height (gravitational potential), then transferring into kinetic stores – causing matter (of the ball) to move downward



Writing Energy conversion (transfer) Stories

Below is an example of the energy conversions taking place in a car. The input energy is stored as Chemical potential from the petrol. This converts into heat energy when it is combusted inside the car energy. Heat energy also converts into kinetic energy, moving the car engine parts, which also makes the car move along the road.

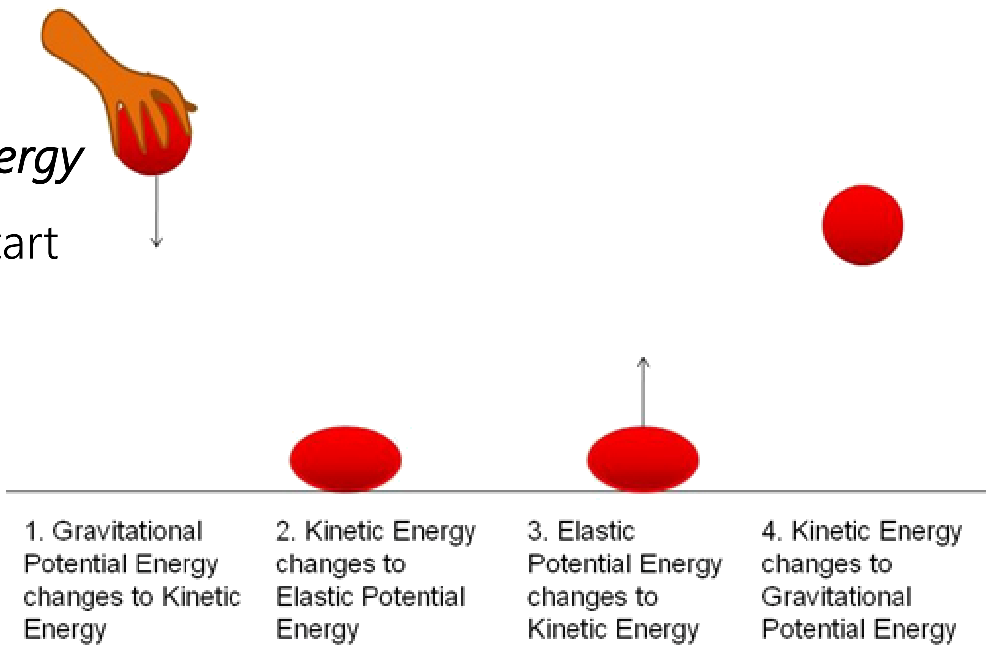


Writing Energy Transformation Stories

This is a picture that shows energy converting from one store to another

Step ONE *Identify what type of **input energy** you start with:* This ball can fall, so we start with Gravitational Potential energy

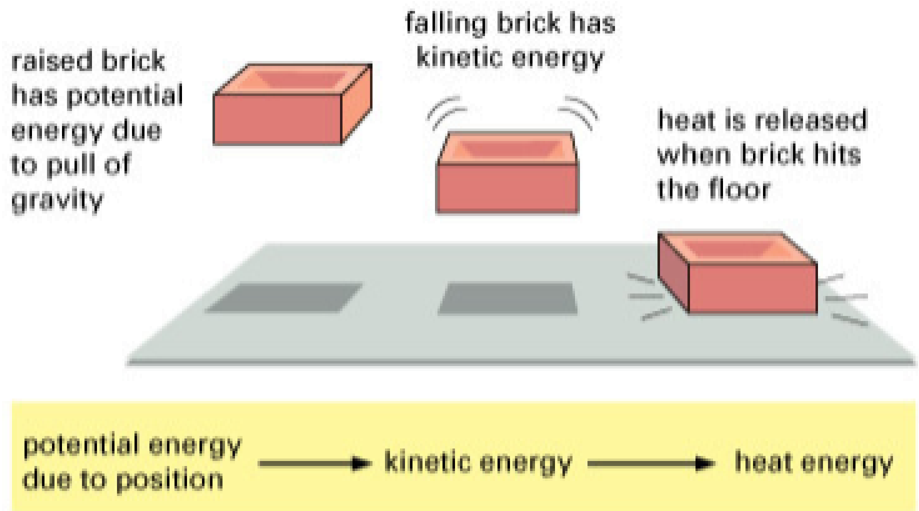
Step TWO *as stuff happens, identify what your starting **energy converts** into:* The ball is falling. It now has Kinetic Energy.

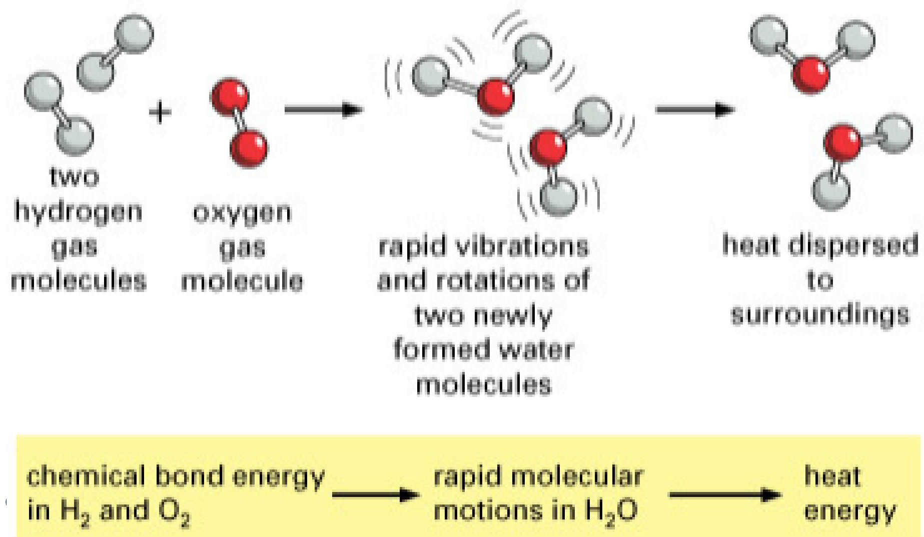


Step THREE *IF anything else happens, identify any further **energy transfers**:* The ball changes shape when it hits the ground which means it has Elastic Potential energy. It also makes a noise so it produces Sound as it transfers

Step FOUR *Continue if there are further energy conversions:* The ball now starts to move upwards so it has Kinetic Energy.

Energy can be transformed from one type to another



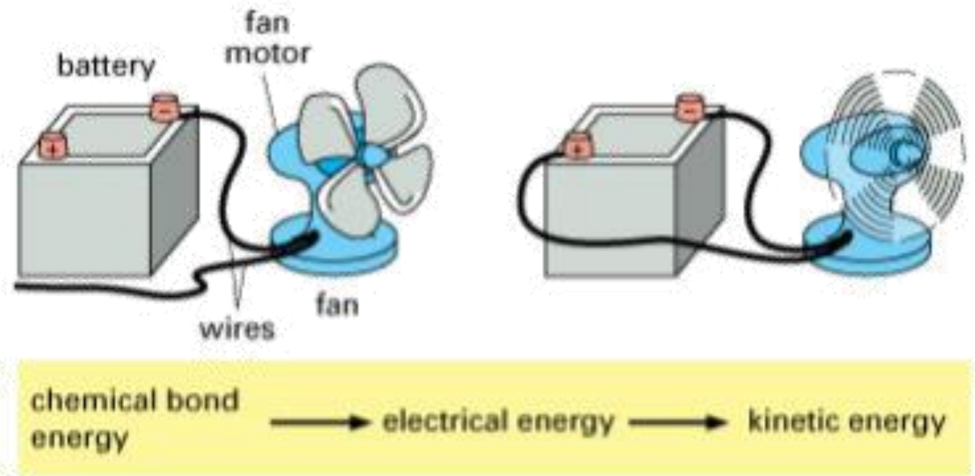


Any object lifted upwards gains in **gravitational potential** energy. This gravitational energy converts back into kinetic energy when it is released or no longer supported. Hydroelectric power stations use the gravitation potential energy of water to flow downwards through a spillway and move turbines.

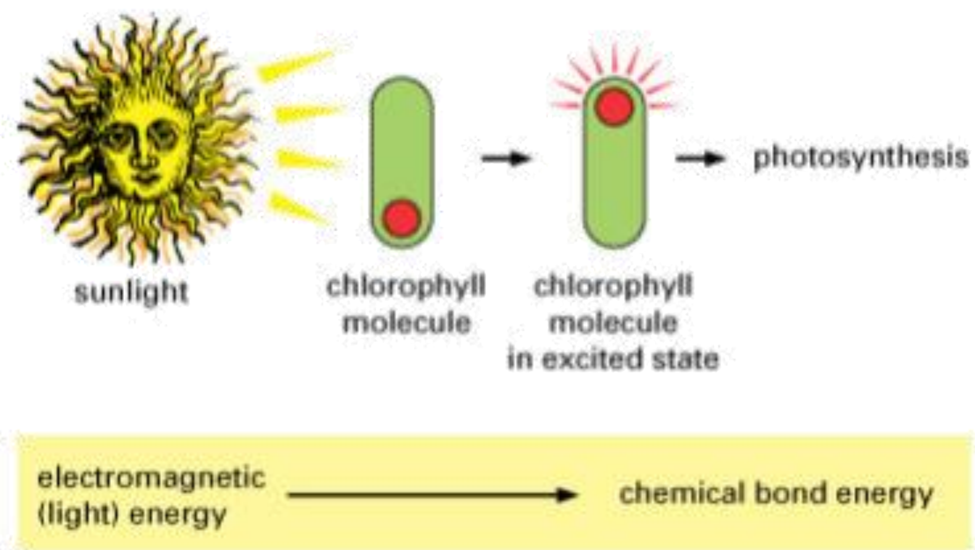
All bonds that hold atoms, ions and molecules together contain **chemical potential** energy. When these bonds are broken or the atoms form molecules of lower energy, then heat energy is released. Respiration in our cells involves releasing energy that is contained within the bonds of glucose molecules.

Energy can be transformed from one type to another

Batteries store energy in the form of **chemical potential** energy. When a complete circuit is connected to the terminals then chemical reactions take place and the potential energy is converted into electrical energy.



Sunlight produces radiant energy in the form of thermal heat and light energy. Only light energy is used by plants and it is converted into chemical potential energy through the process of photosynthesis. Chloroplasts in the leaves contain a chemical called chlorophyll, that captures the light.



How sources of energy are transformed into useful energy and wasted energy

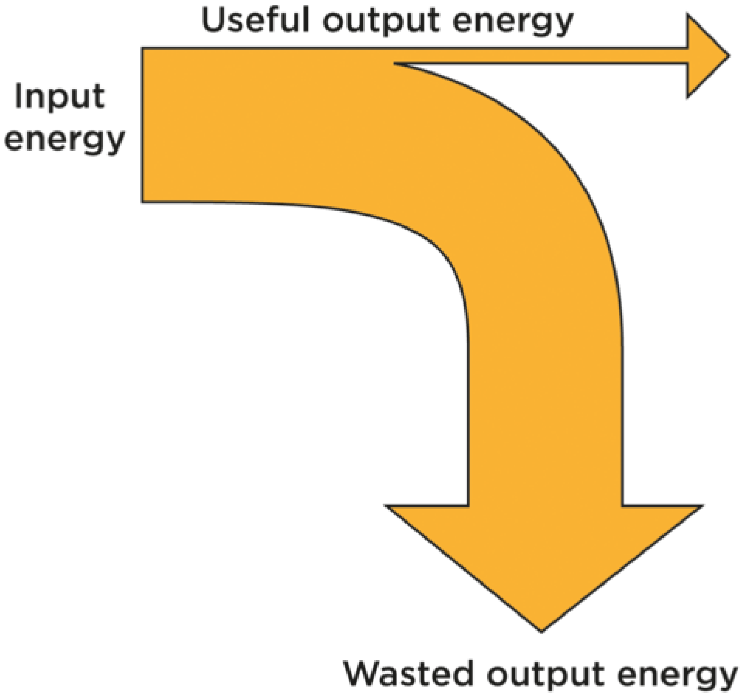
When energy is converted, some of the energy turns into forms we (humans) don't want.
This energy is called **wasted energy**.

Wasted energy takes the form of heat and sometimes sound or light.
During any energy transfer, some energy is changed into heat.
The heat becomes spread out into the environment. (dispersed)
This dispersed energy becomes increasingly difficult to use in future energy transfers.

In the end, all energy is transformed into heat and eventually lost out into space.

Sankey Diagrams

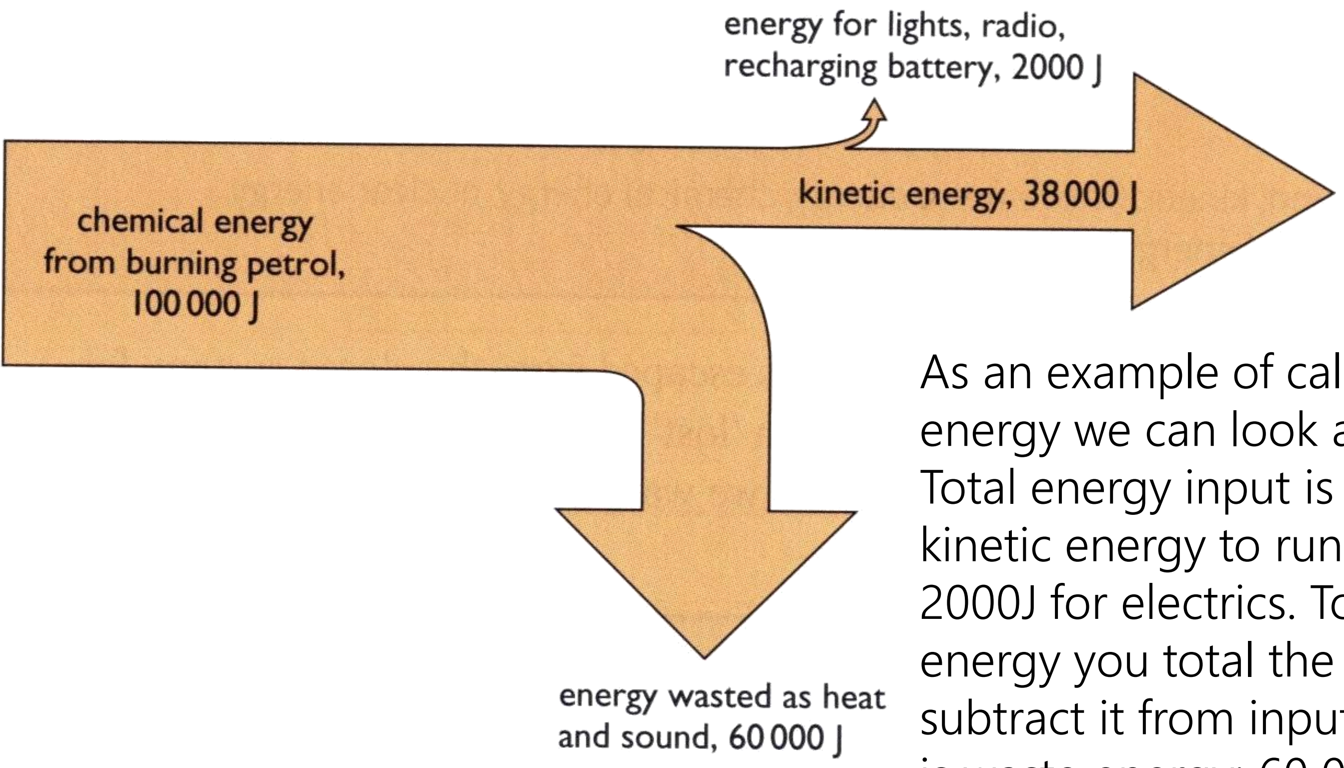
"Energy cannot be made or destroyed but it can be converted from one store "type" into another". This means Energy in = Energy out.



Many objects that use energy do not convert 100% into useful energy. We can use diagrams to show the relative amounts of useful energy (energy that is put to the purpose that we want) and waste energy. Due to the conservation of energy, the useful energy and the waste energy, which together we call the **output energy**, **must equal the total amount of input energy**.

Sankey diagrams summarise all the energy transfers taking place in a process. The thicker the line or arrow, the greater the amount of energy involved.

