Science
Stage 5
Technology and electricity
Part 2

Education & Communities

Distance Education Science Network

Acknowledgments

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Fig 1: power plug www.accesscomms.com.au/reference/powerplug.htm
Fig 2: series circuit CLI
Fig 3: parallel circuit CLI
Fig 4: power point www.resources.mhs.vic.edu.au/science/resources/home_electricity.htm
Fig 5: coloured power plug details www.unitechelectronics.com/sparks.htm
Fig 6: plug and power point www.cnx.org/content/m42416/latest/?collection=col11406/latest
Fig 7: recharger www.allroundsz.manufacturer.globalsources.com/si/6008811961484/pdtl/Mobile-phone/1023666060/Mobile-Phone-Travel-Charger.htm
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Version date: September 2014

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Contents

Outcomes

By completing this unit, you are working towards achieving the following outcomes:

- process, analyse and evaluate data from first-hand investigations and secondary sources to develop evidence-based arguments and conclusions
- apply scientific understanding and critical thinking skills to suggest possible solutions to identified problems
- present science ideas and evidence for a particular purpose using appropriate scientific language, conventions and representations.
- apply models, theories and laws to explain situations involving energy, force and motion
- explain how scientific understanding about energy conservation, transfers and transformations is applied in systems

(Outcomes taken from the BOSTES NSW Syllabus for the Australian Curriculum SCIENCE Years 7 - 10, 2013)
Content Statements: WS7.1b, WS8a, WS9b, PW1e, PW3c

Resources

You will be sent a mini kit to use with this topic. You will also need to collect these items from home:

Part 1:

- a saucer or plate
- two AA batteries

Part 3:

Lesson 1

- piece of A4 paper
- scissors
- needle and thread or tape
- lamp
- saucepan
- teaspoon butter or margarine
- plastic spoon
- stove
- metal spoon
- wooden spoon

Lesson 3

- 2 identical glasses
- double-sided reflecting foil insulation
- two identical chocolates or two cubes of cheese

Please note that the mini-kit we have sent you contains the following items:

1.5V battery holder
two 2.5V flashlight bulbs and holders
4 plastic coated wires with alligator clip ends
Steel wool
Steel pin
Insulating foil
Thermometer

Icons

Here is an explanation of the icons used in Parts 1, 2 and 3

Write a response.

Compare your response with the one in the suggested answers section. Give yourself a tick if you were correct. Make any corrections.

Complete the Send-in exercises corresponding to the lesson.

Perform a practical task or investigation.

Glossary

The following words, listed here with their meanings, are found in the learning material in this part.

AC	alternating current, current moving backwards and forwards many times per second
appliance	device or instrument designed to perform a specific function, especially an electrical device
ceramic	pottery and porcelain made from different clay materials
circuit	a complete path travelled by an electric current
circuit breaker	device that breaks a circuit when the current is too large producing too much heat
coil	a wire coil - wire wound into loops
combustion	burning, using oxygen and releasing carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation funded by the Australian government
current	an electric current is a flow of electrons
DC	direct current , current flowing in one direction
efficient	a lot of output energy for a given input energy
electromagnetic induction	The relative movement of a magnetic field causing electrons to move in a wire
electrons	negatively charged particle from an atom
emissions	gases released
fuse	a device to prevent a high electric current from passing through a circuit.
generator	a machine for producing electrical energy from kinetic energy
grid electricity	electricity distributed by wire networks to homes and businesses
input	the energy and materials that go into a process

insulator	an electrical insulator does not conduct electricity, a heat insulator does not conduct heat
mains electricity	grid electricity
output	the energy and materials that come out of a process
photovoltaic	The production of electric current at the junction of two substances exposed to light
pollution	unwanted substances in air or water, often harmful to living things
solar energy	energy from the Sun including light and heat energy
technology	application of scientific knowledge
transformer	changes the voltage of electricity
transmit	transfer
turbine	machine with blades around a central shaft or rod which rotates when a gas or liquid is directed onto the blades
voltage	the pressure pushing an electric current

In Part 2 of this topic on electricity you will learn how electricity is delivered to homes and businesses in Australia. We will start by looking at the wires and circuits involved.

Lesson 1: Electricity to the home

Most homes in Australia are connected to the mains (grid) electricity supply. In Part 1 you looked at the electricity meter box for your home. The meter box is attached to wires coming from an electric power producer as illustrated in Figure 1.

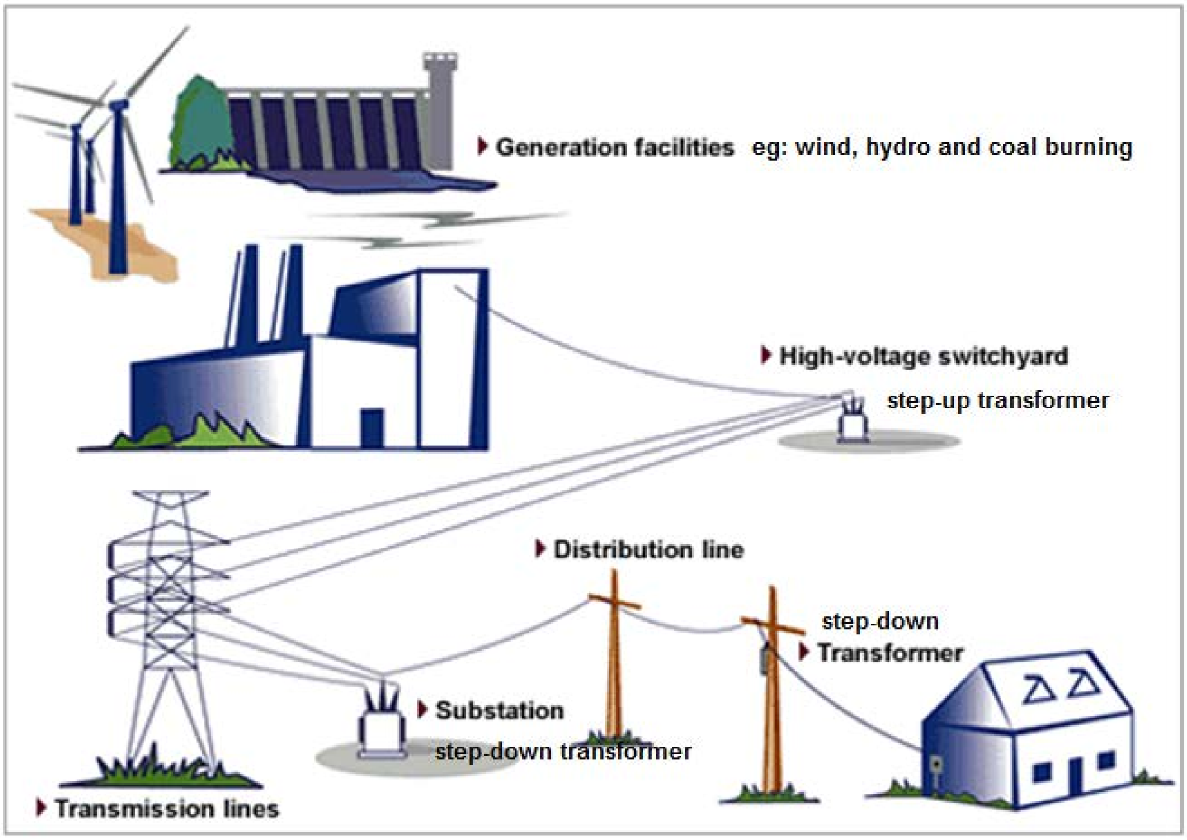


Figure 1

Once the electricity is produced its voltage is increased (stepped up) to a very high voltage in a transformer. This allows a lot of electrical energy to be pushed quickly over long distances through thick conductors. Once near your home substations and transformers on telegraph poles reduce (step down) the voltage so it is safer for home use.

Mains electricity is supplied to your home by active and neutral wires covered in insulating plastic:

- the active wire or live wire brings electricity from a power plant to your meter box - AC (alternating current) at 240 volts.
- the neutral wire carries electricity back to the power plant from the meter box.

In your home the active and neutral wires branch out from the meter box to form many circuits. The meter box contains a circuit breaker or fuse for each circuit.

Figure 2 shows a house with eight different circuits.

