3 Earth resources

HAVE YOU EVER WONDERED...

- if humans could run out of resources like coal or oil?
- why you should save energy?
- how clouds form?
- why people should care about what they put in the air or soil?

After completing this chapter students should be able to:

- describe the Earth's major resources, such as soils, air, rocks, water, living things and sunlight
- explain what is meant by a 'renewable' resource
- discuss timescales for the regeneration of resources
- classify energy sources as either renewable or non-renewable
- compare renewable and non-renewable energy sources
- describe how renewable and non-renewable energy sources are used in Australia and the world
- describe the changes of state that occur in the water cycle
- investigate factors affecting the water cycle in nature
- explore ways that humans manage water and affect the water cycle.

3.1 Major Earth resources

Humans need many things to stay alive, like food, air, water and shelter. Other living things have similar needs. These needs are met by the natural resources on Earth. It is the responsibility of everyone to protect these vital resources.

INQUIRY science 4 fun

Rocks

What is in a rock?

No

Collect this ...

- stereomicroscope or hand lens
- samples of different rocks

Do this ...

1. Carefully study one of the rock samples with the microscope at about ×40 magnification or with a hand lens. Is the material in the rock all the same or is the rock made of different materials?
2. Study the other rocks to see if they have the same materials in them.

Record this ...

Describe what you saw.

Explain how these rocks could be used by humans.

Natural resources

A **resource** is anything supplied by the Earth to satisfy a particular need of humans or other living things. Most natural resources are substances, such as rocks or water. However, sunlight is a vital resource that is not a substance. Sunlight is a form of energy and is needed by almost all living things on Earth. Though it enters the Earth from space and is not a substance, it can be considered to be an Earth resource.

The major natural resources of Earth are its:

- rocks
- minerals and fossil fuels (like coal and oil) found in rocks
- soil
- air
- water
- living things
- sunlight.

Some of these resources are shown in Figure 3.1.1.

Figure 3.1.1 Birds, animals, trees, soil, rocks, water, air and sunlight are resources.

These resources are not just used by humans to make things with or to supply us with energy. Almost all life depends on these resources. Many of these resources need to be protected by humans to assist in the survival of all living things, including ourselves.

Renewable and non-renewable resources

The time taken for a resource to be replaced determines whether it is classified as renewable or non-renewable.

A **renewable resource** is a resource that is replaced by natural processes that occur in a timescale shorter than an average human life. This means that renewable resources take less than eighty or so years to be replaced. For example, most trees can be regarded as renewable resources because they grow to maturity in less than eighty years. The major renewable resources are air, water, sunlight and living things.

Some resources like coal and oil take millions of years to be replaced naturally. So to a human these resources would seem like they are not being replaced. As such, they are considered to be **non-renewable resources**. Rocks and soils are also considered to be non-renewable resources because they take so long to be replaced.

Living things as a resource

Living things are a resource for humans and other organisms. For instance, animals eat plants and other animals. Sometimes living things even use other organisms as places to live. For example, tapeworms live in the gut of other animals. Plants use waste materials from animals and other plants as nutrients. Some plants rely on animals as a way of pollinating flowers, such as in Figure 3.1.2. Humans use plants and animals for food, shelter, building materials, clothing, medicines, fertilisers, fuel and many other purposes.

Figure 3.1.2 This plant relies on the hummingbird to pollinate its flowers. To attract the hummingbird the plant produces a sugary substance called nectar.

Living things also depend on their surroundings to supply other resources that they need. Water, rocks, air and soil supply the materials needed for all life. Sunlight is also essential for plants to make their own food and to keep the Earth warm enough for life to exist.

Living things: a renewable resource

Living things are a renewable resource because they reproduce. A forest that has been cut down can regrow. Animals like the cows in Figure 3.1.3 on page 70 are replaced through reproduction. Replacing some forests may take just a few decades. Others forests take longer. Plantations (where humans deliberately plant trees for timber) can be replaced faster than a natural forest. Replacing animals on farms may take a year or so.

Figure 3.1.3 Animals are a renewable resource because they reproduce.

Air as a resource

Air is a mixture of gases and suspended particles such as dust, smoke and water droplets. The main gases in air and their importance to life on Earth can be seen in Table 3.1.1.

Table 3.1.1 Gases in the air

Gas	Percentage in air	Importance to life
Nitrogen	78	Provides nutrients for plants to make proteins and other chemicals, which humans and other animals can use as food.
Oxygen	21	Essential for most living things, to release energy from food that their bodies can then use.
Carbon dioxide	0.03	Essential for plants to make their own food by photosynthesis.
Other gases such as ozone, water vapour and argon	0.97	Many uses depending on the gas. Ozone shields humans from ultraviolet rays (reducing our risk of skin cancers). Water vapour is part of the water cycle that carries water around the planet. Argon is used in light globes.

Air: a renewable resource

About 21% of the air (by volume) is oxygen gas. Oxygen is constantly being used by animals and plants, but is also constantly being replaced by plants. This allows the oxygen level of the atmosphere to stay about the same. Scientists describe the movement of materials from one place to another and then back again as a 'cycle'. Oxygen cycles through Earth and its atmosphere.

All of the oxygen on Earth is thought to have originally been produced by microscopic plant-like organisms and green plants. Green plants like the one in Figure 3.1.4 use the energy from sunlight, carbon dioxide and water to make their own food. The process is called **photosynthesis**. As well as producing the plant's food, photosynthesis also produces oxygen.

Figure 3.1.4 Green plants use carbon dioxide, water and energy from sunlight to make their food by the process of photosynthesis.

SciFile

Earth's fragile atmosphere

The atmosphere is the very thin layer of air around the Earth's surface. The first astronauts who ventured into space were amazed at how thin and fragile the atmosphere looked from space. Many said it made them think very deeply about the damage humans are doing to the atmosphere.

Only about 0.03% of air is carbon dioxide. This is enough to supply the carbon dioxide needed in photosynthesis. Animals breathe out carbon dioxide because it is a waste product of the processes that release energy in their bodies. So carbon dioxide is also being replaced in the air. It is part of a cycle, where it goes from the atmosphere to plants, and then back again from animals to the air. This cycle of oxygen and carbon dioxide is shown in Figure 3.1.5.

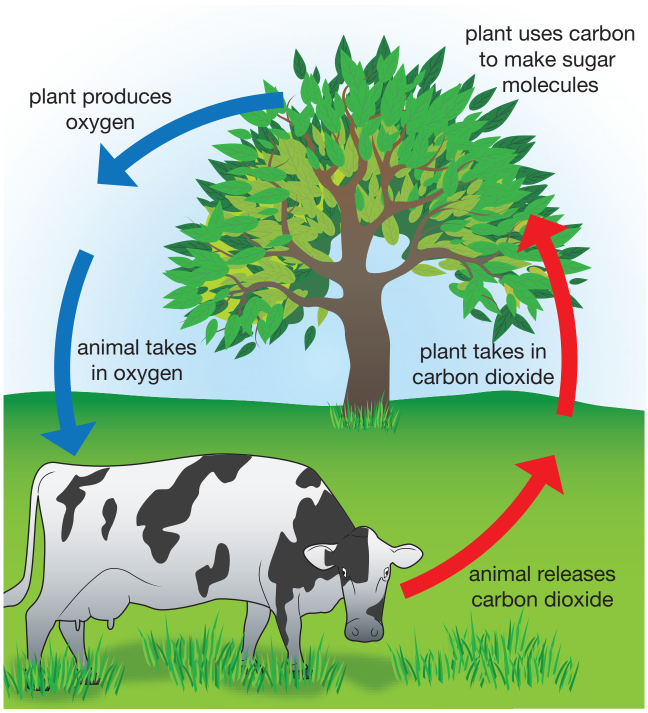


Figure 3.1.5 The exchange of oxygen and carbon dioxide between plants and animals renews these gases in the atmosphere.

Nitrogen gas also has its own cycle as it is absorbed by some organisms and released by others. Gases such as oxygen, carbon dioxide and nitrogen can also move to areas of low concentration where one of them is being used up.

1 p77

Sunlight as a resource

Sunlight has an essential role in supporting life on Earth.

- Plants use sunlight to produce food.
- Sunlight warms the Earth's atmosphere, land and water, keeping it warm enough for most water to stay liquid. If the Earth cooled too much, then all water would freeze and turn to ice. Living organisms contain a lot of water and so they would also freeze.

