Australian Science Teachers Association

Energy

[future challenges]

a resource book of ideas for teachers for National Science Week 2005

[Foreword]

The Australian Science Teachers Association has a long and proud history of involvement with National Science Week. For 21 years, ASTA has promoted the importance of science education and encouraged the celebration of science in schools, initially through "Australian Science in Schools Week" which started in 1984 and, more recently, National Science Week.

National Science Week opens a window on the wonderful world of science. It is packed with activities which celebrate science and its importance to our lives, offering over 600 events for students, parents, families and the general public. These events provide schools and local communities with an ideal opportunity to join in and find out more about science and how it benefits and even transforms our lives.

The 2005 ASTA National Science Week Resource Book, entitled *Energy: Future Challenges* is designed to help teachers recognise and understand links between science and energy. It is an excellent resource for science education, containing a wealth of information, websites, classroom activities, facts and diagrams. *Energy: Future Challenges* will provide students - our leaders of tomorrow - with opportunities to become more scientifically literate about important issues surrounding energy which is the cornerstone of modern society.

The Australian Government is proud to support National Science Week, recognising the value of what has become Australia's pre-eminent celebration of science. The participation of schools in National Science Week is encouraged by providing every school in Australia with a copy of the Resource Book. This publication will help to ensure that our school students are not only aware of Science Week, but are active participants in it.

I am sure that teachers all over Australia will find the Resource Book a great tool in helping them plan and run activities for their students during National Science Week and I commend ASTA on its publication.

The Hon Dr Brendan Nelson MP
Minister for Education, Science and Training
April 2005

Energy

[future challenges]

Teacher Feedback Questionnaire

FAX THIS EVALUATION FORM TO ASTA

02 6282 9477

BY 19 SEPTEMBER 2005 TO WIN

PRIZE 1: LEGO Educational Division Renewable Energy Classroom Solution valued at over $500 (excl GST) donated by Educational Experience, freecall 1800 025 270.

PRIZES: Sets of 4 Energy Posters donated by Educational Experience.

Energy **[future challenges]** is an ASTA resource book of ideas for teachers for National Science Week 2005. The information you provide will help ASTA make improvements to future publications.

YOUR NAME:	YEAR LEVEL THAT YOU TEACH:
YOUR SCHOOL NAME:	YEARS CATERED FOR AT YOUR SCHOOL:
SCHOOL ADDRESS:	
SCHOOL PHONE NUMBER:	SCHOOL FAX NUMBER:
SCHOOL EMAIL ADDRESS:	ASTA MEMBER: YES/NO (If yes, which science teachers association)

PLEASE INDICATE YOUR RATINGS

FEEDBACK CRITERIA: *Energy* [future challenges]

1. Overall response to the book	1	2	3	4	5	
A valuable resource ◀						▶ Of little value
Well presented ◀						▶ Poorly presented
Information sections were helpful ◀						▶ Not helpful
Supports an inquiry approach to student learning ◀						▶ Does not support an inquiry approach
Applicable beyond National Science Week 2005 ◀						▶ Not Applicable
2. Resource book content	**1**	**2**	**3**	**4**	**5**	
Too complex ◀						▶ Too simple
Includes activities relevant to class level I teach ◀						▶ Irrelevant to my students
Created student interest ◀						▶ Little interest created
Provided a springboard to other ideas and activities ◀						▶ No scope for creativity
Additional resource links were useful ◀						▶ Not useful
Appropriate methodology ◀						▶ Inappropriate Methodology

3. What did you find most valuable about the book?

Why?

4. What did you find least valuable about the book?

Why?

[Contents and Acknowledgements]

Australian Science Teachers Association

Australian Government

Department of Education, Science and Training

NATIONAL SCIENCE WEEK

Welcome to the the 21st edition of the Australian Science Teachers Association (ASTA) National Science Week resource book *Energy: Future Challenges*. It contains information and activity ideas for teachers to use as a focus for National Science Week and beyond.

ASTA supports and assists teachers for National Science Week in every state and territory. Elsewhere in this book is a list of contacts and other resources available to you.

ASTA acknowledges that this book is made possible from funding received through the Australian Government's National Innovation Awareness Strategy and major sponsors, the Australian Coal Association and the Department of Environment and Heritage: Australian Greenhouse Office.

ASTA Council thanks and congratulates all those involved in the researching, writing, design and scientific validation of *Energy: Future Challenges.*

Thanks also to the ASTA reviewers and the eight ASTA National Science Week Science Teacher Association Representatives. Their work is evidence of their commitment to achieving recognition against the ASTA national professional standards for highly accomplished teachers.

I hope that you find this book useful in your endeavours to raise the awareness of science amongst your school community and contribute to a scientific literate society. Your feedback is welcome.

Gary Thomas

Gary Thomas

ASTA President

ASTA acknowledges the following for their valuable input during the development of this book: Jan Elliott, SEA*ACT; Anne Forbes, STANSW; Ann Manion, STAQ; Carolyn Montgomery, STAWA; Liz Ryan, STAT; Vicki Shegog, STAT; Annie Termaat, SEA*ACT; Sandra Woodward, STANSW, Leon Deleuil, ASTA Editor Journal

The authors would like to thank the following people and organisations for their help with the research and writing of this book: Dr Prame Chopra, ANU; Rebecca Short, DEUS; Yolande Strengers, AusWEA; Natali Nagy, Origin Energy; Alison Cornish, Energetech Australia Pty Ltd; Carmel Anderson, CO_2CRC; Dr John Bradshaw, Jason Vella, Dr Kate List, Len Hatch, Geoscience Australia; DrChris Speros, CS Energy; Mark O'Neill and Paula Matthewson, ACA; Sue Fama, David Jamrozik, Hydro Tasmania; Narrele Kellie, Snowy Hydro; Mark Diesendorf, Sustainability Centre; Melanie Hutton, WWF; Ian Hore-Lacey UIC; Tracey Gobey, Stanwell Corporation Limited; Annette Kennewell, Educational Experience; Lloyd Cleaver, All Saints College.

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Publisher: Australian Science Teachers Association, PO Box 334, Deakin West ACT 2600

Printer: Canprint

McNeil, L and Cleaver, C
Energy: Future Challenges
ISBN: 0-9580663-3-7

[Introduction]

Hi, i'm Energy Dude, and i am going to light your way through this resource book of information and interactive teaching ideas. i hope i electrify and energise you.

Energy: Future Challenges has been designed as a teacher resource to assist teachers in developing inspiring, informative and interactive lessons about energy.

All background information and activities derive from the theme future challenges, and are aimed at developing students' scientific literacy and skills in the field of energy. The overriding objective has been to encourage students to begin/continue to formulate informed decisions about the significant social, environmental and economic issues that are associated with the generation and use of energy.

[How to use the book]

Every energy source, both renewable and non-renewable, has been examined using the most current information available. All topics are self-contained, allowing teachers to select at random information and activities. Each topic is structured to include scientific information about the topic, details about Australian industry, case studies, and the latest innovations in the field. Web links and references are included for each topic to enable teachers and students to conduct further research on any detail addressed in the chapter.

Activities

Activities are included in every topic to engage students in the significant concepts introduced. Activities are able to be adapted to suit most age and skill levels. Where relevant, all activities are linked to websites for further information.

Websites/Resources

Where appropriate websites and references have been suggested to enable readers to access further information and activities. All websites were deemed appropriate at the time of publication. It cannot be guaranteed that all websites will continue to be available after publication.

Did You Know?

Interesting snippets included as a light and easy way to retain your interest!

Questionnaire

Please complete the questionnaire and return to ASTA to ensure we continue to improve.

Curriculum Guidelines

This resource book is intended to enhance all teaching programs within your school. They are not specifically curriculum linked, although the activities are designed to reflect a broad sweep of nationwide curriculum outcomes.

The information and activities are not intended to be prescriptive but able to be incorporated wherever it is deemed appropriate or relevant.

Safety Awareness

All student activities included in Energy: Future Challenges have been designed to minimise hazards, however, there is no guarantee that a procedure will not cause injury. Teachers should test all activities/experiments before using them in class and consider the OH&S requirements within their state or territory. All necessary safety precautions should be outlined clearly to students. Students must be provided with all safety equipment necessary prior to the commencement of experiments/activities.

ASTA and Clue Communication take no responsibility for the safety of teachers and students participating in any of the activities in the book.

[What is Energy?]

Matter and energy make up the universe in which we live. Energy is needed to do work; to provide power and light to cities and towns; to power vehicles, trains, planes and rockets. Energy is needed to provide heating for homes, to cook food, to play music, to give a picture on the television. Energy powers machinery in factories and tractors on a farm. Energy from the Sun provides light during the day, and enables plants to grow. The Sun's heat energy dries clothes on the line and sustains life on Earth.

In fact, most of our energy comes from the Sun. Physicists believe that in the centre of the Sun there is a constant nuclear reaction happening. Two hydrogen molecules crashing together form a helium molecule as well as a significant amount of energy.

DID YOU KNOW?

$E = mc^2$. Energy = mass x speed of light squared. Energy is the ability or potential of something to do work. Therefore all matter is considered to be a form of energy.

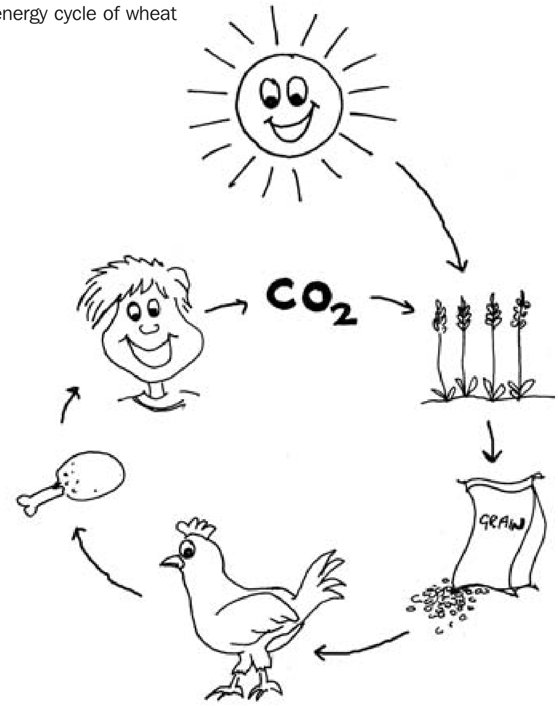
DID YOU KNOW?

The concept of energy has only been around for the last 150 years.

The energy cycle of wheat

Energy changes form ("transforms") at each step in the food chain. Leaves absorb sunlight for photosynthesis – the plant takes in sunlight and combines it with carbon dioxide (CO_2) from the air and water and minerals from the ground to grow and create seeds – the energy of the sunlight is stored in the leaves and inside the stalk as sugars and starch. The wheat is harvested and the grain is fed to chickens – the chickens use the stored energy in the wheat to grow and to move – they store some energy in muscle tissue (protein) and in the fat. The chicken is slaughtered – the chicken is bought from the butcher and cooked. When eaten the chicken's meat and fat is converted into stored energy in the human's body – the human plays netball, using the energy from the chicken to run around the court throwing and catching the ball. As the body uses the energy from the chicken, it breathes in oxygen and exhales CO_2 – that CO_2 is used by other plants to grow. It's a big circle!

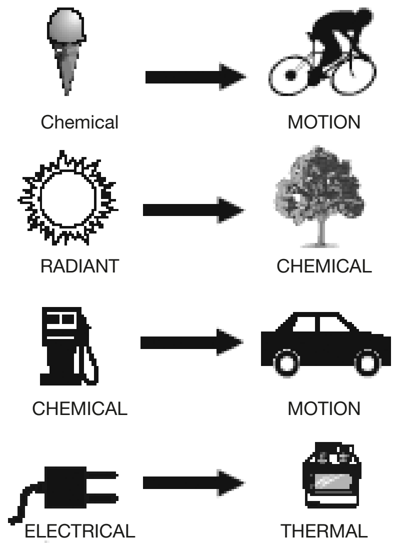
The energy cycle of wheat



The law of conservation of energy

(1st law of thermodynamics)

The law of conservation of energy states that energy cannot be created or destroyed. It can only be transformed from one form to another as well as transferred from one body to another but the total energy remains the same.



The transformation of energy. *Source: Energy Information Administration*

DID YOU KNOW?

If 10 kilograms of matter spontaneously turned into energy there would be enough energy to power a 100W light bulb for 285 million years.