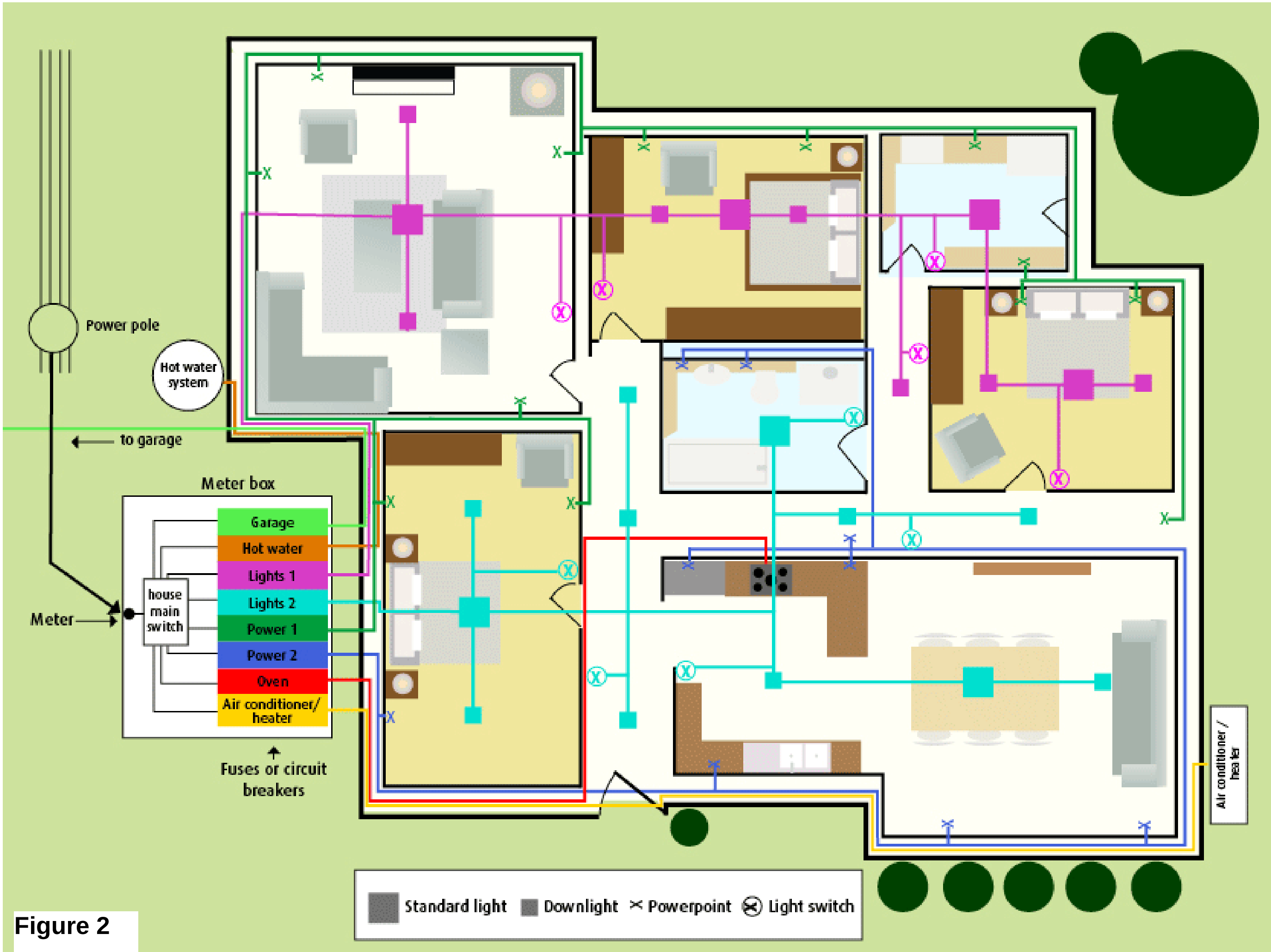


Figure 2

When an appliance is plugged into a power point and switched on:

1. electricity from the active wire moves from the meter box through a circuit breaker to the active slot of a power point
2. electricity then moves to the active pin of the plug
3. electricity moves through the appliance and back to the neutral power point pin.
4. electricity moves from the neutral socket slot to the meter box.

active wire ⟹ **appliance** ⟹ **neutral wire**

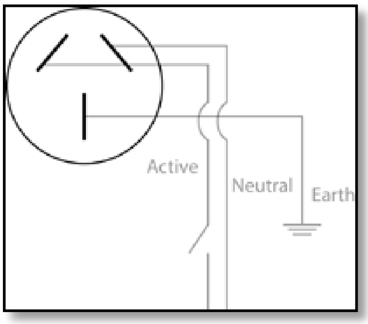


Figure 3: Power point slots

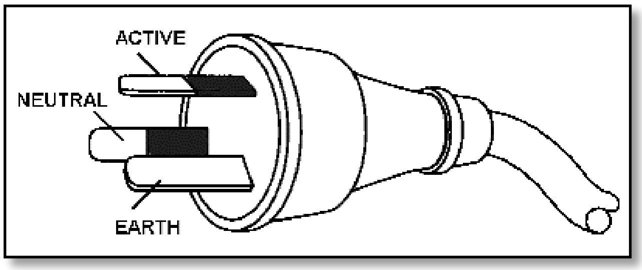


Figure 4: Appliance power plug

In the meter box a meter measures the amount of electricity used by the appliance. The circuit breaker or fuse in the meter box breaks a circuit if its wires get too hot. This can occur if a lot of appliances are turned on in a circuit at the same time.

Activity 1: Analysing household circuits

1. Describe the changes in voltage that occur as electricity moves from a power plant to a home.

   ____

   ____

2. Explain why there are two wires going from a telegraph pole to your home.

____

____

3. In Figure 2 trace the Power 2 circuit that leaves the Power 2 circuit breaker in the meter box.
Imagine you are in the kitchen in the morning and you turn on the toaster, the kettle, the microwave, your phone recharger and the iron. Everything was going well until you turned on the iron. When you switch on the iron everything goes off.
Explain what breaks (turns off) the Power 2 circuit.

____

____

Compare your responses with the ones in the suggested answers section

What about the third pin in a plug?

Most electrical appliances have three pin plugs. The longer pin is called the earth. It connects to the vertical earth slot in a power point which is connected to the ground via the meter box. In your home the earth wire from the meter box will be connected to a water pipe leading underground.

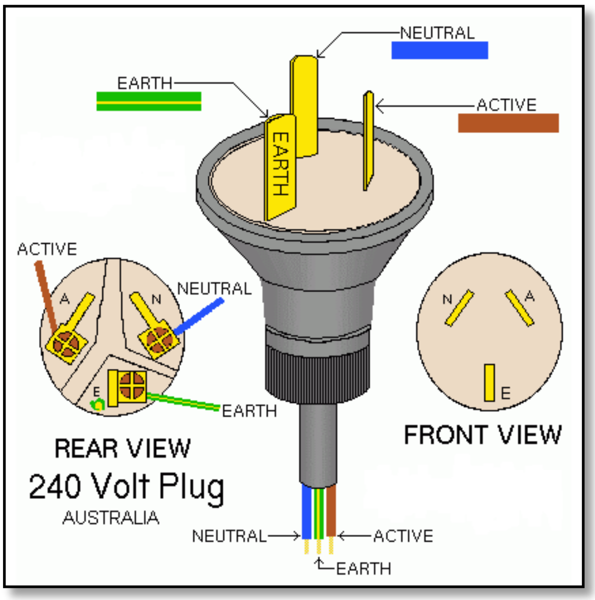


Figure 5

Remember that metals are good conductors of electricity. Electrical appliances with a metal case such as washing machines, toasters and kettles, must have the metal case connected to earth wires in their plugs. Figure 6 shows the safe wiring of an appliance.

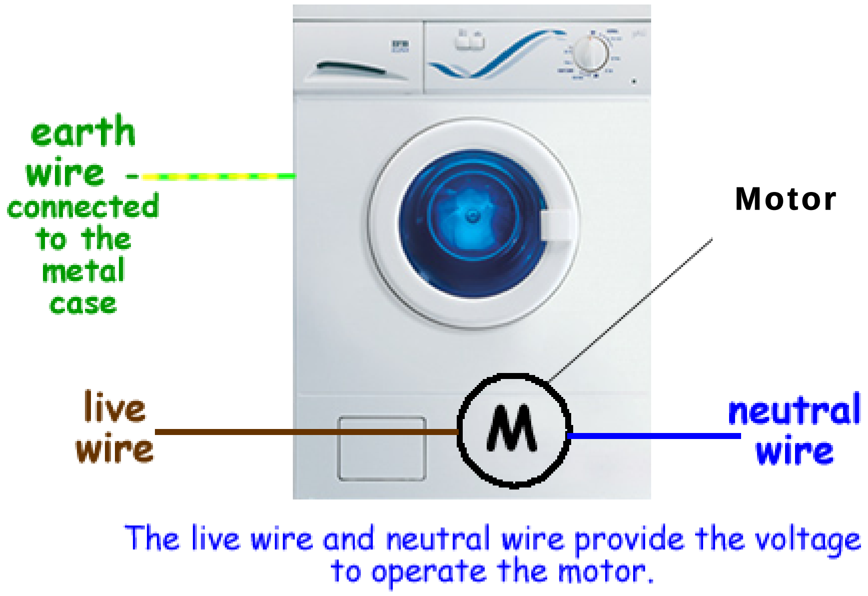


Figure 6

If a fault occurs electricity may flow into the metal casing of an appliance such as a toaster. If the toaster is wired correctly the current will flow to the earth wire as shown in Figure 7a. The flow through the earth wire causes the circuit breaker (or fuse) in the meter box to break the circuit.