Sunlight: a renewable resource

Sunlight is a renewable resource and will be for as long as the Sun keeps shining. The Sun is a star, and will continue to shine for billions of years.

Water as a resource

Water covers most of the Earth's surface and all living things (like the bird in Figure 3.1.6) need it. No organism can live without water for long. For this reason, water is the Earth's most important resource.

Figure 3.1.6 Water is a very important resource on Earth because no living thing can survive without water.

SciFile

Living on other planets

Life cannot exist without water. For this reason, scientists searching for signs of life in space are only looking at planets and moons where water can be detected.

Water: a renewable resource

Water is a renewable resource because it can move from place to place and replenish an area. It has a cycle. However, only a tiny fraction of the water on Earth is made new each day. Some water is made when:

- living things like trees burn
- fossil fuels like petrol and coal burn
- living things release energy in their bodies.

The total amount of water on Earth is thought not to have changed much since the planet formed.

Water will be covered in detail in Unit 3.3 and in Chapter 4.

2 p78

Rocks as a resource

Rocks provide two different resources:

- the rocks themselves
- materials found in rocks.

There are many different types of rock. Some rocks are hard and can be used without altering them or removing any materials from them. These solid rocks are used mainly for roads and buildings, like the one shown in Figure 3.1.7. Other rocks are soft, like limestone and sandstone. These rocks are easy to cut, so they are used in paving and walls. Many of the founding buildings of cities are often built from the local bedrock.

Figure 3.1.7

Stone buildings are built from rocks.

Rocks are made from substances called **minerals**. Minerals differ in their physical properties such as colour and hardness. You can see how minerals appear in a magnified view of a rock in Figure 3.1.8. Many minerals are important resources for humans. A variety of minerals and their uses are shown in Table 3.1.2.

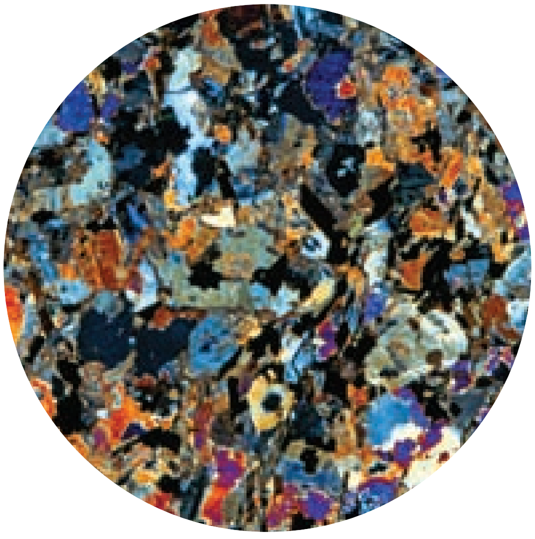


Figure 3.1.8

This is a magnified view of a rock showing that it is composed of different minerals. Each different colour is a different mineral.

Table 3.1.2 Minerals and their uses

Mineral	Main use
Bauxite	Contains aluminium. Aluminium is used for making aircraft, drink cans and high voltage powerlines.
Haematite	Contains iron. Iron is used to make steel, which is used in car bodies, nails, ships and bridges.
Malachite	Contains copper. Copper is used in electrical wiring.
Halite	Contains sodium chloride (table salt). Sodium chloride is used in food preparation and medical applications.

Rocks contain some of the minerals that are needed by living things. As the rocks gradually break down, they release minerals which end up in the water of oceans and lakes, and in the soil. From the water and soil, the minerals are taken up by plants and animals, providing them with necessary trace elements.

Rocks also contain resources that are not minerals. Water is often found in rocks. The fossil fuels oil, natural gas and coal are energy sources that are found in or between layers of rock deep below the ground.

Rocks: a non-renewable resource

Most of the rocks of the Earth were formed millions of years ago. However, in a few places, rocks are still forming today. Some rocks form when hot liquid from inside the Earth cools either below or above the ground. This type of rock is called **igneous rock**. Volcanoes (like the one in Figure 3.1.9) are places where igneous rocks form. The igneous rocks that form below ground can take thousands to millions of years to form. Igneous rocks form on the surface in a day or so because the liquid rock (lava) cools quickly in the air.

Figure 3.1.9

Although new rocks form in and around volcanoes every day, they cannot be considered a renewable resource because the overall process takes so long.

Other types of rocks form when sediments stick together and harden to become rock. This type of rock is called **sedimentary rock**. Most sedimentary rocks form over many thousands or millions of years.

Only a tiny fraction of the Earth's rocks is being replaced each year. The replacement takes so long that rocks are not considered to be renewable resources. Therefore the minerals in the rocks are non-renewable resources. Oil and coal are materials that are found in or between rock layers, and are also non-renewable resources. Oil and coal were formed from dead plants and animals that lived many millions of years ago and are not being formed today.

Soil as a resource

Rock can be worn away by the processes of weathering and erosion. These natural processes have been wearing away rocks throughout the Earth's history.

Weathering

Weathering is the process of breaking rocks down into smaller pieces. Weathering happens in the following ways:

- Changes in temperature between day and night or because of weather and the seasons, can split rocks.
- Water settles in cracks in rocks. As water freezes into ice it expands (gets larger), widening the crack even more.
- Running water and waves can gradually wear away rocks.
- Strong winds blast rocks with small rock particles that wear the rocks away.
- Natural chemicals in the air, soil and water attack substances in the rock. The rock then crumbles and may form a cave like the one shown in Figure 3.1.10.

Figure 3.1.10 This limestone cave was formed by the action of rainwater containing acid that attacked the limestone rocks over a long time.

Erosion and deposition

Rocks are broken down into **sediments** by the process of weathering. Sediments can build up around the parent rock or can be carried away by water, wind and ice in a process called **erosion**. Water, wind and ice are referred to as **agents of erosion**.

The sediments that are carried away from weathered rock by water, wind or ice are eventually dropped somewhere. You can see this in Figure 3.1.11 on page 74. The process where sediments drop out of a moving stream of water, wind or ice is called **deposition**.

SciFile

Sink holes

Sink holes can appear suddenly in areas where limestone is the common type of rock. Sink holes are formed when the limestone below the surface is weathered by chemical action and caves form and then collapse. This sink hole appeared in 2010, in Guatemala, South America, right next to someone's home!

Figure 3.1.11 This sandstorm approaching the Saudi Arabian capital Riyadh shows how much erosion and deposition the wind can cause.

The deposited sediments are added to any soil they fall on, making new soil in the process. Soils are composed of:

- fine rock particles (sediments)
- living organisms (such as worms and moss)
- **humus** (decaying wastes and dead organisms)
- water
- dissolved minerals and gases.

You can see these in Figure 3.1.12.

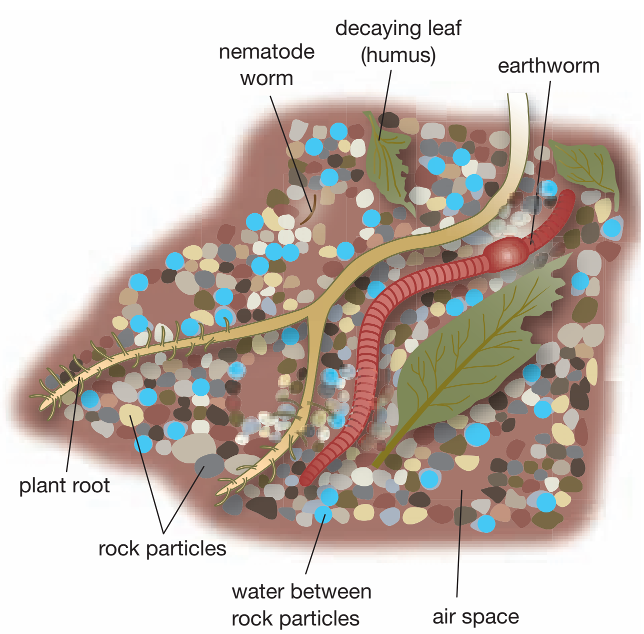


Figure 3.1.12 Soil consists of many components which can support the growth of plants and animals.

INQUIRY science 4 fun

In the dirt

No

What is in soil?

Collect this ...

- stereomicroscope or hand lens
- samples of different soils

SAFETY
Wear gloves and do not inhale dust.

Do this ...

