Lesson Eleven

Physics: Energy Resources

Aims

By the end of this lesson you should be able to:

- understand the differences between renewable and non-renewable energy resources
- describe how fossil fuels were formed and are used
- describe the use of several non-renewable energy resources
- evaluate the impact of the use of energy resources on the environment

Context

This lesson continues the work on energy begun in Lesson Seven.

Introduction

Energy, as we saw in Lesson Seven, "gets things done". Modern society does lots of things, so it needs a lot of energy. The main uses of energy are for:

- transport (cars, trains, planes, etc.)
- heating buildings
- generating electricity

In the modern world, we use a variety of **energy resources** to provide this energy. There are three main sorts of these:

fossil fuels
nuclear power
renewable energy resources

Each of these has various advantages and disadvantages, concerning:

- whether they will run out
- how much they damage the environment, and
- how easy they are to use

Activity 1	Walk around your house and draw up a list of jobs for which energy must be brought in from outside as natural gas or electricity. What would your life be like without energy resources?

Fossil Fuels

A **fuel** is any material which can be burnt to release energy in the form of heat. A **fossil fuel** is one found underground that is the remains of organisms which lives millions of years ago. There are three important types of fossil fuel:

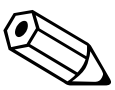
- coal
- oil (petroleum, also called crude oil)
- natural gas

Fossil fuels are very concentrated forms of chemical energy, which makes them extremely useful. A big problem is that they produce the gas **carbon dioxide** as they burn. We shall look at this problem later on.

Fossil fuels are all **non-renewable** energy resources. This means they are not reformed (at least on a human time scale): once used up, that's it!

Get it right! "Natural gas" is the name given to the fossil fuel which is provided to UK homes in pipes, and is used for central heating boilers and gas stoves. It is largely a compound called methane. It is often called "gas", but that is misleading, because air is also a gas!

"Oil" is the common name given to petroleum, which is extracted from underground. Again this is confusing, because there are other oils found in your kitchen, like olive oil and sunflower oil, which are foods made from plants.

Activity 2	Wood can also be used as a fuel. Is it a renewable or a non-renewable energy resource? Explain your answer.
	

Coal

Coal was formed from trees which grew on land millions of years ago, especially in a time called the **Carboniferous Period** about 300 million years ago. The trees fell into swamps, which stopped them rotting away completely. They were buried under layers of rock, which produced higher temperature and pressure, turning them into coal.

Coal

Coal is mainly the element **carbon**, which produces carbon dioxide as it burns. It also contains quite a bit of the element sulfur. This forms a harmful gas called **sulfur** dioxide as it burns. This gas attacks human respiratory systems causing bronchitis, and it dissolves in rain to form **acid rain**. Acid rain corrodes buildings and kills trees in forests and life in lakes. Coal produces more carbon dioxide and sulphur dioxide as it burns than the other fossil fuels, so it is the fuel which causes the worst **pollution** of the air.

Being a solid, coal will not flow through pipes like the other fossil fuels, so it is less convenient to use. It used to be used to heat homes and to drive steam trains, but its main use today is in **power stations** to generate **electricity**.

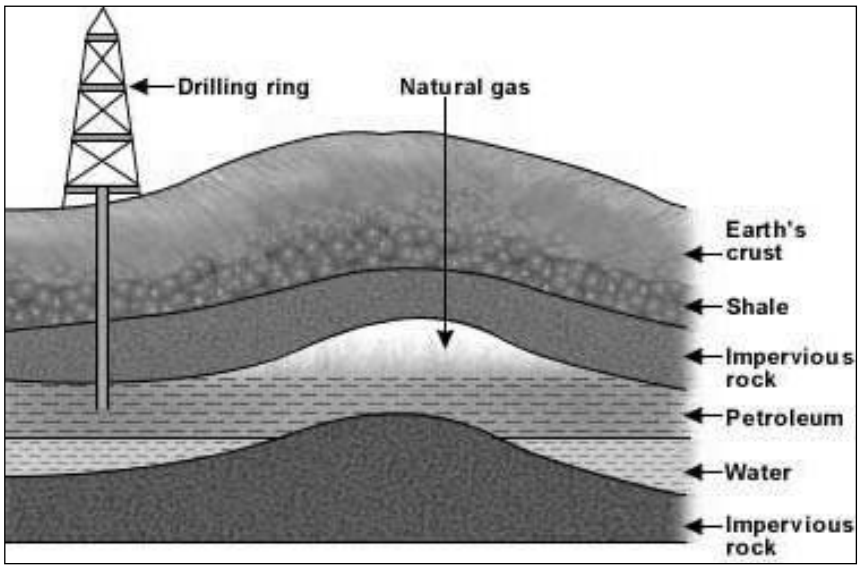
There is a lot of coal. It is due to run out much later than oil or natural gas.