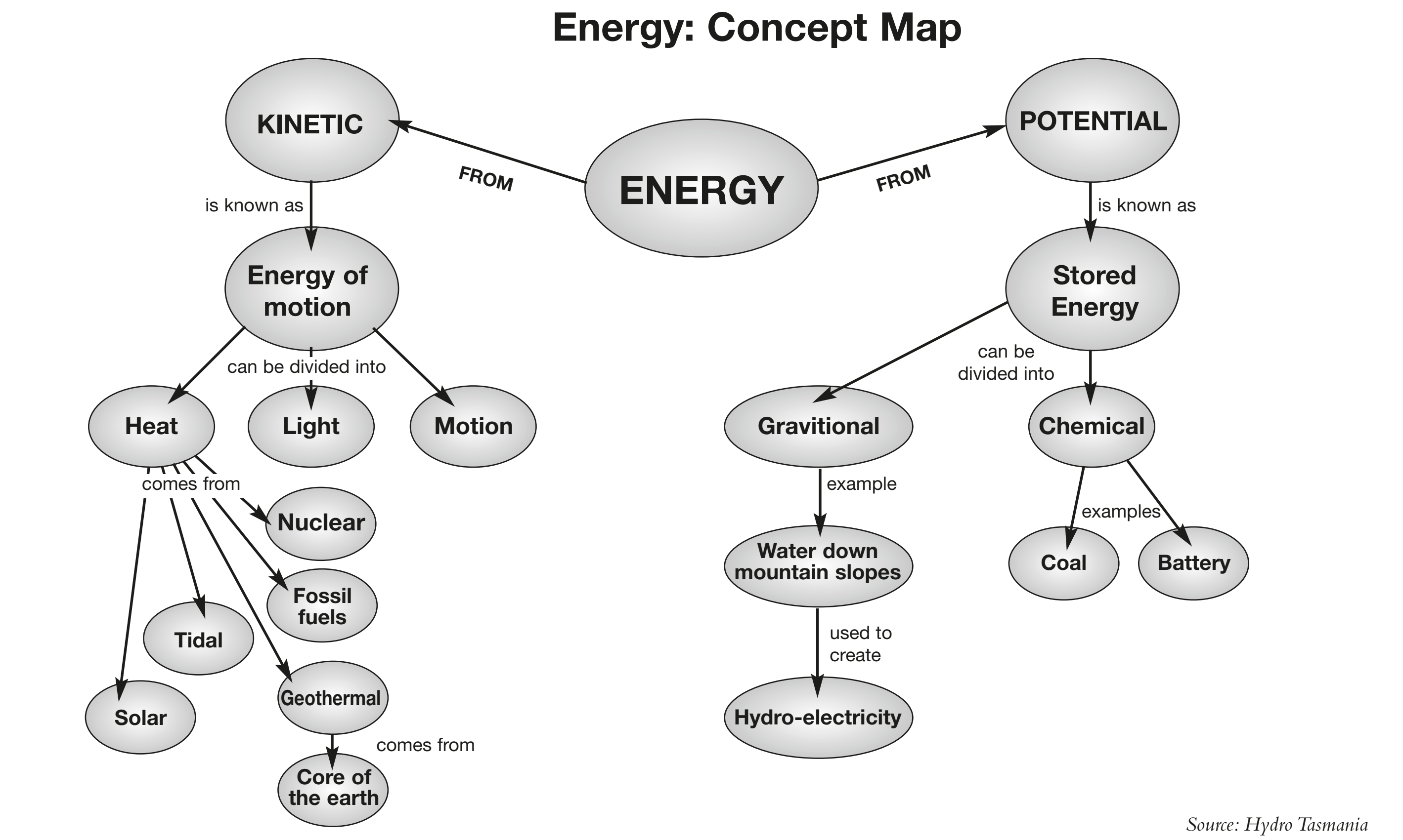
DID YOU KNOW?

One kilogram of butter has the same stored energy as one kilogram of TNT.

Energy: Future Challenges

Australia's population is increasing and its economy expanding, requiring more and more energy to power it. Our current energy solutions cannot be sustained. The challenge is to meet our rapidly growing energy needs in a more environmental, sustainable way, without undermining the affordability, reliability and security of our energy supply. There are three main elements to achieving this: increasing energy efficiency, increasing the use of renewables, and reducing the impacts (including emissions) of fossil fuels through the introduction of new technology.

Forms of energy



Source: Hydro Tasmania

DID YOU KNOW?

2005 is the Einstein International Year of Physics.

A hundred years ago this year at the age of 26, Einstein proposed the most widely known equation in physics ($E = mc^2$). The link between mass and energy helped explain the heat source of the sun and stars, and paved the way for nuclear power and the creation of matter and antimatter in the laboratory. Today high energy physicists routinely convert energy into matter and vice versa as allowed by Einstein's formula. Since Einstein's work, physics has transformed our lives - lasers, nuclear power, the web and more. Link: www.aip.org.au/wyop2005

www.

Energy facts
www.eia.doe.gov/kids/energyfacts/index.html

Energy facts and activities
www.energyquest.ca.gov/story/index.html

History of electricity
www.actewagl.com.au/education/electricity/generation/geothermal.cfm#overview

Lots of fabulous ideas for energy activities in the classroom
www.sustainableenergy.qld.edu.au/html/activitysheets.html

Introduction to energy
www.solarschools.net/ed_resources/formsofenergy.aspx

About Einstein Year
www.einsteinyear.org

Sustainable energy
www.seda.nsw.gov.au/renewable.asp,
www.sustainableenergy.qld.edu.au/fact/factsheet_4.html

Fossil fuels
www.nrel.gov/clean_energy/whatis_re.html

References

Martineau S, Slimy Science and Awesome Experiments, Koala Books, NSW, Australia. (2000)

Savage P, Let's Experiment!, CSIRO Publishing, Vic, Australia. (2002)

Ardley N, 101 Great Science Experiments, Dorling Kindersley Book, London, UK. (1997)

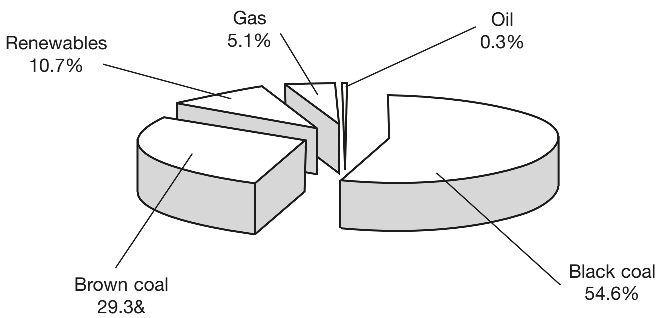
[Generating Electricity]

Electrical energy is used to power most things in our modern society including computers, televisions, fridges and freezers, vacuum cleaners, toasters, stereos and lights. It is also very important for industry as it is the source of power for manufacturing as well as for refining and processing minerals. In the process of generating electricity often an energy source is burnt in a power plant to heat water. The water is converted into steam and this provides the energy to turn a machine called a turbine. The turbine is connected to a generator which produces electricity. This is sent through power lines to provide energy for buildings of all types.

What is a power station?

A power station is a place that converts or changes a form of potential energy to electrical energy or 'electricity' - it does not "make" electricity.

Electricity generation in Australia by fuel type



Source: www.aph.gov.au/library/pubs/rp/2000-01/01RP08.htm

A ACTIVITY - Timeline of electricity

Research the famous people of electricity: Benjamin Franklin, Michael Faraday, James Watt, Thomas Edison, Albert Einstein. What was their contribution? Write a short report detailing the scientific discovery of each person and why their discovery was so significant. Create an electricity timeline detailing significant discoveries/advancements.

EXPERIMENT - Transforming energy

Aim: To demonstrate energy transformation: potential energy to kinetic energy and kinetic energy to potential energy, for different objects.

Try squashing a balloon and then letting it go; pulling a rubber band and letting it go; lifting up a super ball and dropping it. Draw up a table listing a range of objects including elastic/rubbery objects. Record the results ie. what happens to the objects when force is applied and when it is released? Explain the results in terms of the conversion of energy.

EXPERIMENT - Static electricity

Aim: To demonstrate the effect of static electricity.

Cut out some tiny people from tissue paper. Blow up a balloon and tie a knot in the end. Rub the balloon on top of your jumper or on your hair. Hold the balloon above the tiny peoples and watch them jump! Where does the kinetic energy of the tissue people come from?

? DID YOU KNOW?

On average each person in the industrialised world consumes about six times the amount of energy as each person in the developing world.

Renewable Energy

Renewable sources of energy are those that are constantly replenished and don't run out, ie. sunshine, wind, flowing water and organic material (bioenergy). Renewable energy technologies include solar power, solar thermal, wind turbines, hydro power, wave and tidal power, biomass-derived liquid fuels, biomass-fired generation.

Non-Renewable Energy

Fossil fuels draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. While renewable energy sources have an important role to play in electricity production, they are not yet able to provide sufficient or reliable enough base load power.

Cogeneration

Cogeneration is a high-efficiency energy system that produces both electricity and valuable heat from the one fuel source. Cogeneration systems offer major economic and environmental benefits by turning otherwise wasted heat into useable energy, thereby cutting CO_2 emissions by up to two thirds compared to a conventional coal-fired power station.

A ACTIVITY - Comparing energy sources

Create a table of all of the different energy sources, renewable and non-renewable. List the social, economic and environmental advantages and disadvantages of each. Write a summary detailing your findings. Write a conclusion explaining your theory for solving the world's future energy challenges.

[Greenhouse Gases]

ACTIVITY - Understanding Greenhouse Gases

Interview with Professor N.R.Gee, expert in climate change.

Use the following questions to find out more about greenhouse gases.

- What is a greenhouse gas?
- What are the names of these gases?
- What role do they play in the atmosphere?
- What are the other gases that make up the atmosphere?
- What is global warming?
- What can we do to prevent global warming?
- What is a CO_2 sink?
- Could the ozone layer repair itself over millions of years if people stopped using synthetic chemicals?

Links:
www.greenhouse.gov.au/education/factsheets/index.html
www.abc.net.au/science/planetslayer/greenhouse_qa_renewables.htm

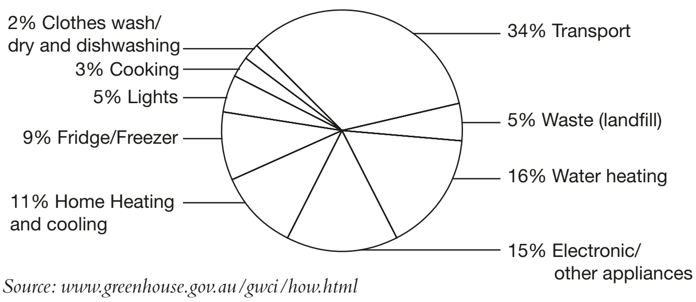
DID YOU KNOW?

We have been burning so much fossil fuel that there is now 25% more CO_2 in our atmosphere compared with 200 years ago.

What activities produce greenhouse gases?

- Burning fossil fuels: coal, oil or gas
- Clearing land
- Aspects of farming: eg. raising cattle and sheep, growing rice, using fertilisers
- Producing waste: garbage and sewage
- Manufacturing: eg. producing cement and aluminium

Household Greenhouse Gas Emissions



Source: www.greenhouse.gov.au/gwci/how.html

ACTIVITY - Global Warming

Looking at the graph above, what activities do you carry out each day that create greenhouse gas emissions? What could you do instead of these activities?

List as many ways as you can think of to reduce greenhouse gas emissions in your community. Calculate the amount of greenhouse emissions generated by your house and car

Links: www.greenfleet.com.au/signup/subscribe.asp
www.abc.net.au/science/planetslayer/greenhouse_calc.htm

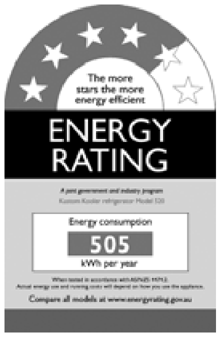
EXPERIMENT - Recreate the greenhouse effect

Aim: To demonstrate the greenhouse effect

Take two identical jars, fill each with 2 cups of water. Put 5 ice cubes in each jar. Wrap one jar in a plastic bag (this is the greenhouse jar). Put both jars in the sun for one hour. Measure the temperature of the water in each. What did you find?

Measuring Energy in Kilowatts (kW)

The Energy Rating Label is an efficiency indicator used on most white goods, indicating its energy efficiency as well as how much electricity it uses. Fridges, dishwashers, washing machines, clothes dryers and air conditioners are all required by law to have an Energy Rating Label, rating energy efficiency from one to six stars. The more stars, the more energy efficient an appliance is.



ACTIVITY - Interpreting the energy efficiency of appliances. Compare the energy rating of different appliances. Refer to: **www.energyrating.gov.au/productmenu.html**

The Kyoto Protocol

The Kyoto Protocol is an international treaty designed to limit global greenhouse gas emissions. Many countries, including Australia, have signed the Protocol, although the Australian government has decided not to ratify it.

Energy and the Economy

Energy demand is growing every year and Australia's economy is substantially underpinned by energy commodity exports and industry. Investment in greenhouse-intensive industries, including natural gas, aluminium production, coal, paper and metal processing is of great significance to our economy. Our future energy choices should take into consideration economic as well as environmental principles.

ACTIVITY - Reasons for and against ratifying Kyoto

DEBATE: The Australian government has based its decision not to ratify Kyoto on economic, not environmental, principles.

www.

Greenhouse gas calculator
www.greenpower.com.au/go/calculator.cgi

Interactive, student-friendly activities about the environment
www.abc.net.au/science/planetslayer/greenhouse_qa_renewables.htm

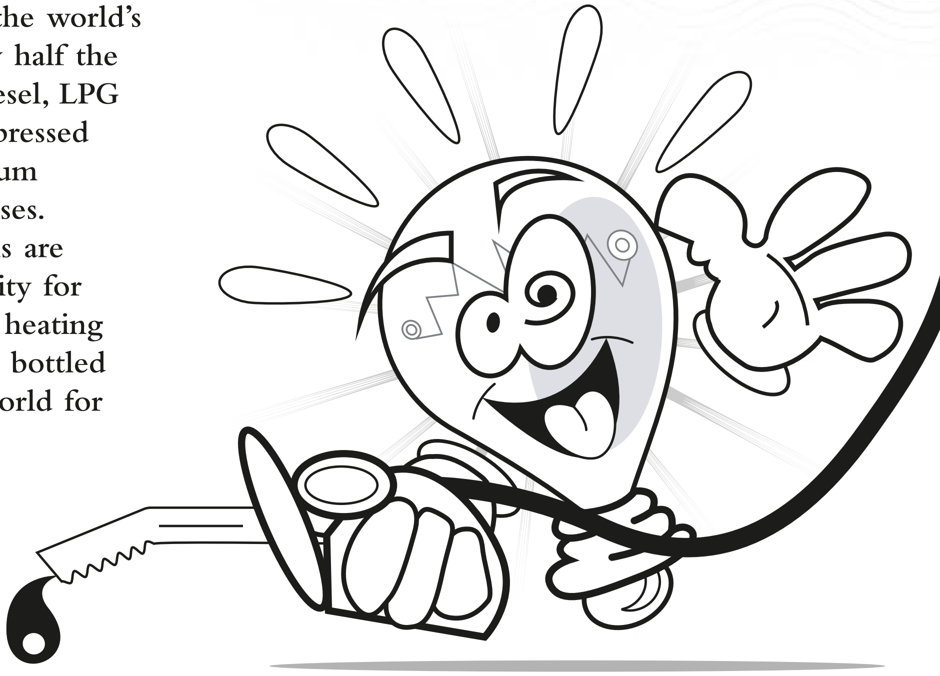
An alternative economic perspective on the Kyoto Protocol
www.environmentbusiness.com.au/Datasheets/Kyoto.htm

National Carbon Accounting System
www.greenhouse.gov.au/ncas/background.html

Kyoto Protocol
www.greenhouse.gov.au/international/kyoto/index.html

[Oil and Gas]

Petroleum fossil fuels meet about 80% of the world's demand for transportation fuels and nearly half the world's primary energy demand. Petrol, diesel, LPG (liquefied petroleum gas), and CNG (compressed natural gas) are the most common petroleum products used in cars, trucks, trains and buses. In many parts of the world petroleum fuels are used in power stations to generate electricity for industries and the electricity that provides heating or air conditioning. Kerosene and LPG are bottled and used in homes in some parts of the world for cooking and heating.