Calculating Wasteful energy Example

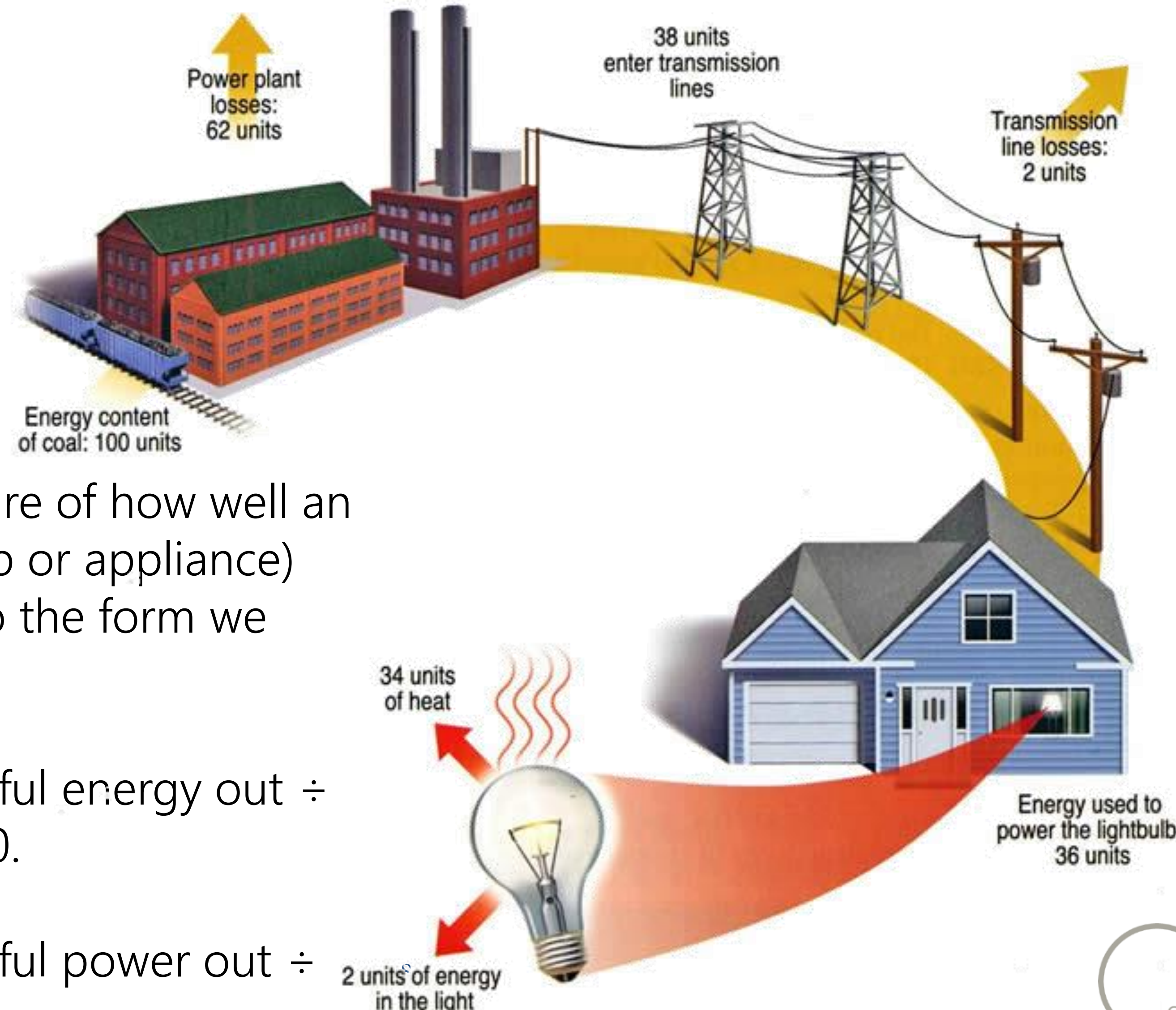


As an example of calculating wasteful energy we can look at a car engine.
Total energy input is 100 000J and the kinetic energy to run the car is 38 000J plus 2000J for electrics. To calculate the waste energy you total the useful energy and subtract it from input energy. The remainder is waste energy: 60 000J

Waste energy = Total input – useful energy
Waste energy = 100000 – (38000 + 2000)
Waste energy = 60000J

Energy efficiency – how sources of energy are converted into useful energy and wasted energy

extra info



Efficiency is a measure of how well an energy user (i.e, bulb or appliance) transfers energy into the form we want.

efficiency (%) = (useful energy out ÷ total energy in) x 100.

or

efficiency (%) = (useful power out ÷ total power in) x 100

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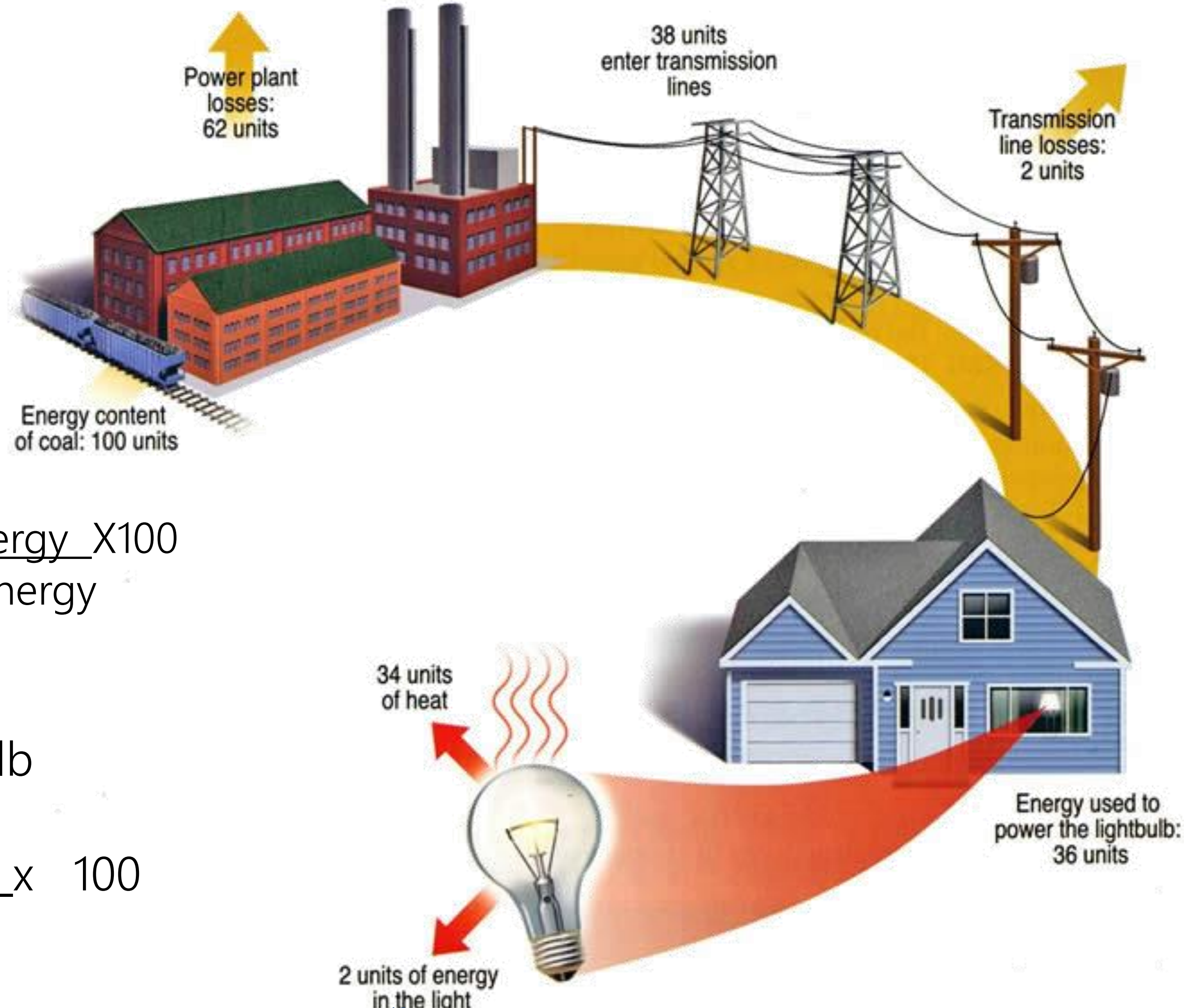
Calculating Energy efficiency

extra info



$$\text{Efficiency} = \frac{\text{Useful energy}}{\text{Input energy}} \times 100$$

Efficiency of light bulb

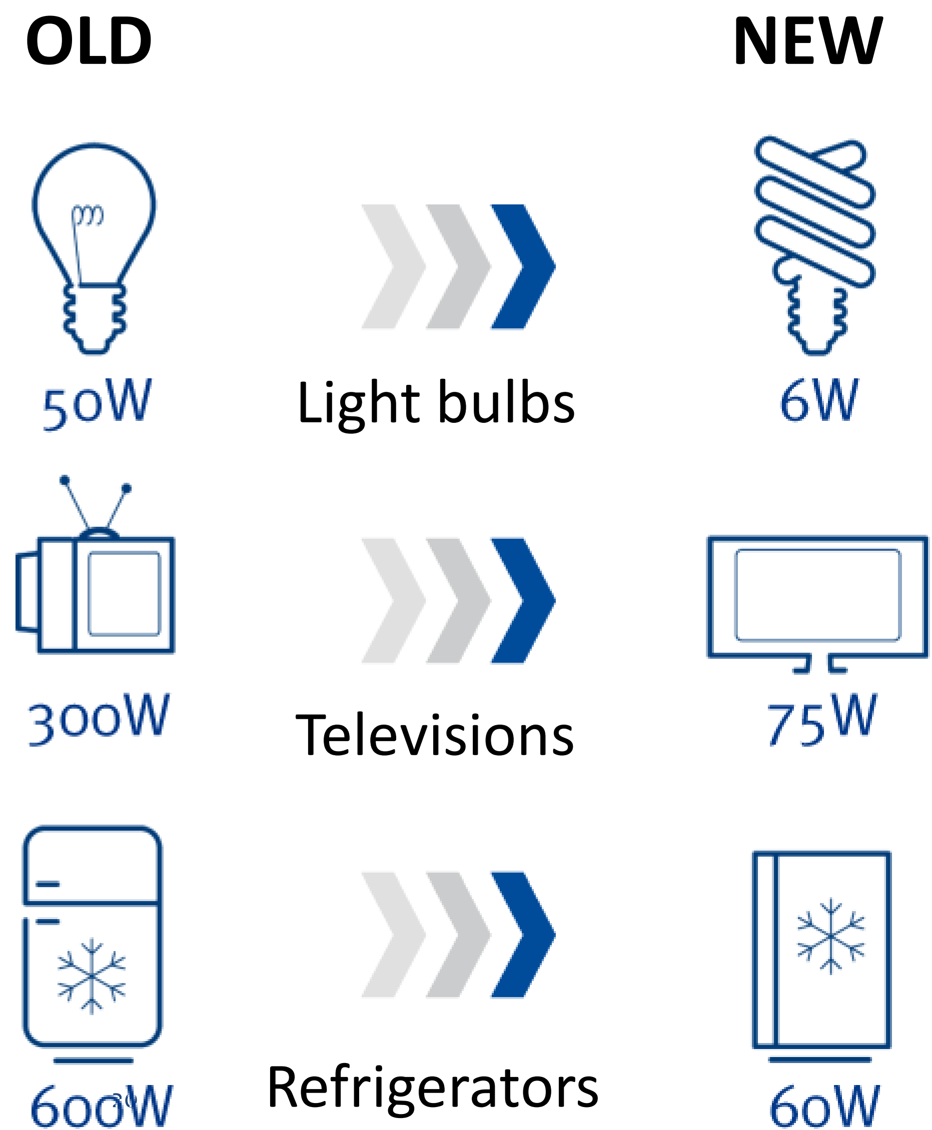
$$\text{Efficiency} = \frac{2}{36} \times 100$$

Efficiency = 5.6%

Becoming more energy efficient

extra info

Appliances for use around the house are being designed to be more energy efficient. This means that they require less input energy to produce the same amount of useful energy output. Less waste energy is produced in the form of heat and sound.

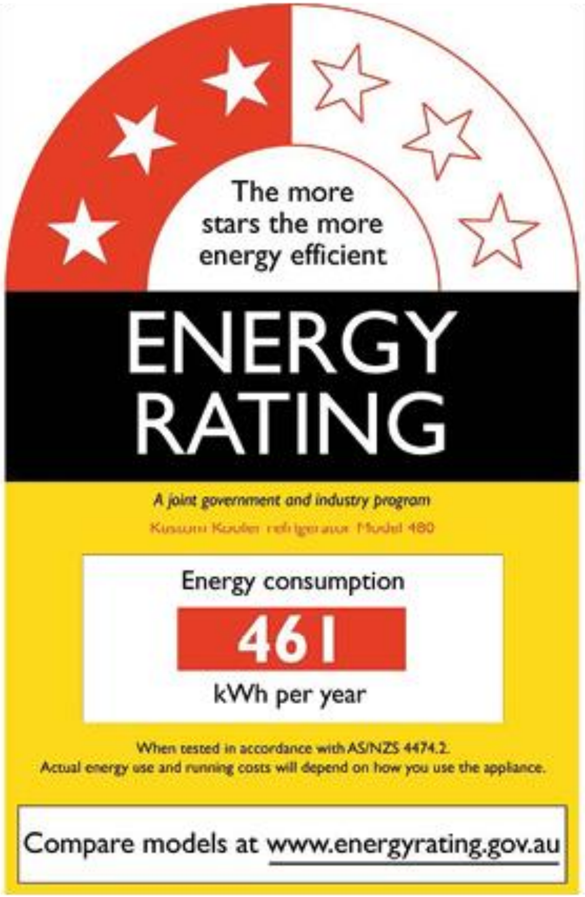


Comparing household appliances for efficiency rating

Appliances are sold with an energy rating sticker. The more stars an appliance has the more energy efficient it is.

As similar appliances need to use approximately the same amount of useful energy, the more efficient appliances will save you money to run.

If less electricity is needed in many houses, then less electricity is required to be generated. This can have a positive impact on the environment if electricity generation uses fossil fuels.



Energy efficiency – comparing types of light bulbs

extra info

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	Incandescent	Compact Florescent	LED
Life Span (average)	1,200 hours	8,000 hours	50,000 hours
Watts of electricity used (equivalent to 60 watt bulb).	60 watts	13-15 watts	6 - 8 watts

Each of these types of bulbs produces the same amount of useful energy but require different amounts of input energy

extra info

Power and Appliances

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Different appliances use different amounts of energy over time (Power). Because most of the energy for appliances inside the house is supplied by electricity, running to many appliances at once can over load the circuits, triggering the fuse to "blow" and cause a power outage.