1. Study one of the soil samples with a stereomicroscope at about ×40 magnification or with a hand lens. Is the material in the soil all the same or is it made of different materials? Try to work out what things are in this soil.
2. Study the other soils to see if they have the same materials in them.

Record this ...

Describe what you saw.

Explain why some samples were similar while others were different.

Soil profiles

When you dig down into the soil you can often see different layers (as shown in Figure 3.1.13). These layers are called **horizons** and together the horizons make up the soil profile. The top layer (A horizon) is often a dark brown or black colour due to the high humus content from the organic matter it contains. Most plant roots are found in this top layer of soil. This horizon provides nutrients needed for plant growth. The next layer (B horizon) is called the subsoil. The subsoil is usually more compacted, contains less air and less humus and is therefore lighter in colour. The third layer (C horizon) is broken bedrock. At the bottom is unaltered rock. Horizons B and C usually have little impact on plant growth.

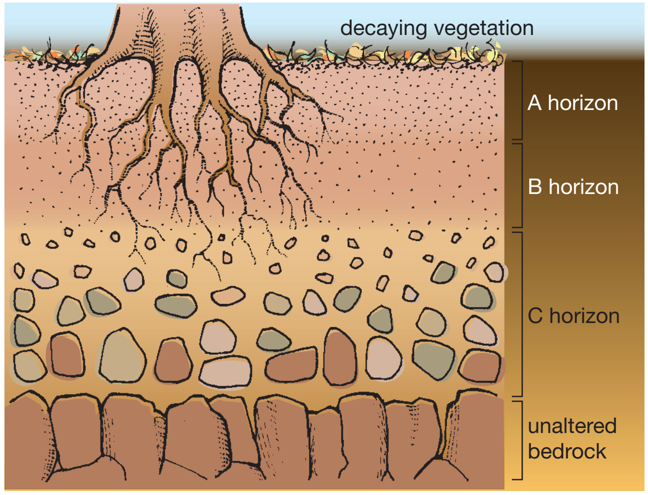


Figure 3.1.13 A soil profile shows that soil has clear layers which are revealed as you dig down.

Fertilisers

Fertilisers are materials that supply mineral nutrients to plants. They contain substances like phosphorus and nitrogen, which plants need to live. Farmers often add them to the soil to improve crop growth.

Common fertilisers are:

- untreated animal droppings such as manure from sheep or chickens
- 'blood and bone'. This is the dried and cooked remains of meat and bone from abattoirs
- chemical fertilisers. Many are manufactured from animal droppings. For example, bird droppings can be processed into a fertiliser called superphosphate.

There is evidence that excessive use of chemical fertilisers is damaging soils and streams and rivers. For this reason, some farmers are reducing their use and are using natural fertilisers instead.

Soil: a non-renewable resource

In some places the rock particles carried by water, wind and ice can build up quickly. An example is where many rivers carrying sediments meet in one place called a river flood plain. In this way the soil is continually added to. Soil can also be enriched by humans in home gardens or on farms. Adding fertilisers or mulch (rotting leaves, bark and twigs) adds nutrients to the soil.

However, in most places on Earth, soils are not being renewed. If a farmer's soil blows away in the wind (or a tornado like the one in Figure 3.1.14) or is washed away in floods, then it is not likely to be replaced in the farmer's lifetime. Some soils form in places where the rocks on the Earth's surface are weathered. However, this process takes hundreds or thousands of years to form soil only a few centimetres thick. Therefore most soils are not considered to be a renewable resource.

Figure 3.1.14 A tornado is a rapidly spinning column of air that forms during certain weather conditions. Tornadoes can strip topsoil from the ground and make it very difficult for any crops to grow.

3 p79 3.1 3.2

3.1 Unit review

Remembering

1 **List** the major resources of the Earth.

2 **List** the main causes of weathering.

3 **List** the ways rock particles can be carried away by erosion.

4 **List** the components of soil.

5 **Recall** what is produced by green plants in photosynthesis.

Understanding

6 **Define** the term *resource*.

7 **Explain** why living things can be considered a renewable resource.

8 **Explain** why minerals in rocks are not considered a renewable resource.

9 **Explain** why soil is such an important resource.

10 **Explain** how rocks are a resource for humans.

Applying

11 **Identify** the major resource on Earth that sustains all life.

12 **Identify** the major Earth resources that are:
  a renewable
  b non-renewable.

Analysing

13 **Classify** the following as renewable or non-renewable:
  a gum trees
  b water
  c sand
  d cows.

14 **Compare**:
  a renewable resources with non-renewable resources
  b erosion and weathering
  c erosion and deposition.

Evaluating

15 **Justify** the following statements:
  a Forests are renewable resources.
  b Soils are non-renewable resources.

Creating

16 **Construct** a table summarising the major resources of the Earth, including how they are a resource for humans and whether the resources are renewable or not.

Inquiring

1 Research the methods used to reduce the effects of soil erosion at the beach or on farms.

2 Research the benefits of adding compost to soils.

3 Forests are renewable. However, to replace them so that they reach the condition called *old growth forest* can take a long time (up to 250 years). Research old growth forests and why scientists consider them important.

4 Research the evidence that Aboriginal people in Australia have used fire to manage the land for thousands of years. In your answer discuss the benefits of the use of fire, particularly the recent discoveries of the effect of smoke on germination of seeds.

3.1 Practical activities

1 Renewing air

Purpose

To investigate whether a green plant produces oxygen.

Materials

- 3 × 250 mL conical flasks labelled A, B and C
- 3 small test-tubes
- 3 one-hole stoppers each with a filter funnel
- aluminium foil to cover one conical flask
- pieces of a leafy green plant such as geranium
- straw
- 3 test-tube stoppers
- test-tube rack
- wooden splint
- matches

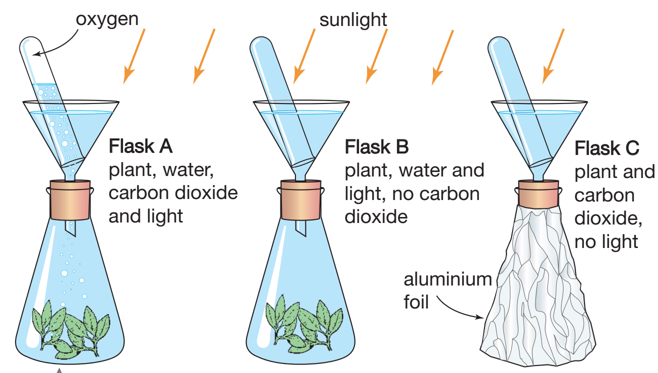


Figure 3.1.15

Procedure

1. Place a number of pieces of the plant in each conical flask and fill the flasks to the brim with water.
2. Using the straw, blow bubbles through the water in flasks A and C for one minute. This adds carbon dioxide to the flasks.
3. Place a stopper with the filter funnel into each flask. Make sure some water enters the stem of the funnel.
4. Wrap flask C with foil so no light can enter.
5. Carefully add water to three-quarter fill each filter funnel. Then fill each test-tube with water and carefully turn the test-tubes upside down and place them in the filter funnels as shown in Figure 3.1.15.
6. Place the conical flasks outside in direct sunlight for the day if possible. Otherwise use a strong light in the laboratory and leave it on until the next day.
7. The next day, carefully lift the test-tube out of flask A, place a stopper in the top of the test-tube and place it in a test-tube rack.
8. Light the wooden splint and hold it near the test-tube in the rack. Quickly blow out the wooden splint, remove the test-tube stopper and hold the glowing splint in the test tube.
9. Repeat steps 7 and 8 with the other test-tubes and record what happens.

Results

Record your results in a table like the one below.

What happened to splint		
Test-tube A	Test-tube B	Test-tube C

Discussion

1. **Describe** the results for each test-tube.
2. Oxygen gas has the ability to make a glowing splint of wood catch fire again. **Deduce** whether any of the test-tubes contained oxygen.
3. **Propose** what happened in the three conical flasks.
4. **Explain** how this experiment is relevant to the importance of air as a resource.

2 Water-holding capacity

Purpose
To compare the water-holding capacity of different soils.

Materials
- 3 plastic filter funnels
- retort stand and 3 clamps, or filter stand
- 3 × 100 mL beakers
- 50 mL measuring cylinder
- cotton wool
- dry soil samples such as clay, loam, sand

SAFETY
Care must be taken not to inhale any soil particles. Wash your hands after completing the practical.

Procedure
1 Set up the equipment as shown in Figure 3.1.16, with a cotton wool plug in the neck of each funnel.