The origins of oil and natural gas

Most of the world's oil was formed from microscopic plants and animals that died in the ocean between 50–500 million years ago. The partly decomposed remains of these organisms and land plants fell to the seabed and were covered by a bed of mud and sediment and compressed by the enormous weight of the matter above, into rock-like shale. These shales are the source rocks for oil and gas. Where the earth's temperatures are between 60°C–200°C the organic matter contained in the source rocks is transformed into complex compounds of hydrogen and carbon – hydrocarbons. These hydrocarbons of petroleum take three forms:

- solid, such as bitumen
- liquid, such as crude oil
- gas, such as methane and ethane (gas generally forms at slightly higher temperatures than oil).

DID YOU KNOW?

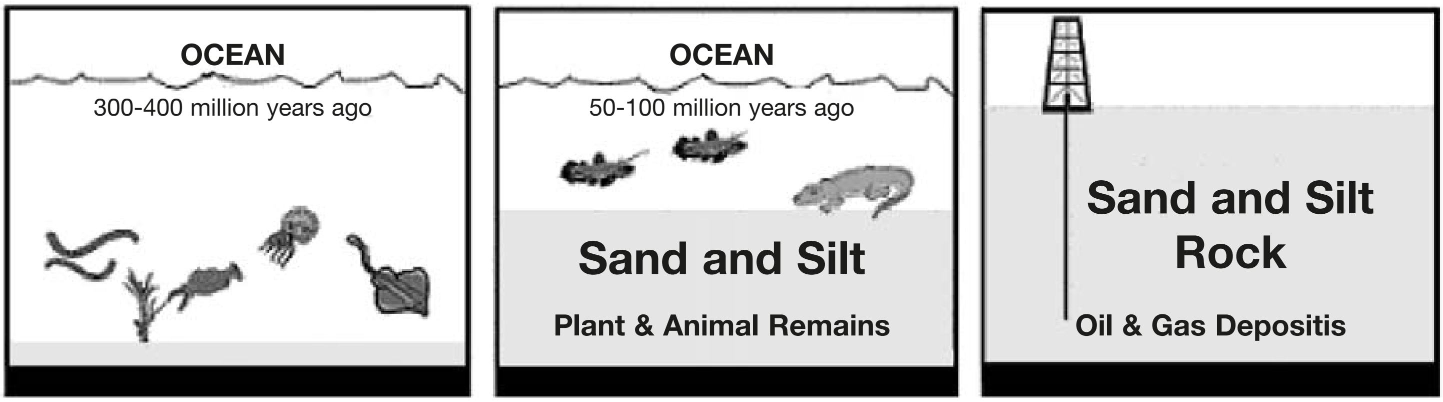
Petroleum-bearing rock only contains between 5 and 25% oil and gas.

DID YOU KNOW?

The migration of petroleum from source rock to a reservoir rock may be as little as 1 cm a year.

Oil and natural gas formation

Source: www.energyquest.com.au



Tiny sea plant sand animals died and were buried on the ocean floor. Over time, they were covered by layers of sand and silt.

Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through layers of sand, silt and rock to reach rock formations that contain oil and gas deposits.

DID YOU KNOW

The word "petroleum" means "rock oil" or "oil from the earth." Petros is the Greek word for stone or rock and oleum is Latin for oil.

ACTIVITY - Your life without oil

List all of the uses that you can think of for oil (petroleum products) in day-to-day life.

List alternatives for these products? Plan a day in your life without petroleum products.

EXPERIMENT - Lets make natural plastic!

Aim: To compare the decomposition of natural and oil-based plastic.

Pour 120ml milk into a saucepan. Bring to the boil the milk then add two teaspoons of vinegar. This will cause the milk to curdle. Strain the milk through a strainer - pour the liquid into one jar and the curd into the other. Add one teaspoon of vinegar to the curd and leave the mixture to sit for two hours. It should turn into a solid yellowish mass. Pour off any liquid. Knead the mass into a dough. Mould the dough into a spoon, shape and put it on greaseproof paper overnight. Compare your spoon to a plastic spoon. Record your observations. Bury both spoons in a plot of soil for two weeks. Dig them up – what differences can you observe? Record your findings. What does this tell us about the decomposition ability of natural and oil-based plastics? Think about why we don't use natural plastic for all of our plastic uses.

DID YOU KNOW?

Crude oil varies from oilfield to oilfield in colour and composition from light yellow, like olive oil, to thick black, like treacle.

ACTIVITY - Oil and the Environment

Where are oil and natural gas exploration currently occuring in Australia? Plot them on a map.

Link: www.ga.gov.au/oceans/pet_geol.jsp

List as many points as you can think of for and against oil exploration in Australia.

What are the environmental consequences associated with exploring and using petroleum products?

EXPERIMENT - Do oil and water mix?

Aim: To simulate the effects of an oil spill in the ocean.

Fill a jar half full with water and add blue food colouring to simulate the ocean. What happens when half a cup of vegetable oil is added? What happens when you shake the bottle? What happens when you stop shaking the jar? Why does the oil float on the top?

DEBATE - Oil and gas exploration is an essential part of Australia's economy (consider environmental and economic issues).

Oil uncovered - the discovery process

Step 1 Geological surveys – generally carried out by geologists to map the surface geology of area with aerial and satellite images.

Step 2 Geophysical surveys – indicate what lies beneath the surface using gravity, magnetic and seismic surveys. The results are interpreted by a computer determining the likely presence of hydrocarbons, therefore the suggestions that petroleum deposits lie beneath the surface.

Step 3 Exploration rigs – An onshore or offshore rig set up at the site and an exploration well (or 'wildcat') is drilled.

Step 4 Exploration drilling – most offshore wells in Australia are 2,500–4,000 metres deep and onshore wells are generally 2,000–3,000 metres deep. They can take weeks or months before the targeted location is reached.

Step 5 Evaluating the reserves – an engineering team evaluates the discovery and estimates the reserves.

ACTIVITY - The Discovery of Oil and Gas

What geological conditions must exist for oil and gas to be formed?

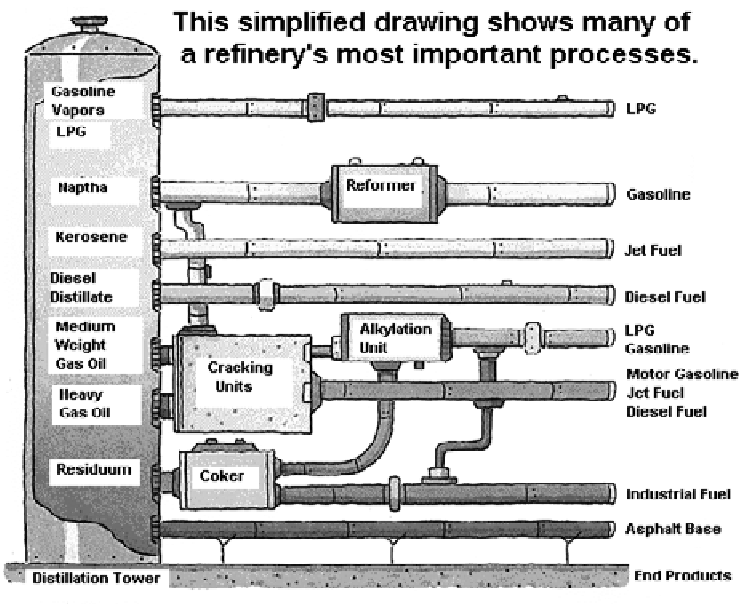
EXPERIMENT - How solid is a rock?

Aim: To discover which rocks are permeable and which are impermeable.

Divide students into groups. Each group should collect five rocks. Provide each group with samples of sedimentary rocks eg. sandstone, limestone, shale or granite. Drop 5 drops of water onto each rock. Predict and record what happens to each rock. What are the properties of permeable rocks? Discuss the type of rock that oil forms in.

How is the petroleum processed?

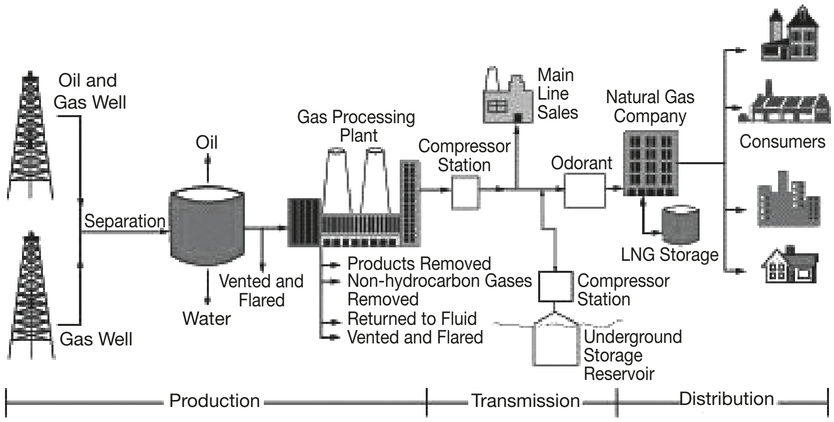
Crude oil is of little use in its natural state. It must be piped or transported by rail from the production facilities to oil refineries where its components are processed into refined products. The crude oil is broken down by a process called catalytic cracking. The crude oil is separated into useable petroleum products, most of which are used to produce energy.



Source: Energy Information Administration

How is gas processed?

Gas goes to gas processing plants where all residual water is removed before components such as ethane, natural gas liquids like methane, propane and butane, as well as impurities such as CO_2, nitrogen and heavy metals are removed from the methane gas stream.



Gas processing plant. *Source: Energy Information Administration*

A EXPERIMENT - Methane from manure

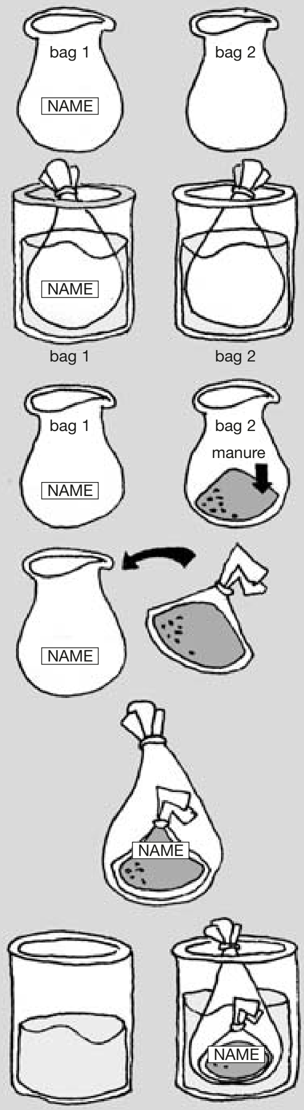
Aim: To produce methane from manure.

Materials: 2 heavyweight plastic bags with closures (elastic bands or the like), duct tape, permanent felt marking pen, large bucket (with volume measurements), water, 2 cups fresh manure, thermometer.

Prepare the bags - on one plastic bag (Bag 1), place an 8-cm strip of duct tape to write initials in permanent felt marking pen. Blow air into both bags, seal and place in the water - look closely for air leaks. Use only bags without leaks! Dry the bags.

Prepare the biogas digester - place about two cups of manure in Bag 2. Squeeze all the air out of Bag 2. Close the bag by twisting the top tightly down about 8-10 cm. Leave room for the gas to inflate the bag. Loop the twisted part of Bag 2 over and tie it carefully. Let no air in! Place Bag 2 (with the waste) inside Bag 1, removing all of the air in Bag 1 and closing it as you did Bag 2. Estimate the volume of your Bag 1 and its contents. Submerge the closed double bag in water. Measure the water it displaces. Record this volume on the data sheet. Dry off the bag. Store the bag at room temperature. Record the location of the bag on the duct tape, using a permanent felt marking pen. Make sure the bag identification, its location, the temperature of the location, and the starting date are recorded on the data sheet. Observe the bag every day. On the observation chart, record any changes for 5 to 10 days (or until some of the bags in the classroom seem to be nearly full of gas). To find the estimated final volume of the bag, submerge the closed bag in water. Measure the displaced water. Record the volume. Calculate the volume of gas in your bag (final volume minus starting volume). Compare the amount of gas produced under different temperature conditions.

Extension: Which generators seemed to produce the most methane? The least? What factors (variables) seem to influence the production of gas?



! TEACHER DEMONSTRATION - Testing the gas (safety warning)

With help, submerge a gas-filled bag in a sink or large tub filled with water and puncture a hole in the double plastic bags with a sharp instrument. Allow the gas to bubble into submerged, water-filled gas collection bottles. You may need to collect the gas from several bags. After filling several bottles, test a few of them by bringing a long taper near the mouths of the bottles. Have the students compare the flame to that produced by burning natural gas (e.g. in a gas cooktop). Compare the clean burning of methane and natural gas to the characteristics of kerosene or another lower-grade fuel.

? DID YOU KNOW?

Natural gas pipelines make up over 14,000 kilometres of pipeline in Australia and are increasing.

[Oil and Gas]

How long will it last?

It is estimated that at our present rate of consumption the world has around fifty years of crude oil and over seventy years of natural gas reserves, although innovations in the exploration industry as well as increased exploration is leading to the increase of reserves of oil and gas in recent years.

A **ACTIVITY - Oil: A potential crisis?**

Why is it politically and economically significant that 75% of the world's known oil reserves lie in the one region? What have been some of the historic consequences of this? What is OPEC?