	Light Bulbs	Radio	Television	Computer	Laptop Computer	Cordless Phone	Microwave
Starting Watts	50 - 150	100 - 200	150-500	800	200	25	1000
Running Watts	50 - 150	100 - 200	150-500	800	200	25	1000

	Coffee Maker	Slow Cooker	Blender	Hand Drill	Reciprocating Saw	Chainsaw	Electric Fan
Starting Watts	600 - 1500	250	850	1000 - 1500	960	1200	600
Running Watts	600 - 1500	250	400	400 - 600	960	1200	200

Transformation losses and inefficient use increase the amount of energy required

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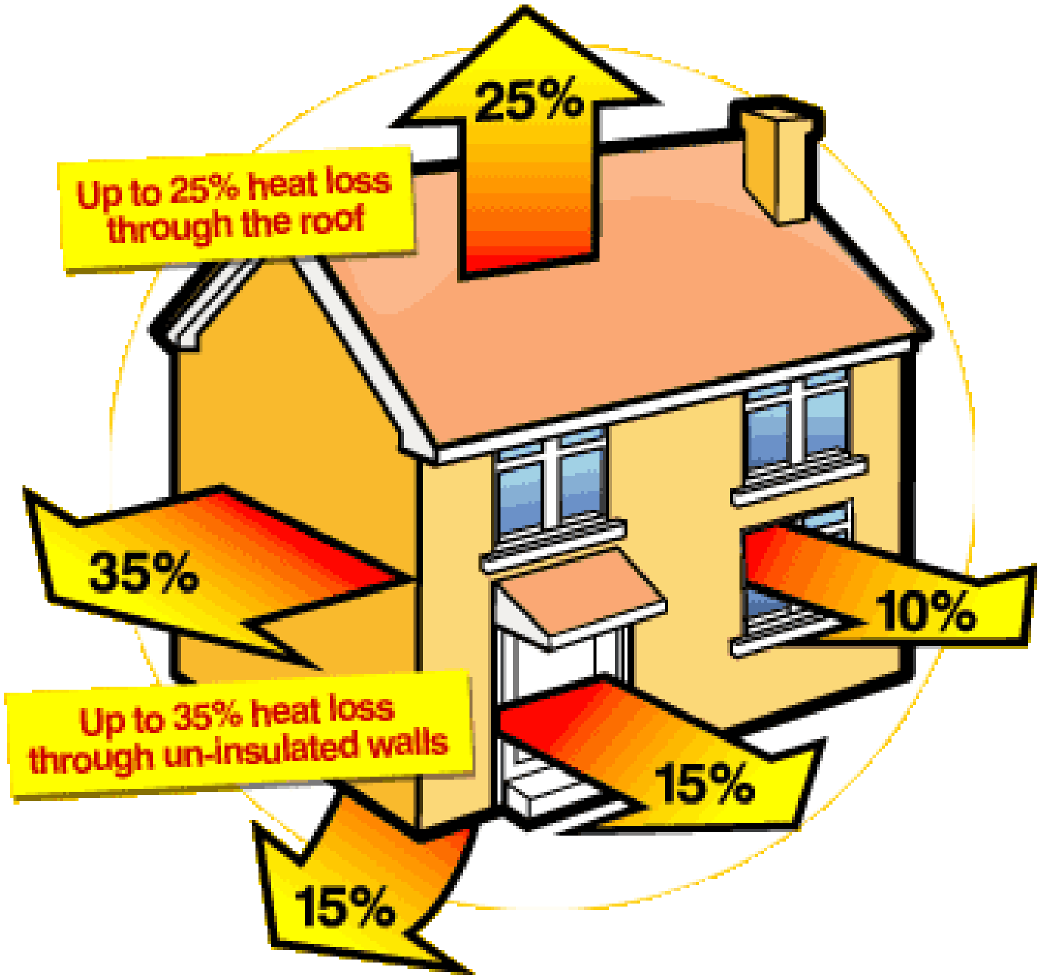
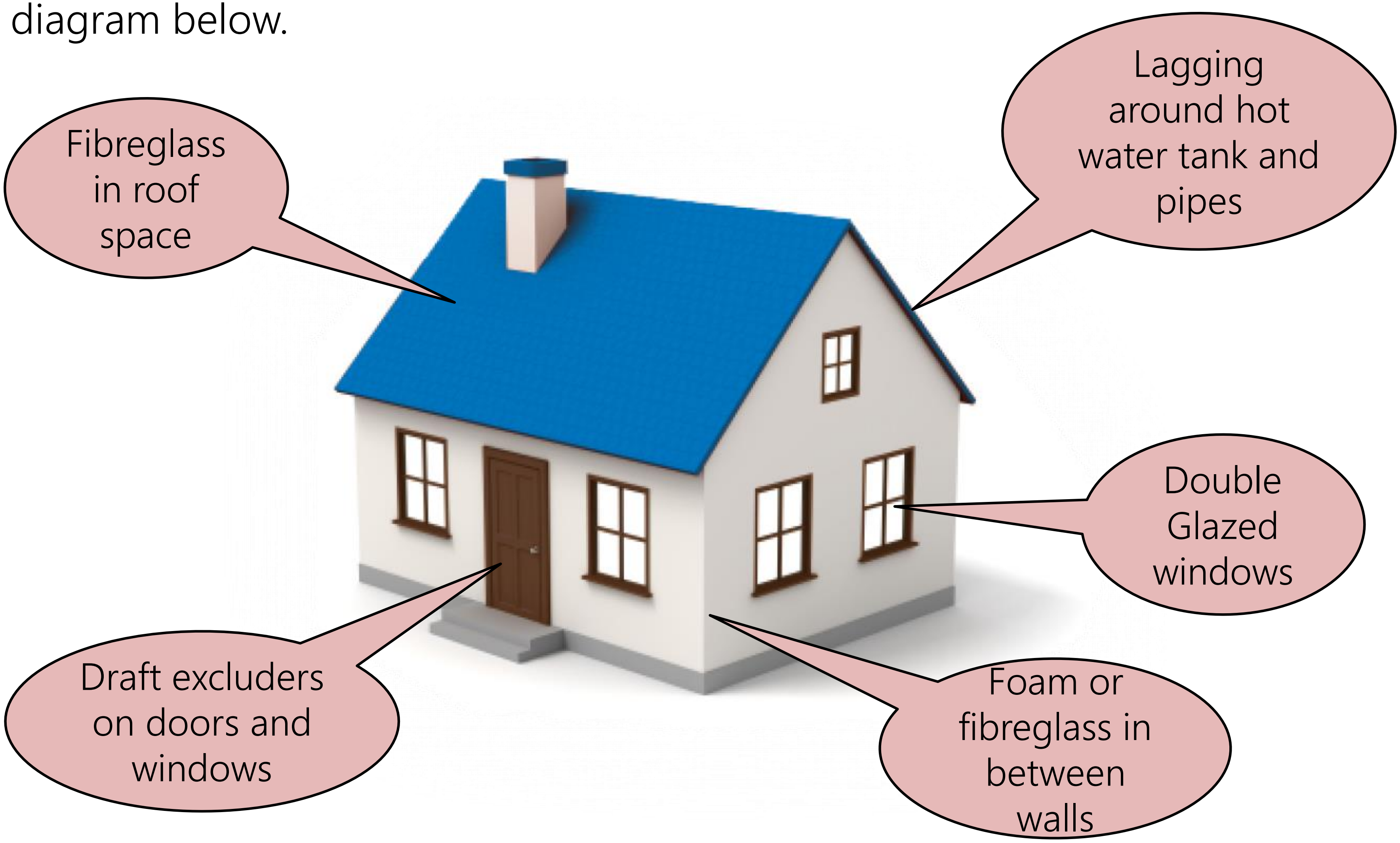


A large amount of energy use in a home is spent on heating. If a home is **poorly insulated** (with materials that do not conduct heat) then the heat will easily escape and more energy will be required to maintain the temperature to a suitable level.

Leaving lights on when not being used, using standard incandescent light bulbs instead of the CFL or LED bulbs and leaving appliances switched on at the wall when not in use are all inefficient uses of energy.

Reducing energy loss from our homes

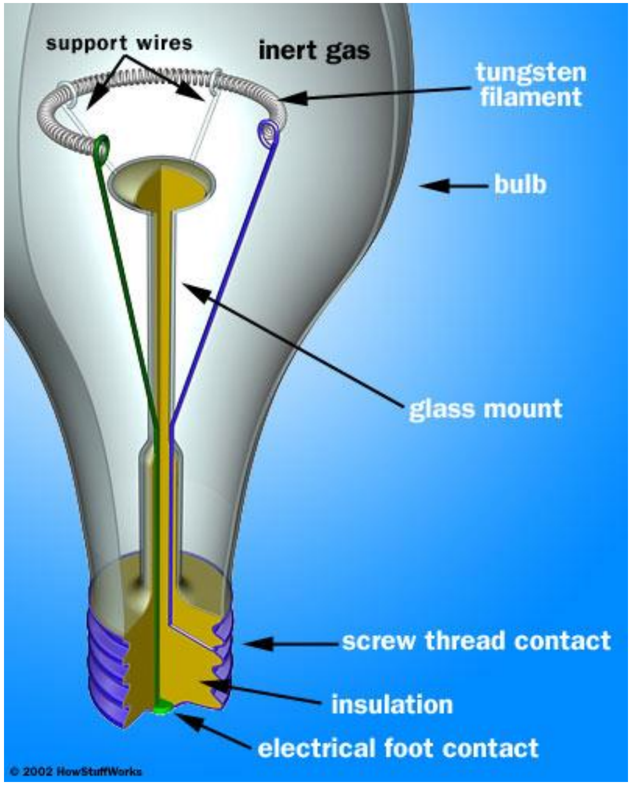
It is important to reduce the loss of heat from our homes. This is done by increasing the insulation of our homes using the methods shown in the diagram below.



Power = energy / time

Power is equal to the rate of energy change
For a bulb the more the power **across** it the brighter it will be
Power is measured in watts, W.
The **watt** (symbol: W) is equal to one **joule** per second.

A person climbing a flight of stairs is doing work at the rate of about 200 watts; a highly trained athlete can work at up to approximately 2,000 watts for brief periods. An car engine produces 25,000 watts while cruising. A typical household light bulb uses 40 to 100 watts.



Power Calculations

Calculate Energy use from power output. – Measure in Joules (J)

Energy (J) = Power (W) x time (in seconds)

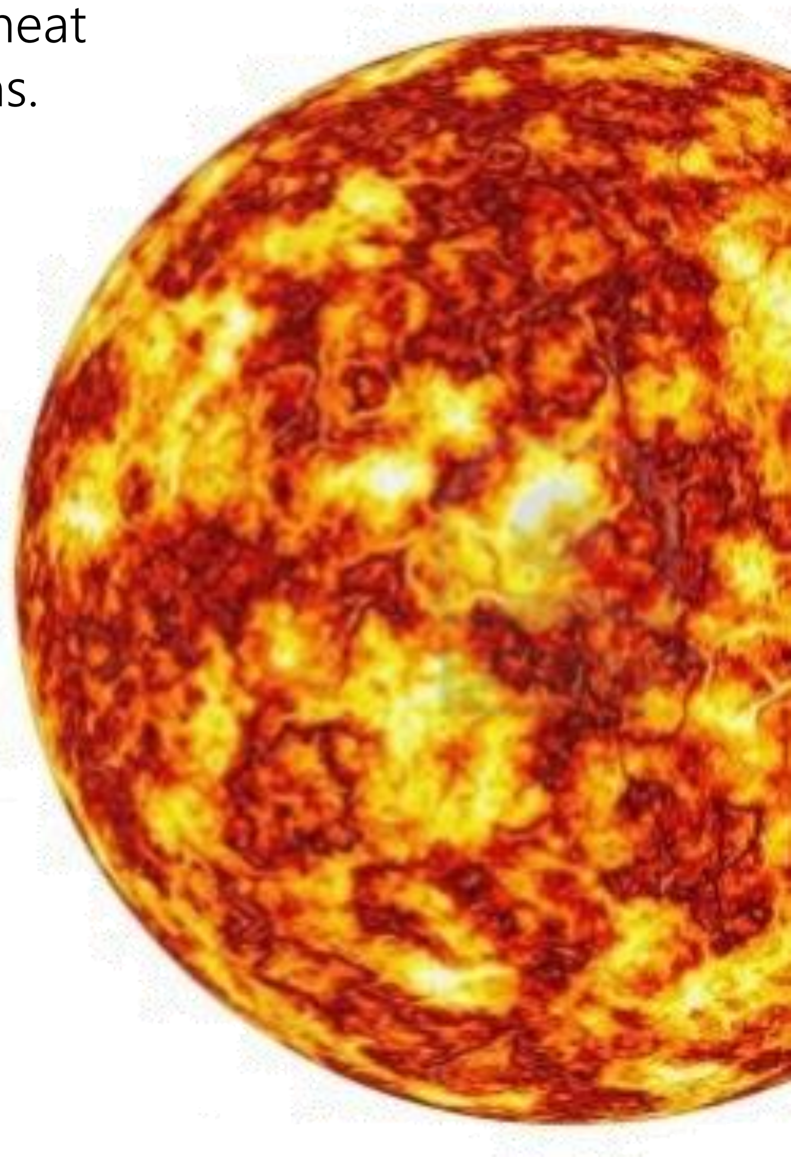
Question: If a Jug is used with a power of 2000W for 3 minutes how much energy would it use?

Answer: 3 minutes = 180seconds

Energy = 2000W x 180s
Energy = 360 000J OR 360KJ
(1 KJ = 1000J)

Earths energy comes from the Sun

A star is a mass of extremely hot gas. It emits heat and light energy produced by nuclear reactions.



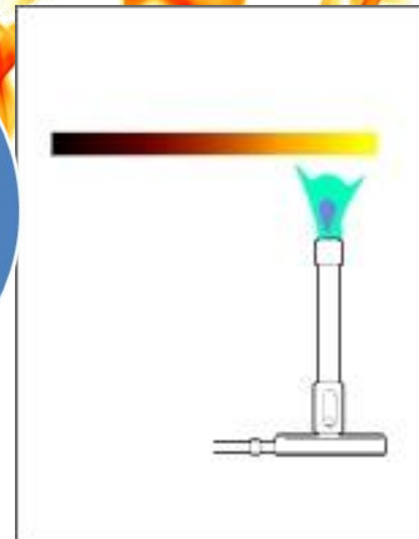
The sun consists of extremely hot gases held together in a sphere by gravity. Nuclear reactions occur inside the sun. Hydrogen is changed into helium and huge amounts of energy are released. The interior temperature is 14 million °C, and the surface temperature is 5,800 °C.

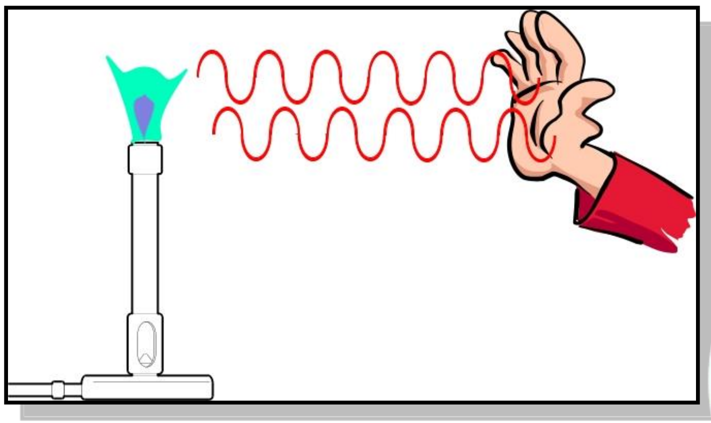
The nuclear (fusion) reaction inside the Sun generates electromagnetic radiation in the form of energy: heat (infrared), light (visible), radio waves, Ultra violet. The Sun does make X-rays but our atmosphere stops them from reaching Earths surface.

Heat Energy can be transferred by conduction, convection or radiation

Methods of heat transfer

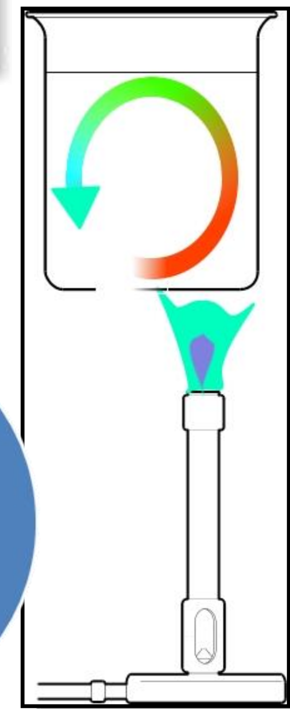
Conduction of heat along a solid object





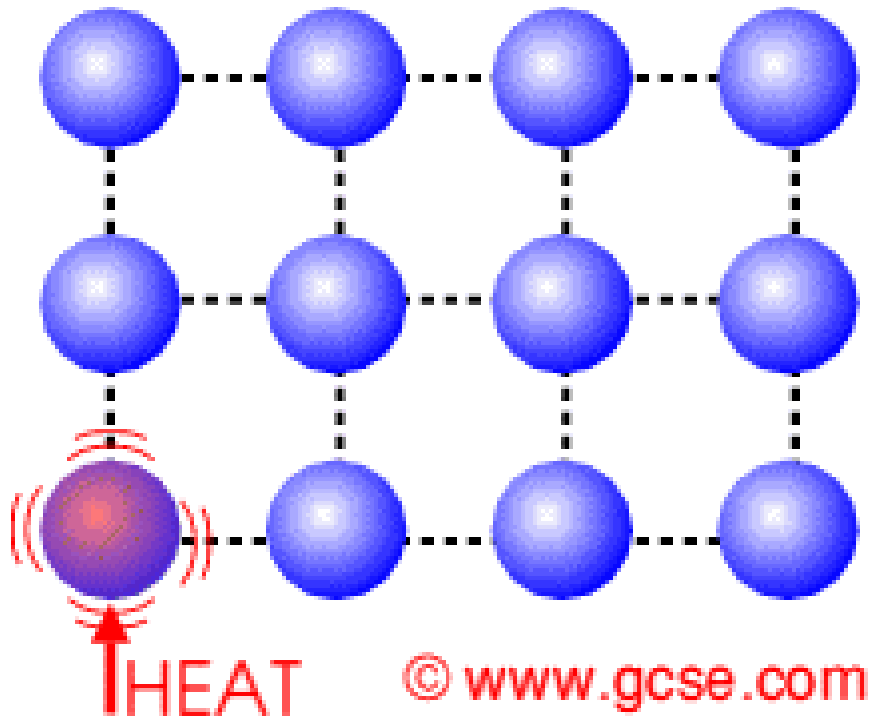
Radiation of heat waves from hot objects