2 Half fill each funnel with a different type of soil.

3 Pour 20 mL of water into each funnel and collect any water that comes through. If no water comes through a particular soil, add another 20 mL water to that soil until some water runs through it.

Results
Record in a table how much water you added to each soil and how much water collected in the beaker.

Discussion
1 a **Identify** the soil with the largest water-holding capacity and the soil with the smallest capacity.
  b **Justify** your decision.

2 **Outline** some possible reasons why the soils had different water-holding capacities.

3 Soils described as 'well drained' allow much of the water that enters them to pass through them. Labels on plants at a plant nursery sometimes say that the plant likes well-drained soils. **Propose** the characteristics of soils that make them well drained.

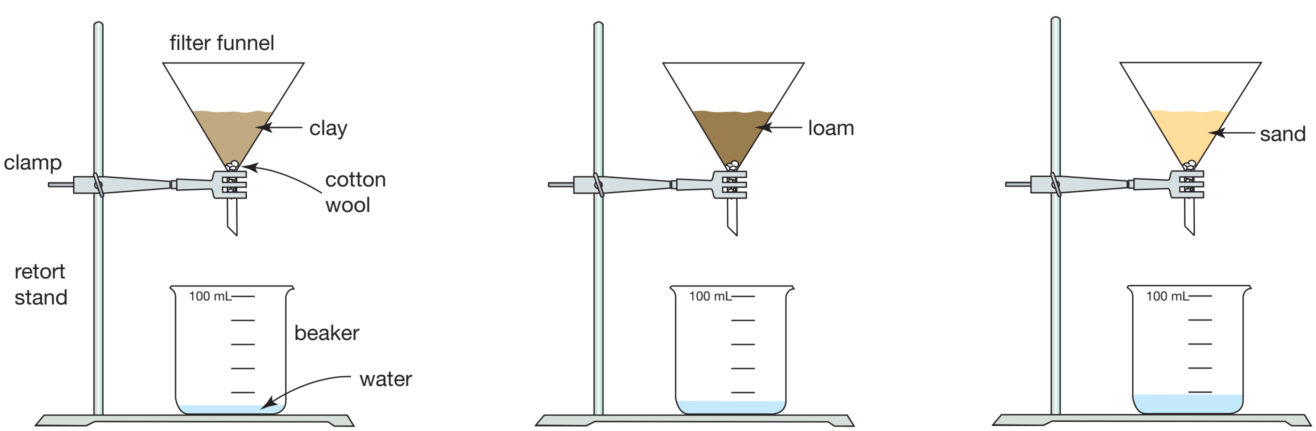


Figure 3.1.16

3 Erosion on a slope

Purpose

To design and conduct an investigation to test if the amount of soil erosion caused by water depends on the slope of the land over which the water runs.

Materials

- plastic gutter
- loam soil
- sandy soil
- bucket
- tap
- hand lens or microscope
- protractor
- wooden blocks or bricks

SAFETY

Care must be taken not to inhale any soil particles. Wash your hands after completing the practical.

Procedure

1. In your design you can use any equipment your teacher has provided or agreed to supply to you.
2. Decide in your group how you will proceed. Draw a diagram of the equipment you need and the procedure you will use to conduct your investigation. Construct a list of the materials you will need.
3. Show your teacher your procedure, and if they agree, collect your materials and conduct your investigation.
4. Record your results.

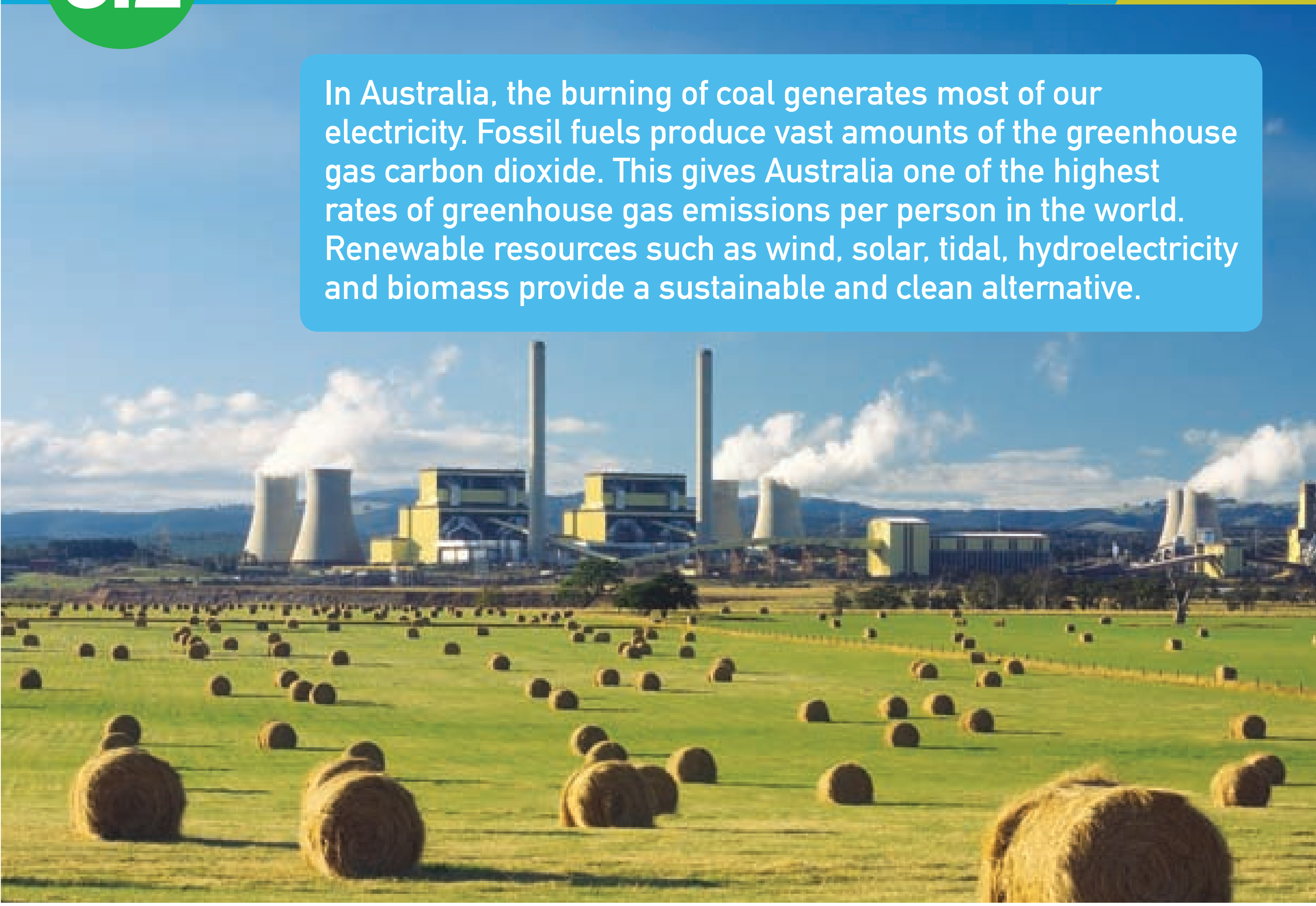
Discussion

Construct a prac report for your investigation.

Figure 3.1.17 Does the slope of the land affect the amount of soil erosion caused by water?

3.2 Energy sources

In Australia, the burning of coal generates most of our electricity. Fossil fuels produce vast amounts of the greenhouse gas carbon dioxide. This gives Australia one of the highest rates of greenhouse gas emissions per person in the world. Renewable resources such as wind, solar, tidal, hydroelectricity and biomass provide a sustainable and clean alternative.



Energy demand

Early humans had basic energy needs. Without electricity and fossil fuels, their energy needs were met from sunlight and from burning fuels like wood and dried animal manure. Energy demands have risen dramatically in recent times. This can be seen in Figure 3.2.1. Appliances and gadgets such as televisions, iPods, home entertainment units, gaming consoles and computers require a lot of energy to manufacture. They also require ongoing energy to use. Climate-controlled living rooms and the convenience of car and air travel come at an energy cost too. Table 3.2.1 shows that, relative to many parts of the world, Australia and other Western societies such as the United States and Europe consume large amounts of energy.