DEBATE - It is hazardous to have significant global dependence on one primary energy source.

Natural Gas

While it is common for traps to contain both oil and gas, most of the world's gas reserves are found in giant gas fields which contain little or no crude oil. About 40% of the world's gas reserves lie in the former Soviet Union.

A **ACTIVITY - Gas and the Environment**

What is the main energy use for natural gas in Australia?

What are the advantages and disadvantages of natural gas as an energy source?

? **DID YOU KNOW?**

For each hour of heating your house, you produce: 0.7kg CO_2 (gas heater), 2kg CO_2 (2 bar electric radiator), 3.3kg CO_2 (open fire).

Vehicle exhaust emissions

Vehicle exhaust fumes are a major contributor to air pollution and the greenhouse effect. For every litre of petrol used, 2.3 kilograms of CO_2 is released from the exhaust. The Australian transport sector accounts for 77.2 million tonnes of Australia's total net greenhouse gas emissions, representing 14.2% of Australia's total emissions. Until 1986 lead emissions from cars also contributed a significant amount of airborne lead in Australia's urban areas.

The following table gives an indicative guide to annual CO_2 tailpipe emissions from petrol vehicles travelling 15,000 kilometres annually with varying fuel consumption rates. This shows you can make a difference.

Fuel consumption	Annual carbon dioxide emissions
6 L/100km	2070 kg
8 L/100km	2760 kg
10 L/100km	3450 kg
12 L/100km	4140 kg

Source: www.greenhouse.gov.au/fuellabel/environment.html

A **ACTIVITY - Considering fuel consumption**

Analyse the table above. What conclusions can you draw about the size of the car engine and the amount of CO_2 emissions? What tips would you give a driver for reducing fuel consumption when driving?

Link: www.mynrma.com.au/environment.asp

EXTENSION - Viscosity of oils

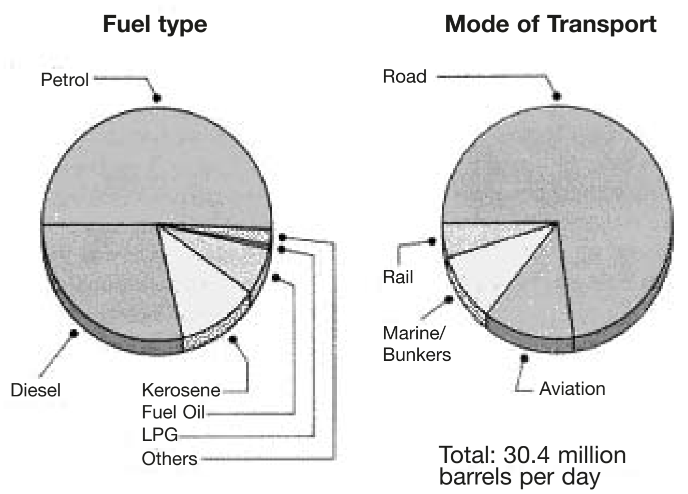
Aim: To design an experiment to record the viscosity of different oils.

A service station has some unlabelled bottles of motor oil. They need to determine what type of oil is in each bottle. Remember, oil viscosity reduces as oil gets hotter so high viscosity oils must be used in engines running at high temperatures. The samples are in a number of plastic vials. Design an experiment to test the different viscosities. Describe how you would determine whether one or more of the oils was a multiviscous oil, like 10-40W. This might require that you measure viscosities at various temperatures. A. Order the results from highest to lowest. The owner will then know which is which. B. Based on your results, which oil do you think would help a high-powered racing car engine run best? C. Which would you recommend for a slow running engine in a cold climate, such as a tractor for pulling an arctic sled. Explain why you made your choice.

Petrol alternatives

Petrol, one of the major derivatives of petroleum, is used throughout the world as a motor vehicle fuel. Diesel, liquid petroleum gas (LPG), compressed natural gas (CNG), methanol, ethanol, hydrogen and biodiesel are all petrol alternatives.

World fuel consumption



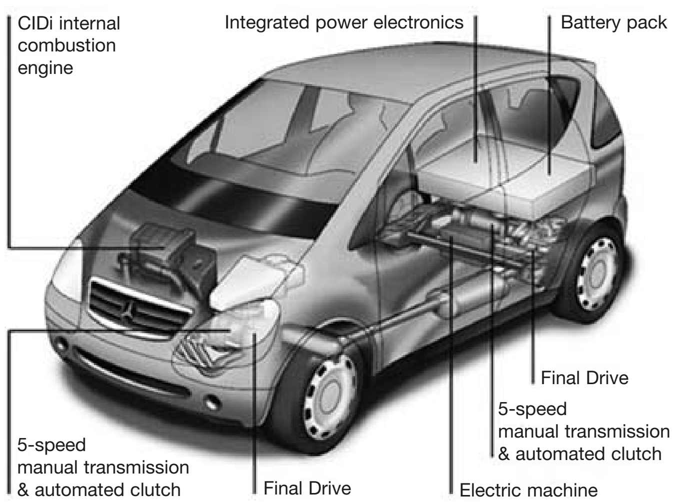
Source: www.aip.com.au/industry/fact_alt_fuels.htm

A ACTIVITY - Petrol alternatives and the implications

Analyse the graphs above. What can you do to contribute to a reduction in the percentage of fossil fuel consumed on a daily basis for transport?

What are the main obstacles that face the transport industry in terms of achieving sustainability in the future?

Competition: Recycled cooking oil is available from petrol pumps in Tokyo for running cars. Design a car using an alternative fuel source such as cooking oil.



Hybrid Electric Car. *Source: www.howstuffworks.com*

Future challenges

- Fossil fuel depletion
- The cost of exploration
- The environmental impact of exploration
- The environmental impact of such a heavy global reliance on petroleum products for transportation
- Innovations leading to the development of more efficient fuels that generate lower CO_2, benzene and particulates emissions should continue to be a priority of petroleum companies
- The ongoing refinement and development of alternative fuel vehicles. This would lead to reduced manufacturing costs and an increase in demand for these cars, having a long-term positive spin-off for the environment.

New technology should be the primary focus for significantly reducing vehicle based emissions (hybrid cars, more efficient engines and ultimately hydrogen fuel cells). People should also begin to think about turning to alternative forms of transport such as bikes, walking, public transport or carpooling.

The cutting edge

1. Hybrid electric car

Until the provision and storage issues of hydrogen are resolved, the compromise is at this stage, the hybrid electric car.

www.holden.com.au/www-holden/jsp/environmentcommunity/environmentcommunity.jsp?link=holdenenvironment&heading=vehicles&topic=ecommodore)

2. Natural gas innovations

Greening the bus fleet in South Australia with CNG.
www.transport.sa.gov.au/environment/air_greenhouse/busgreening.asp

Www.

Origins of oil and gas
www.energyquest.ca.gov

Animated journey through the oil exploration process
www.shell.com

Issues to do with petroleum products
www.aip.com.au/industry/fact_benzene.htm

Hybrid cars
whyfiles.org/005electcar/index.html
www.hybridcars.com/

Great activities and student-friendly information
www.petroleumclub.org.au
www.eia.doe.gov/kids/classactivities/teachers&students.html#intermediate
www.abc.net.au/science/planetslayer/greenhouse_qa_kyoto.htm

Methane experiment
www.uq.edu.au/_School_Science_Lessons/topic16.html#16.1.3

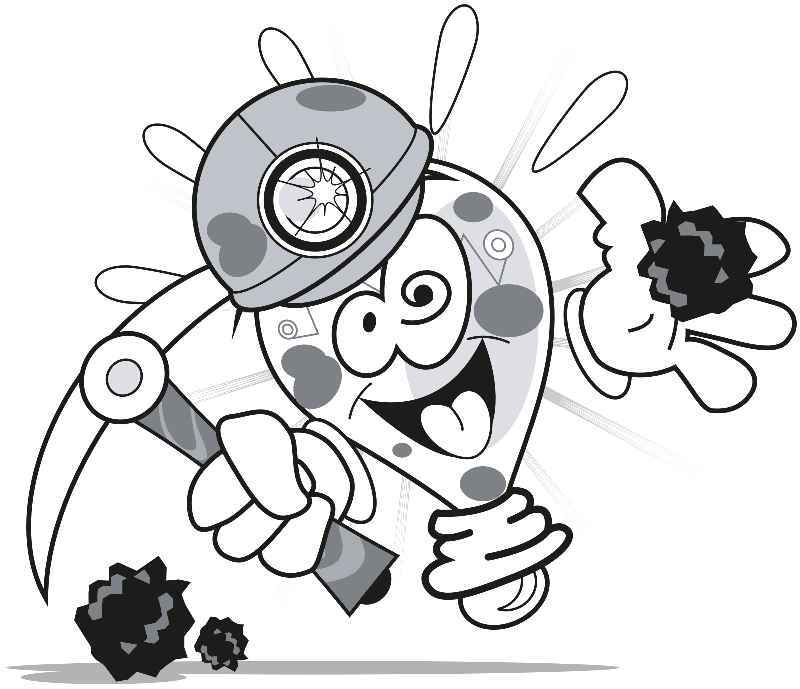
Printed

Essentially Oil and Gas – co-produced by Australian Institute of Petroleum and Australian Petroleum Production and Exploration Association Ltd

Ardley, N. 101 Great Science Experiments, Dorling Kindersley. London. UK. (1997)

[Coal]

From trees to coal. Coal is formed from the fossilised remains of plants – it is a fossil fuel.
It originates from peat which forms when large amounts of plant material are preserved when the ground is saturated with water (providing anaerobic conditions). The saturated ground does not allow the plant material to decay and over millions of years the plant debris is squashed by sediment build up, the water is squeezed out and chemical conversion to coal occurs. The longer the time involved and the greater the pressure, the higher the energy value of the coal produced.

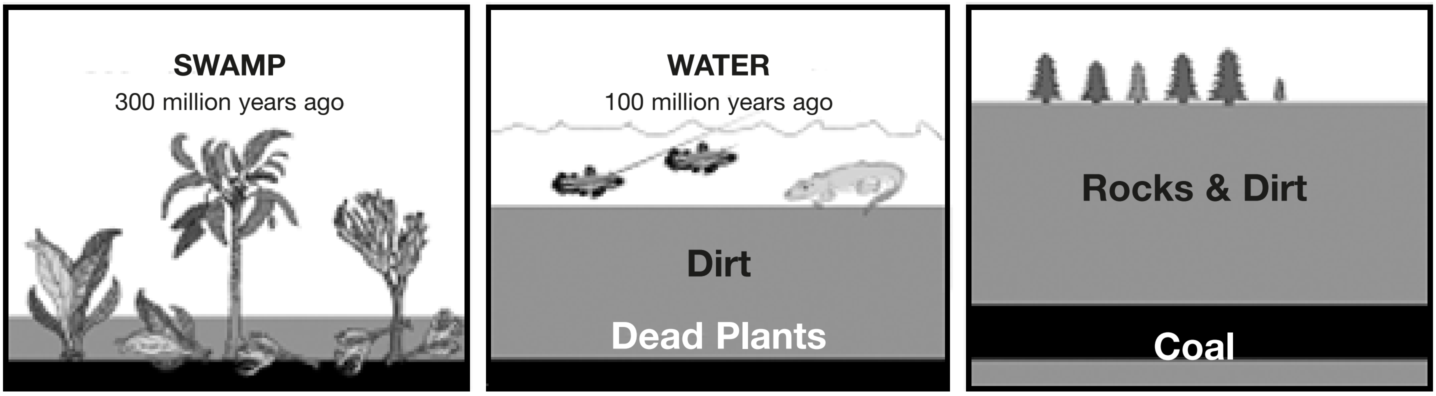


DID YOU KNOW?

A one metre thick coal seam may have started out as a pile of plant material 120 metres thick and taken over 200 million years to form.

How coal was formed

Source: www.energyquest.com.au



Before the dinosaurs, many giant plants died in swamps. | Over millions of years, the plants were buried under water and dirts. | Heat and pressure turned the dead plants into coal.

ACTIVITY - Make your own fossils

Collect leaves, shells, twigs etc. Make up a mixture of plaster of Paris and tip it into small plastic containers. Let the mixture stand for a minute and coat the objects to be fossilised with Vaseline. Press the coated object into the plaster and leave to set. When it has set (1-2 days) remove the object. Describe the fossil. Find out what a paleontologist does. Invite a palaeontologist to come and talk to your class.

DID YOU KNOW?

Victoria and SA are the only State producing brown coal, as 93% of Australia's brown coal reserves are found in the Latrobe Valley.

ACTIVITY - Make your own coal seam

Make a coal seam in a glass box (e.g. an old fish tank) by carefully layering separate beds of sand, clay, old leaves, moss and sawdust, followed by more sand and clay. Cover this with water and leave to settle over a number of weeks. Note any changes, in particular any oily film on the surface of the water. Notice the rate of change and the type of change. Record your observations in labelled and dated diagrams.

Link: (www.nswmin.com.au/education/energy.pdf)

Extension: Design an experiment to show how anaerobic conditions affect the rate of decay of plant material.

DID YOU KNOW?

Coal is Australia's largest commodity export accounting for 75% of Australia's fossil energy resources.

DID YOU KNOW?

Explorer George Bass found outcrops of coal at what is today known as Coalcliff (near Wollongong, NSW) in 1797.

What's in coal?

Coal is composed largely of carbon atoms (50-97%) linked together with some hydrogen (3-13%), oxygen, and smaller amounts of nitrogen, sulphur and other elements. It also contains a little water and grains of inorganic matter that remain as a residue known as ash when coal is burnt.

DID YOU KNOW?

The thickest seam of coal anywhere in the world is the 233 metres of brown coal which occurs at Loy Yang in Victoria.

Coal Mining

There are two methods of coal mining:-

- Underground or 'deep' mining
- Surface or 'open-cut' mining

The choice of method is largely determined by the geology of the coal deposit, in particular the depth of the seam below the surface. The majority of the world's coal reserves are recoverable by underground mining.