Convection currents in liquids or gases

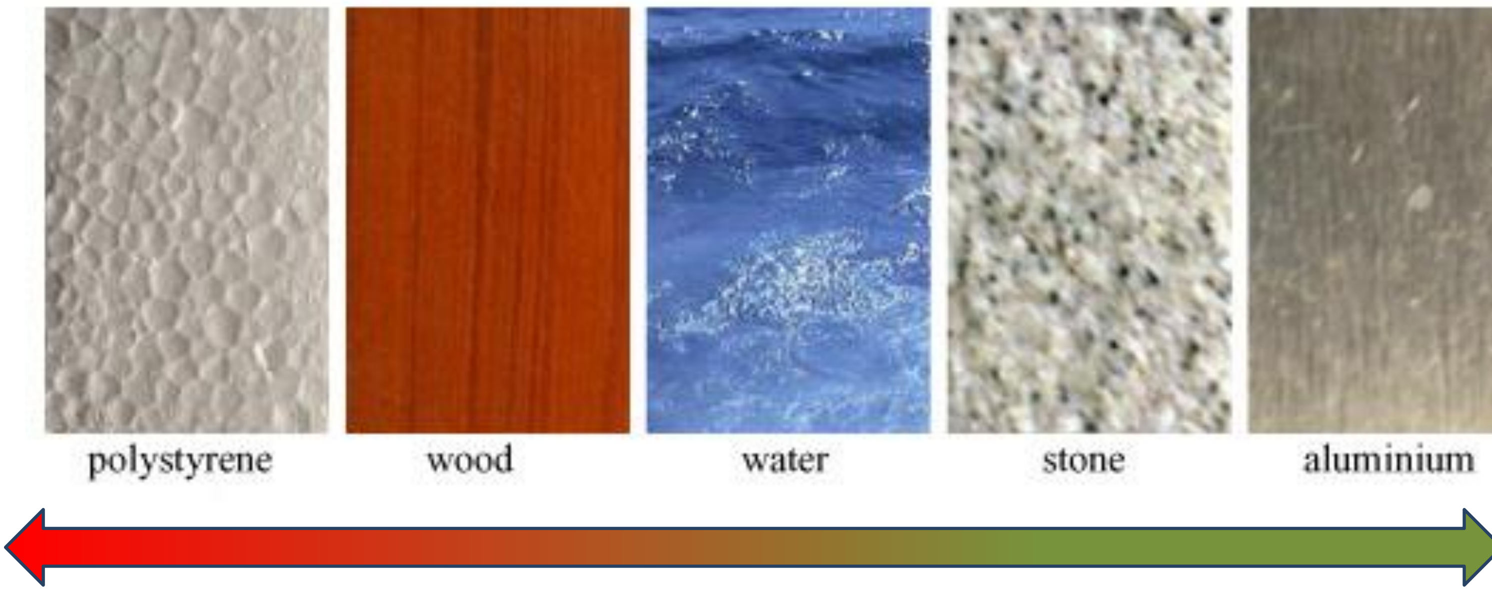


Solids transfer heat energy by Conduction

When heat is transferred by conduction – the atoms remain in fixed solid position – and the heat energy is transferred from one atom to another by being carried by moving electrons surrounding the atoms. The more heat energy an electron has the faster it moves. Some materials conduct better than others. They are called **conductors** and include metals which have electrons that are free to move. Those materials that cannot conduct heat are known as **insulators**. They have no free electrons to carry the heat energy.



Conductors and insulators



More insulating

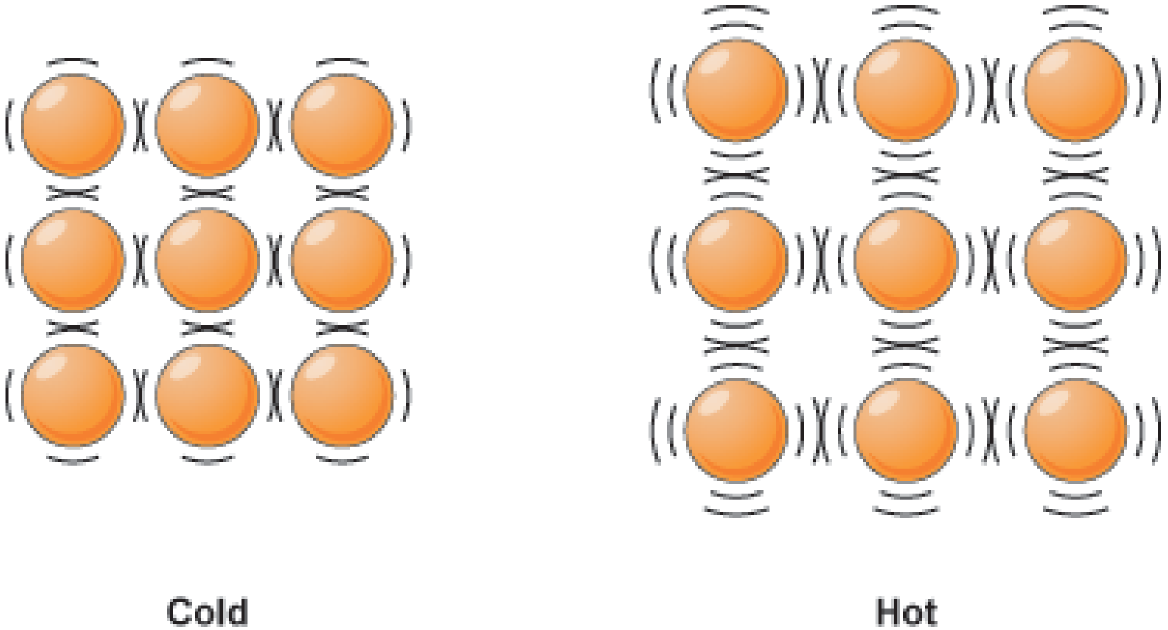
Man made plastics are good insulators of heat because they have no free moving electrons or charged particles.

More conducting

Metals and stone are good conductors of heat because they have free moving electrons to carry the heat.

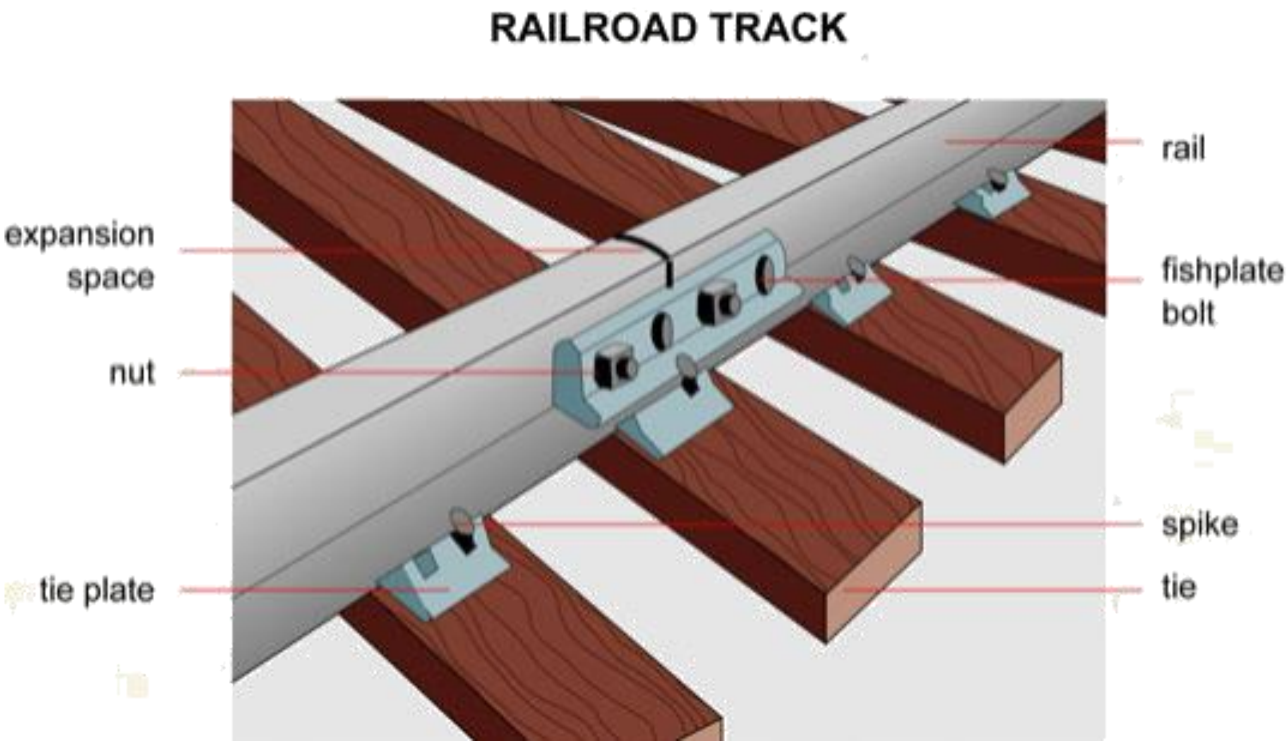
Expansion and Contraction of solids

When matter expands or contracts only the **space between** the particles changes: not the size of the particles.
The particles in a **solid** vibrate more when it is heated, and take up more space.
The particles in a **liquid** move around each other more when it is heated, and take up more space.
The particles in a **gas** move more quickly in all directions when it is heated, and take up more space.



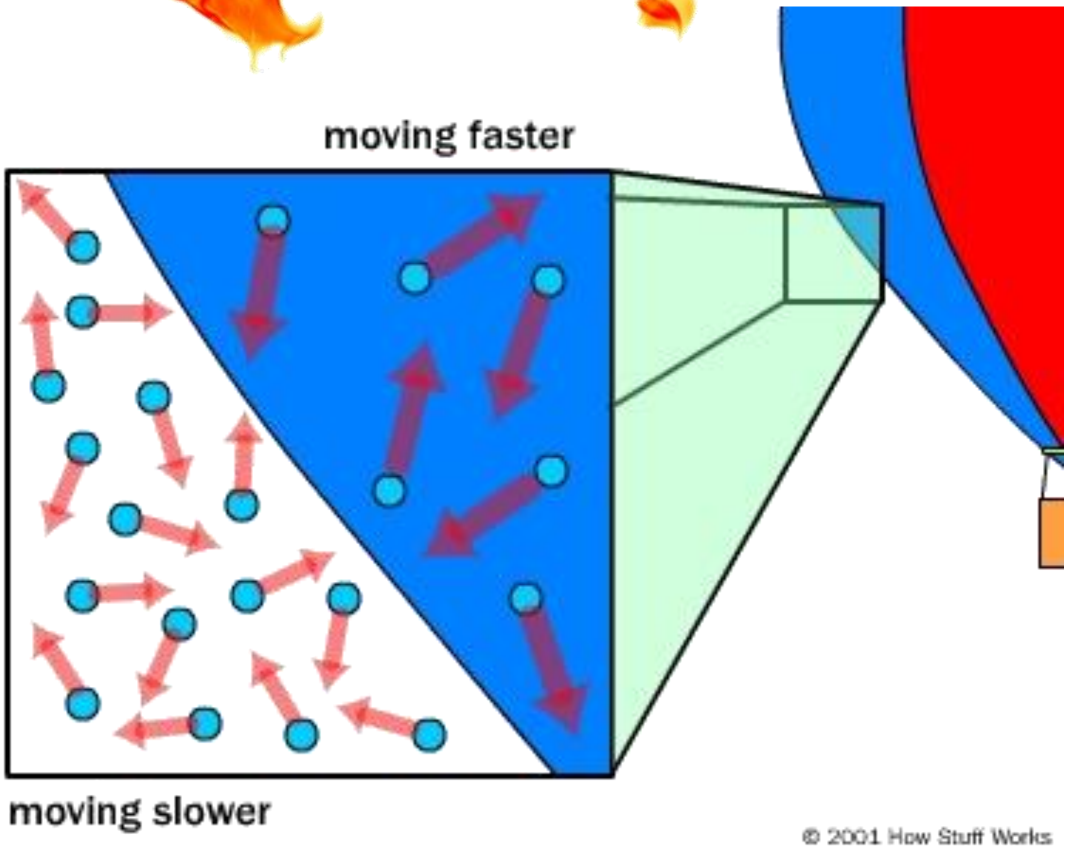
Expansion and Contraction of matter

Matter **expands** or gets bigger when it is heated up. It **contracts** or gets smaller when it is cooled down.
Some types of matter, such as metals, conduct heat very well and therefore the effects of expansion and contraction are more obvious.
Structures such as bridges and railway tracks that are made out of metal have to be built with **gaps** so they don't warp out of shape when exposed to higher temperatures during summer.

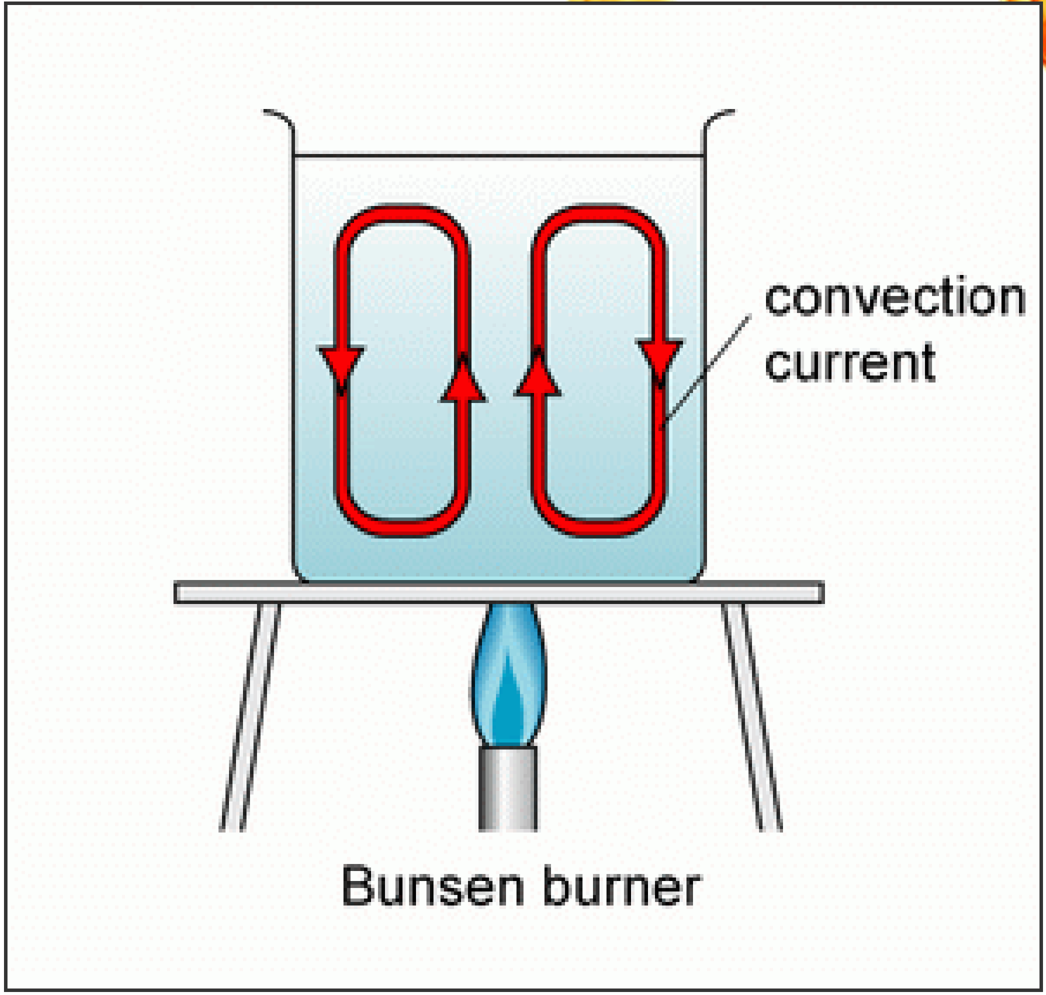


Gas and Liquids transfer Heat Energy by Convection

When you heat the air in the balloon you increase the kinetic energy of the air particles. The air particles absorb the heat energy and this makes them move faster. Air particles are pushed out of the balloon, as they take up more space.
A hot air balloon rises because it is filled with hot, less dense air and is surrounded by colder, more dense air.