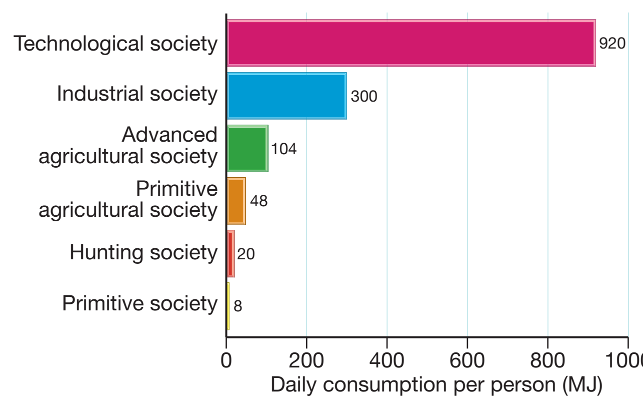


Figure 3.2.1 Comparing the energy needs of primitive cave dwellers with the energy used in today's society highlights the massive increase in energy consumption of recent times.

Table 3.2.1 Energy use per person (GJ) in various countries

Country	Yearly energy use per person (GJ) [1 GJ = 1000 million J]
Australia	240
Canada	348
China	48
Egypt	32
El Salvador	29
Ethiopia	12
Greece	113
Italy	131
Pakistan	19
United Kingdom	164
United States	327

Non-renewable energy sources

Oil, coal, gas and nuclear are energy sources that cannot be replaced. Energy sources such as these are called **non-renewable** energy sources. Oil, coal, gas and their products (such as petrol and diesel) are called **fossil fuels**.

Some 300 million years ago, the dead remains of prehistoric animals and plants were covered by layers of mud, sand and dirt. Pressure and heat below the Earth's surface gradually transformed these remains into the different fossil fuels than can be found today. The original source of energy for these fuels was the sunlight absorbed by the prehistoric plants, and stored in their remains or in the remains of the animals that ate the plants. When burnt, fossil fuels release large amounts of energy but also large amounts of the **greenhouse gas** carbon dioxide. This increased concentration of carbon dioxide in the atmosphere is thought to contribute to climate change.

Nuclear fuels, such as uranium and plutonium, are other non-renewable sources of energy that are used to generate electricity. Small amounts of these fuels can produce large amounts of energy in a chain reaction in a process called nuclear fission. This chain reaction is carefully controlled in a nuclear power plant. The heat created is used to generate electricity. Nuclear power plants do not produce greenhouse gas emissions and are used as the main power source in many countries. However, the process of nuclear fission used in the plants produces wastes that remain radioactive for thousands of years. Safe storage of these wastes remains a problem.

Figure 3.2.2 shows that more than 80% of the world's energy supply is obtained from oil, coal and gas. These are all non-renewable fossil fuels. Australia has plentiful supplies of coal and it is relatively cheap. Major energy sources used in Australia include:

- black and brown coal, to produce steam used to generate most of our electricity
- petrol to power most of our cars, with some using LPG (liquefied petroleum gas, another fossil fuel)
- diesel to power most trucks and some trains
- natural gas for much of our cooking, central heating and hot water services.

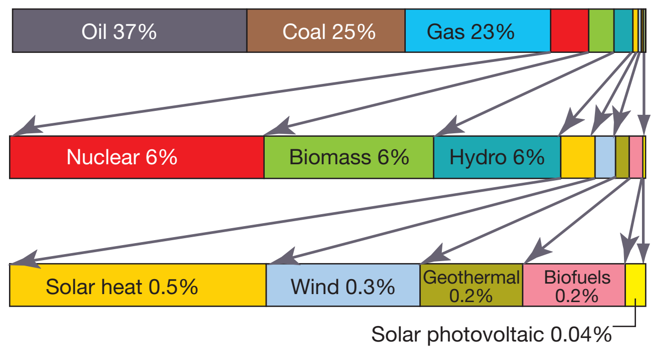


Figure 3.2.2 This chart shows where the world's energy comes from. The second and third rows show detail that cannot be seen in the eight smallest bands of the original (top) graphic.

SciFile

Brown isn't green

Brown coal releases a third more carbon dioxide than the same amount of black coal for only half the heat. Trials are being conducted to develop 'clean coal' technologies to capture and store carbon dioxide emissions from power plants such as Loy Yang. Loy Yang power station, in the Latrobe Valley in Victoria, consumes up to 60 000 tonnes of brown coal per day to supply about one-third of Victoria's energy. Most environmentalists argue that it should be shut down.

Renewable energy sources

Renewable sources of energy can be used over and over again. To build an energy supply for the future and to limit greenhouse gas emissions there is a need to switch from fossil fuels to renewable sources. Power companies offer households the option to buy all their electricity or some of it from an accredited green power provider. This means that by paying slightly more you can buy electricity that has been sourced from renewable energy. Key sources of renewable energy are:

- moving water
- Sun
- wind
- heat within the Earth
- oceans and rivers
- biomass.

Hydroelectricity

Gravity causes things to fall, including water. Water falling from a higher to a lower level (such as from the dam shown in Figure 3.2.3) can be used to turn turbines and generate electricity. This form of electricity is called **hydroelectricity**. The Snowy Mountains hydroelectric scheme is the largest hydroelectric power scheme in Australia. It consists of 16 dams, 7 power stations and over 145 km of tunnels. Hydroelectric schemes are a renewable energy resource. However, large-scale projects change the way rivers flow and alter the environment.

Figure 3.2.3 The energy of falling water is used to turn turbines that generate electricity in a hydroelectric power station.

Biomass

Biomass describes energy that is obtained from materials such as dead plants, plant matter, or animals and their wastes. These materials contain stored energy captured from the Sun. This energy can be released for use in many different ways:

- Heat energy is released when products such as wood or dried manure are burnt.
- When organic wastes such as fruit peelings and grass clippings are put into landfill, they decompose, producing methane and carbon dioxide gases. This gas mixture, called **biogas**, can be collected from landfill sites and the methane gas then used as a fuel.
- Biogas can be produced from human sewage and animal wastes. Production is conducted within tanks fitted with digesters that encourage breakdown of the waste.
- Agricultural crops such as corn (shown in Figure 3.2.4) and sugarcane can be fermented to produce ethanol, which is used as a liquid fuel. Agricultural wastes such as rice husks can also be used to produce ethanol.
- Vegetable oils from plant seeds such as oil palm, sunflower, canola, soybean, sesame and linseed can be converted into biodiesel fuel.
- Algae are harvested to produce biodiesel fuel.

3.3
1 p90

SciFile

A sugar rush

Brazil produces vast crops of sugarcane and uses some to produce ethanol. Most new cars are designed to run on ethanol. This change has lessened Brazil's dependence on oil – its cars are essentially solar powered!

Figure 3.2.4 Corn ethanol is produced in this processing plant in Iowa, USA. The corn grain shown here is a waste product of the process and is sold as animal feed.

Solar energy

Light from the Sun is a valuable renewable resource. It can be used in many ways to provide energy.

- The direction a house faces (its orientation) can help to reduce the need for additional heating and cooling. Using interior materials that absorb sunlight through the day and then release heat at night also helps.
- Sunlight can be used to heat rooftop solar panels to provide households with hot water.
- **Solar cells** (such as that shown in Figure 3.2.5) use materials called semiconductors to convert sunlight directly into electricity. Rooftop solar cells can provide household electricity, and any extra electricity generated can be fed back into the electricity grid. Solar cells are expensive to produce, but their generating capacity is increasing each year. This is reducing the cost of producing electricity using solar cells.
- A solar pond consists of a large volume of water to which salt is added. The pond is lined with black plastic. Sunlight heats water at the base of the pond, and the heat can be used to generate electricity.
- Large-scale solar energy systems, such as that shown in Figure 3.2.6 on page 84, rely upon vast arrays of mirrors to concentrate sunlight. These devices can be used to generate electricity with no greenhouse gas emissions.

Figure 3.2.5 Solar cells are useful for providing energy to small-scale devices such as calculators or garden lighting and for providing electricity in remote areas. The solar cell in this picture is on top of the phone booth.

INQUIRY science 4 fun

Using the Sun

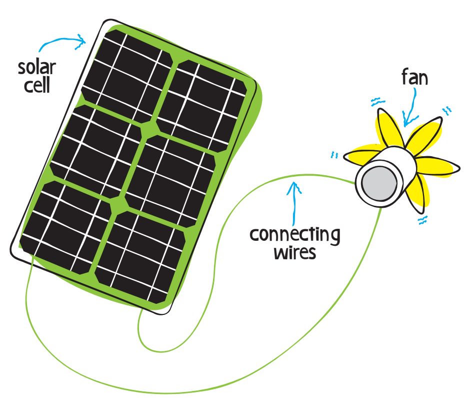
What energy changes occur with a solar cell?