Coal and Energy

The energy in coal originally comes from the Sun. The energy is stored in the chemical bonds (chemical potential energy). To release the stored energy from the chemical bonds the coal is burnt. When coal is heated to around 1400°C the original chemical bonds break and reform new bonds producing mainly CO_2 and water. During this process energy is released in the form of heat.

Coal (mainly hydrocarbons) + oxygen → burn → **carbon dioxide + water + HEAT + ash (the inorganic material).**

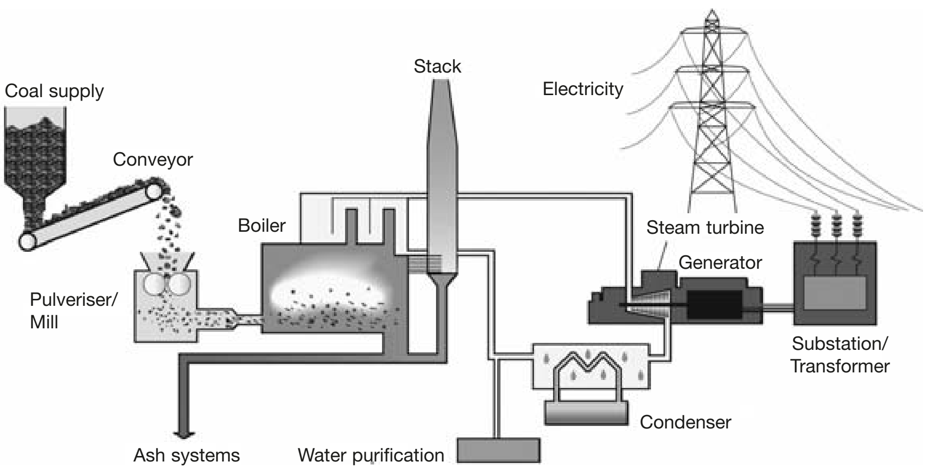
Using coal

Coal has a wide range of important uses - the major ones being:

- Electricity generation
- Steel production
- Cement manufacture

Of all the electricity generated worldwide, about 37% is produced from coal. In Australia coal is used to produce about 85% of the electricity supply.

The use of coal in electric power generation is the largest contributor to Australia's greenhouse gas emissions, accounting for about 38% of total greenhouse gas emissions.



Source: World Coal Institute

Source: Australian Coal Association

Source: Stanwell Corporation Limited

The diagram above shows the production of electricity from coal.

Step 1 The coal is pulverised into a powder.

Step 2 The powdered coal and air is then blown into a boiler furnace

Step 3 The coal is heated to break the chemical bonds and release energy (heat energy)

Step 4 The heat is transferred via a heat exchanger to water causing it to boil and produce steam.

Step 5 The steam is piped into a turbine which converts the heat energy into rotational energy.

Step 6 A drive shaft couples the turbine to an electrical generator which transforms the rotational energy into electricity.

Visit the CS Energy Website **(www.csenergy.com.au/learning_centre/how_elec_is_made.asp)** to see an animated diagram showing how electricity is produced.

ACTIVITY - Why does coal need to be pulverised?

SAFETY WARNING

TEACHER DEMONSTRATION - To demonstrate this, sprinkle flour over a candle or Bunsen flame and it burns in a flash. Try to burn a pile of flour, or lumps of flour and it won't burn.

Link: www.bbc.co.uk/cbbc/eurekatv/big_dustexplosion.shtml
www.sci_wiz.tripod.com/Exploding_Flour_Tin.htm

ACTIVITY - The energy changes in coal

Draw a flow chart showing the energy changes throughout the production and use of coal. Hint - use terms such as potential energy, electrical energy.

DID YOU KNOW?

Each of us will use the energy from 200 tonnes of coal in our lifetime. Mostly this will be used as electricity and in the production of materials such as steel and aluminium.

DID YOU KNOW?

As well as being used to produce electricity, coal is used in the production of iron and steel. Coal and its products are also used in the production of some common materials like baking powder and soda water.

DID YOU KNOW?

Each energy transformation in the electricity production process results in energy losses with the result that only about 35-42% of the original energy is converted to electricity.

Source: Australian Coal Association

The Future Challenges

There are two ways to reduce the greenhouse gas emissions from the use of coal – increase the efficiency of conversion of coal into electricity and/or prevent CO_2 from entering the atmosphere. Cutting edge technology by the coal industry is reducing the production of greenhouse gases.

The Cutting Edge

Integrated Gasification Combined Cycle (IGCC)

The IGCC process turns coal into a synthetic hydrogen-rich gas which can be burned in a gas turbine to produce electricity or converted to a range of useful chemicals or liquid fuels such as diesel. The advantages of IGCC are that most pollutants usually associated with coal are eliminated and CO_2 can be captured at a far lower cost than in a conventional coal fired power station.

www.australiancoal.com.au/cleantech.htm – a diagram showing how IGCC works.
www.cat.csiro.au/3_4.htm – information on research in Australia

Oxy-fuel combustion

Oxy-fuel combustion or oxy-firing involves the combustion of pulverised coal in oxygen, rather than in air, in order to reduce the overall volume of waste gas from the process. The potential advantage of this technology is that existing power stations can be modified to facilitate the capture of CO_2 from the exhaust gases for geosequestration. (see Geosequestration section – p.42)

Lignite dewatering and drying

This technology involves reducing the moisture content of the coal by either mechanical or thermal means. The coal can then be used more efficiently in combustion or in IGCC processes.

ACTIVITY - Moisture content of coal

Describe why coal can be used more efficiently when moisture has been removed. Think about what happens if you try to use wet wood to light a fire. Design an experiment to show how decreasing the moisture content of a fuel would increase the efficiency when burnt.

Ultra Clean Coal (UCC)

CSIRO and more recently UCC Pty Ltd has developed a technique to chemically dissolve the mineral impurities from coal leaving a clean solid powder for combustion. The use of UCC as a fuel in a gas turbine has the potential to reduce greenhouse gas emissions by up to 25% compared to conventional coal combustion.

www.

Everything you need to know about the Australian Coal Industry
www.australiancoal.com.au

Latest coal research
www.australiancoal.csiro.au

Environmental initiatives in the coal industry
www.coal21.com.au

Fantastic teaching resource and activities
www.nswmin.org.au

Lesson plans and activities
www.teachcoal.org

Where to buy coal samples (ph 07 33454253) or
www.treasureenterprises.com

Heaps of activities and information
www.eia.doe.gov

Case study
www.anglcoal.com.au

Case study
www.coalop.com.au

Case study
www.pacificcoal.com

The global industry
www.wci-coal.com

Power station case studies and animation
www.csenergy.com.au

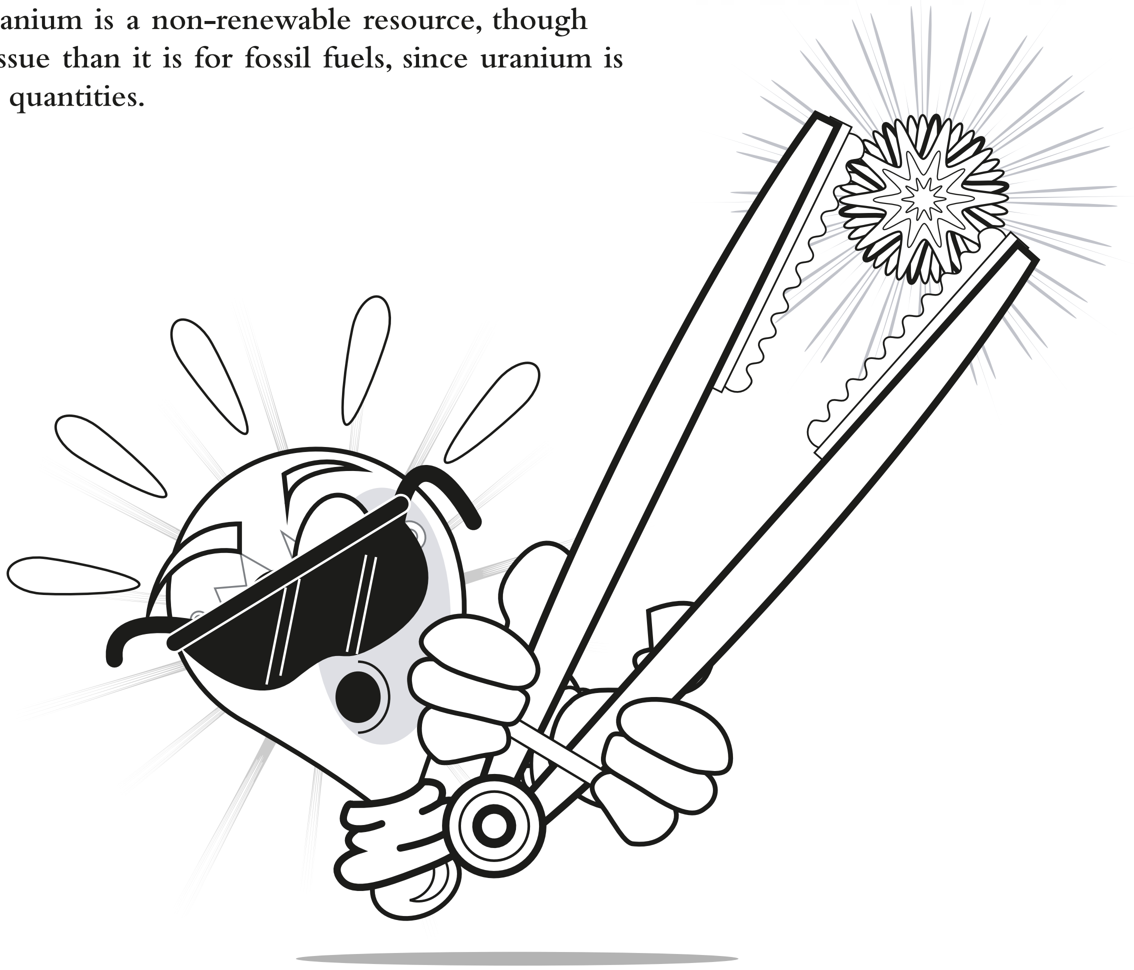
References

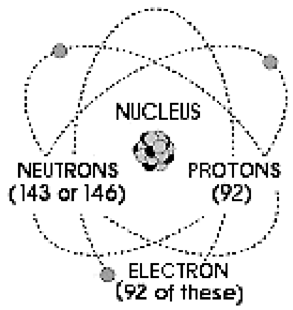
Cook B, Coal in a Sustainable Future – ITAM, Osmond Earth Sciences, Adelaide (2003).

Saddler H, Diesendorf M, Denniss R, Clean Energy Future Report (2004) available from wwf.org.au

[Uranium and Nuclear Energy]

Uranium does not produce CO_2 emissions when used in a nuclear reactor and only a small amount is required to produce a large amount of energy. Uranium is a non-renewable resource, though scarcity is less of an issue than it is for fossil fuels, since uranium is used in much smaller quantities.





What is uranium?

- Uranium is a very heavy (dense) metal which can be used as an abundant source of concentrated energy.
- Uranium is one of the heaviest of all the naturally-occurring elements. Uranium is 18.7 times as dense as water.
- Uranium is naturally radioactive and is usually found in the form of uranium oxides, eg U_3O_8. CO_2
- Uranium occurs in slightly differing forms known as 'isotopes". Natural uranium as found in the earth's crust is a mixture largely of two isotopes: U-238 and U-235. The isotope U-235 is important for nuclear energy because under certain conditions it can readily be split, yielding a lot of energy.

A ACTIVITY - Make your own sedimentary rock

a) Make your own sedimentary rock – melt dark chocolate and pour over the base of a plastic container. Sprinkle coconut over the top of the chocolate. When the dark chocolate has set mix marshmallows into melted milk chocolate and pour into the container. Leave to set and then consume your sedimentary rock.

b) Mix cement with water and allow to harden in a plastic container. For the second sample, mix cement with twice as much sand and then add water. Allow this to set in a container. After a few days break open both your sedimentary rock samples and describe the properties of both the samples.

Where does Australia fit in?

Nuclear energy provides 16% of the world's total electricity production, equivalent to thirteen times Australia's total. Nuclear energy is not currently used in Australia, however the existence of uranium in Australia has been known since the 1890s. In the 1930s ores were mined at Radium Hill in South Australia to recover minute amounts of radium for medical purposes. Today Australia has the largest identified uranium resources of any country. There are three operating uranium mines in Australia, Ranger in NT, Olympic Dam and Beverley in South Australia. A fourth is cleared to start construction: Honeymoon, in South Australia.

The debate over the use of nuclear power in Australia centres on the safety of the energy production process and the storage and disposal of waste. There are also discussions about the mining of uranium in Australia and the threat of it's use to produce weapons. While renewable sources have an important role to play in electricity production, they are not yet able to provide sufficient or reliable enough base load power.

? DID YOU KNOW?

Uranium was discovered in 1789 by Martin Klaproth, a German chemist, in the mineral called pitchblende. It was named after the planet Uranus, which had been discovered eight years earlier.

[Uranium and Nuclear Energy]

Where does uranium come from?

Uranium is widespread in many rocks, and even in seawater. However, like other metals, it is seldom sufficiently concentrated to be economically recoverable. Useful and easily recoverable deposits of a mineral are referred to as an orebody. Traditionally, uranium was extracted from open cut mines and deep shaft mines, Recently solution extraction (in situ leach) in which solutions are injected into underground uranium deposits to dissolve uranium, have become more widely used. When the uranium is extracted from the ore it is referred to as 'yellowcake' U_3O_8 because of its yellow colour.

ACTIVITY - Uranium extraction

Find out more about how uranium is extracted from the ore.
One of the waste products from the extraction of uranium is called tailings. What happens to the tailings? What are the environmental and economic issues to do with disposal or use of the tailings?
Research the environmental issues to do with "In Situ" mining. Which method do you think is more environmental for use in Australia?