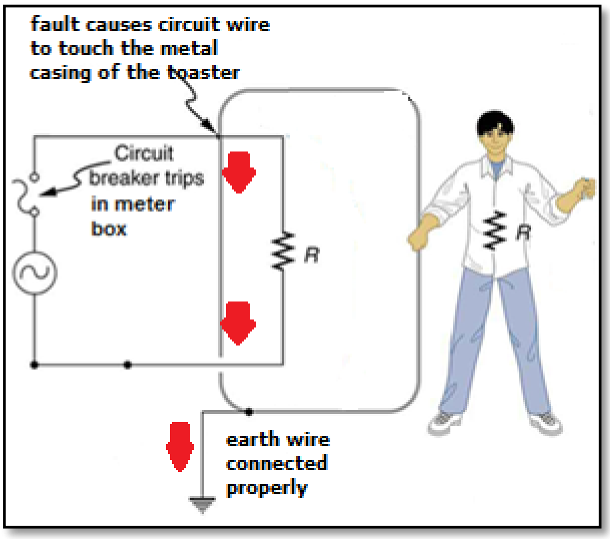


Figure 7a: Earth wire correctly connected

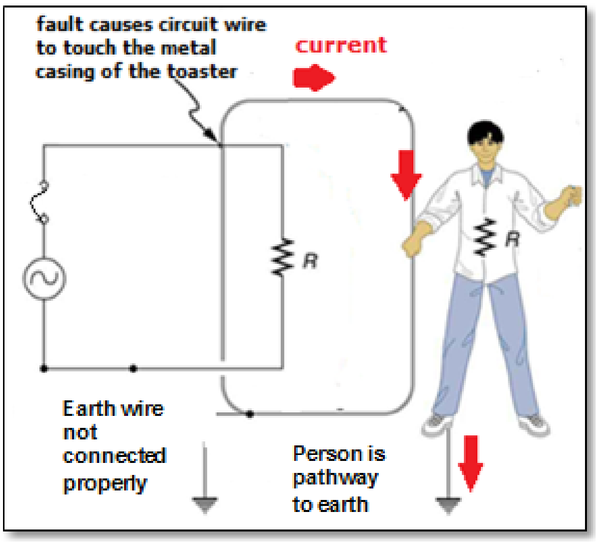
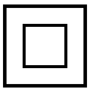


Figure 7b: Earth wire not connected. The person will receive an electric shock

Figure 7b shows what happens when a fault occurs, and the earth wire is not connected properly. If you touch the metal casing of the toaster, the current will flow through the low resistance of your body to get to Earth. This would give you an *electric shock*.

Two pin plugs

Figure 8

Have you ever wondered why your phone recharger or your hair dryer only has a two pin plug. Such appliances do not need an earth pin as they are totally surrounded by plastic which is a great insulator. This protects you from any electrical fault by preventing electricity flowing to you. These appliances are called **double insulated** and will be marked with this symbol 

Short Circuit

A short circuit is shorter than the intended circuit in an appliance or house wiring. Somehow a fault occurs and wires that shouldn't touch, do connect. This causes the electricity to flow through a shorter circuit path. This can cause more current to flow through wires producing **more heat** as illustrated in Figure 9.

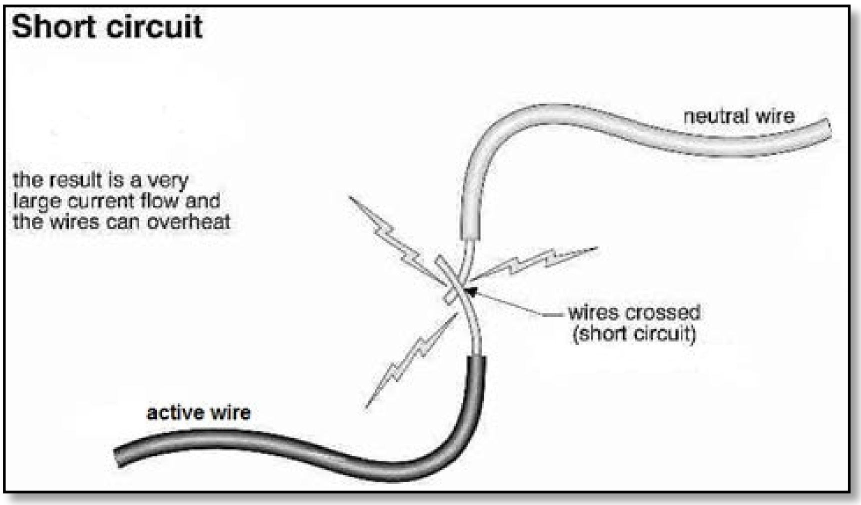


Figure 9

Again a circuit breaker in the meter box in your home will act as a safety device and will operate to stop the flow of electricity in the short, hot circuit.

Activity 2: Analysing power points

1. Have a look at your toaster to see if it has a metal base. Have a look at the plug attached. Most toasters have a three pin plug. Why is this so?

   ____

   ____

2. What would happen if the live active wire in a double insulated hair dryer touched the plastic case?

   ____

   ____

3. Explain three conditions that will cause a circuit breaker to “trip” or turn off and stop power to a circuit.

   ____

   ____

   ____

Compare your responses with the ones in the suggested answers section

Think back over the main points in the lesson then read the following summary.

Summary of Lesson 1

- Main supply (grid) electricity in Australia supplied by power stations is delivered to homes as AC 240V electricity.
- An active (live) wire and a neutral wire are connected to the home through the meter box to take electricity to and from the power station.
- AC is alternating current (backwards and forwards) and DC is direct current (in one direction).
- Appliances with metal cases have three pin plugs: an active/live pin, a neutral pin and an earth pin.
- Appliances with two pins are double insulated
- A short circuit can allow a large current to flow and a lot of heat to be produced.

EXERCISE

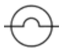
Complete the exercises for Lesson 1 in the Send-in exercises

Lesson 2: Types of circuits

Now you will learn about the different types of electric circuits that can be used in your home.

Remember these circuit diagram symbols from Part 1.

A power point source of electricity is represented by the symbol 

A light is represented by the symbol 

Series and Parallel Circuits

Series Circuit - the light globes in this circuit are arranged one after the other. None of the light globes will shine if the circuit is broken in any place. If one globe breaks, this will break the circuit and none of the globes will light up.

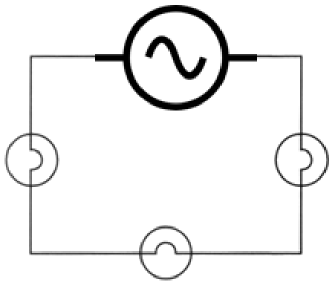


Figure 10: Series circuit

Parallel Circuit - the light globes in this circuit are parallel to each other. An electric current travels along three different pathways. If one of the light globes breaks there will be two pathways left. Two lights will keep shining in this parallel circuit.

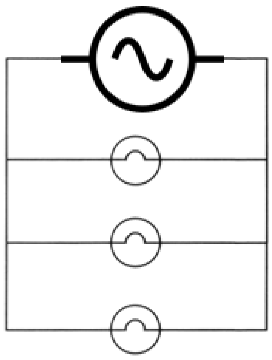


Figure 11: Parallel circuit

Now you will investigate if there is a difference in the brightness of lights wired in series or parallel.

Activity 3: Investigating bulbs in a parallel and series circuit

Aim: To see if globes in a series or parallel circuit glow most brightly.

Materials:

two AAA batteries (each produce 1.5 volts)

one 1.5 V battery holder

two 2.5 V flashlight bulb and holder (each uses 0.3A of current)

four plastic coated (insulated) wires with alligator clip ends

Method:

Step 1: Set up the circuit as shown in Figure 11a.

Connect the red and black alligator wire clips to battery wires.

The two 1.5V AAA batteries connected one after the other in the battery holder give a 3V voltage push in the circuit.

You have created a series circuit. Notice how brightly the bulbs shine.