Collect this …

- solar cell
- connecting wires
- electric motor with a fan

Do this …

1. Use the connecting wires to connect the solar cell to the electric motor.
2. Stand outside (preferably on a sunny day) with the solar cell facing the Sun.



Record this …

Describe what happened.

Explain why you think this happened.

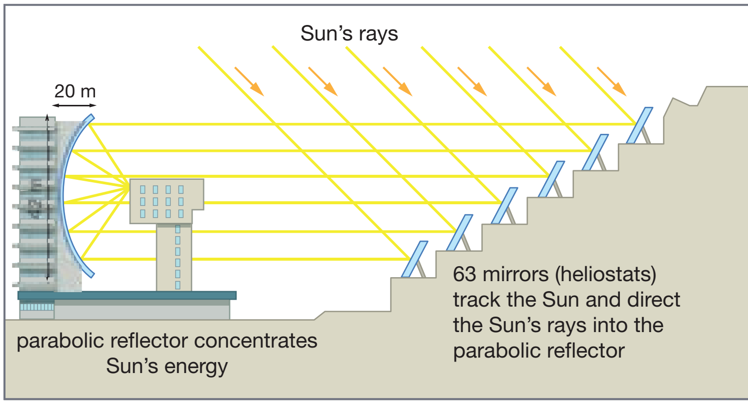


Figure 3.2.6 A solar furnace can produce temperatures up to 3800°C. Solar furnaces can be used to generate electricity or to conduct experiments on materials at extreme temperatures.

Wind energy

Wind energy has been used for centuries and windmills have long been used in Australia to pump water. Wind turbines are like large windmills but are used to generate electricity. Wind farms are located in windy places. You can see a wind farm in Figure 3.2.7.

2 p91

Figure 3.2.7 Wind energy generates no greenhouse gas emissions. Nearby residents may object to wind farms because they do produce noise and occasionally birds may be injured by the turbines as they spin.

Energy from the ocean

There are a number of different techniques that harness energy from the ocean. Although these techniques are generally expensive to establish, they offer a clean energy source once they are operating. An **oscillating wave column** (shown in Figure 3.2.8) and a **tidal barrage** (shown in Figure 3.2.9) are two examples.

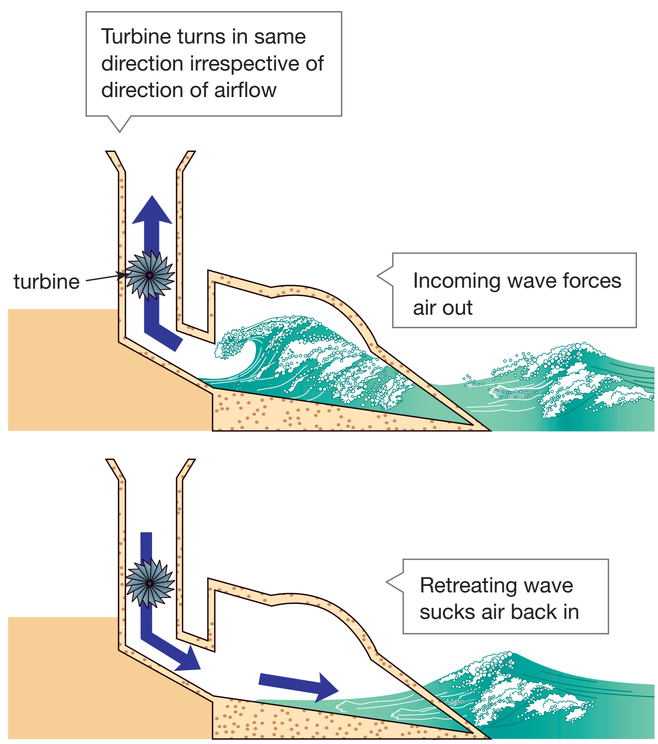


Figure 3.2.8 The oscillating wave column relies on the pressure of the waves to suck air in and out around a turbine to generate electricity.

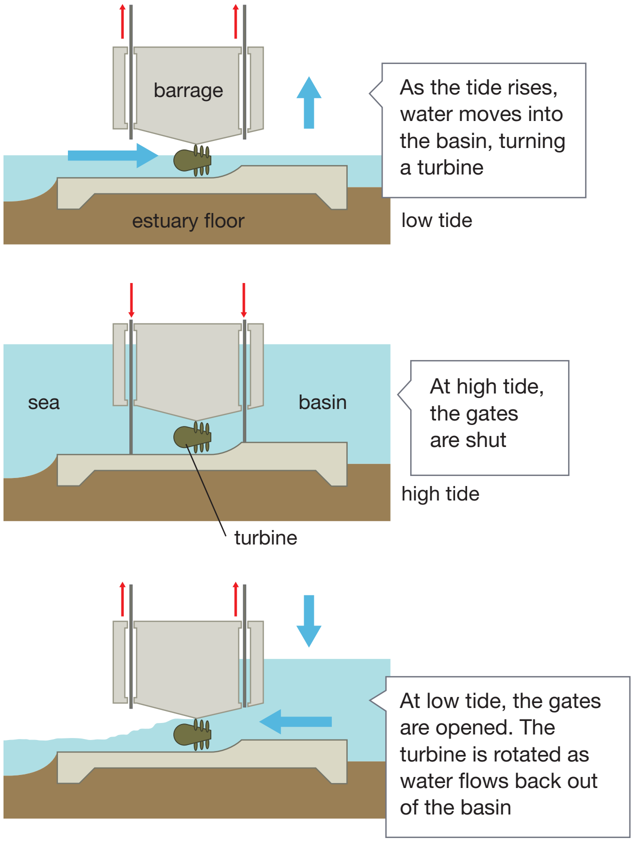


Figure 3.2.9 At low tide, the gates of the tidal barrage open to allow water to fill a basin. These gates are shut at high tide. When the tide is low, the gates are reopened and the pressure of water rushing out is used to generate electricity.

Geothermal energy

Beneath the Earth's crust lies molten magma (melted rock). In Iceland, Japan and New Zealand, this heat lies fairly close to the surface and heated water may burst from the surface as a natural hot spring or geyser like the one shown in Figure 3.2.10. This heated water can be used directly to generate electricity. Another way to use **geothermal energy** is to pump water underground through drilled channels and circulate it through the hot rock. The water is heated by the rock and is used to generate electricity when it returns to the surface. This is shown in Figure 3.2.11. A geothermal power plant has been built at Birdsville, in Queensland, and plants are being developed in South Australia. Geothermal power plants tap into a plentiful natural energy source. However, they are limited to specific areas and can result in pollutant gases escaping from below the Earth's surface.

Figure 3.2.10 This steam is produced by geothermally heated water in Iceland.