Convection Currents

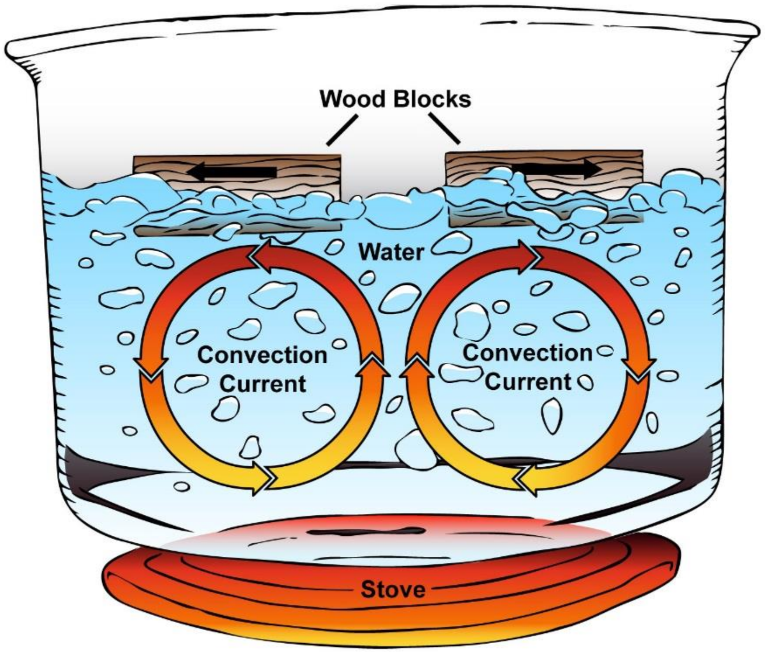


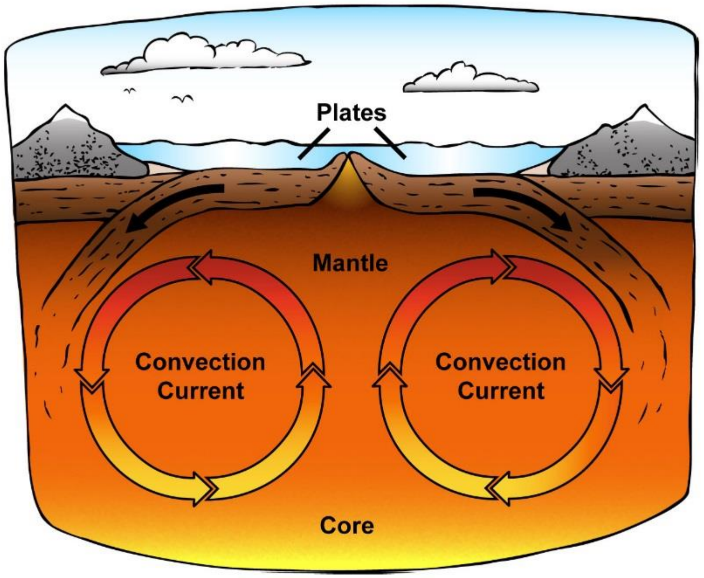
Convection occurs when free moving particles found in liquids and gases have heat energy added to them. The gas/liquid particles gains kinetic energy and as they collide into each other they push apart more. The hotter area of liquid or gas becomes less dense or lighter and rises away from the heat source. As the particles lose energy they slow down and become closer to each other which makes them denser and they fall back down. This movement creates **convection currents** where the particles circulate.

Expansion, Contraction and Density in liquids

In liquids the hotter and expanded, less dense substance rises above cooler and denser liquids. This creates **convection currents** and causes the movement of particles containing heat energy.

Molten Magma under the earth's surface moves due to convection currents when the heat from the Earth's core causes it to expand. When the magma reaches the earth's surface under the crust it cools, contracts and gains in density, so it sinks again.





Expansion, Contraction and Density in Gases

As matter expands the density (mass of matter in a given volume) will decrease making it "lighter".

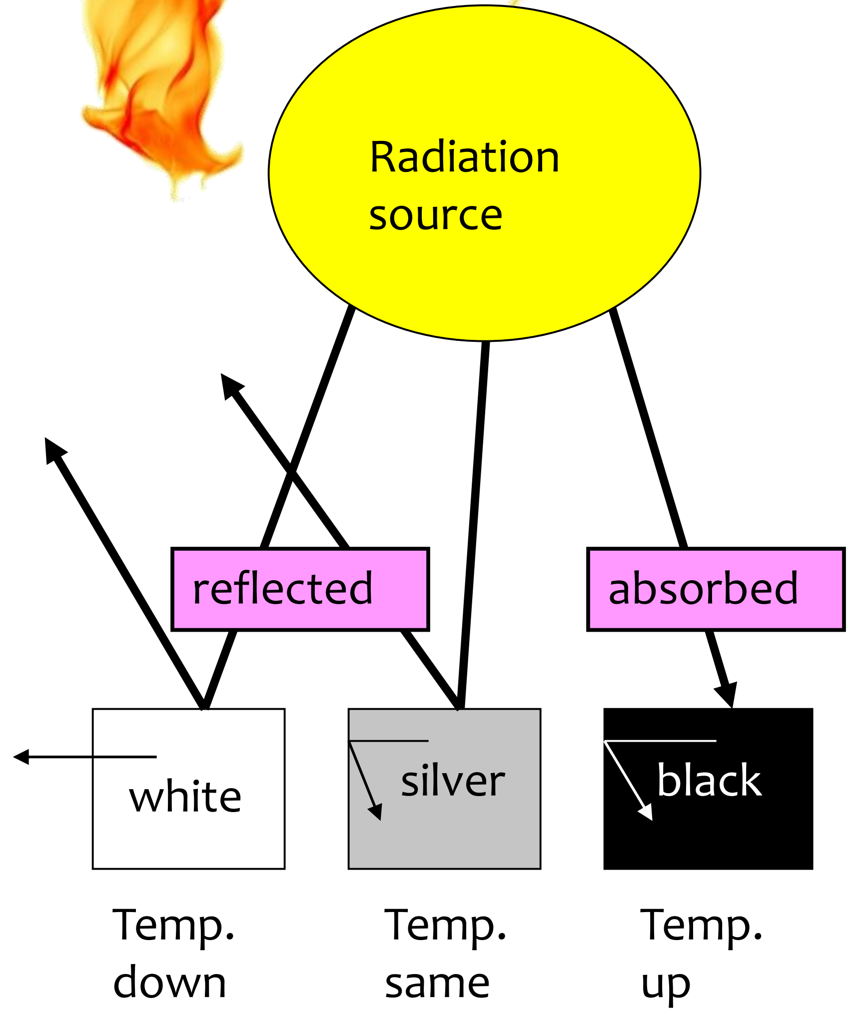
In a gas the warmer particles that are moving faster due to their increased kinetic energy are colliding with each other more. This creates more space between the particles and therefore makes that area of gas less dense. The less dense gas will rise above the colder more dense. This is why hot air rises to the top of a ceiling in a heated house.

Heat expands the space between air particles and cause the balloon to inflate when heated

Heating water to create expanding steam powered many engines and began the industrial revolution

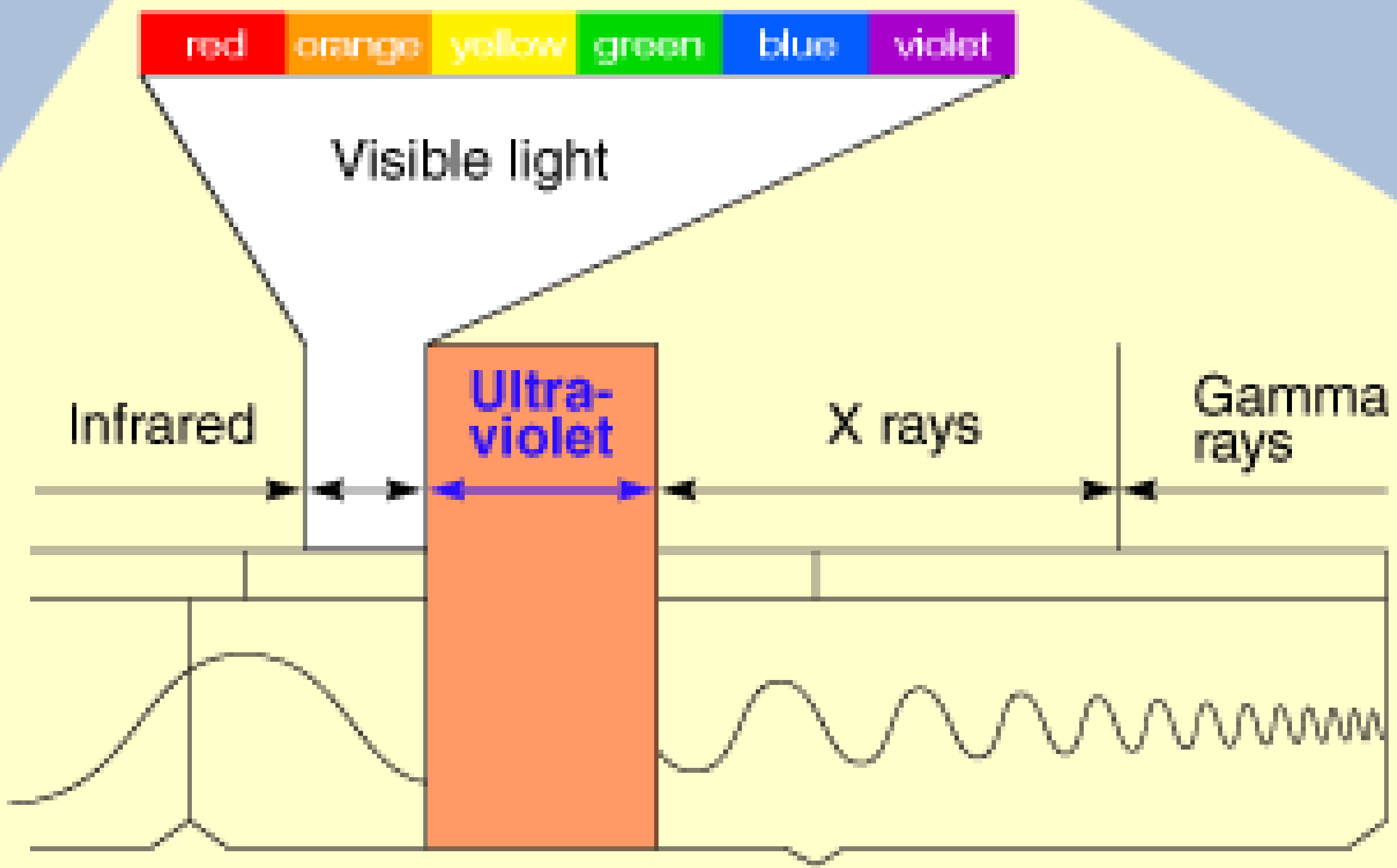
Vacuums transfer heat energy by Radiation

Any hot object emits heat energy in the form of **radiation.**
Heat Energy can transferred in waves – it does not need a medium to travel through. Our greatest source of radiation waves comes from the sun.
White and silver objects **reflect** radiation and very little heat energy is transferred to them.
Black objects **absorb** radiation and a large proportion of the heat energy is transferred to them.



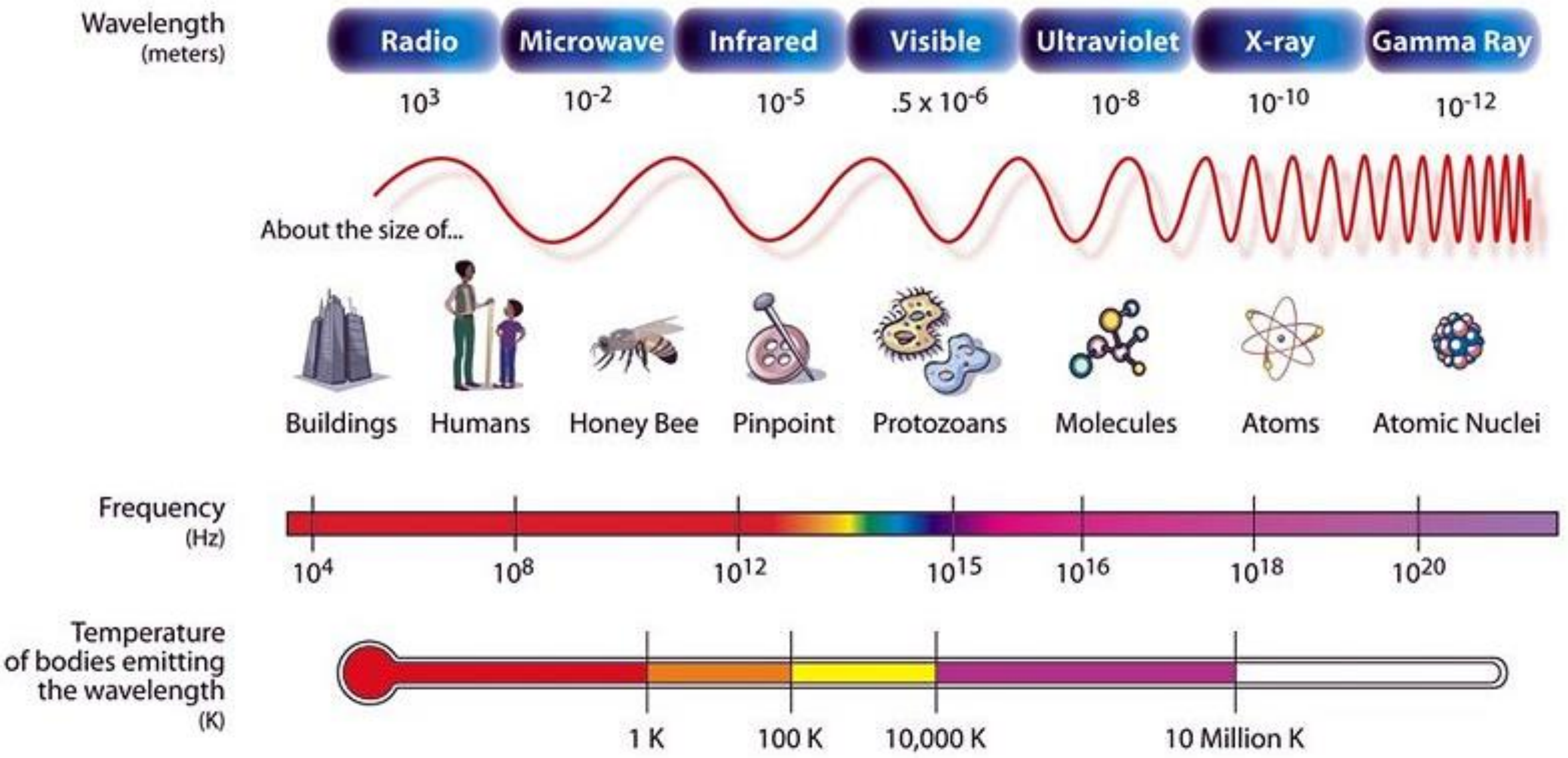
The Sun produces energy that is distributed to the Earth

The Sun releases large amounts of energy. The energy can be **emitted** from the energy source in the form of **electromagnetic radiation** and travels in **electromagnetic waves.** Heat, Light, radio waves and x-rays are all forms of electromagnetic radiation.