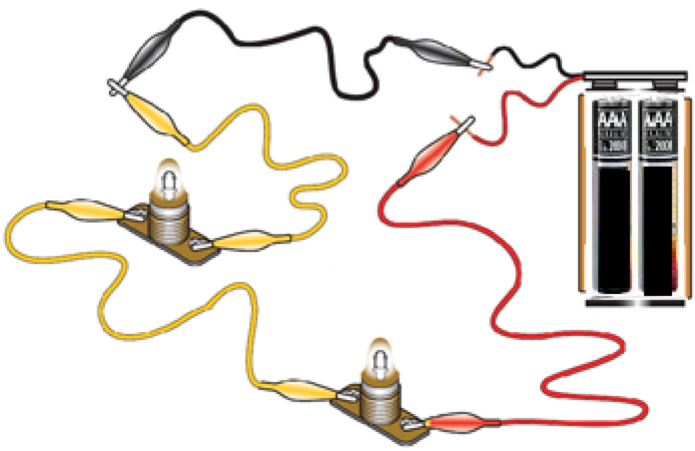


Figure 11a

Step 2: Set up the circuit as shown in Figure 11b

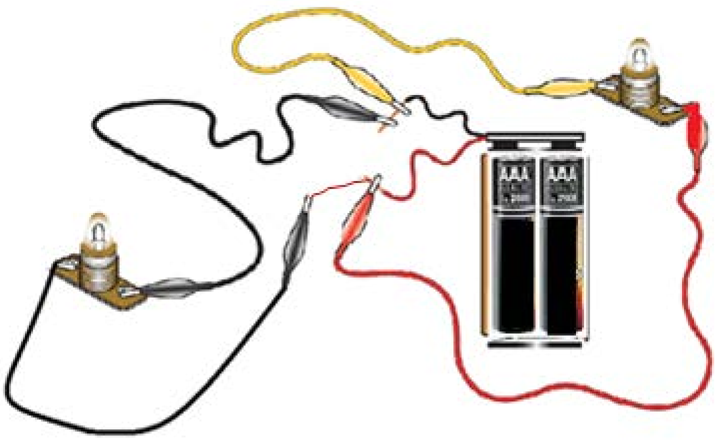


Figure 11b

Connect the red and black alligator wire clips to the battery wires.

You have created a parallel circuit. Notice how brightly the bulbs shine.

Step 3 Record your observations by comparing the brightness of the two circuits you created.

Observation of brightness: _______________________________________

____

Conclusion: (a statement relating back to the aim of the experiment).

Complete the following conclusion statement.

The globes in the parallel circuit shone _____________ brightly than the globes in the series circuit.

Compare your responses with the ones in the suggested answers section

Can you think why this is so?

Remember in Lesson 4 of Part 1 you learnt about the relationship between current, voltage and resistance called Ohm's Law. It can be written as an equation:

$$I = \frac{V}{R} \quad \text{or} \quad V = IR \quad \text{or} \quad R = \frac{V}{I}$$

Where V is voltage, I is current and R is electrical resistance of the wires and the globes.

In the parallel circuit you made, each of the two circuit pathways receives the full circuit voltage from the batteries and the maximum current.

When the two light bulbs are connected in series, the resistance of the overall circuit pathway doubles. This reduces the current flow through the globes and the brightness.

If you made these two circuits and let them work for days you would notice that the batteries in the parallel circuit would go "flat" before the series circuit. This is because the parallel circuit uses more electrical energy (current).

Activity 4: Analysing different types of circuits

1. Describe the difference in the arrangement of lights in a series circuit and a parallel circuit.

   ____

   ____

2. Explain why household circuits are usually wired as parallel circuits.

   ____

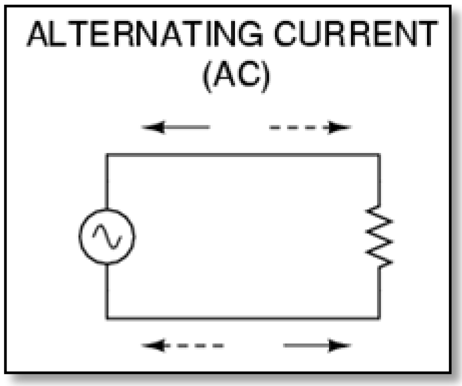
   ____

Compare your responses with the ones in the suggested answers section

More about AC and DC electricity

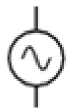
AC - stands for alternating current since the current changes direction back and forward.

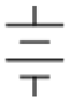
Remember the mains supply electricity delivered to your home is 240V AC which means the alternating current is pushed with a voltage of 240V. This current moves backwards and forwards 50 times a second which is called 50 hertz (Hz).



DC - stands for direct current where the current flows in one direction only.

Notice the different symbol for AC and DC power in the circuit diagrams for Figure 12 and Figure 13

 is the power symbol for AC electricity

 is the power symbol for DC electricity

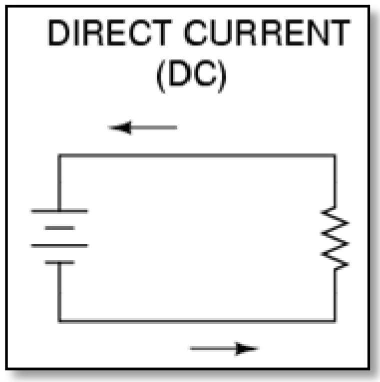


Figure 13

Power stations today produce AC electricity as it is easier to increase its voltage push by transformers to send the electricity over long distances. DC electricity cannot be transmitted more than 2km without losing voltage and so cannot travel very far from a power station.

Batteries produce DC electricity.

Figure 14

Have a look at your mobile phone recharger that you use to recharge the phone battery. You may find an information label on the recharger or the box it came in.

Figure 15 shows an example of such an information label.

Reading from the top the label tells you:

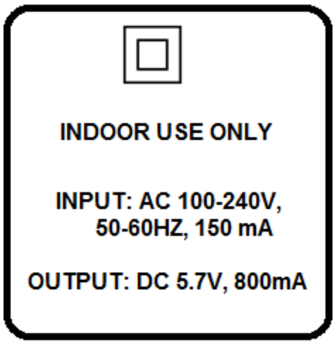


Figure 15

- it is double insulated and will not conduct a current to you when you touch it, (remember this symbol from page 14)
- it is to be used inside
- it can be used in power points that deliver an INPUT of between 100 and 240 Volts, AC electricity going backward and forward 50-60 times a second (50Hz)
- it uses 150 mA (milliamperes) of current (1 mA = $\frac{1}{1000}$ amps).
- it contains a transformer that transforms the AC INPUT from the main supply power point to an OUTPUT of DC electricity.
- The DC electricity produced has a voltage of 5.7V and a current of 800mA to recharge the phone battery

Recharging the phone battery gives it a store of DC electricity that can power your phone for about 24 hours.

Activity 5: Analysing electrical labels

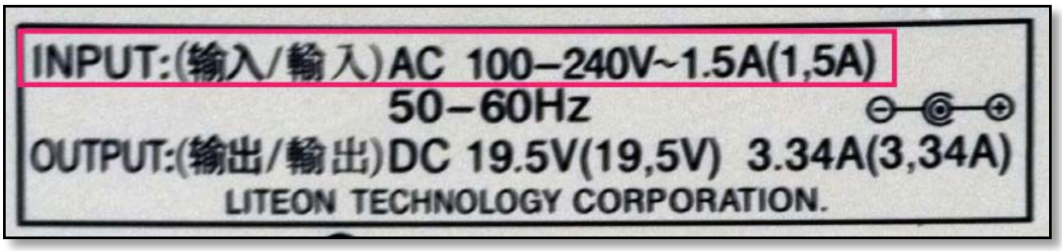


Figure 16

In this label of a charging device describe:

1. the INPUT current

   ____

2. the OUTPUT current

   ____

Compare your responses with the ones in the suggested answers section

Safe practices

To use electricity safely you need to remember that:

- electricity will take the shortest, easiest path to earth with the least resistance
- large currents will transform a lot of electrical energy into heat energy

Here are some safety tips to follow.

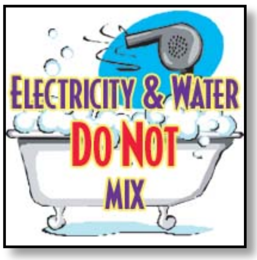


Figure 17

1. Keep all cords and appliances dry and clear of water or damp areas. Water and your body have low resistance and can allow electricity to flow easily to earth giving you an electric shock.
2. Make sure all electric cords are in good condition with insulation covering all wires.

3. Don't put metal objects into appliances as metals are very good conductors.
4. Do not plug a lot of appliances into one power point. This will prevent too much current moving through the circuit.
5. When changing fuses or circuit breakers in the meter box, always disconnect the power by turning the main power switch off first.
6. Don't fly kites around power lines. Electricity can travel to earth down strings of kites that become tangled in power lines, and can cause fire or shock.

Figure 18

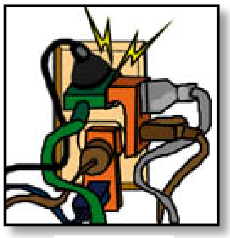


Figure 19

Figure 20

Think back over the main points in the lesson then read the following summary.