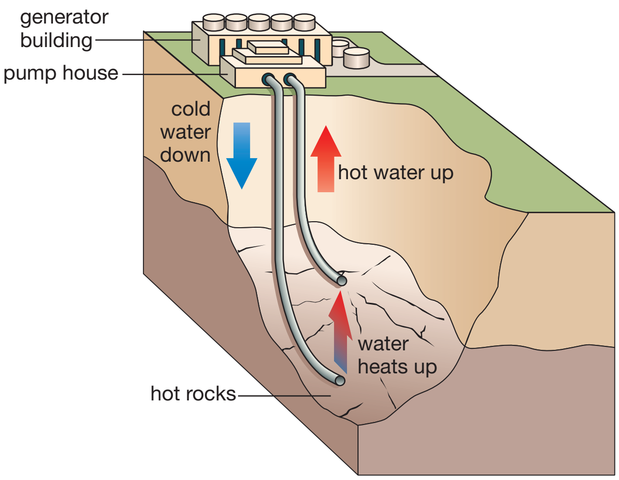
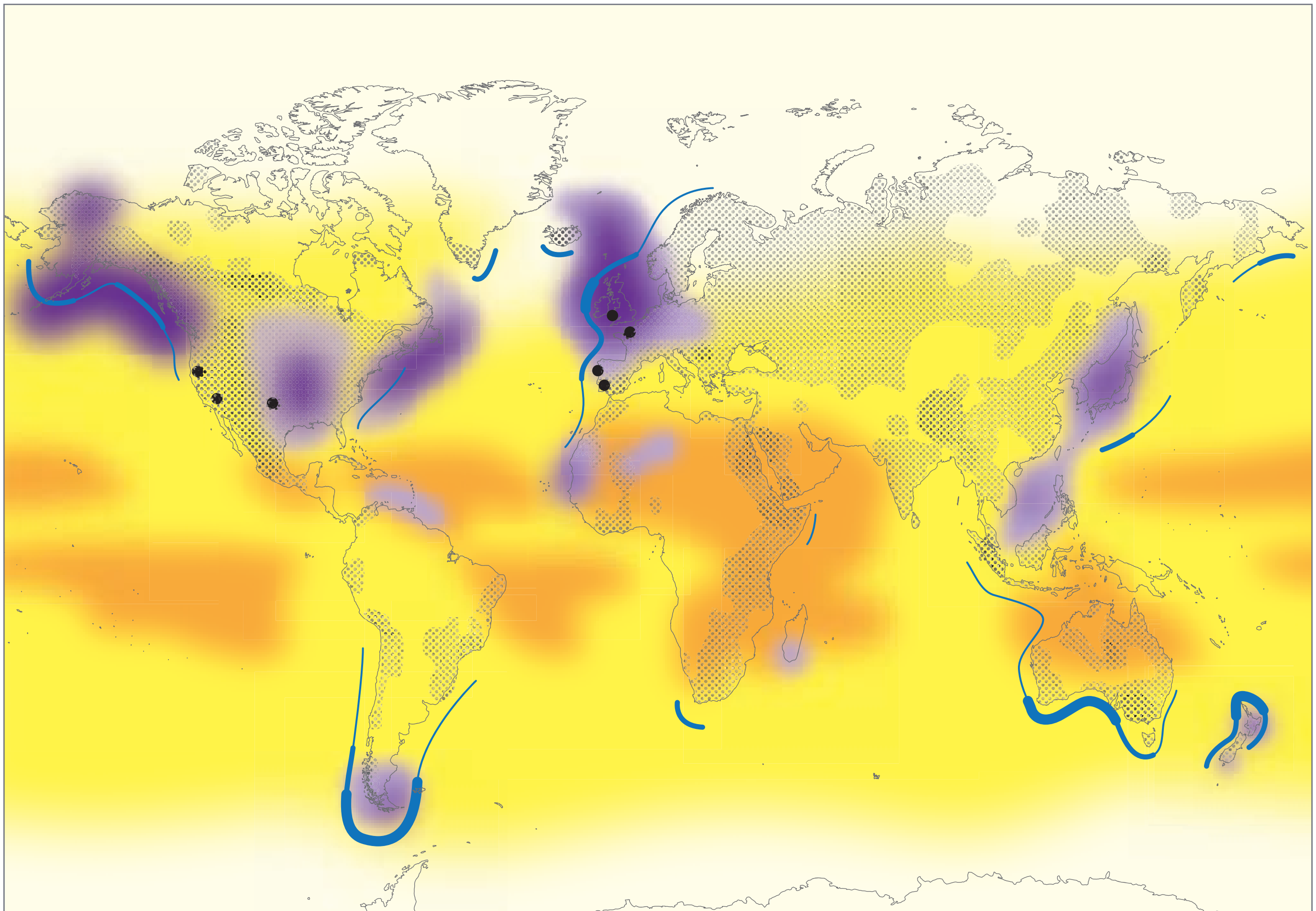


Figure 3.2.11 A geothermal power plant relies upon cold water being pumped below the surface where it is naturally heated over hot rocks and then returns to the surface.

The big picture

A major problem associated with many renewable energy sources is that their output is not continuous. Wind turbines, solar systems and wave generators rely upon the wind blowing, sunlight being present and waves crashing. Better methods need to be developed to store energy when demand is low so it can be used when demand rises. Figure 3.2.2 on page 81 shows that solar energy, geothermal energy and wind energy provide a small fraction of the world energy supply at present. A better approach is to utilise a number of renewable sources of energy. Figure 3.2.12 on page 86 illustrates the enormous potential of renewable energy sources worldwide and highlights the regions best suited to each type.



World energy generation (TWh/year)

Source	Current production	Technical potential
Geothermal	59	138,000
Wind	130	106,000
Solar	4	43,600
Biomass	239	23,000
Wave and tidal	0.5	not available

Figure 3.2.12 The depth of yellow shading indicates the average solar radiation reaching the surface of the Earth. The purple zones indicate regions of high wind speed. The blue lines indicate high tidal activity.

Energy conservation

Reducing the energy we use will ease demands on resources and will minimise greenhouse gas emissions. Here are some ways you can make a difference:

1. Switch off TVs and computers when they are not needed.
2. Walk, ride a bike or catch public transport instead of driving.
3. Use blinds and fans in summer instead of airconditioners.
4. Insulate yourself in winter by wearing a jumper and using blankets or thicker doonas.
5. Drink tap water rather than bottled water.
6. Use cloth bags or a backpack for shopping. Avoid purchasing products with lots of packaging.
7. Reduce the amount you buy, reuse what you have before throwing it away, and recycle goods you no longer need.

SCIENCE AS A

HUMAN ENDEAVOUR

Use and influence of science

Umeme Kwa Wote—Energy for all

Figure 3.2.13 In 2008, an experimental program was launched in Kenya that enabled people to recharge a solar-powered lamp such as this one in an energy hub.

About one quarter of the world's population do not have access to an electricity supply.

For many generations, fishermen living by the shores of Lake Victoria, in Eastern Africa, have relied upon kerosene lamps to light their homes and catch fish at night. Kerosene is readily available in remote areas and easy to buy in small quantities. However, it is expensive and highly flammable, and at times kerosene leaks into the lake, adding to its pollution. It is estimated that the burning of kerosene in lamps around the lake produces about 50 000 tonnes of carbon dioxide gas every year.

In April 2008, a lighting company built the first 'energy hub', on the banks of Lake Victoria. Its name is *Umeme Kwa Wote*, Swahili for *energy for all*. It is an energy station consisting of 42 solar panels installed on its roof. These panels convert the tropical sunlight into a clean supply of electricity. Three hubs have been built in Kenya and one in Uganda, with hopes to build another 100 energy hubs in Africa and 20 in Asia.

For a small fee, locals can use this electricity to recharge energy-efficient fluorescent lamps for use on their boats and in their homes. They can also take a rechargeable battery from the energy hub to power fishing lamps. A typical lamp is shown in Figure 3.2.14. It relies on an 11 W globe and is watertight and dust resistant. Costs are much lower than the equivalent costs for kerosene, the light from the lamps is brighter, it carries no health risks, and no greenhouse gases are produced in the process.

The battery can also be used to charge small appliances such as mobile phones and radios. When the batteries are flat, they are brought back to the hub for recharging and are swapped for a charged battery.

The woman shown in Figure 3.2.13 is carrying a lantern with an internal rechargeable battery. This lantern operates for 8 hours, or even longer when switched to a lower power LED light designed to provide enough light to read a book at night.

Figure 3.2.14 These fishermen are dragging their net into the waters of Lake Victoria. They hope to catch sardines attracted by the light source.

3.4

3.2 Unit review

Remembering

1 a **State** one key advantage associated with the use of fossil fuels.
  b **State** two key disadvantages associated with fossil fuel use.

2 **State** one advantage and one disadvantage associated with the use of nuclear fuel.

3 **List** the three sources of energy that supply the majority of the world's needs.

4 **List** five types of seeds that can be used to produce biodiesel fuel.

5 **Recall** another name for a solar cell.

6 **State** the fraction of the world's population that has no access to electricity.

Understanding

7 **Explain** the difference between renewable and non-renewable sources of energy, giving an example of each type.

8 **Outline** how fossil fuels are formed.

9 **Define** the term *biomass*.

10 **Describe** five different ways sunlight can be used as an energy source.

Applying

11 a **State** the average energy use in gigajoules (GJ) of an Australian over a year.
   b **Calculate** this value in joules (J).

12 Each situation below describes different energy changes. **Use** the options in the box below to **identify** which type of energy is being used in each case.

hydroelectricity
oscillating wave column
biomass
fossil fuel
tidal barrage
solar energy
geothermal energy
wind energy

a Wood is burnt in a camp oven to boil a kettle.
b Natural gas is used to heat a saucepan of pasta on a stove.
c Falling water turns turbines that generate electricity.
d Sunlight falling on a photovoltaic cell is directly converted into electricity.
e Turbines rotate as air flows through them and this is used to generate electricity.
f A turbine rotates in one direction and then the other as moving water sucks air past its blades.
g Water flows rapidly over a turbine, which is used to generate electricity.
h Water pumped below the surface of the Earth is heated and used to generate electricity.