Heat energy belongs to the electromagnetic spectrum

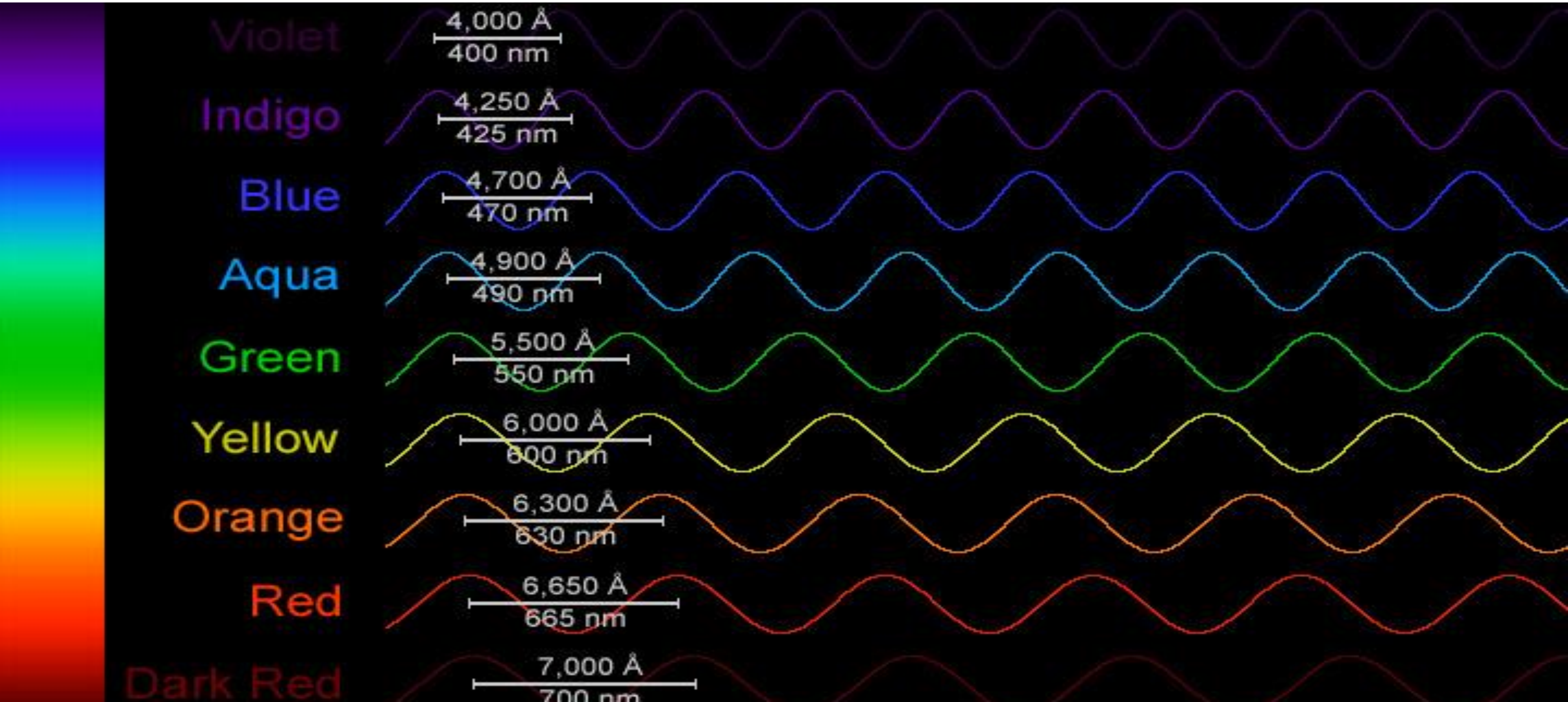
Heat is a type of energy called electromagnetic (EM) radiation. There are other kinds of EM radiation such radio waves, microwaves, x-rays, etc. Heat travels as infrared waves. All of the types of EM radiation together are known as the **electromagnetic spectrum.**



Energy can be transferred as waves

extra info

Light and other types of electromagnetic radiation from the sun and even further away stars travel through space in a vacuum – an area of very little or no atoms. Light does not need matter or a substance through which to travel. Each particular type of electromagnetic radiation, including each different colour of light, has a unique fixed length of wave, called the **wavelength** (λ), that it travels in.



The method of heat transfer is linked to the state of matter

Heat Transfer type	What does it travel in?	Does it require matter to travel?	Description	example
convection	Liquid And gas	yes	Heat energy contained by particles that move and carry it.	Hot air balloon rising when burner is going
conduction	solids	yes	Heat energy is passed from particle to particle.	A metal spoon heating up in a hot drink
Radiation	In a vacuum	no	Heat energy travelling in infra-red waves at the speed of light	Skin warming up while sitting in the sun

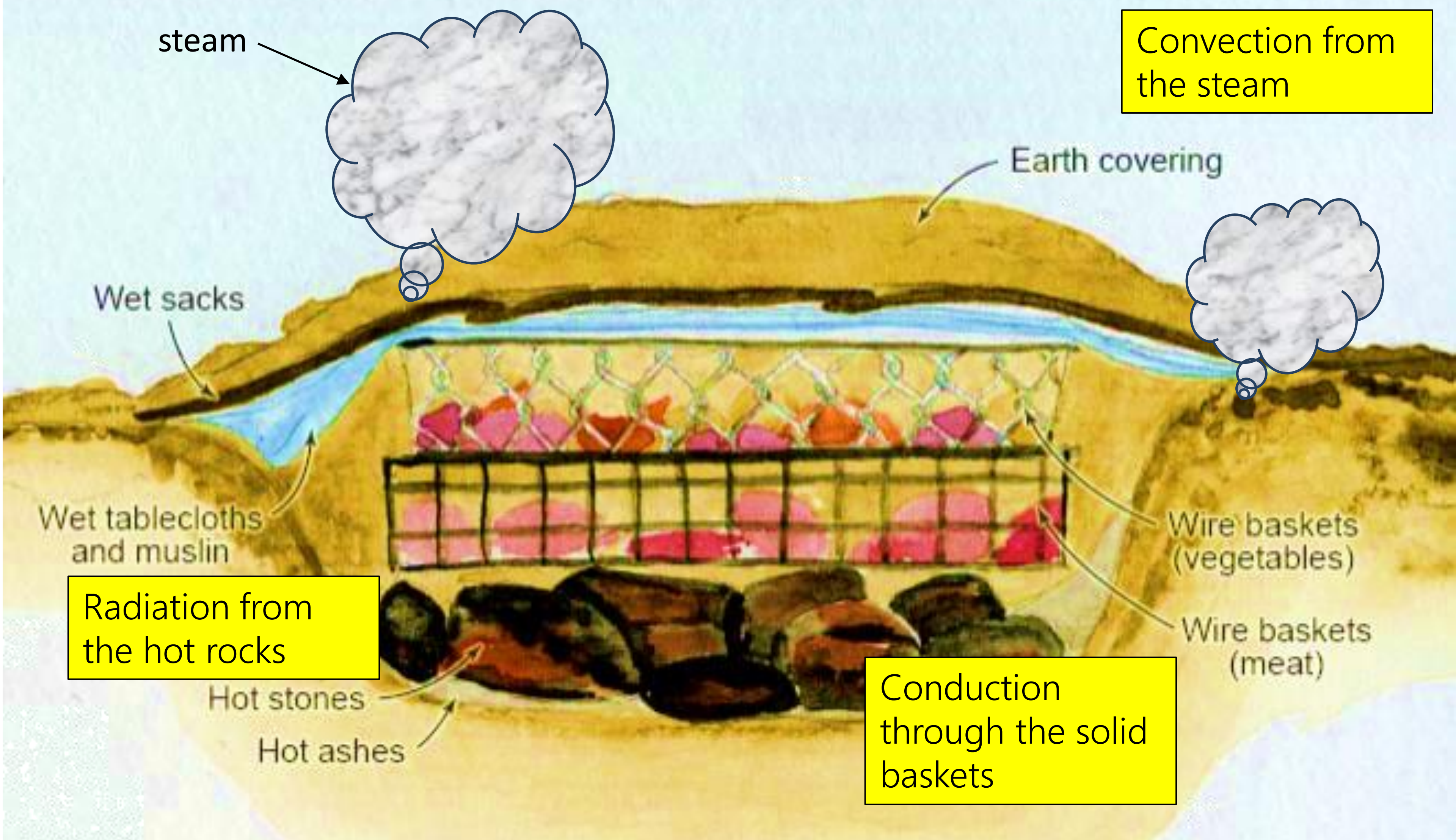
The method of heat transfer is linked to the state of matter

Conduction passes the heat energy from particle to particle and occurs in solids when the particles are fixed in place. This is like the rugby players passing the ball from one to another.

Convection requires particles to move around such as in liquid and gas and carry around the heat energy like a rugby player carrying the ball and running.

Radiation does not require particles to move the heat energy. This is like a rugby ball kicked which then moves by itself down the field without any players required.

Some situations transfer heat by many ways



In this Hangi there are many types of heat transfer occurring

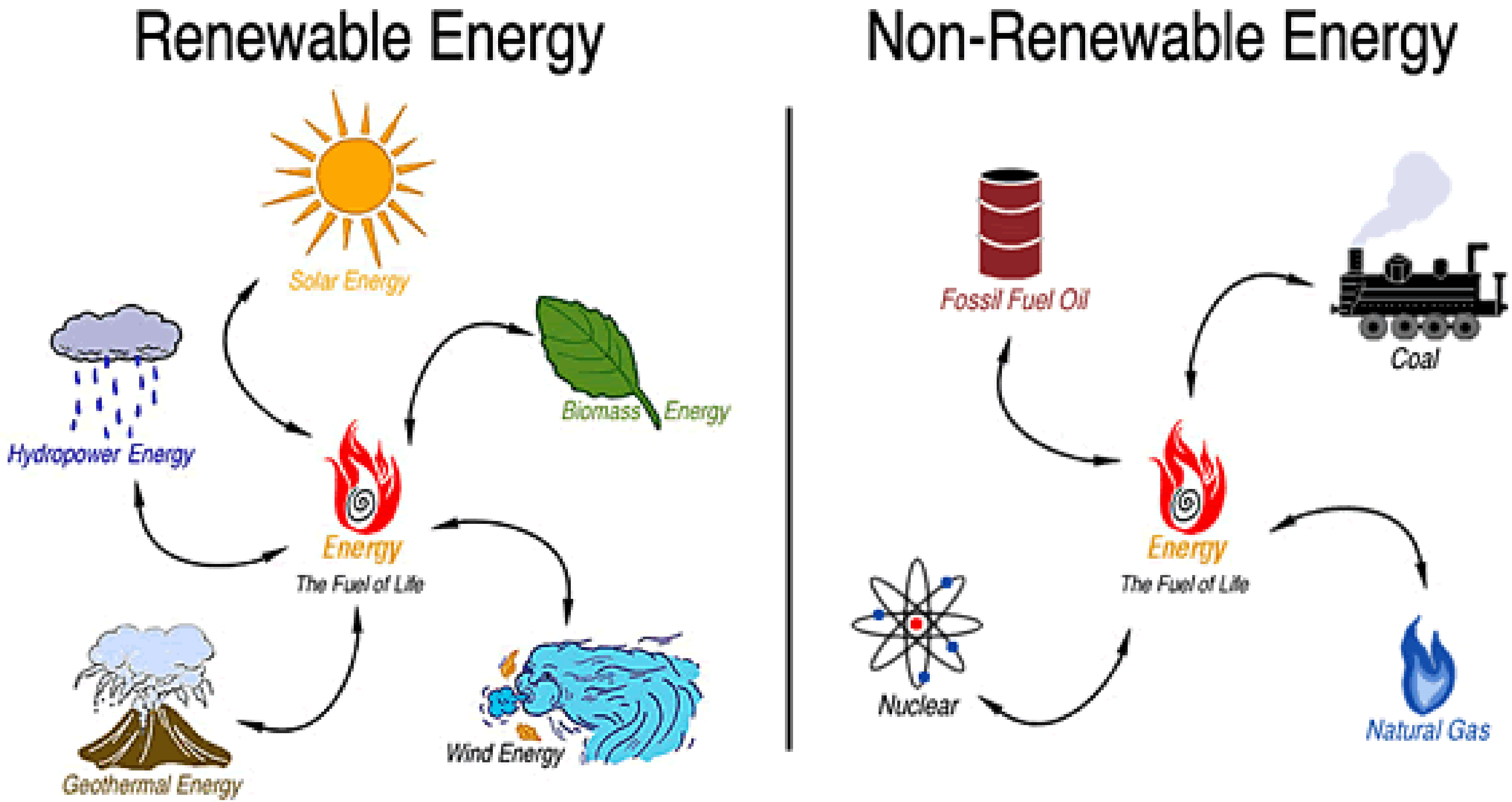
Renewable and Non-Renewable Energy

extra info

Energy sources can be divided into renewable and non renewable energy.

Renewable energy sources can be used continuously without running out. Renewable energy is available in unlimited amounts and technology has developed so we can convert it into electricity, heat and fuel for human use.

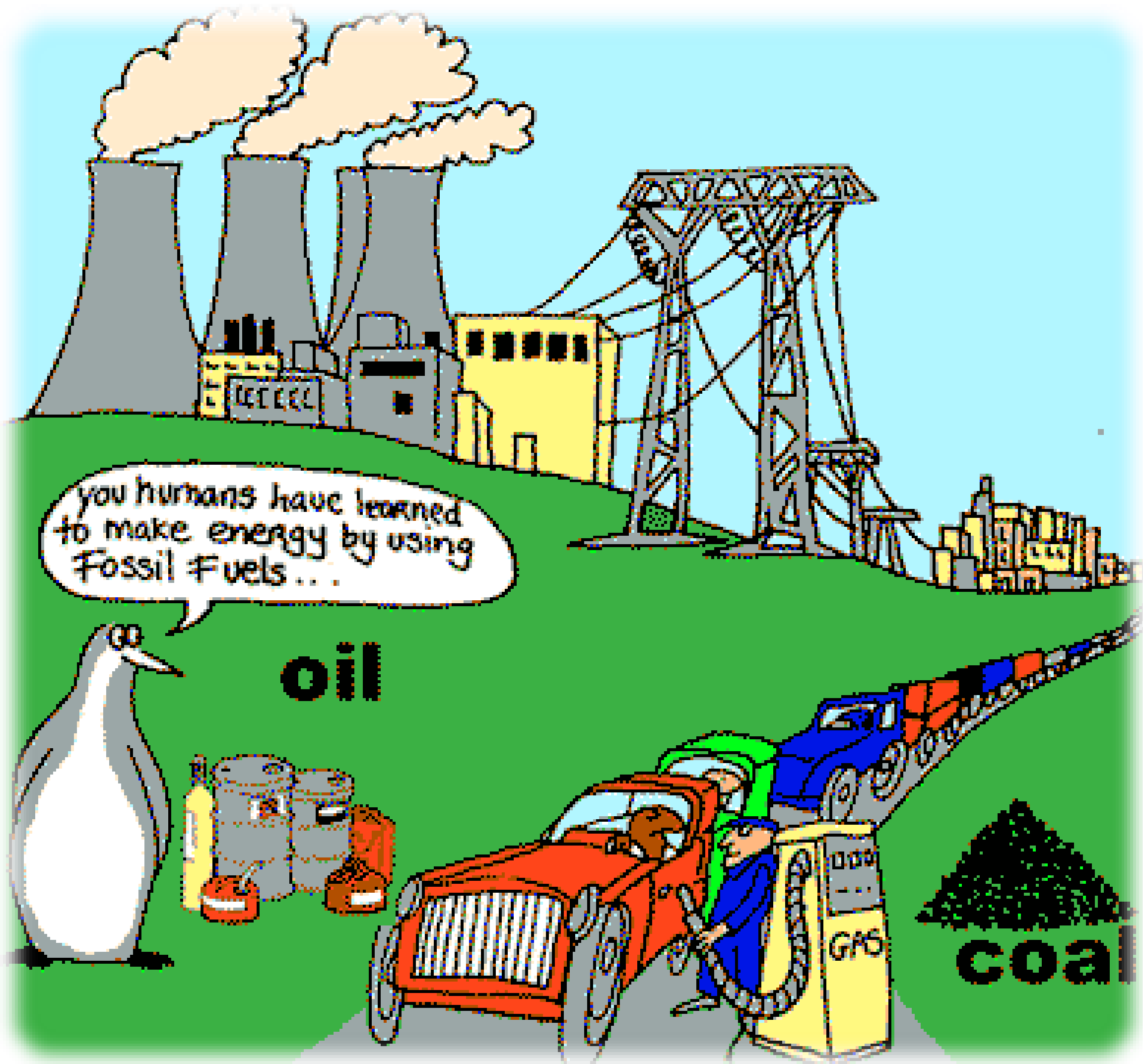
Non-renewable energy resources have often taken many millions of years to form and they are in limited supplies. Once they have been used up they can not be replaced.