Summary of Lesson 2

- There are two types of ways circuits can be wired – in a series arrangement and a parallel arrangement.
- House circuits are usually wired in parallel.
- Electricity will take the shortest and easiest (lowest resistance) pathway to earth.
- Batteries produce direct current electricity (DC)
- AC 50 hertz means the current goes backwards and forwards 50 times a second
- Care must be taken when using electricity:
  1. A flow of electricity into your body can cause an electric shock.
  2. Electrical energy can transform into heat energy and cause a fire.

EXERCISE

Complete the exercises for Lesson 2 in the Send-in exercises

Lesson 3: Producing electricity

In this lesson you will learn how electricity is produced on a large scale. A developed country like Australia requires huge amounts of electrical energy for daily use in homes and businesses.

Burning fuels

In Australia, over 60% of mains supply electricity is generated by the burning (combustion) of coal. Australia's largest power station is at Eraring in NSW and it produces 2880MW of electricity per day from burning coal (1 megawatt (MW) = 1 000 000 watts)

The heat energy from the combustion boils water. Steam is produced and is used to turn turbine blades. The turbines are connected to generators that produce electricity. The coal is the input resource and electrical energy is the output resource. Figure 21 summarises the process.

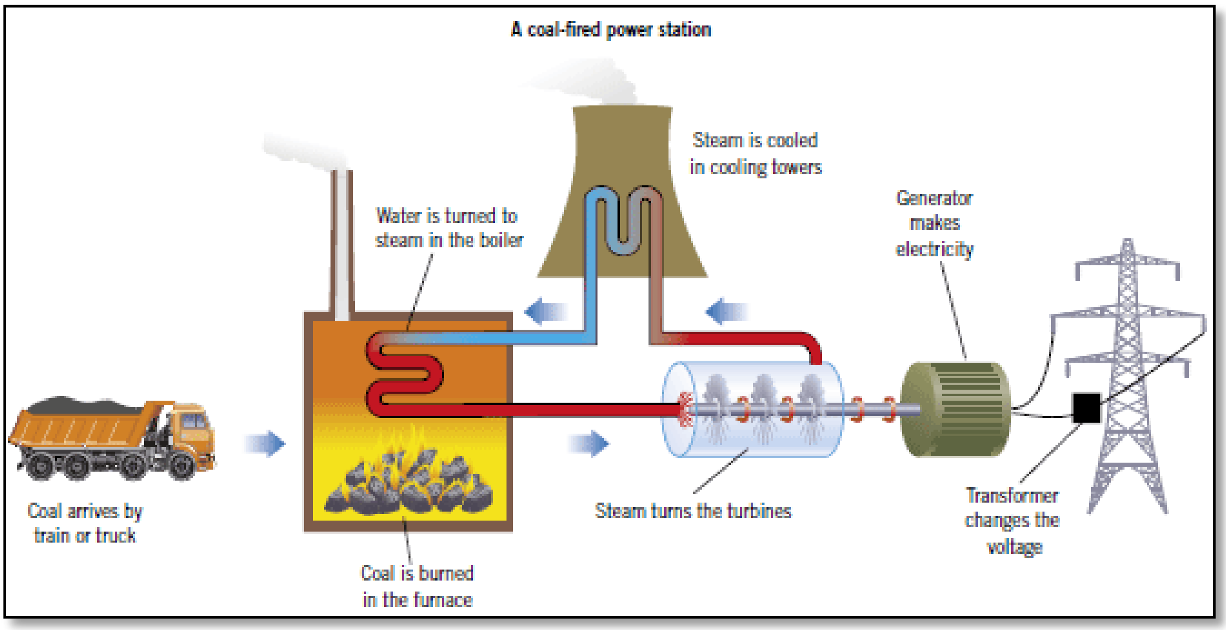


Figure 21

The process can be represented by the following flow diagram:

Coal is mined and transported to power station → Coal is burned to release heat energy to boil water to produce steam → Steam passes through turbines and turns the turbine blades → The turbine is attached to a generator that rotates and produces electricity

The steam that turns the turbine blades can also be produced by burning other fuels such as natural gas. Biogas (from decomposition of plant and animal materials) is used on some farms and council tips to generate electricity.

When a fuel is burnt (combusted) the chemical energy in the fuel is transformed into heat energy. The heat energy is transformed into kinetic energy when the turbine blades and the generator parts move. The kinetic energy is transformed into electrical energy in the generator.

chemical energy ⇨ heat energy ⇨ kinetic energy ⇨ electrical energy

Remember, kinetic energy (KE) is energy of movement.

Turbines turned without burning fuels

Turbine blades can also be turned by falling water, wind and waves. These methods use kinetic energy to turn the blades and work the generator.

kinetic energy ⇨ electrical energy

What happens in the generator?

Generators use magnets and coils of wire. Moving a magnet through a coil produces (induces) an electric current in the coil by making electrons move. Moving the magnet in the opposite direction reverses the direction of the current. This produces alternating current AC. The process is called electromagnetic induction.

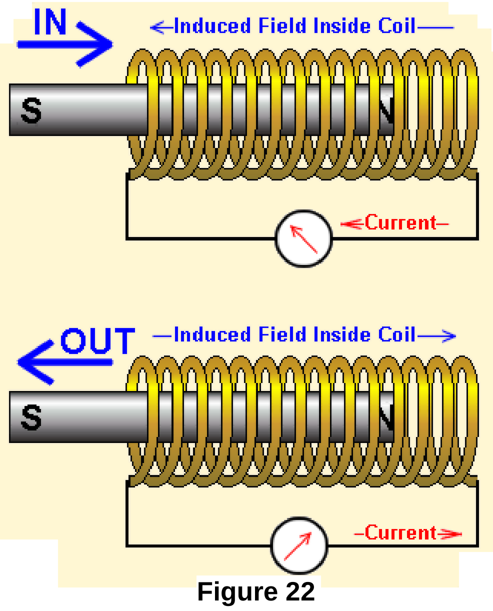


Figure 22

Figure 23

You have probably seen a simple generator working to power lights for a bicycle as shown in Figure 24. A bike generator can also be used to charge a mobile phone battery as shown in Figure 23.

A generator can also be called a 'dynamo'.

Figures 24 and 25 show how one type of bike generator/dynamo works. A small magnet is placed in a container with a wire wrapped around it. Another magnet is attached to the revolving bike wheel. As the wheel goes round it passes the container and causes the magnet inside to move. This magnet movement induces a current in the coil to power the bike lights or recharge a mobile phone.

Figure 24

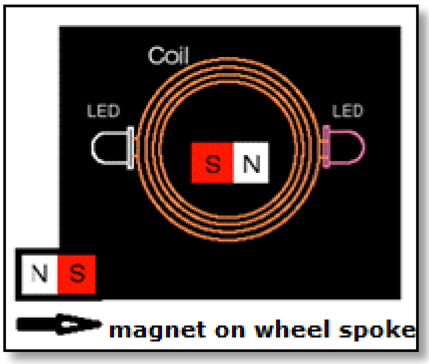


Figure 25

Activity 6: Analysing electricity generators

1. What source of energy can be used to turn turbine blades that move the parts in a generator?

   ____

   ____

2. What movement induces an electric current in a generator?

   ____

Compare your responses with the ones in the suggested answers section

Is coal burning an efficient way of generating electricity?

Australia has large supplies of coal and an established coal-fired power industry. Burning coal to produce electricity, however, has a number of disadvantages:

Figure 26

- the industry is given billions of dollars per year in business subsidies from the Australian government.
- high levels of emissions are produced - particles and gases released into the atmosphere such as sulphur dioxide, mercury, coal dust and carbon dioxide (a greenhouse gas).
- a lot of water is used and polluted in the process.
- landscapes and agricultural land are damaged by mining the coal.
- it is an inefficient way of producing electricity**.** There isn't a lot of electrical energy output compared to the amount of chemical energy input from coal. This is illustrated in Figure 27 on the next page.