Activity 3

Go to YouTube at www.youtube.com and enter "coal mining" into the search box to see several videos about coal mining.

Oil

Oil and natural gas were both formed from microscopic plants and animals living in the sea millions of years ago. When they died, their bodies settled on the bottom. They were buried under layers of rock, which produced higher temperature and pressure, turning them into liquid oil and natural gas. If covered with an **impermeable** layer of rock (one which will not let liquids or gases escape) they stayed trapped.



As we saw in Lesson Ten, oil (petroleum) is a mixture of liquids that can be separated by fractional distillation. All of the liquids are compounds known as **hydrocarbons** because they contain both carbon and hydrogen. When they burn they produce carbon dioxide (although less than coal) and harmless water vapour.

Here is a list of the different liquids obtained from crude oil, with their boiling points and main uses. As you can see, LPG, petrol, kerosene, diesel oil, gas oil and fuel oil are all burned as fuels. Because they are liquids (except for LPG) and will flow through pipes, they are the most convenient form of fuel for transport.

Fraction	Boiling point (°C)	Uses
LPG (Liquefied Petroleum Gas)	Below 20	'Calor' and 'Camping' gas
Petrol (Gasoline)	20 – 125	Fuel for cars
Naphtha	125 – 175	Raw material for the chemical industry, used to make plastics, drugs and chemicals for agriculture
Kerosene (Paraffin)	175 – 250	Aviation fuel for jet engines
Diesel Oil and Gas Oil	250 – 350	Transport fuel (lorries, buses) and central heating fuel
Lubricating oil	350 – 400	Lubricants
Fuel oil	400 – 500	Fuel for ships and power stations.
Residue	500 +	Grease for lubricants; bitumen for roads

Our supplies of petroleum are being used up fast. It is due to run out completely this century at the current rates of use.

Activity 4

To find out more about the fractional distillation of petroleum, and about petroleum in general, go to YouTube at www.youtube.com , and put "petroleum refining" into the search box.

Natural Gas

Natural gas is formed along with oil, as described above. It is largely the compound **methane**, which consists of the elements carbon and hydrogen. It is the "cleanest" of the fossil fuels, because it produces least carbon dioxide, and no other harmful gases, when it burns.

Natural gas is mainly used in two ways:

- In homes, other buildings and factories to provide heat for cooking and to keep people warm
- In power stations to generate electricity

Gas stove flames
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It is a little more difficult to use than liquid fuels, because it needs pipes laid to carry it around the country, and it is explosive if the pipes leak. However it is much more convenient for heating a home than coal, which involves shovelling it onto the fire and clearing away the ash afterwards!

Like petroleum, our supplies of natural gas are being used up fast. It is due to run out completely this century at the current rates of use.

Carbon Dioxide and the Greenhouse Effect

Fossil fuels are extremely important energy resources. Since the Industrial Revolution in the 1700s the modern world has been based on them. But there are two big snags about their use:

- because they are non-renewable they are going to run out, in the case of petroleum and natural gas quite soon, and
- they release carbon dioxide gas into the air when they burn, which contributes to the **greenhouse effect**.

If you are in a greenhouse or car in direct sun with the windows shut, the inside rapidly warms up. This is because

the glass will let the sun's heat (thermal energy) in, but not back out.

Carbon dioxide is a **greenhouse gas**. It makes the atmosphere similar to glass, trapping the sun's heat in and stopping it escaping back out into space. The more carbon dioxide there is in the air, the greater this effect becomes, and the more the earth warms up. This is called **global warming**, and is partly caused by the burning of fossil fuels. It is expected to have very serious consequences later on this century.