Mark on a map where uranium is mined. Why is it mined in these places? **Visit www.uic.com.au/emine.htm for information.**

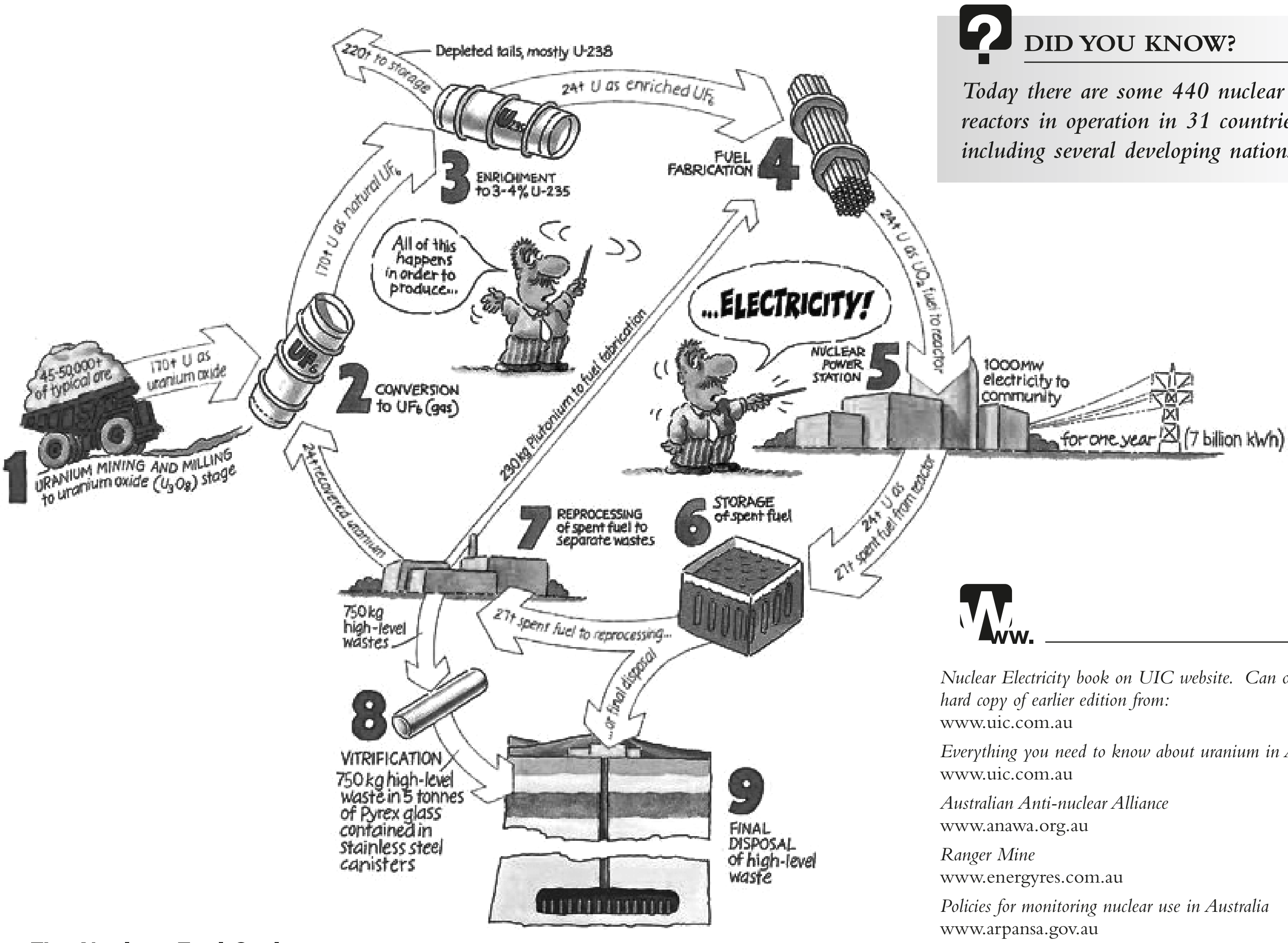
Uranium Mining Case Study – The Ranger Mine

Aerial view of the Ranger Mine and plant. *Source UIC website*

ACTIVITY - Ranger Mine

Research the environmental, economic and social issues to do with the Ranger Mine. Debate the issues associated with the mining of Uranium in Australia.

Visit **www.anawa.org.au/** and **www.energyres.com.au/ranger/**



DID YOU KNOW?

Today there are some 440 nuclear power reactors in operation in 31 countries, including several developing nations

The Nuclear Fuel Cycle

For an explanation of each of the steps in the Nuclear Fuel Cycle visit the Uranium Information Centre website **www.uic.com.au**

www.

Nuclear Electricity book on UIC website. Can obtain hard copy of earlier edition from:
www.uic.com.au

Everything you need to know about uranium in Australia
www.uic.com.au

Australian Anti-nuclear Alliance
www.anawa.org.au

Ranger Mine
www.energyres.com.au

Policies for monitoring nuclear use in Australia
www.arpansa.gov.au

Australian nuclear research
www.ansto.gov.au

Web elements
www.webelements.com

Enrichment research
www.silex.com.au

Uranium for electricity

The generation of electricity using nuclear energy is a clean and efficient way of boiling water to make steam which drives turbine generators. Except for the reactor itself, a nuclear power station works like most coal or gas-fired power stations.

The nucleus of the U-235 atom comprises 92 protons and 143 neutrons (92 + 143 = 235). When the nucleus of a U-235 atom captures a neutron it splits in two (fission) and releases some energy in the form of heat. At the same time two or three additional neutrons are thrown off. If enough of these expelled neutrons cause the nuclei of other U-235 atoms to split, releasing further neutrons, a fission chain reaction can be achieved. When this happens over and over again, many millions of times, a very large amount of heat is produced from a relatively small amount of uranium. The heat is used to make steam to produce electricity.

Spent fuel storage

Used fuel is stored to reduce its radioactivity. The time taken for the radioactivity to decrease is dependent on the half-life of the isotope. **Link: www.vcs.ethz.ch/chemglobe/ptoe/_/92.html**

Future Challenges

There are a number of widely discussed issues to do with the use of nuclear energy in Australia.

A ACTIVITY - Half life

Put 50 M&M's in a bag. Shake the bag and pour out the M&M's. Count the number of M&M's with the print side up and eat them. These ones have decayed. Return the un-decayed ones to the bag and continue the process until all the M&M's have decayed. Graph the number of undecayed items versus time. What is the half life of the M&M's? (Adapted **www2.ncsu.edu/ncsu/pams/sciencehouse/learn/CountertopChem/exp32.html**)

ACTIVITY - The chain reaction

Visit **www.energyquest.ca.gov/projects/nuclear.html** - to do an activity with dominoes to show a chain reaction

CHALLENGE - Waste disposal

Final disposal of waste is delayed to allow its radioactivity to decay. Forty years after removal from the reactor less than one thousandth of its initial radioactivity remains, and it is much easier to handle. The most favoured method for disposal in Australia is burial in dry, stable geological formations some 500 metres deep.

Design a system of disposal for the nuclear waste in Australia. Think about all the safety and economic issues associated with the disposal.

A ACTIVITY - Uranium: The Issues

Fill in the following table and make your own assessment of the issue being discussed. After completing the table, decide if you believe that uranium should be mined in Australia and used to produce electricity.

AREA OF CONCERN	ISSUES (Political, Environmental, Safety, Social or Economic)	What do you think?
Capable of fulfilling base load?		
Nuclear weapons		
Disposal of spent fuel		
Safety of the reactor		
A sustainable resource?		
Uranium and greenhouse gas production		

Use the web links provided this chapter for help with this activity

A ACTIVITY - RADIATION LEVELS

Use the Geiger counter in the Uranium Quick Guide on the Energy Resources **www.energyres.com.au** website to find out about the emission of radiation.

ACTIVITY - Nuclear fusion to produce energy

How is fusion different to fission? At the moment why is it so difficult to use nuclear fusion to harness energy? Find out how deuterium could be extracted from sea water and how tritium could be produced. What would be the advantages of using deuterium and tritium to produce energy over using uranium? Visit **www.fusion.org.uk/info/reaction.htm** to find out more about the nuclear fusion reaction.

The Cutting Edge

Nuclear Fusion Power

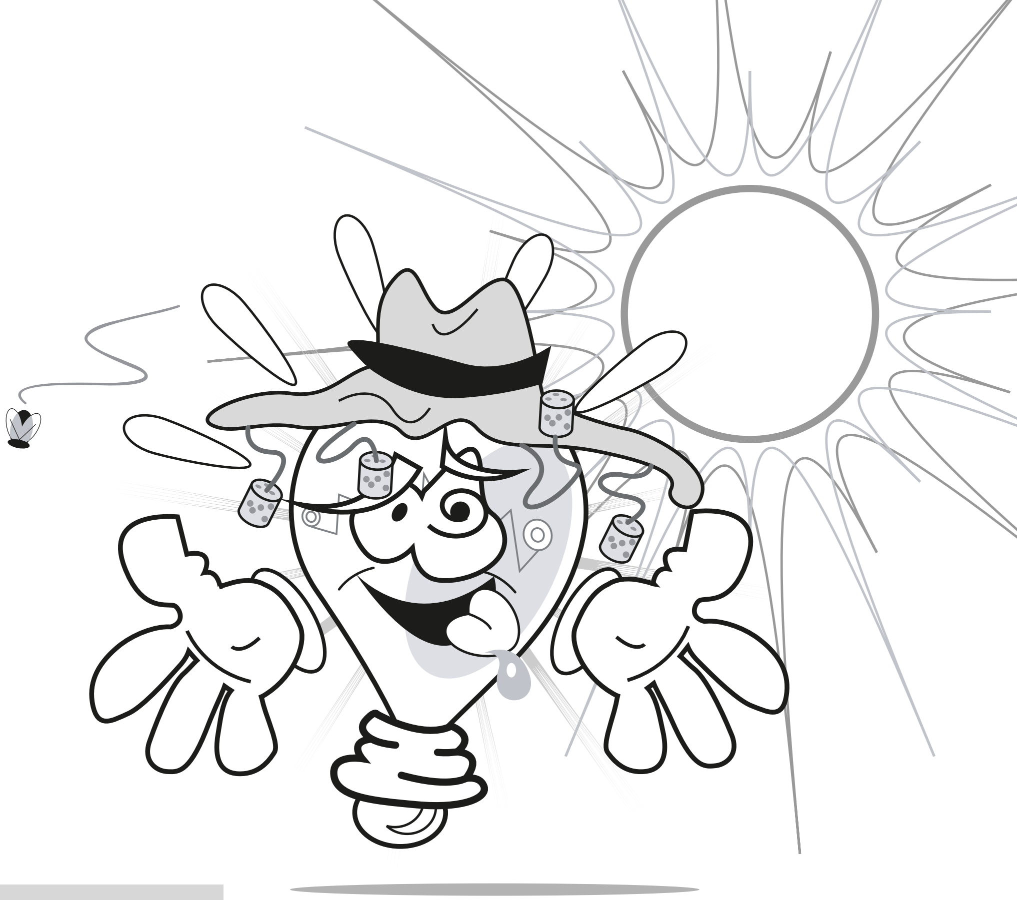
Fusion power offers the prospect of an almost inexhaustible source of energy for future generations, but it also presents so far insurmountable scientific and engineering challenges.
Link: www.fusion.org.uk

Enrichment technologies

Currently the only research being carried out in Australia in the area of nuclear energy is carried out by Silex. Silex is pioneering the development and commercialisation of its proprietary laser-based isotope separation technology. This technology is used to enrich the uranium to the 235 isotope.
Link: www.silex.com.au

[Solar]

The sun's rays. **Solar energy is the world's largest energy source. It is clean and renewable and the source of most renewable energy on Earth – wind, hydro, tidal and wave energy, photovoltaic cells, solar thermal and bioenergy (biomass and biogas) energy systems are all driven by the sun. Solar energy technology is used in three ways in Australia: solar thermal hot water, solar thermal electricity and photovoltaics.**



ACTIVITY - The ultimate source of energy

Explain the process by which solar energy assists with the production of the following types of renewable energy: wind, hydro, tidal, wave, photovoltaic cells, solar thermal and bioenergy.

Link: www.solarschools.net/ed_resources/solarenergy.aspx

Solar Thermal Energy

Sunlight is transformed most efficiently into solar thermal energy when it shines on dark surfaces. Most of the visible light that falls upon dark surfaces is absorbed and very little is reflected. The main applications for solar thermal energy at present are for heating swimming pools, heating water for domestic use, and heating buildings.

DID YOU KNOW?

British astronomer John Herschel was one of the first people to use solar energy during an expedition to Africa in the 1830's. He built a solar collector box to cook food.

DID YOU KNOW?

In Australia hot water accounts for about 27% of residential energy use and on average only about 5% of households have solar hot water systems.

ACTIVITY - Capturing the sun's energy

Bring in a range of coloured t-shirts (including black and white). Students should stand in the sun wearing different colours. Ask them to record which one makes them feel the hottest/coolest. Discuss why?

EXPERIMENT - Solar Heat Energy

Aim: To demonstrate the effect of colour on the absorption of heat energy.

One large and 2 small pie tins (the large and one small one painted black). Measure 200mL of water into a cup, record the temperature. Pour 100ml of the water into each small pie tin. Put plastic wrap over each tin. Put the pie tins in direct sunlight for about 20 minutes. After 20 minutes pour the water into two separate measuring cups. Take the temperature of each. Which one heated the most? Why?

Try the experiment with the large pie tin and the small tin painted black inside. Follow the instructions of the previous experiment. Which tin heated the water to the highest temperature? Why? Change some of the other variables eg. Depth of water, presence of a plastic cover. What changes do you observe? Why?

COMPETITION - Design your own solar hot water system.

Hold a class competition to design a solar hot water system. The winning design will heat 250mL of water to the highest temperature in thirty minutes on a sunny day.

COMPETITION - Designing a solar cooker

Hold a class competition to design a solar cooker. The winning design will toast the tastiest marshmallow.

Example: line the inside of a large plastic bowl with aluminium foil, shiny side up. Secure the foil with double-sided tape. Make the foil as smooth as possible. Face the cooker into the sun. Try toasting a marshmallow on the end of a stick in the cooker. Try using other materials and shapes for the base. Test which design toasts the marshmallow the fastest. Report on the most effective design for a solar cooker. Why does colour and shape make such a significant difference when capturing the sun's energy?