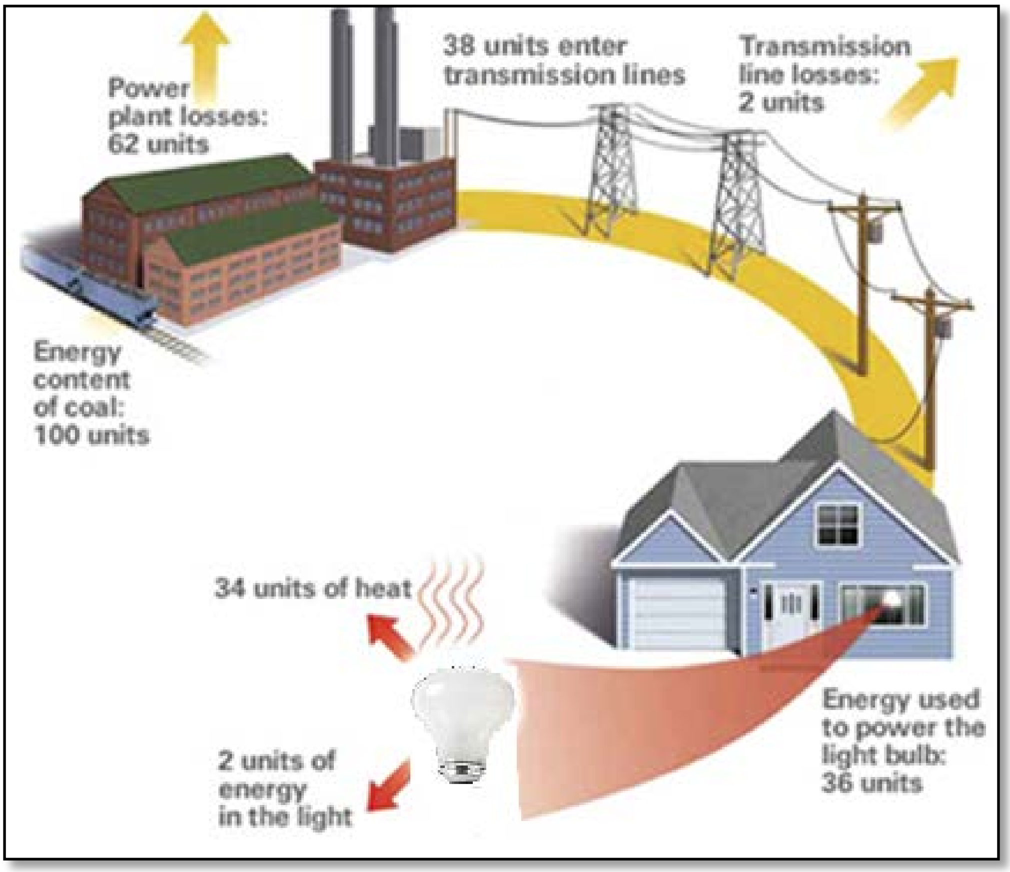


Figure 27

Activity 7: Analysing coal burning

1. Trace the energy path from coal burnt to a light switched on in Figure 27 above.

   a) How many units of light energy does the burning of 100 units of coal produce? ___________

   b) How many units of energy is lost in production and transfer of electricity from 100 units of coal energy? ____________

2. Read the following medical report extract and then answer the questions

DEA Doctors for the Environment Australia
www.dea.org.au

The true cost of coal

Contrary to dominant views about the industry, coal-fired power is not the cheapest fuel and its value to the community is dubious. The health impacts of mining, transporting and burning coal are well known and pose one of the most significant health issues of our time (lung, heart and brain diseases). The only rationale for using coal is that it is the cheapest source of energy.

But according to the research, it's not! The costs of tax concessions from the Australian government need to be considered. The total costs of coal mining, transport and burning need to be taken into account to understand the true cost of coal.

These costs include the healthcare costs of people affected by coal pollution, economic losses and environment damage to water sources, land and food production. Take into account the costs of climate change and extreme weather events resulting from coal burning (carbon dioxide emissions) and the picture gets even worse.

All published studies indicate that the true cost of coal is much greater than the market price per tonne. There are no studies that contradict this view. A CSIRO analysis details expectations that solar energy will compete on costs with coal burning as early as 2016.

It is vital that governments recognise the economic, health and environmental realities, and act upon them.

a) In the article doctors say there are many costs to Australians of using coal burning to produce electricity. Underline the costs in the article then list a health cost, an economic cost and an environmental cost.

Health cost - ____

Economic cost - ______________________________________

Environmental cost - __________________________________

b) What alternative electricity production has the CSIRO suggested as a cheap, healthier alternative?

____

Compare your responses with the ones in the suggested answers section

Energy efficiency

If there is only a small amount of energy wasted in an energy transfer or transformation we say that the process is very efficient. A lot of useful energy is produced.

If the amount of energy input and the amount of useful energy output are known the efficiency can be calculated:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

Efficiency is often stated as a percentage.

$$\%\ \text{efficiency} = \frac{\text{output}}{\text{input}} \times \frac{100}{1}$$

For the production of light energy from coal burning shown in Figure 27 the efficiency is:

$$\text{Efficiency} = \frac{\text{2 light energy units of output}}{\text{100 chemical energy units of input}}$$

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

$$= 2\%$$

Scientific research and technological developments are leading to more efficient ways and low emission ways of producing electricity.

Example of a solution to increase energy efficiency

A lot of energy transformed from the chemical energy in coal is lost to the air as heat energy in producing and transmitting electrical energy.

Figure 28

It would be much more efficient if you could produce electrical energy close to where you are going to use it.

You have probably seen a number of homes in your area with solar roof panels.

Some are producing electricity by using:

- solar cells
- small wind turbines
- fuel cells

Some homes are using solar panels and fuel cells to also produce heat energy that is used to produce hot water without using electricity from the grid.

Efficiency is so high in such homes that not all the electricity produced is used by the household. The excess electricity can be fed back into the main supply electricity grid. The household receives money for its electrical energy from the electricity grid power company.

Summary of Lesson 3

- Over 60% of Australia's electricity is produced by burning coal to produce steam to turn turbine blades that move generator parts.
- Falling water, the movement of wind and waves can be used to turn turbine blades that move generator parts.
- In a generator a magnet moves inside a coil of wire and this causes electrons to move in the coil producing a current.
- Burning coal to produce electricity is not very efficient and is costly.
- Coal mining and burning may cause health problems and produce high emissions of carbon dioxide gas.
- Producing electricity next to where it is to be used is much more efficient than having it transferred over a distance.

EXERCISE

Complete the exercises for Lesson 3 in the Send-in exercises

Lesson 4: Efficient, low emissions technology

In this final lesson for Part 2 we will look more closely at wind and solar energy technologies that can help reduce electrical energy bills and emissions of carbon dioxide and other pollutants.

Wind turbines at home and for power plants

Wind turbines use the kinetic energy of wind to make a generator work. Figure 29 shows how a wind turbine moves a generator to produce electricity. Trace the steps in the diagram.

The kinetic energy of wind (1) turns blades (B). This turning (2) produces movement (3) in the generator (G) to produce a direct current output.

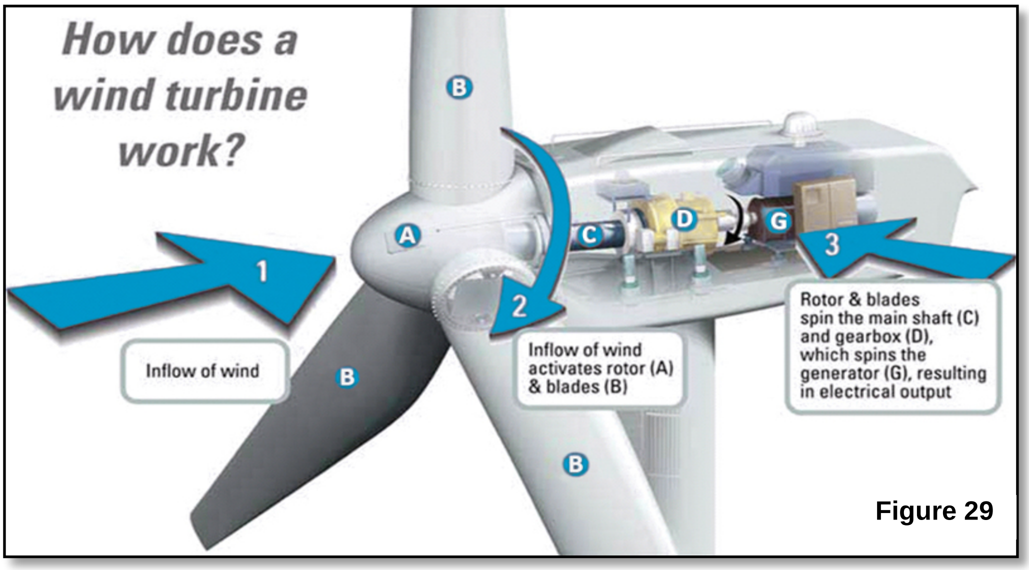


Figure 29

There are no emissions of carbon dioxide or other pollutants when using a wind turbine. Some emissions, however, are produced during its manufacture and installation.

Some of the kinetic energy from the wind is converted to sound energy as the blades move. This affects its efficiency as it reduces the kinetic energy transformed into electrical energy.