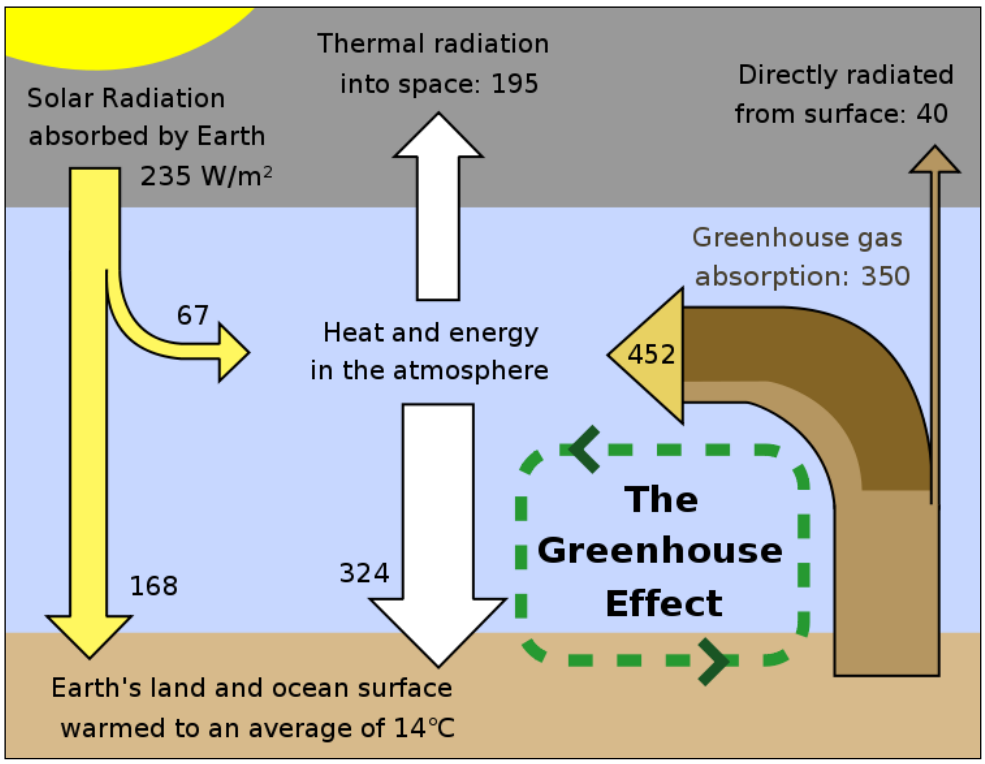

Diagram to show the Greenhouse Effect
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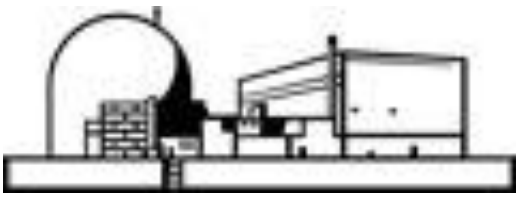
This figure is a simplified diagram of the flows of energy between space, the atmosphere, and the Earth's surface, and shows how these flows combine to trap heat near the surface and create the greenhouse effect. Energy exchanges are expressed in watts per square metere (W/m^2).

Activity 5

To find out more about the greenhouse effect and global warming, go to YouTube at www.youtube.com, and put "greenhouse effect" into the search box.

Nuclear Power

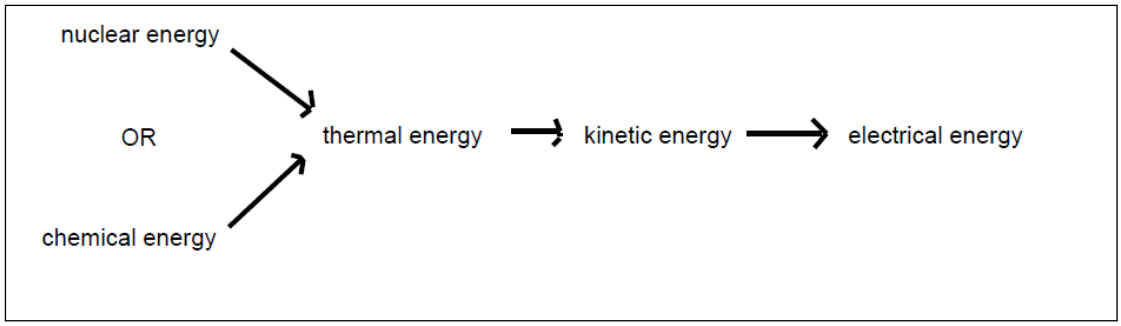
Nuclear power stations use nuclear energy from the element **uranium** that can be mined from underground. They do not produce carbon dioxide, so they do not contribute to global warming. However uranium is also a non-renewable resource and the supplies of it are limited. It is also a very dangerous material to handle.