Links: www.geocities.com/thesciencefiles/solar/cooker.html solarcooking.org/

Generating Solar Thermal Electricity

Solar collectors fall into two general categories: non-concentrating and concentrating.

- Non-concentrating solar collectors – the area collecting the solar energy is the same as the area absorbing the energy.
- Concentrating collectors – the area collecting the solar energy is far greater than the area absorbing it providing maximum energy conversion efficiencies. Concentrating solar collectors are used in the generation of solar thermal electricity.

Currently there are three types of solar-thermal power systems in use or under development the solar dish, solar power tower and parabolic solar trough. Australia has some exciting developments in the area of solar trough developments, for example the Stanwell solar concentrator design may be used in 'hybrid' power stations, and is suitable for remote towns.

ACTIVITY - Stanwell solar concentrator

Link: www.solarschools.net/ed_resources/activities/qseif_solar_trough.pdf

Read the Stanwell case study. Describe the process by which electricity is being generated in this power plant.

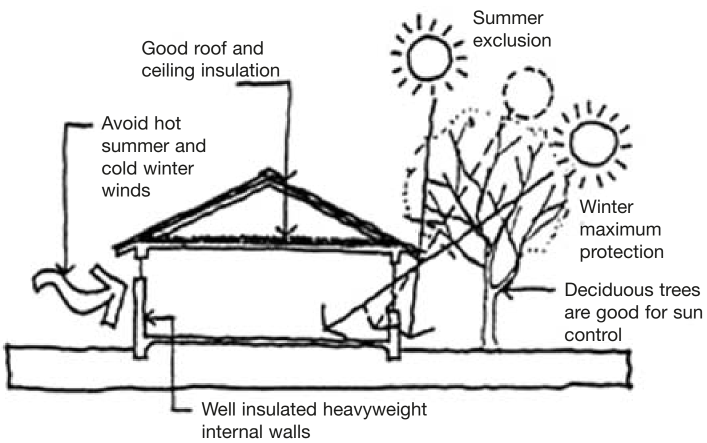
What are the social, economic and environmental implications of this innovation now and for the future?

Passive Solar Heating and Daylighting

Today, many buildings are designed to take advantage of passive solar heating and daylighting employing techniques such as:

- the north side of the building having large, north-facing windows (south facing in the northern hemisphere)
- materials that absorb and store the sun's heat being built into the sunlit floors and walls so that the floors and walls will then heat up during the day and slowly release heat at night, when the heat is needed most.

Many of the passive solar heating design features also provide daylighting. Daylighting is the use of natural sunlight to brighten up a building's interior and reduces the need to have lights on). Daylighting needs to be carefully done as it can also decrease the passive design of a house with large glass surfaces losing as much heat as they attract.



Passive solar house design.
Source: www.ecologicalhomes.com.au/passive_solar_architecture.htm

ACTIVITY - Passive solar architecture

Links: www.greenhouse.gov.au/yourhome/technical/fs31.htm, www.solarhouseday.com/index01.shtml

What are the main economic advantages of passive solar heating?

In what ways have Australians adapted their homes to reduce the impact of the sun's heat and light? Look at communities in regions of Australia exposed to extremely high temperatures. What adaptations have they made to their houses/lifestyle?

Consider your house. Does it take advantage of passive solar heating?

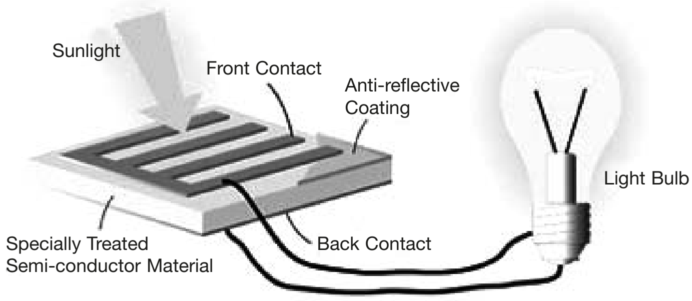
COMPETITION: Design a house including as many passive solar heating and daylighting features as possible. Consider the different materials you will be using in the house. Why have these been chosen? What difference will they make to optimising the use of solar energy in this house?

Construct a model of the house.

EXPERIMENT: Smooth Black Stone (Effects of insulation)
www.sunwindsolar.com/a_scripts/n_lessons.php

EXPERIMENT: Insulation
www.need.org/needpdf/Experiments.htm

Photovoltaic Cells



Source: Solar in Schools *Created by GreenspondTSG*

Photovoltaic (PV) cells are used to convert sunlight directly into electricity.

How a PV cell works

A PV cell works by the energy of a photon being partially absorbed by a dual layer of semiconducting material (one layer N-type and the other layer P-type) causing electrons to be released and flow freely creating electricity.

A single PV cell is able to produce only a small amount of electricity. PV cells can be connected together on a multi-cell solar panel to produce larger amounts of electricity.

Singleton Solar Farm
Source: Department of Energy, Utilities and Sustainabilty

[Solar]

ACTIVITY - PV cells in everyday life

To view the functioning of a PV cell
www.eere.energy.gov/solar/multimedia.html

How many solar cells would be needed to provide the daily electricity requirements of your house?

Link: www.montanagreenpower.com/solar/curriculum/lesson7.html

What prevents more people from using solar energy in their homes?

What global economic and environmental benefits could derive from more people using solar energy in their homes and businesses?

Case studies

1. A 220kW solar power station for the Anangu Pitjantjatjara Lands being constructed in South Australia.
   Link: www.greenhouse.gov.au/renewable/recp/pv/nine.html
2. Solar power is one of the world's fastest growing renewable energy sources.
   Link: www.planetark.com/dailynewsstory.cfm/newsid/17234/story.htm
3. The Australian government Solar Cities trials
   Link: www.deh.gov.au/minister/env/2004/mr15jun904.html
4. Want cheap, green electricity? First, build a 20,000-acre greenhouse to trap and heat air. Then build a colossal tower 1km tall in the middle of it.
   Links:
   www.time.com/time/2002/inventions/rob_tower.html
   www.smartmoves.questacon.edu.au/newmoves/technology.asp?subTech=Renewable+Energy+%2D+Solar+Power+Tower&supergroup=Renewable+Energy

More case studies: www.greenhouse.gov.au/renewable/recp/pv/fourteen.html

Enviromission's Solar Power Tower

Source: Time Magazine

DID YOU KNOW?

Enough sunlight hits the earth every hour to supply the world with solar energy for a year.

ACTIVITY - A plentiful resource

Why is solar energy not more commonly used if this is the case?
List the advantages and disadvantages of solar energy in Australia.

Future Challenges

Although the amount of solar energy available is very high, it is a dilute energy source, which makes it difficult to harvest efficiently. For electricity generation solar power has limited potential, as it is too intermittent. On a small scale (and at relatively high cost) it is possible to store electricity. On a large scale any solar electric generation has to be worked in with other sources of electricity with full back-up supply. The future challenge for solar energy will be to reduce the capital, energy and materials costs of conversion, maintenance and storage as well as to continue developing technology, increasing the efficiency of solar collector systems.

SLIVER cells. *Source: Origin Energy*

Cutting Edge

1. Origin SLIVER cells. Increasing the efficiency and affordability of PV cells.
   Link: www.originenergy.com.au
2. Solar power tower
   Link: www.enviromission.com.au
3. Dye Solar Cell – 'artificial photosynthesis'.
   Link: www.abc.net.au/catalyst/stories/s1241478.htm
4. Solar Sailor – a catamaran powered by dual renewable energy.
   Link:www.greenhouse.gov.au/renewable/recp/pv/fourteen.html

www.

www.re-energy.ca/t_solarelectricity.shtml
www.solarschools.net/ed_resources/renewableresources.aspx

Great solar activities including ideas for building solar powered gadgets
www.sunwindsolar.com
www.juliantrubin.com/solarprojects.html
www.re-energy.ca/t-i_solarelectricitybuild-1.shtml

Solar ideas for building a house
www.greenhouse.gov.au/yourhome/consumer/index.htm

Solar lighthouse
www.deh.gov.au/minister/env/2004/mr07dec04.html

Stanwell Energy Park
www.stanwellenergypark.com/links.asp

CSIRO
www.csiro.com.au

Solar cooking
www.ecolivingcenter.com/articles/solarcooking.html

References

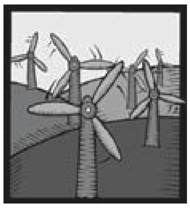
Singleton, G, 101 Cool Science Experiments, Hinkler Books Pty. Ltd, Australia. (2002)

Bosak, S, Science is…, Scholastic, Canada. (1991)

National Science Week 2005

13-21 August 2005

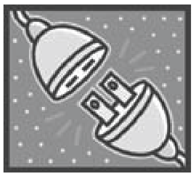
Schools Theme:
Energy – Future Challenges



ASTA is a federation of the state/territory Science Teachers Associations (STAs). Find out about programs, functions, activities and support in your state through your **STA National Science Week Representative**.

RESOURCES & ASSISTANCE FOR SCHOOLS

- **Free PERSONAL copy of Resource Book - ASTA Members only**
- **NScWk School Grants**
- **Access to ASTA STA National Science Week Representative**
- **Schools Kit to every Science Coordinator - includes a resource book**



The aim of National Science Week is to raise the profile and increase public awareness of science, technology and innovation in our society. ASTA aims to increase school participation in National Science Week.

Science Teachers Association Representatives

In each state and territory there is a representative from the local Science Teachers Association to assist schools, teacher and student participation in National Science Week. Email, or give them a call.

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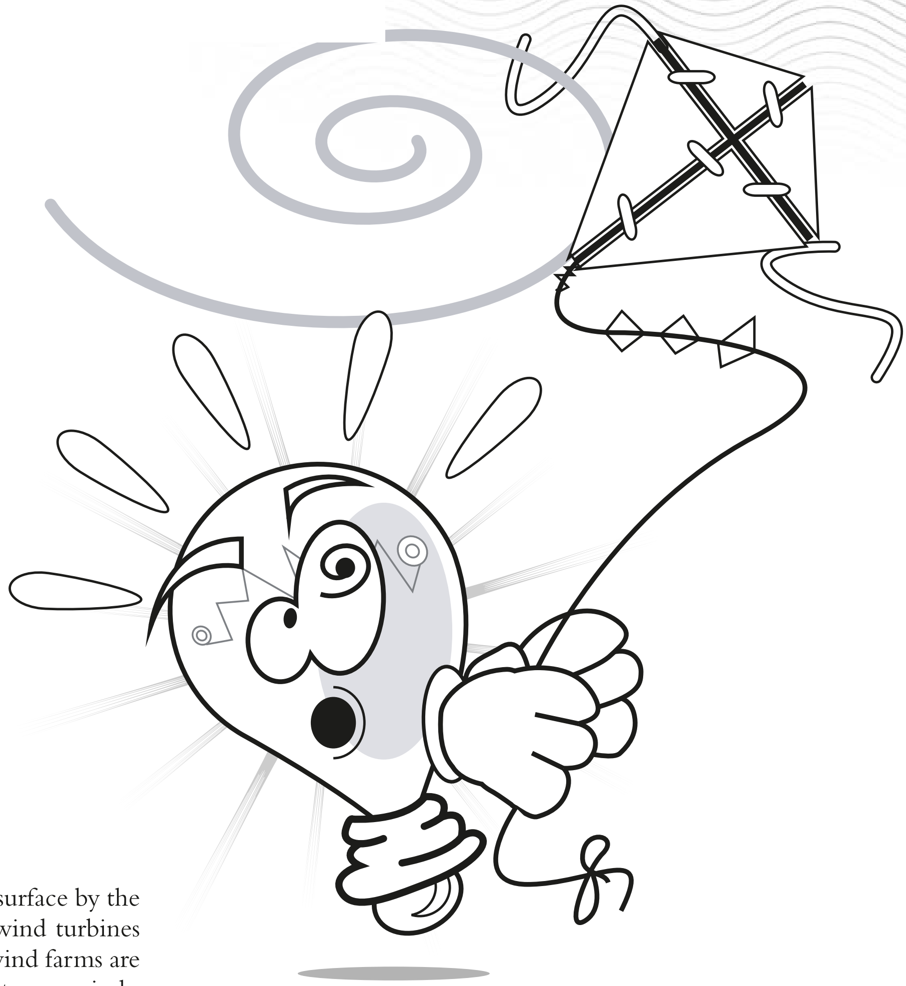
Science Teachers' Association of Western Australia (STAWA)
Mark Merritt • t 08 9246 3422 • e mark.merritt@det.wa.edu.au

Australian Science Teachers Association

Australian Government
Department of Education, Science and Training

World Year of Physics

[Wind]



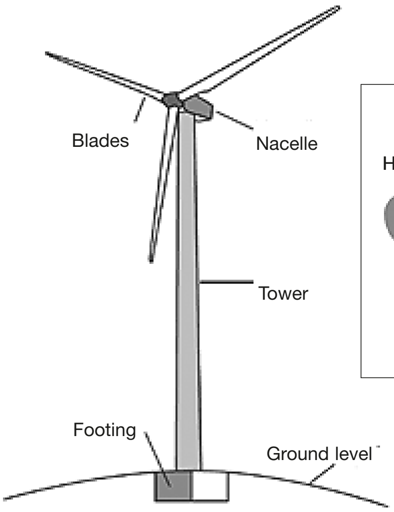
Capturing the wind. **We have been harnessing the wind's energy for centuries - over 5,000 years ago, the ancient Egyptians used wind power to sail their ships. The earliest known windmills were in Persia (Iran) and were used to grind grain. The basic windmill design was improved centuries later in Holland, where they were used extensively to pump water and to grind grain, an activity that farmers around the world have been practising since. Today, the wind turbine is used to transform the wind's energy into electricity.**

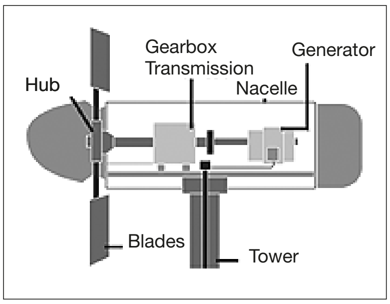
The reliability of wind energy.