Non-Renewable Energy

extra info

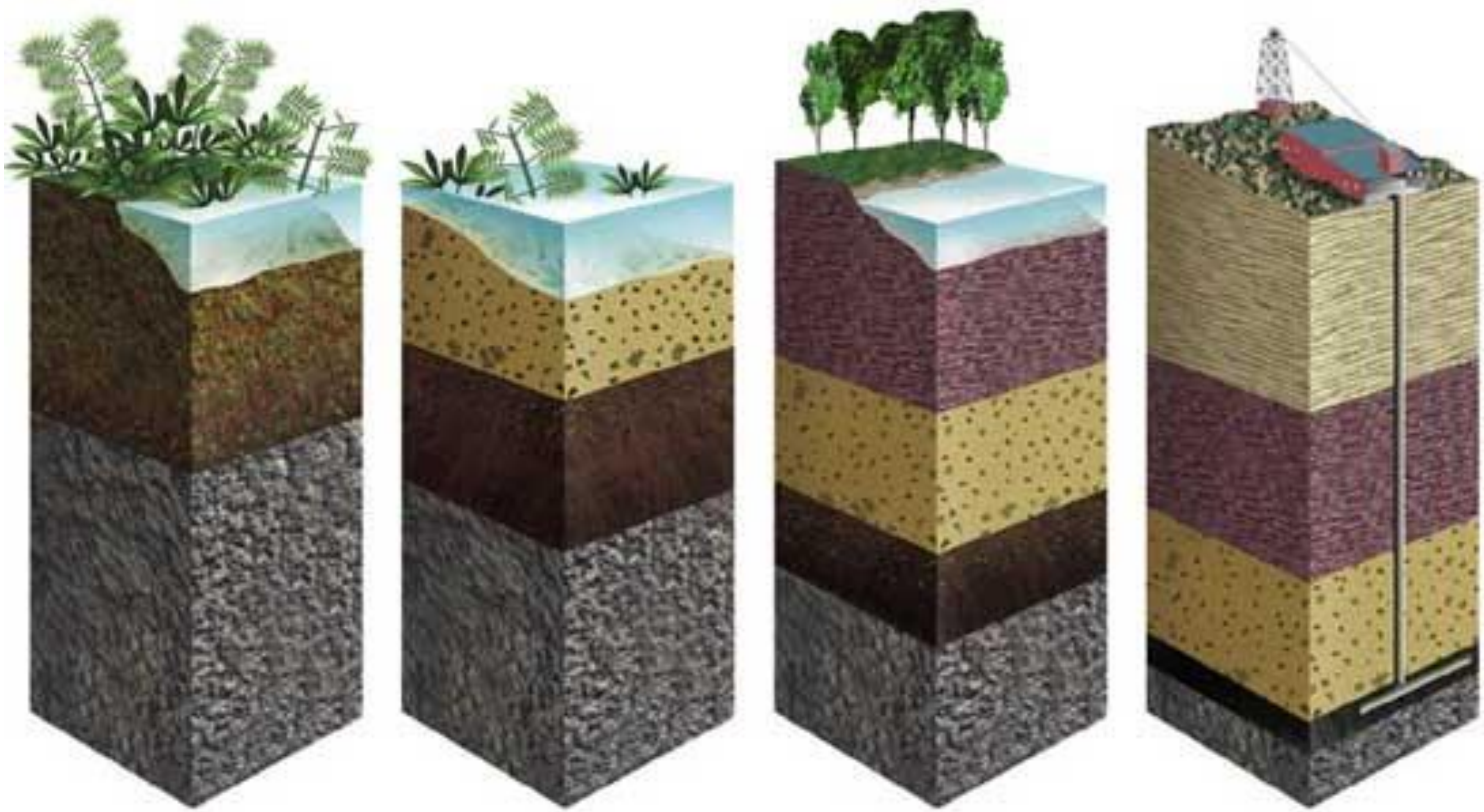
Non renewable energy is energy that comes from the ground and is not able to be replaced within a useful period of time. **Fossil fuels** are the main category of non renewable energy. Fossil fuels include; coal, oil and natural gas. These resources come from animals and plants that have died millions of years ago and then decomposed to create a useable source of energy for humans. **Mined minerals** such as uranium used for nuclear power are also non renewable sources of energy.



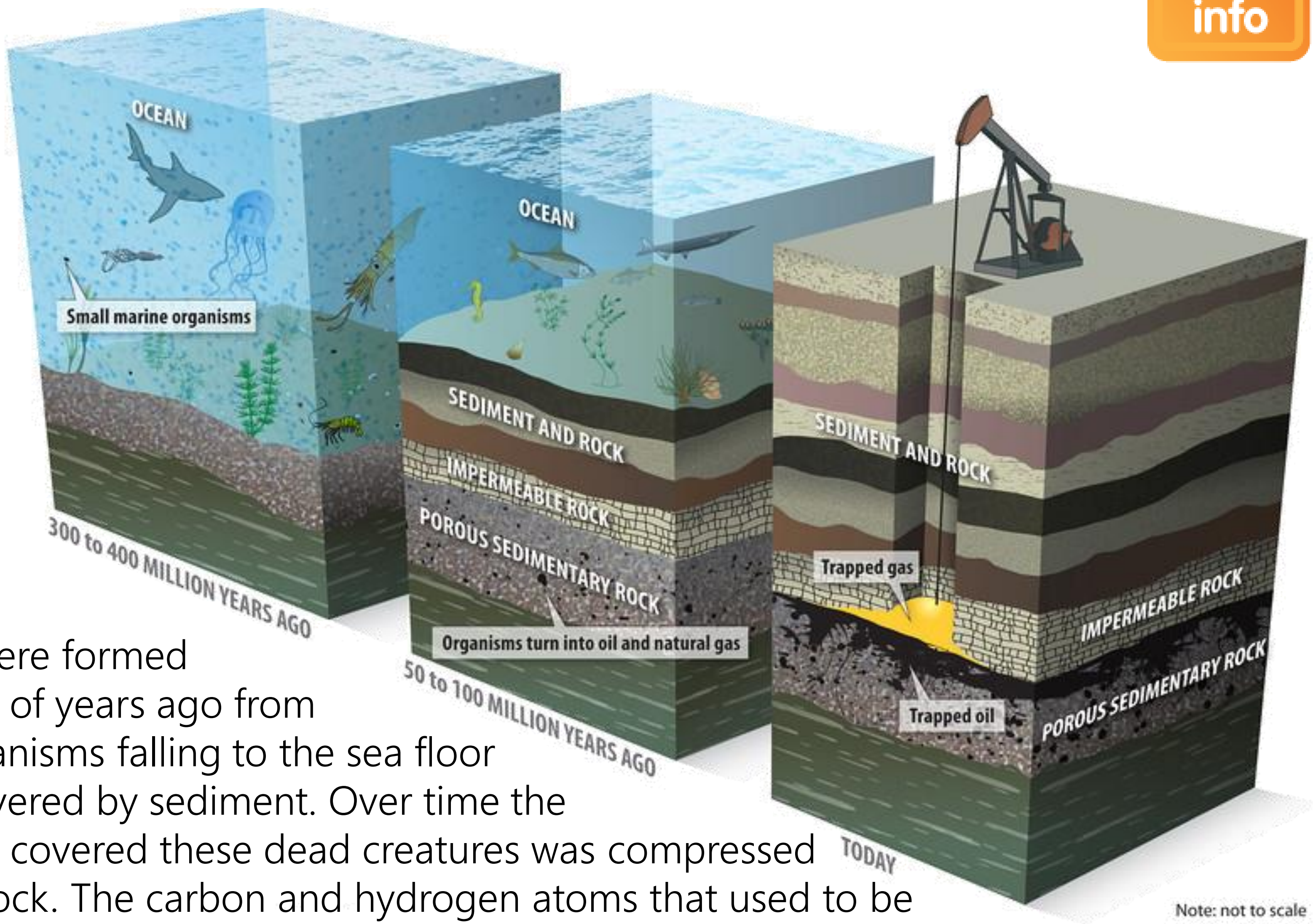
Fossil Fuels - Coal

extra info

Coal was formed millions of years ago when plants fell into peat swamps and were buried by heavy earth and rocks. Over millions of years, the weight of the rocks and heat in the ground turned the plants into coal.
Most of the world's coal was formed 300–350 million years ago during the **Carboniferous** period that was warm and damp, ideal for plant growth. New Zealand coals are much younger – they were made 30–70 million years ago and they are a less energy rich fuel. Coal is mined either underground or in large open cast mines.



Fossil Fuels – Oil and Gas



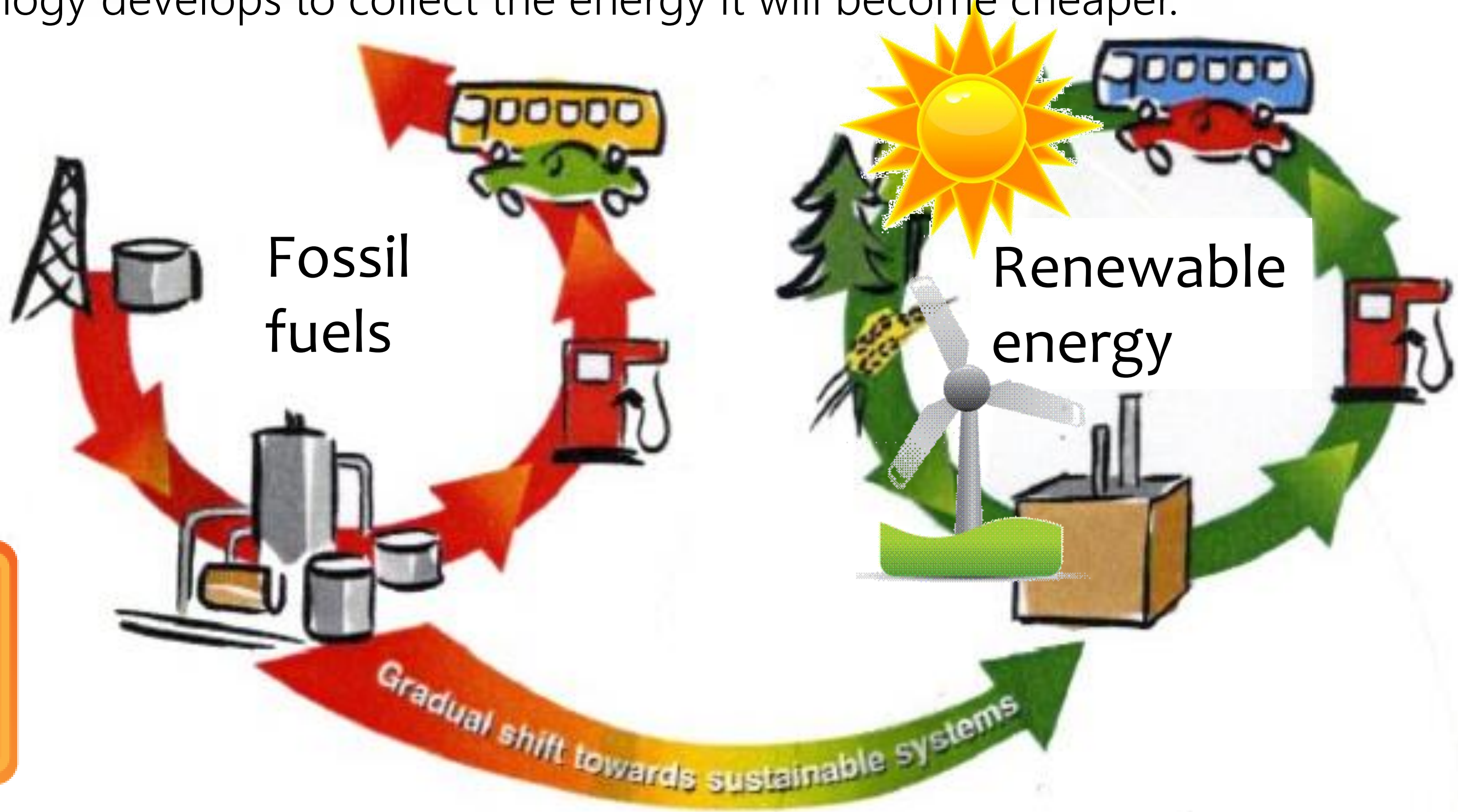
Oil and gas were formed many millions of years ago from dead sea organisms falling to the sea floor and being covered by sediment. Over time the sediment that covered these dead creatures was compressed and formed rock. The carbon and hydrogen atoms that used to be part of the dead organisms bodies reformed into fuel – the liquid form called oil and the gas form. Oil and gas are mined by drilling deep into the ground from oil rigs.

Renewable Energy

Energy is generated by the sun, and is stored in a variety of forms. It is locked into **biomass** through the process of photosynthesis. Burning biomass releases energy, as does decomposing biomass. Energy is stored in the oceans and fresh water where the movement of the earth and gravity release it through **tides** and **flowing rivers.** The earth's spin generate **waves** and **wind**. Heat, created from the center of the Earth, is released through **geothermal** activity. All of these energy sources can be used by humans.

The limits of fossil fuels and the unlimited energy of the sun

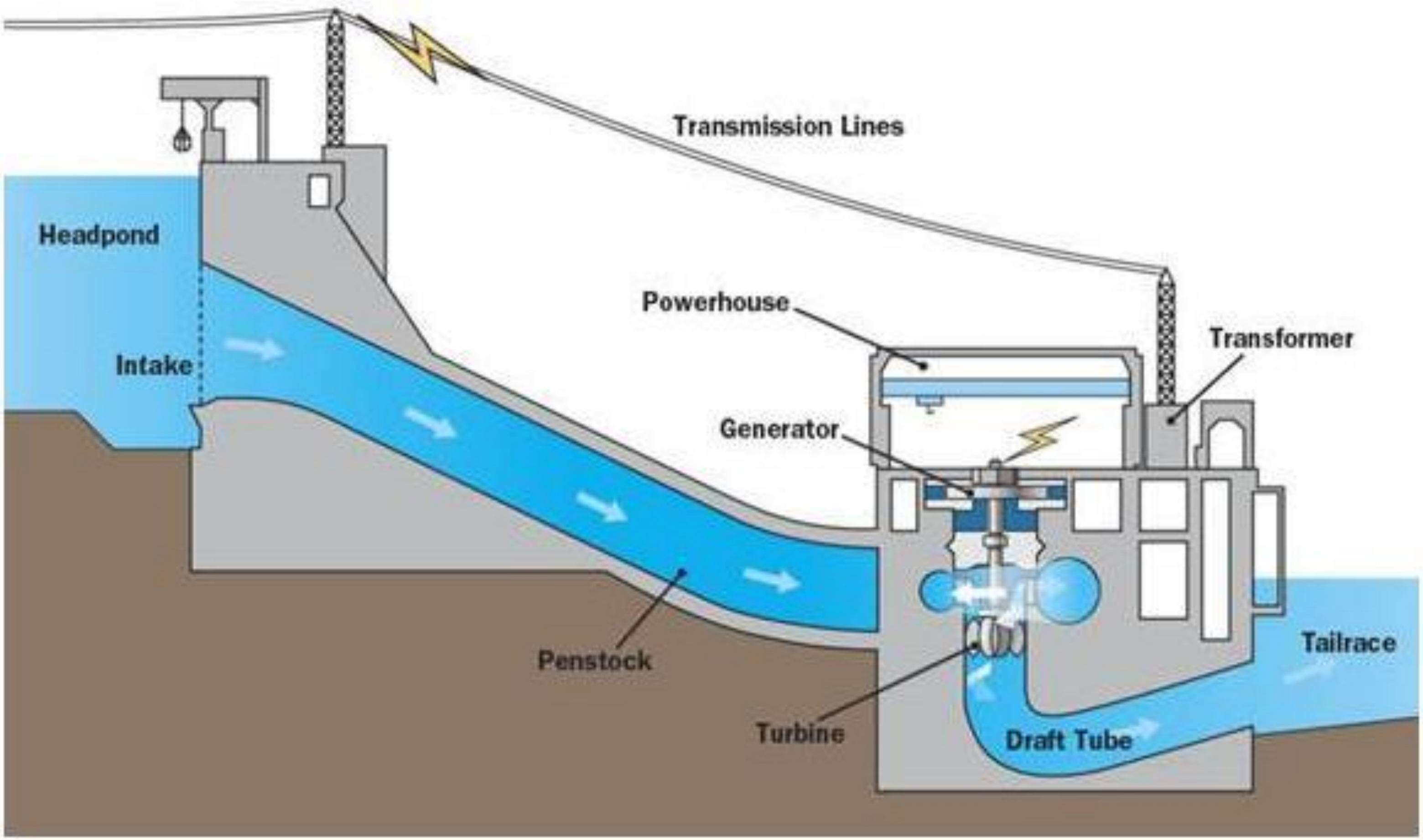
Fossil fuels are a limited resource. Extraction and mining can be expensive and can damage the surrounding area. Carbon dioxide gas, that is released upon burning the fuels, are contributing to the warming of the climate. Human society has a dependence on fossil fuels for energy but needs to consider alternative renewable energy sources to replace decreasing coal, gas and oil supply. Renewable energy is sustainable and in many cases produces little or no harm to the environment. As new technology develops to collect the energy it will become cheaper.