Nuclear power is extracted from uranium by splitting its atoms, a process called **nuclear fission**. Unfortunately, both uranium itself, and the elements formed when it is split, are highly **radioactive**. This means, if let out, they can cause **cancer** and other problems. As a result, both building a safe nuclear power station, and safely storing the spent fuel from it, is very expensive.

Generating Electricity

All **power stations**, whether nuclear power stations or ones running on fossil fuels, work in the same way. The fuel produces heat (thermal energy) which boils water in a **boiler**. This produces a high speed jet of **steam** which pushes the blades of a **turbine** round and round very fast. The turbine turns a **generator**, which transfers this kinetic energy into electrical energy. The energy transfers are:



Nuclear Power Plant_
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Renewable Energy

All of the energy resources studied so far share two problems:

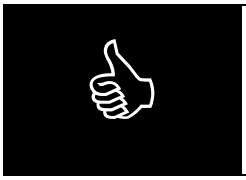
- they are non-renewable, so they are going to run out, and
- they produce dangerous materials as a by-product.

For this reason, we have recently been turning to alternative sources of energy, particularly to generate electricity. These are called **renewable energy resources**, or "renewables" for short. There are several different sorts of these, but we shall only look at the most important ones.

Renewables are not going to run out, and they do not produce hazardous by-products, but compared to fossil fuels they have two serious disadvantages:

- they are much more inconvenient to use, and
- they are often much more expensive to set up

This is why we are still mainly using fossil fuels, despite their disadvantages.



Get it right! "Renewable" does not mean the energy can be re-used. It means that the energy resource can be reformed.

Solar Energy

Solar energy means energy which reaches us from the sun. This energy is mainly in two different forms:

- thermal energy, and
- light.

Fossil fuels were obtained from the light in solar energy millions of years ago. All our other energy resources also rely on solar energy, except for nuclear power, geothermal energy and tidal energy (see below):

- wind power, hydroelectric power, wave power and solar heating panels depend upon thermal energy from the sun;

- photovoltaic cells and biofuels depend upon light energy from the sun.

Wind Power

Wind turbines harvest the kinetic energy of the wind and transfer it to electrical energy. The wind's kinetic energy was originally transferred from the sun's thermal energy heating the air, ground and sea.

Many of them are being built as **wind farms** on hilltops and out to sea where it is often windy. Unfortunately, the wind does not blow all of the time! Also, many people do not like looking at them on hilltops, and the ones out to sea are expensive to build.

Wind Farm

Hydroelectric Power (HEP)

A dam is built to collect water in a lake in a hilly area. As the water runs downhill from the lake, its gravitational potential energy is transferred to kinetic energy, which turns a generator to produce electricity. The water's GPE originally came from the sun's thermal energy which evaporated the water from the seas so it could fall as rain over the hills.

HEP is much used in hilly areas like Scandinavia and Scotland, but is less useful in flat areas. It means flooding a lot of land to build the lake.

The Karun-3 Dam in Iran
http://commons.wikimedia.org/wiki/File:Karun3-dam.jpg

Log on to Twig and look at the film titled: **Building the Hoover Dam**

www.ool.co.uk/1335gh

The construction of the then-largest dam in the world: how was the construction of the dam achieved and what is its legacy today?

Geothermal Energy

The inside of the earth is very hot, because of the nuclear reactions which go on there. At some points, the hot centre comes close enough to the surface to be able to drill down to it easily. Water is pumped down to be heated, and returns as steam to drive a generator in a power station.

This only works in the few places where the earth is hot enough close enough to the surface, for example in Iceland. In Iceland, buildings are heated using this heat too, as well as the heat being used to generate electricity.

Geothermal Power Station
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Solar Heating Panels

These are painted black to absorb the sun's heat, filled with water, and placed on the roofs of houses. The warm water is

pumped back inside to the house's hot water system, reducing the amount of other energy needed to provide the house's hot water.

Solar panels on the roof of an old building
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Unfortunately this only works well in the summer and in countries with a lot of sunshine (not really the UK, then!) In some hot places, like the Californian desert in the USA, the sun's thermal energy is harvested using mirrors to produce steam to run power stations.

Photovoltaic Cells

Log on to Twig and look at the film titled: **Solar Cell**

www.ool.co.uk/786wz

Also called a photovoltaic cell, a device that converts light directly into electricity.

These are large panels which harvest the sun's light energy and convert it directly into electricity.