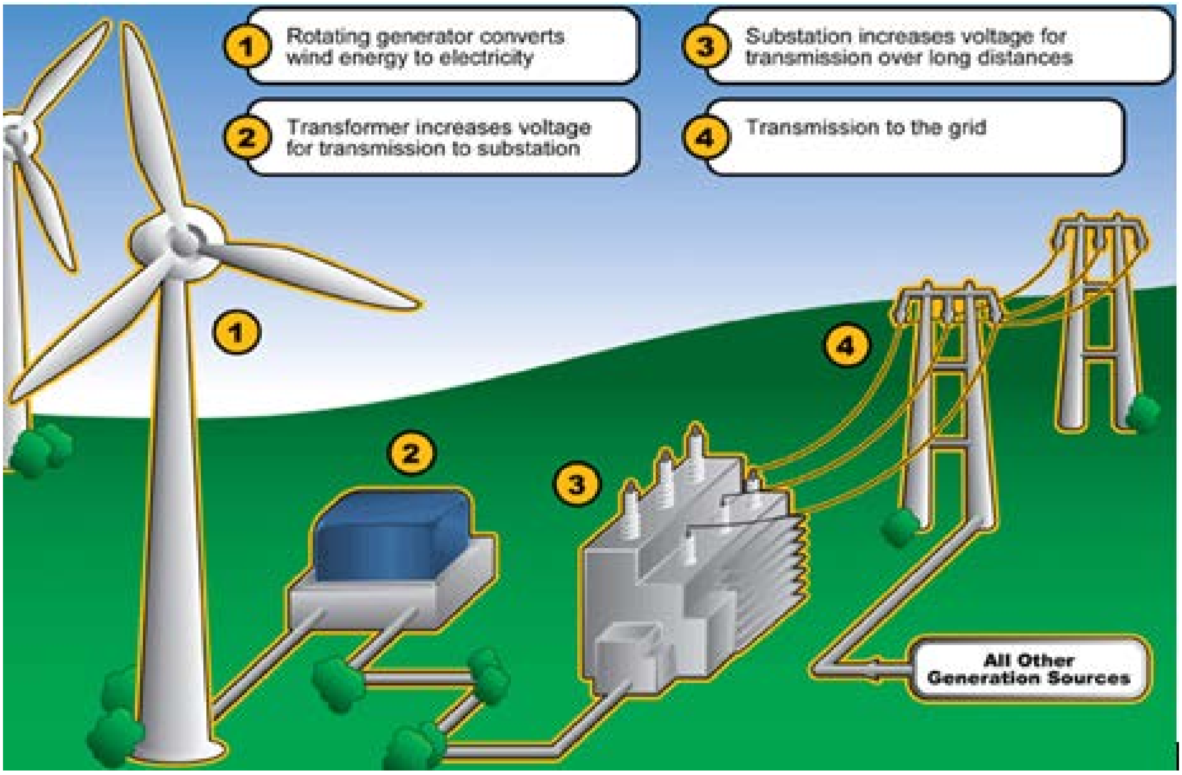


Figure 30

When many wind turbines are used to produce electricity we call it a wind farm. South Australia has a lot of wind farms and 27% of its electricity was generated by wind turbines in 2014.

Nationally, 4% of Australia's electricity was generated by wind in 2014.

Figure 31: 420MW Macarther farm in Victoria

Solar electricity at home

Solar energy includes light energy and heat energy the Earth receives from the Sun. Photovoltaic Solar Panels turn sunlight into direct current (DC) electricity, which is converted into alternating current (AC) electricity for use in the home using an inverter.

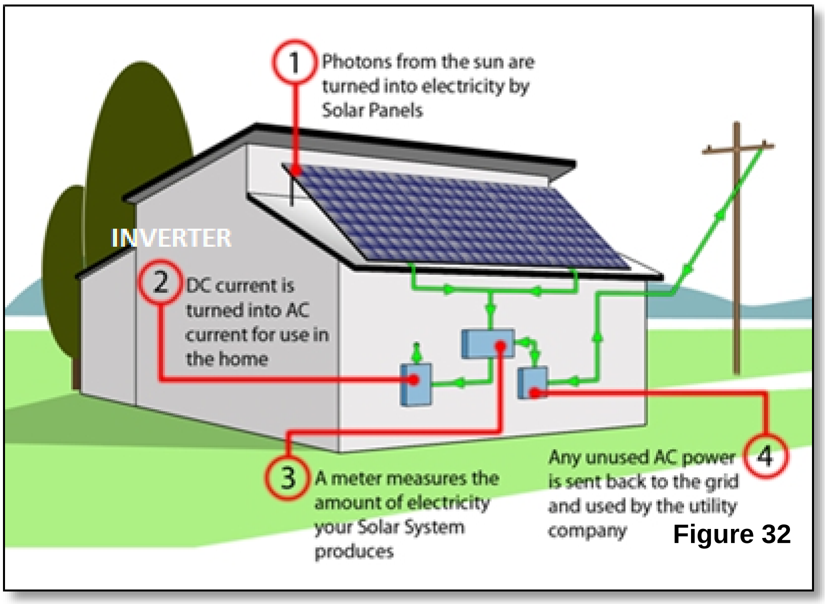
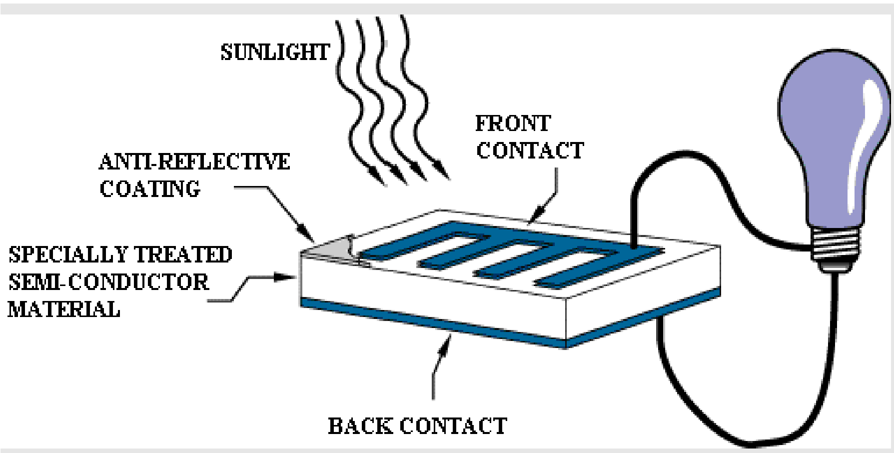


Figure 32

The Photovoltaic Solar Panels are made up of photovoltaic (PV) solar cells. Figure 33 explains how a PV solar cell works.



When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material.

If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current (electricity). The electricity produced is DC (direct current).

Solar panels can also be used on a large scale to form power stations to supply grid electricity. Figure 34 shows the 150000 solar panels at the Greenough River solar farm power station near Geraldton in Western Australia.

This was built with funding from the local council, a state government power organisation and a Chinese solar company. It produces 10 megawatts (MW) of electricity.

Figure 34

Activity 8: Analysing wind and solar

1. Explain how wind can be used to produce AC electricity for home circuits.

____

____

2. Explain how light energy from the Sun can be used to produce AC electricity for home circuits.

____

____

____

____

____

Compare your responses with the ones in the suggested answers section

Fuel cell for home use

Have a look at Figure 35 below. It shows the efficiency of an Australian ceramic fuel cell (BlueGen) developed by the CSIRO. It is the world leader in efficient electrical energy production. It transforms chemical energy into electrical energy and heat energy and shows that 100% energy input produces an 85% useful energy output for a home or business. 60% of the input energy is used to create electricity and 25% is used to create heat to heat water.