extra info

Hydroelectric energy

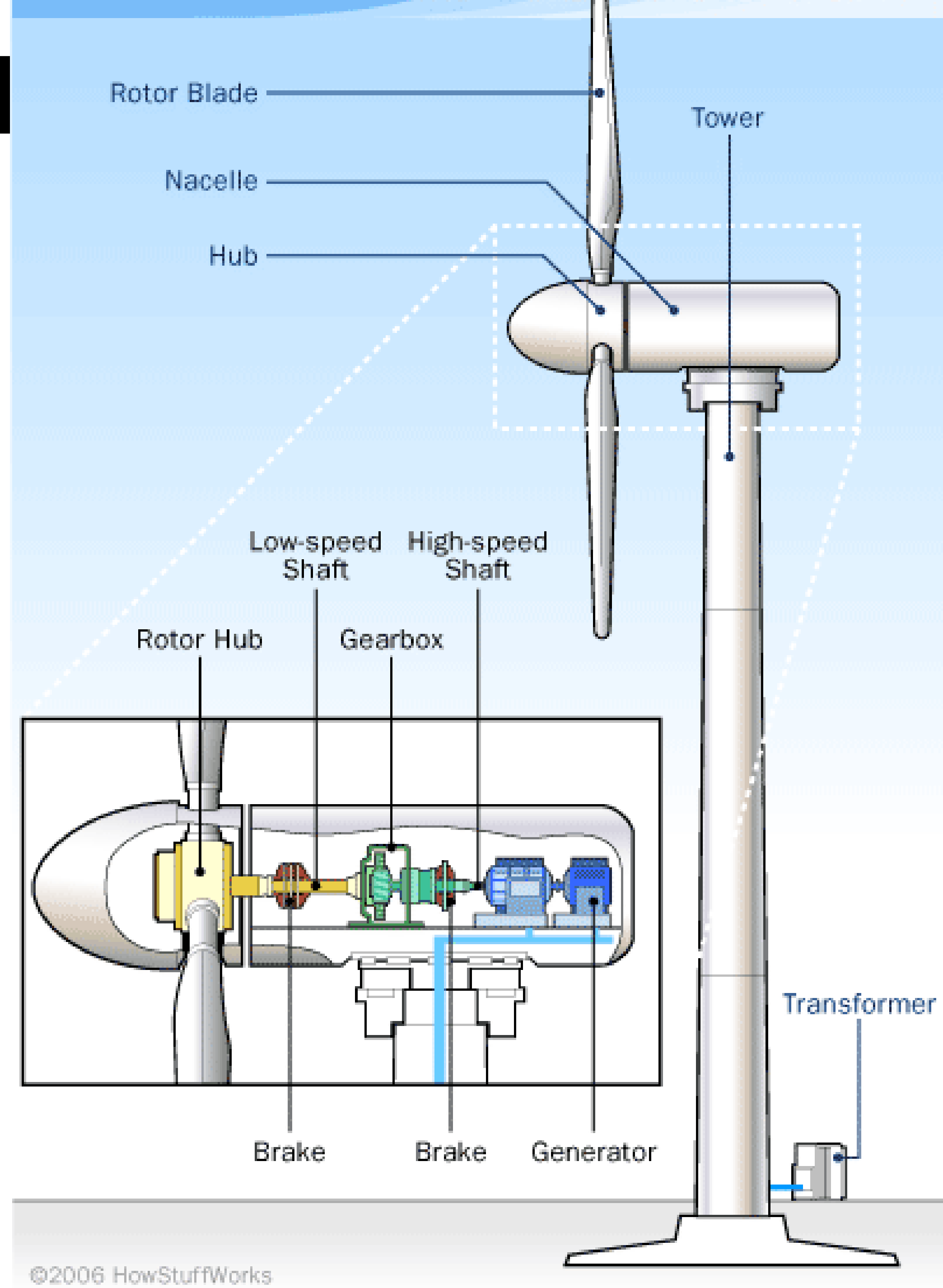
Hydroelectric power makes electricity by using the energy from falling water. The water comes from big dams across rivers, and flows down great tubes to drive electricity generators. New Zealand is fortunate to have many rivers, such as the Waikato river, which are suitable to make use of this type of energy source.



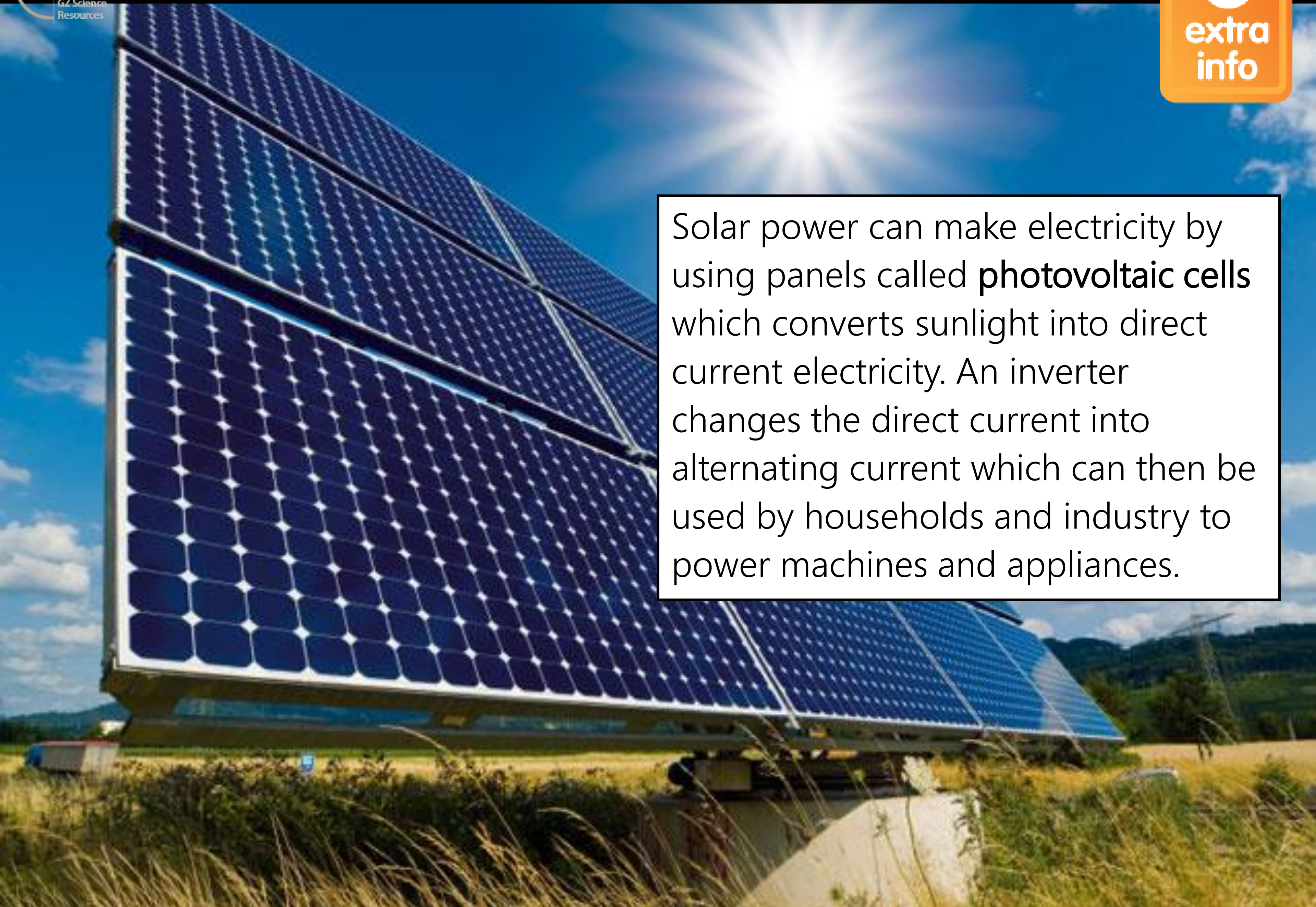
Wind energy

extra info

Wind power can drive a turbine with a propeller and generate electricity. Wind power is becoming more popular in New Zealand and a number of "farms" have been created such as along the hills in Manawatu and the new site between Hamilton and Raglan.



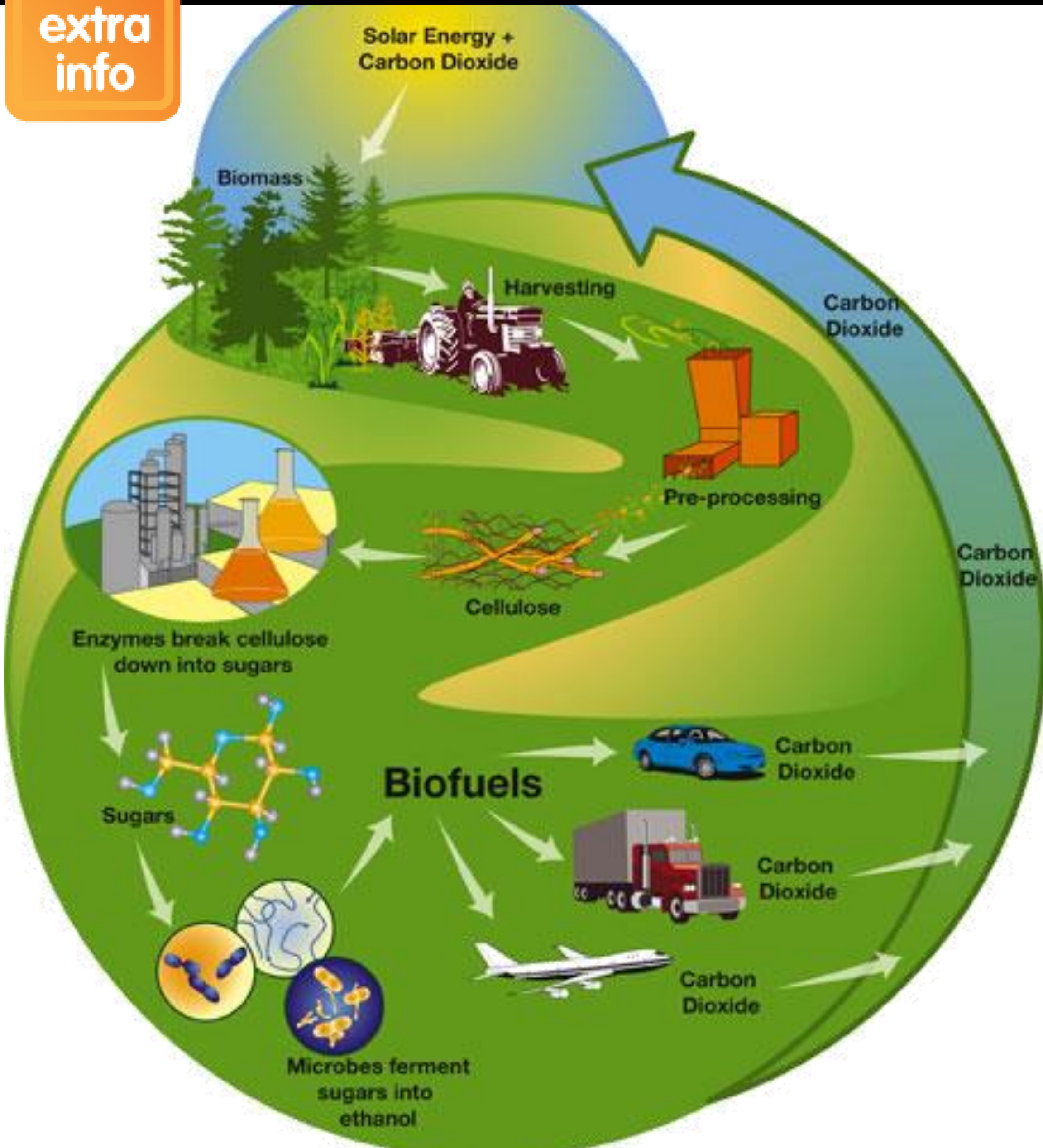
Solar energy



Solar power can make electricity by using panels called **photovoltaic cells** which converts sunlight into direct current electricity. An inverter changes the direct current into alternating current which can then be used by households and industry to power machines and appliances.

extra info

Biomass energy

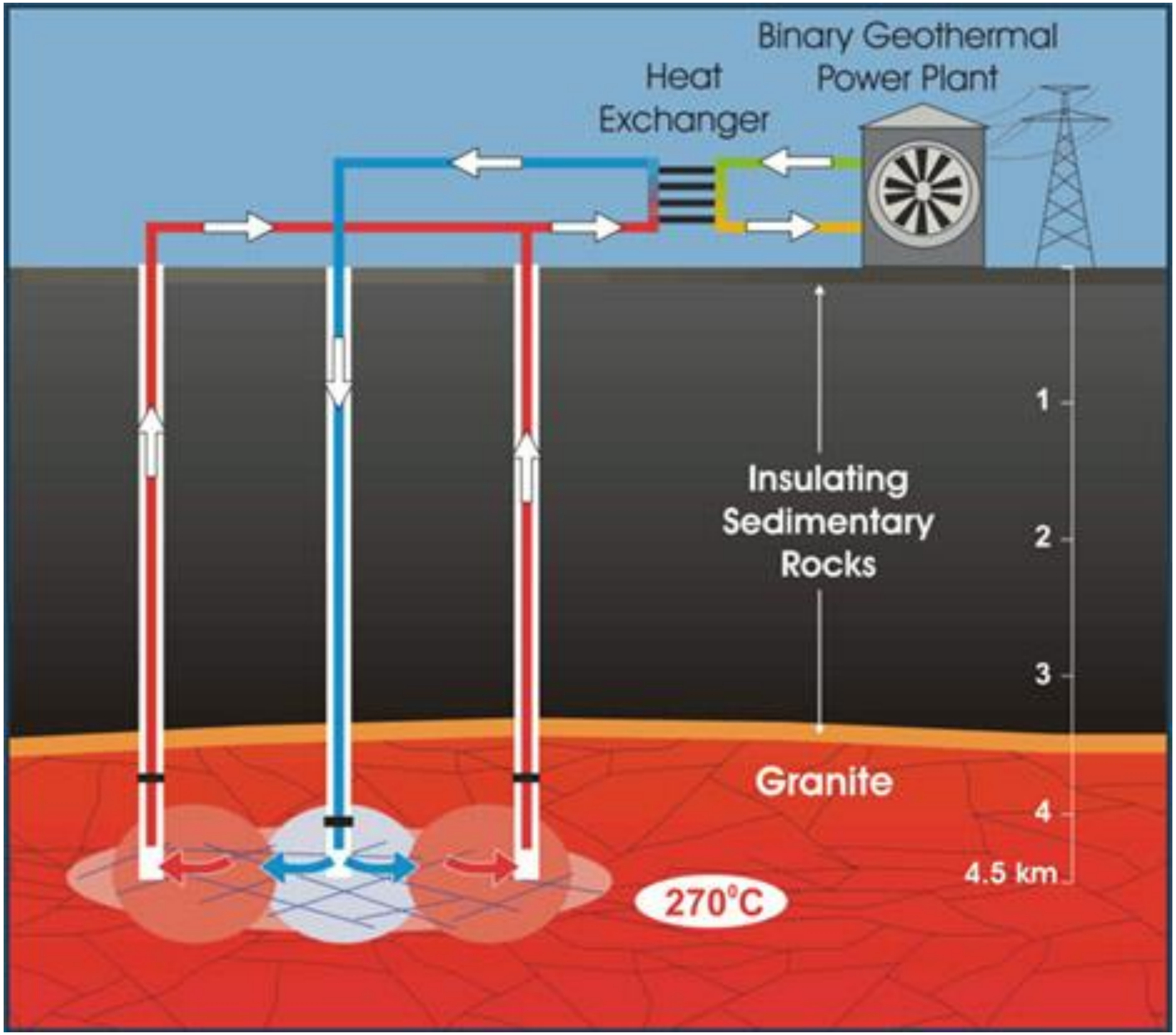


Biomass relies on the photosynthetic ability of plants to convert solar energy into chemical energy. The chemical energy stored in plants is then broken down by **enzymes** and useful **bacteria** into **biofuels** to be used in machinery.

This type of fuel is renewable as long as the same amount of trees are planted to replace those cut down. The carbon dioxide released when burning the fuels will also be reabsorbed by the plants as they grow.

Geothermal energy

Geothermal energy can be used to heat water pumped underground into hock rocks and the steam created then powers turbines to create electricity. Hot steam that comes from naturally occurring vents can also be used.



Summary of Renewable and Non-Renewable energy sources

Energy Source	Renewable/non-renewable	Advantage	Disadvantage
fossil fuels; oil, coal and gas	non-renewable will run out	*free if found *a small amount creates a lot of energy	*damaging to environment *adding to climate change *starting to run out
hydro	renewable not going to run out	*clean and non-polluting *free and cheap to run	*can destroy and flood land when hydro lakes are made *reduces flow of the river
solar	renewable	*free once set up and non-polluting	*does not run at night *solar panels can be expensive
wind	renewable	*free once set up and non-polluting	*turbines expensive to set up *noisy and some people do not like the look of them
nuclear	non-renewable	*very small amounts of chemicals needed for a lot of energy	*creates nuclear waste *can cause dangerous accidents with radiation
geothermal	renewable	*free once set up and non-polluting	*can only be used in a few areas
biofuel	renewable	*can be used in machinery that uses petrol	*creates pollution *needs land to grow plants
tidal	renewable	*free once set up and non-polluting	*only works at certain times and places