Photovoltaic Cells
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These cells are very useful in small applications like calculators, and in remote areas where it would cost too much money to lay power cables to provide electricity. Unfortunately, the cells are very expensive to produce in the first place and, of course, not everywhere gets much direct sunlight all year (or at night!)

Biofuels

Biofuels are replacements for petrol and diesel oil that are produced from crops. Sugar cane is used to produce **ethanol** as a substitute for petrol in cars, and oil seed rape to produce **biodiesel** for lorries, tractors and buses. The chemical energy in them has been transferred from the sun's light energy by the crop plants used to make the fuels.

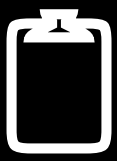
Unfortunately this means the land is not available to grow food, and land is in increasingly short supply as the human population grows.

Log on to Twig and look at the film titled: **Biofuels**

www.ool.co.uk/1327tn

Can biofuels become the sustainable fuels of the future? Or does the energy used for their production, and impact on biodiversity mean they do more harm than good?

Extension Activity 1



Pick one of the forms of renewable energy discussed above, or tidal or wave energy, and do a research project on it using the internet. The Wikipedia http://en.wikipedia.org/wiki/Main_Page and YouTube www.youtube.com websites are good places to start. Also put the name of the energy resource into a search engine like Google at www.google.co.uk .

As part of your project you should aim to carry out some or all of the following tasks:

1. Choose a form of renewable energy and briefly describe the source of the energy. Include a map to show key energy sources for UK use.

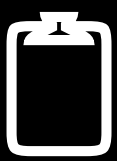
2. Explain briefly how this energy source is transformed into a form of energy that we can use

3. Make a list of six different energy sources in the UK in ranked order showing where your chosen energy source fits into this list.

4. Make a bar graph to compare energy use from your chosen source with five other sources of energy.

5. Make a table showing the advantages and disadvantages of each of these six energy sources using the following column headings: availability of source energy, cost to convert to usable form of energy; set-up costs; availability to potential users.