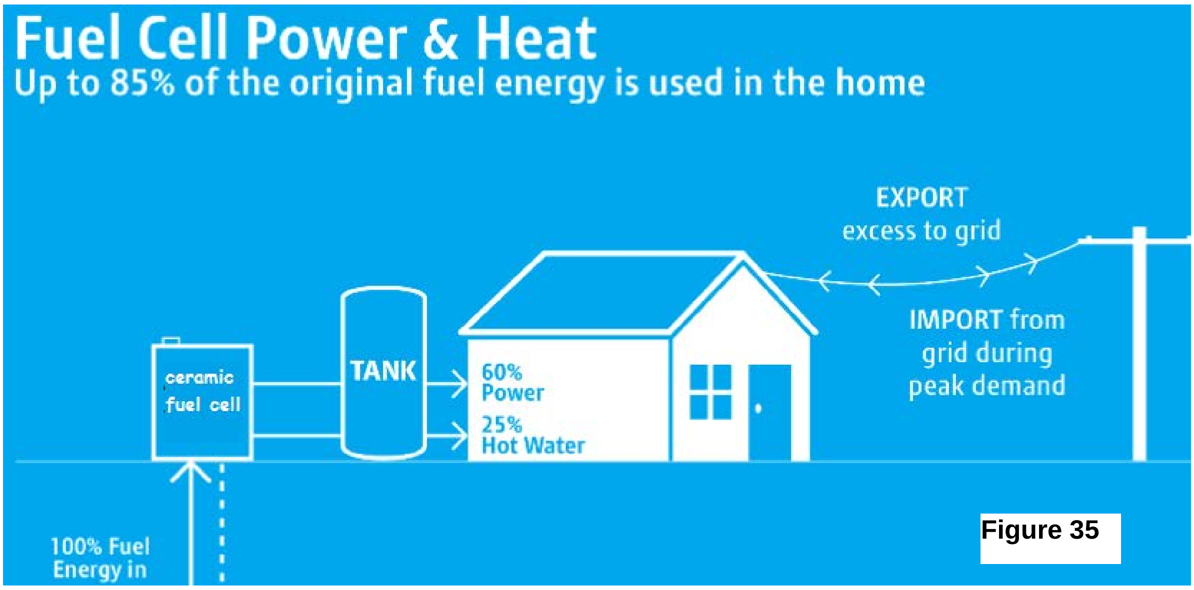


Figure 35

Ceramic fuel cells produce electricity directly from a chemical reaction between natural gas (methane) and a ceramic plate.

In the reaction, electrons are lost from molecules in the gas fuel (eg methane). The electrons can be conducted through attached wires to produce DC electricity. The DC electricity can be converted to AC electricity by an inverter.

The reaction releases heat energy. It is an exothermic reaction. The heat can be used to heat water. The hot water can be used in the home in water taps and in pipes for space (room) heating.

Figure 36

As you can see from the pie graph in Figure 37, hot water for taps and energy for heating and cooling the home account for a large percentage of the average household energy use. Using the heat energy produced greatly increases the efficiency of a fuel cell as an energy provider.

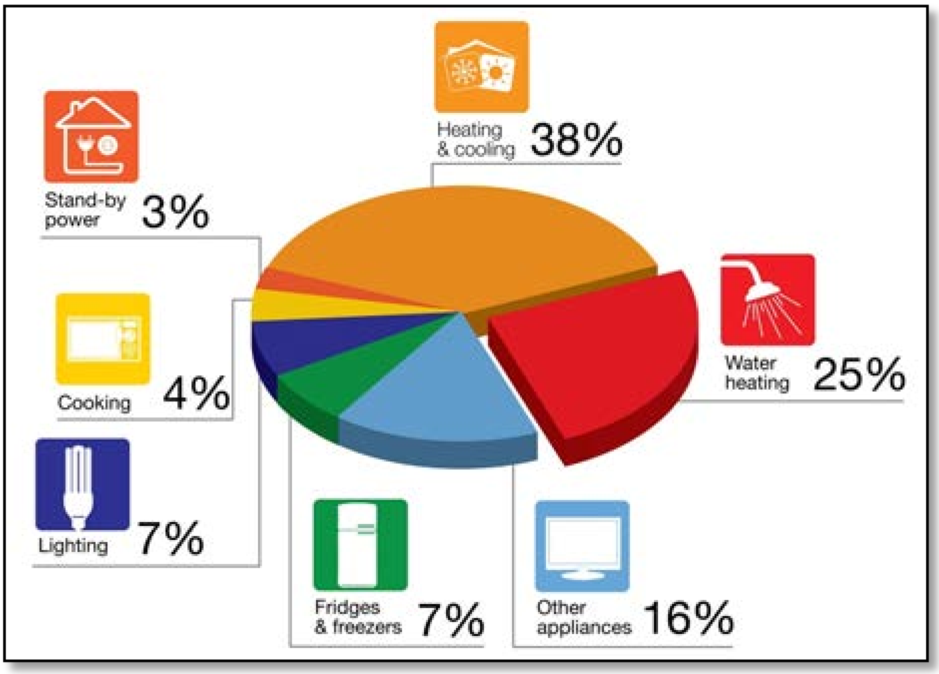


Figure 37: Average household electrical energy use

The chemical reaction in the ceramic fuel cell emits small amounts of carbon dioxide when compared to the combustion reaction of burning fuels to produce the same amount of electricity.

Activity 9: Analysing ceramic fuel cells

1. Use the pie graph to state the percentage of electrical energy which is used to provide hot water for the average home ______________

2. How would installing a ceramic fuel cell reduce a household hot water bill? ____

Compare your responses with the ones in the suggested answers section

Think about the main points in the lesson then read the following summary.

Summary of Lesson 4

- Wind turbines use kinetic energy of wind to move generator parts to produce AC electricity without carbon dioxide emissions.
- Photovoltaic solar panels use sunlight to make electrons move to produce DC electricity without any carbon dioxide emissions.
- Ceramic fuel cells use natural gas and a ceramic plate in a reaction that produces DC electricity and heat energy. Some carbon dioxide is emitted in the reaction but far less than burning coal for electricity.

EXERCISE

Complete the exercises for Lesson 4 in the Send-in exercises

Send-in exercises – Technology and electricity Part 2

Lesson 1: Electricity to the home

1. Explain why some appliances have a three pin plug and some have a two-pin plug.

   ____

   ____

   ____

   ____

2. A toaster has a metal base. To which part of the toaster would you expect the earth wire to be attached? ________________________

   Explain why: ____

   ____

3. Imagine that you plug your toaster into the power point and turn it on and the power goes off. You turn the toaster off. You go to your meter box and find the kitchen power point circuit breaker has switched off. You turn it back on. You go back into the kitchen and turn the toaster on again and find that the circuit-breaker switches off again. Should you stop using the toaster? ________________

   Explain your answer: ____________________________________

   ____

   ____

4. Complete the following statements using the words listed below.

heat	**mains**	**resistance**	**safety**
“short circuit”	**transformers**	**voltage**	

a) ____________ supply electricity in Australia is 240V AC.

b) __________________ can increase or decrease the voltage of alternating current.

c) Circuit-breakers and fuses are essential for _______________ in electric circuits.

d) The electric current flowing in a circuit depends on the resistance in the circuit and the ______________.

e) When a large current flows through a conductor with a high resistance a lot of electrical energy is transformed into a lot of ________________ energy.

f) A _________________ occurs when an electric current takes a shorter path along a path of lower _________________.

Lesson 2: Types of circuits

1. Assess whether it would be better to have Christmas lights wired in series or parallel.

    ____

    ____

    ____

2. Draw a circuit diagram in the spaces provided of a circuit containing an AC power point source and three light bulbs in:

    (a) series and (b) parallel

    Remember to draw diagrams in pencil and use a ruler.

    a) series

    b) parallel

3. Refer to the experiment in Activity 3: Investigating bulbs in a parallel and series circuit.

a) What variables or things did you keep the same in each circuit? (constant variables)

____

____

b) What variable did you change (independent variable)?

____

c) What did you observe or measure to record as your result? (This is called the dependent variable)

____

c) Do you think this was a fair test to compare the brightness of the globes wired in parallel and series? ________________________

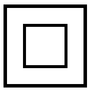
Explain your answer______________________________________

____

4. A label on the plastic case of a portable radio has the following information:

AC: 240V 50 HZ 12W

DC: 9V ("D" SIZE x 6)



a) What is the meaning of AC? ________________________________

b) What does 50 Hz mean?

____

c) If you use this radio without plugging it into a power point, how many batteries does it use to produce a voltage of 9V?

____

d) Would you expect the radio to have a two-pin or a three-pin plug?

____

Explain why: ____

____

e) Would you expect the radio to contain a transformer? ____________

Explain why: ____

____

f) Think back to what you learnt in Part 1 about electricity use and cost. What is the power (measured in watts) used by the radio when it is plugged into a power point? _______________________________

g) What type of current is produced by the 9V batteries used by the radio?

____

Lesson 3: Producing electricity

1. Use the information in Figure 27 to draw a flow diagram to show the energy lost, as the energy from coal is transformed into light energy in a home.

2. Over 60% of Australia's electricity is produced by burning coal. Explain why this makes it difficult for the Australian government to meet its international obligations to reduce carbon dioxide emissions (often referred to as carbon emissions).

____

____

4. Assess whether Australia should continue to use coal burning as its major electricity provider for homes.

____

____

____

____

____

____

Lesson 4: Efficient, low emissions technology

1. Draw a flow diagram to show how light energy from the Sun can power an electric light bulb in a house.

(Remember a flow diagram summarises the steps in a process such as on page 26 of Lesson 3)

2. Look at the pie graph (Figure 37 on page 38) representing the household use of electricity.

a) Describe ways that you could reduce your use of electricity in your home.

____

____

____

____

b) Make a prediction of how changing your activities could reduce the electricity bill for your home.

____

____

____