13 Refer to Figure 3.2.12 to answer the following questions.
  a **State** the current production of electricity from solar sources (in TWh/yr).
  b **State** how much electricity could potentially be produced from solar sources (in TWh/yr).
  c **Propose** three regions of the world that would be best suited to utilising:
    i solar energy
    ii wind energy
    iii ocean energy
    iv geothermal energy.
  d Looking at Australia on this illustration, **propose** which renewable resource you think would be best suited to development in the state or territory that you live in.

14 **Use** Figure 3.2.2 on page 81 to **state** the percentage of world energy consumption supplied by:
  a oil
  b solar photovoltaic energy
  c nuclear energy.

Analysing

15 **Compare** the key advantages and disadvantages between two renewable energy sources, such as solar, wind, tidal, geothermal or hydroelectric energy production.

Evaluating

16 a **Assess** whether nuclear energy is a renewable or non-renewable energy source.

b **Justify** your answer.

17 **Propose** why it is recommended that you switch off appliances at the power source.

18 **Propose** what is meant by the term *green energy*.

19 Consider the suggestions to help households conserve energy use.

a **Identify** one of these that you could easily act on this week.

b **Propose** your own personal list of 10 ways that you could save energy.

Creating

20 Australia has plenty of brown and black coal. It is relatively easily mined and relatively cheap.

a **Construct** an argument for or against the use of coal as an energy resource.

b **Use** the arguments of the class to run a debate on whether coal should continue to be used as a major source of electrical energy in Australia.

Inquiring

1 Find articles in the newspaper, magazines, on TV current affairs shows or on the internet regarding energy use and energy resources. Assess the arguments presented in each article and use your knowledge of renewable and non-renewable resources to summarise the claims made in them.

2 a Summarise the major sources of energy used in the state or territory in which you live. Survey a number of people about the energy that they use and compare whether this is in agreement with your research.

b Investigate the energy sources used by two countries other than Australia. Compare their energy sources with those used in Australia.

c Research and report upon an aspect of renewable energy technology that is being developed by Australian scientists. For example, investigate the work currently being conducted at the National Solar Energy Centre.

d Some people are concerned that harvesting food crops for biofuel production will result in food shortages. Research and report on whether these are valid concerns and recommend strategies to avoid this happening.

e Research the developments being made in 'clean coal' technology. List arguments for using coal-fired power plants in the future, with clean coal technologies. Also list arguments that could be made against the use of such power plants with or without the new technology.

f Some unusual devices are being tested to generate electricity from waves, with names such as 'the Oyster' and 'the Anaconda'. Summarise the development of one type of device designed to harness wave power and construct a model to explain how it works.

3 Research and report on how the solar energy complex shown in Figure 3.2.15 is used to generate electricity.

Figure 3.2.15 This solar energy complex located in the Mojave Desert in California, USA, is an example of a parabolic trough power plant.

3.2 Practical activities

1 Energy from food

The stored chemical energy in food can be used to produce biofuels. Food is also used as your chemical energy.

Purpose

To burn a sample of food and calculate its energy content.

Materials

- food samples such as: Cheezels, crusty bread, Marie biscuit
- cork
- aluminium foil
- paper clip
- retort stand and clamp
- thermometer
- test-tube
- electronic balance
- small measuring cylinder

SAFETY

Do not use peanuts or any nut product.

Watch the burning food sample at all times.

Ensure that the room is well ventilated or complete this experiment inside a fume cupboard.

Procedure

1. Using the measuring cylinder, carefully measure 10 mL of water. Pour it into the test-tube.
2. Cover the cork with aluminium foil. Shape the paper clip like a hook and poke it into the cork.
3. Cut a small piece of your first food sample. Record its mass in your table.
4. Set up the equipment as shown in Figure 3.2.16 so that the food sample will sit about 2 cm below the test-tube.
5. Measure and record the initial temperature of the water.
6. Use the Bunsen burner to set the food sample alight, and then carefully place the burning sample under the test-tube.
7. When the sample stops burning, measure the final temperature of the water and record this result.
8. Repeat the activity using two other food samples.

Results

1. Copy the results table below into your workbook.
2. **Calculate** the change in water temperature by subtracting the initial temperature from the final temperature.
3. For each sample, divide the change in water temperature by the mass of the sample.

Discussion

Compare the different samples and list them in order from the one that contains the most energy per gram to the one that has the least energy per gram.

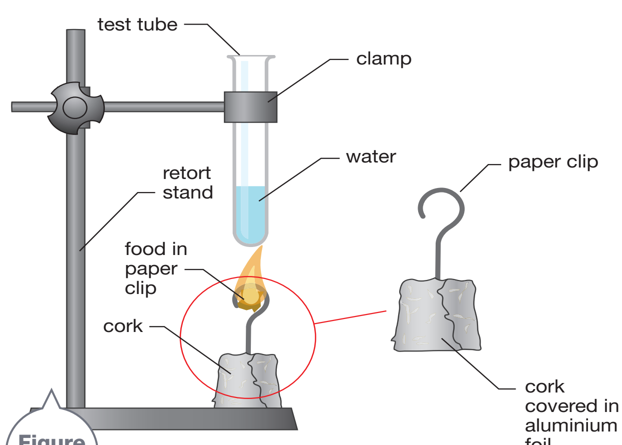


Figure 3.2.16

Food sample	Mass of sample (g)	Initial temperature of water (°C)	Final temperature of water (°C)	Change in water temperature (°C)	Change in water temperature ÷ mass of sample (°C/g)
1					
2					
3					

2 Harnessing the wind

Purpose

To investigate the effect that wind direction has on wind power.

Materials

- fan or a hairdryer
- pinwheel made from a sheet of cardboard (Please go to Pearson Places for a template.)
- nail
- bamboo skewer
- protractor (optional)
- masking tape
- cardboard cylinder
- length of string
- paper clip

Procedure

1. Produce a cardboard pinwheel using the instructions from Pearson Places and tape it securely to a bamboo skewer.
2. Support the pinwheel by inserting it through two holes in a cardboard cylinder as shown in Figure 3.2.17. The pinwheel and skewer should be able to spin freely.
3. Tape a length of string to the skewer where it extends from the cylinder.
4. Tie a paper clip or small sinker to the end of the string.
5. Investigate how the rate of spinning of the pinwheel (as indicated by the height the paper clip rises) is affected by the angle that the wind source (fan or hairdryer) makes with the front of the pinwheel. You could try different angles including 'straight on'.

Results

Present your data in a results table.

Discussion

1. **Describe** any patterns found in your results.
2. **Propose** any improvements that could be made to the design of your prac.

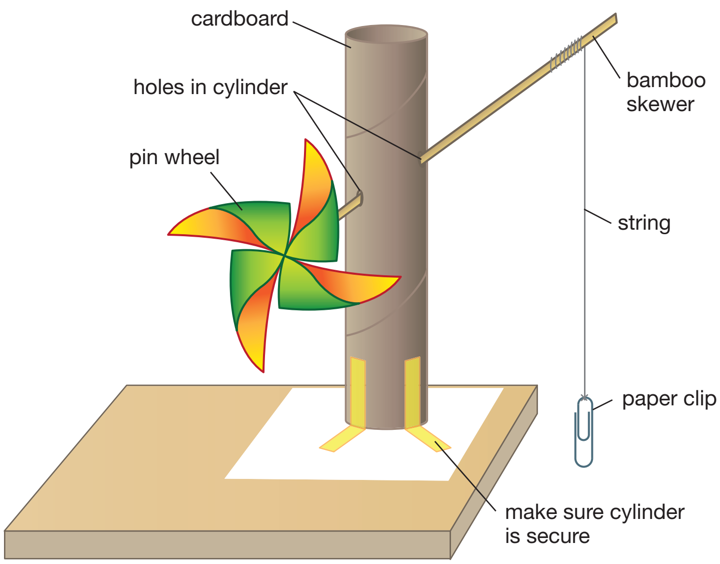


Figure 3.2.17 If the cylinder is unstable, tape it to a thick cardboard base so it is sturdy when standing upright.