Extension Activity 2

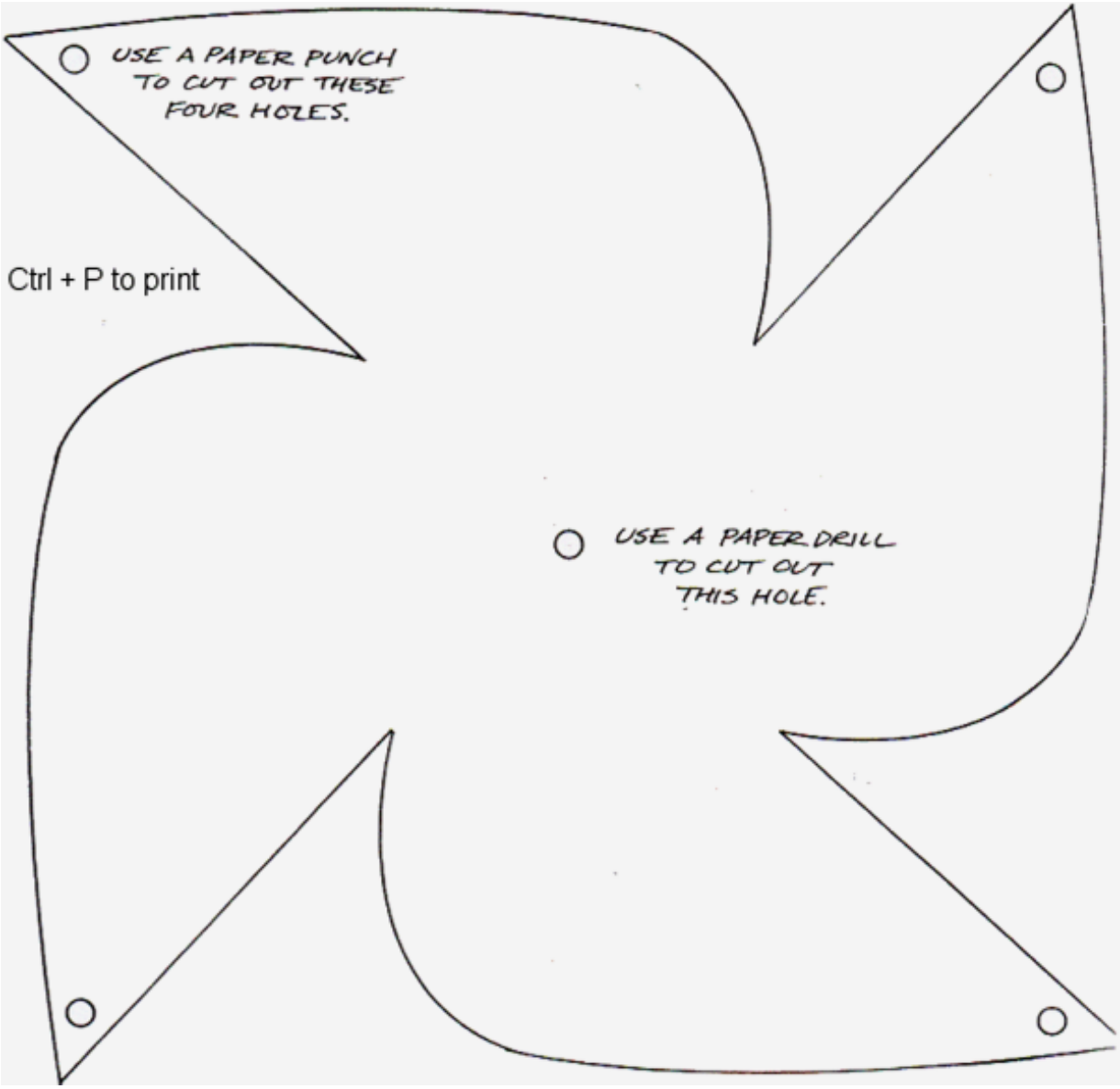


In this activity you are going to design some different windmill shapes and test them to see how effective they are. To keep the test fair you need to use a different design each time but keep the paper size the same. See instructions below.

Materials

Per windmill:

- sheet of paper, 22 cm x 28 cm.
- 2 rubber bands
- straw
- piece of string, 50 cm
- pencil or single hole punch
- scissors
- small paper cup



1. Using one of the templates provided, draw your pattern on a sheet of paper. Transfer all of the pattern's lines and circles.

2. Use a pencil or single hole punch to punch a hole through the centre circle (you may need to fold the pattern in half to use the single hole punch). Then punch a hole in each corner circle.

3. Cut along the solid lines, making sure not to cut the centre hole

4. Insert a straw through the centre hole.

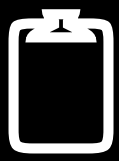
5. Fold each corner along the dotted line and insert the straw through each corner hole. Slide the windmill to the centre of the straw.

6. Wrap a rubber band around the straw on each side of the windmill to keep the windmill in place.

7. Punch two holes on either side of a small paper cup. Thread one end of the string through both holes and tie it to the middle of the string. Tie the other end of the string to one end of the straw.

8. Hold the straw with both hands as shown. Blow on the windmill. As the windmill turns, the straw rotates, winding the string and lifting the cup. For a good working design, you need to make sure that the windmill and straw move as a unit and that the string doesn't slip as the straw rotates.

Extension Activity 3



If you are fired up about renewable energy, investigate the website of The Centre for Alternative Technology at www.cat.org.uk. This Centre, set in mid Wales, makes a superb whole day visit, and even runs residential stays for school-aged children in their Ecocabins!

Keywords

Energy resources
Fuel

Fossil fuel
Methane
Carbon dioxide
Carbon
Hydrogen
Sulfur
Petroleum
Natural gas
Turbine
Generator
Wind turbine
Solar energy
Photovoltaic cell

Renewable
Non-renewable

Acid rain
Pollution
Power station
Impermeable
Greenhouse effect
Greenhouse gas
Global warming
Uranium
Nuclear fission
Biofuel
Hydroelectric power
Geothermal

Self-Assessment Activities

1. (a) Group these energy resources under two headings - renewable and non-renewable:

   Coal, wind power, nuclear power, wood, solar energy, natural gas, geothermal energy, HEP

   (b) Which of the above list are fossil fuels?

2. Correct the mistakes in these statements:

   (a) The fact that the earth is warming up is called the greenhouse effect.
   (b) Carbon dioxide causes acid rain.
   (c) Fossil fuels were formed by the transfer of thermal energy from the sun.
   (d) A nuclear power station uses nuclear fusion as its energy source.
   (e) Gasoline is used as fuel for aircraft engines.

Suggested Answers to Activities

Activity 2

Wood is a renewable energy resource. Once burnt, it can be re-grown within a reasonable timescale.