Wind is created by the uneven heating of the Earth's surface by the Sun. Because wind is an intermittent resource and wind turbines only produce electricity when the wind is blowing, wind farms are only constructed in areas with recorded reliable strong winds. Research is being carried out to develop turbines that can produce electricity efficiently at low wind speeds in order to increase the potential of wind energy in the world. Currently wind energy in Australia only has the capacity to generate a small proportion of the countries electricity needs.

How does a wind turbine work?

A wind turbine generator consists of a foundation, tower, nacelle and a rotor (three blades mounted on a central hub). In Australia, towers are made of enclosed tubular steel and are usually white or light grey in order to create as little visual impact as possible. The towers are between 50 and 80 metres tall to take advantage of the faster, less turbulent wind. They have internal ladders to provide access to the nacelle, which contains the drive-train, gearbox, generator and controlling equipment.



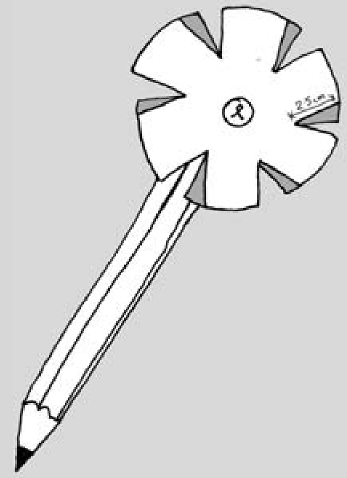


Components of a wind turbine. *Source: reslab.com.au/resfiles/wind/index.html*

A ACTIVITY - How does a windmill work?

Cut a 4cm circle from an aluminium tray. Divide the circle into six equal segments, drawing lines to divide the segments. Make a cut of 2.5 cm from the edge along each line. Fold up one edge of each segment to make the blades (the same edge on each segment). Thread one bead onto a pin, push the pin through the centre of the windmill. Put another bead on the pin. Push the pin through the eraser on the end of a lead pencil.

Conduct experiments with the windmill: is it more effective when its blades face to or away from the wind? Try different designs of windmill: larger circle, more or less blades. What effect does each of these changes have on the windmills efficiency? Try attaching the windmill to a piece of fishing line and blowing it at different wind (or fan) speeds. Which design performs the best (travels the furthest up the fishing line?



[Wind]

ACTIVITY - Design a turbine

Your task is to make a model of an electricity plant with a turning turbine. Renewable resources must be used to turn the turbines in the plant. Try using the wind or falling water. Glue ice cream sticks onto the edges of a matchstick. Try gluing the ice cream sticks at different angles. Obtain two identical wheels (Lego or similar) and join the spokes with ice cream sticks.

- What effect do different materials have on the efficiency of the turbine?
- What type of materials work the best?
- Try rotating the turbine with different amounts of energy
- How much of the energy source is needed to rotate the turbine?
- Observe the effectiveness of different energy sources.

How much energy goes into building wind turbines?

It takes only six months for a wind turbine to pay back the energy used in its manufacture. Over its twenty-year lifetime, a wind turbine will produce more than fifty times the energy used in its manufacture, transportation and erection.

From wind to electricity.

Wind turbines convert the kinetic energy of wind into mechanical power. This mechanical energy can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. Wind turbines are used as stand-alone applications, connected to a utility power grid or even combined with a photovoltaic (solar cell) system. Stand-alone wind turbines are typically used for water pumping or communications. Farmers and people living in remote, windy areas can also use wind turbines to reduce their electricity bills. The contribution of wind energy in Australia is currently quite small relative to the total generation of electricity.

What is a wind farm?

A wind farm is the name used for any group of adjacent wind turbine generators that are connected electrically. In Australia, wind farms are built with between one and sixty wind turbines, each turbine generating its own electricity. The electricity from each turbine flows through cabling connecting all of the turbines within the wind farm out into the grid. The turbines are usually arranged to maximise use of the wind available and placed sufficiently far apart to avoid interference with one another.

DID YOU KNOW?

Wind electrical power is generally proportional to the speed of the wind cubed. This means that if the wind speed doubles, the power generated is multiplied by eight.

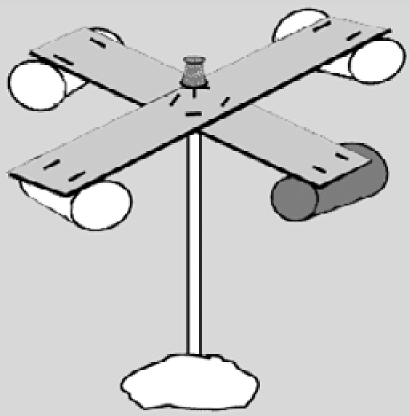
EXPERIMENT - Measure the wind

Aim: To construct an instrument for measuring the wind.

Make an Anemometer (for measuring wind speed).

Cut off the rolled edges of 4 paper cups (to make them lighter). Colour the outside of one cup with a marking pen. Cut 2 rectangular strips of stiff cardboard the same length. Cross them over at right angles. Staple them together. Staple the cups to the end of the cardboard strips, all facing the same direction. Push a pin through the centre of the cardboard strips (where they cross each other) and pin it (cups on the under side) to the eraser end of a lead pencil. Blow the cups to make sure the cardboard spins freely. Place modelling clay on a hard surface outside. Stick the lead end of the pencil into the clay so that the anemometer stands upright (you could also stick the pencil into the ground or into a container of plaster of Paris and wait for it to set). Count the revolutions per minute. Measure the wind speed at different times of the day – how would a weather forecaster convert this to kms per hour? Move the anemometer to different positions. What effect do buildings and trees have on the wind speed measured?

Link: www.energyquest.ca.gov/projects/anemometer.html



Source: www.energyquest.ca.gov/projects/anemometer.html

Woolnorth Wind Farm. *Source: Hydro Tasmania*

Source: Stanwell Corporation Limited

DID YOU KNOW?

Less than 1% of the land on a wind farm is taken up by wind turbines. More than 99% can still be used for other profitable activities, such as farming.

ACTIVITY - Wind energy and the environment

Using a map of Australia, indicate where the wind farms are in Australia.

Link: www.auswea.com.au

- What does each of these locations have in common?
- What are the most significant issues regarding the expanded use of wind energy in Australia?

DEBATE - There is no future for wind power in Australia.

DID YOU KNOW?

The earliest wind farm was connected in Australia in 1988, at Salmon Beach, Esperance, Western Australia.

DID YOU KNOW?

In Australia, a wind farm can displace between 65,000 and 115,000 tonnes of CO_2 each year.

The issues

"Wind farms might affect local weather, and slow down the wind that drives them, U.S. research has found..."

Link: www.abc.net.au/science/news/enviro/EnviroRepublish _1227393.htm

ACTIVITY - Researching the issues

1. What happens when the wind stops blowing?
2. How predictable is wind power?
3. Are wind farms too noisy?
4. Are wind turbines just bird blenders?
5. Are wind turbines aesthetically confronting?
6. Is wind power-generated electricity expensive?
7. What will happen to the expansion of the renewable energy industry when Australia fulfils its Mandatory Renewable Energy Target (MRET)?

Research the issues associated with wind energy listed above and write a brief response to each of the questions.

Links: www.auswea.com.au
www.hi.com.au/resource/rfactsa.asp?kla=13&subtopicid=3510

Is it possible to believe everything you read or hear? How do you reach your own conclusions on the effectiveness of wind farms in Australia?

Explain the social, economic and environmental advantages and disadvantages of wind power in Australia.

Future Challenges

Currently wind energy in Australia has the capacity to generate only a small proportion of the country's electricity needs. The most significant challenge for the wind power industry is to develop a wind turbine that can produce electricity efficiently at low wind speeds in order to increase the potential of wind as a reliable energy source. Environmental concerns including visual impact, noise pollution and threat to birds need to be addressed.

The cutting edge

Wind energy capacity in Australia almost doubled in the last 12 months with 380 megawatts (MW) of wind energy capacity installed by the end of 2004. This is significantly higher than the 198 MW of installed capacity at the end of 2003 and represents another milestone for this emerging industry.

Wind energy around the world

Wind energy is one of the fastest growing technologies in the world. In 2002 some 6,700 MW of new wind energy generation was installed internationally, representing an annual growth of almost 30%. Germany alone installed more than 3,200 MW in 2002. Wind energy is used in many countries including Germany, Denmark, Spain, India, and the USA. In areas of northern Europe and around the UK, there is growing interest in the possibility of offshore wind farms, with several large offshore wind farms being commissioned in recent years.

Innovations

Wind turbines continue to get taller, quieter, more efficient and able to produce more energy. With the advancement of meteorological technology the installation of better wind forecasting systems has enabled authorities to better predict the output from wind turbines, making them an increasingly reliable source of electricity generation.

Case studies

1. Australia has a rapidly expanding wind energy capacity.
   Link: www.auswea.com.au/projects/projects.aspin
2. A country run on wind.
   Link: www.greenpeace.org.au/climate/solutions/ renewables/casestudies.htm

Www.

Facts about the generation of wind
www.nrel.gov/clean_energy/wind.html
www.sustainableenergy.qld.edu.au/fact/factsheet_8.html
www.eia.doe.gov/kids/energyfacts/sources/renewable/wind.html

How does the land change the wind?
www.seda.nsw.gov.au/ren_wind01.asp

Activities
www.jaconline.com.au

Lots of interesting facts about wind farms in Australia
www.auswea.com.au/projects/est

Issues regarding wind energy
www.hi.com.au/resource/rfactsa.asp?kla=13&subtopicid=3510

References

Begbie, C, Earth, Air, Fire & Worms, CSIRO Australia, ACT, Australia. (1994)

Fun facts about wind energy

Wind energy is already providing over 40 million people with clean energy around the world. Find out how YOU can make the POWER-ful switch to renewable energy!

WIND ENERGY AND THE ENVIRONMENT

- There are currently 295 wind turbines around Australia producing enough energy to power more than all the homes in Canberra and displacing 1.5 million tonnes of greenhouse gas emissions per year, the equivalent of taking almost 350,000 cars off the road.
- Typically each turbine can produce enough energy to meet the needs of up to 1000 homes per year.
- Electricity consumption due to the burning of fossil fuels is the largest source of greenhouse emissions in Australia (45%).
- A wind turbine offsets all the energy used in its construction and installation in less than six months, and then generates completely clean energy for over 20 years.
- Wind farms produce electricity directly from a natural, clean, free and sustainable energy resource.

WIND AND REGIONAL BENEFITS

- Wind turbines can provide a valuable income for farmers in rural and regional areas. Each farmer typically receives around $5000 per turbine per year to host them on their property.
- Wind energy brings significant investment and job benefits to rural and regional communities, the very areas that stand to suffer the most from the effects of climate change, like more severe droughts and floods.
- Less than 1% of the land is used by a wind farm, leaving property owners to continue normal farming on 99% of the land.

THE COST OF WIND ENERGY

- The cost of wind energy has declined by three quarters since the 1970s and it is now one of the most cost effective renewable energy technologies.
- The cost of wind energy is expected to overlap with the price of fossil fuels within 10-15 years time, provided that Australia keeps up with international growth.
- Wind turbines for today's wind farms cost up to $3 million each.
- Wind energy technology is the world's fastest growing electrical generation source.
- Because renewable energy sources like wind power are more expensive than fossil fuels, energy wholesalers and large energy users are required to purchase some of their power from these clean sources of energy through the federal government's Mandatory Renewable Energy Target.
- Wind energy is one of 23 renewable energy technologies available to meet the federal government's Mandatory Renewable Energy Target (MRET).

WHAT CAN YOU DO TO SUPPORT WIND ENERGY?

- Everyone can support clean energy sources like wind power simply by purchasing it! Your family or school can purchase Green Power for a small additional weekly cost. For details, phone the Green Power hotline on 1300 723 588.
- You can also encourage your local, state and federal governments to support renewable energy by writing them a letter about the importance of clean energy sources like wind power.

FIND OUT MORE!

For more facts about wind energy visit:

www.auswea.com.au/WIDP/factsheets.htm

AusWEA website: **www.auswea.com.au**

[Geothermal]

Energy from the Earth's core.
Geothermal energy is heat energy originating deep in the earth's molten interior. It is the only renewable source of energy that can be tapped all year round, regardless of climatic conditions or the time of day and there are no storage facilities required.

ACTIVITY - Clay Earth models

Directions:

1. Make a small ball of red modelling clay to represent the inner core of the earth.
2. Add a layer of white modelling clay to represent the outer core.
3. Add a layer of brown modelling clay to represent the mantle.
4. Add a layer of green modelling clay to represent the crust.

5 Place the clay model on a paper plate.

Using plastic knives, have students cut the model in half so that they can see the layers of the earth.

Geothermal energy is harnessed for the generation of electricity and space and water heating. There are four main types of resource: hydrothermal reservoirs, hot dry rock (HDR), geopressured brines, and magma.

Hydrothermal is the only source used to generate commercially viable energy in Australia while HDR is at the stage of development where it could be an important energy source in the next ten years. Geopressured brines and magma are still undergoing research and development in Australia.

The temperature of the Earth's core is estimated to be between 3,000 and 5,000°C, about the same temperature as the surface of the sun.

High geothermal activity occurs where the earth's crust is thin and molten rock and steam force their way to the surface at high pressure. Rock and water (rainwater that has seeped into the earth) close to the surface of the earth are heated by the magma that has reached the surface.

Some of this hot geothermal water travels back up through faults and cracks and reaches the earth's surface as hot springs or geysers (which is used in the generation of electricity in countries such as Italy, Iceland, New Zealand and Japan), but most of it stays deep underground, trapped in cracks and porous rock. This natural collection of hot water is called a geothermal reservoir.

ACTIVITY - Watch the volcano erupt!

SAFETY WARNING.

Materials needed: modelling clay, small bottle, shallow pie tin, warm water, red food dye, liquid detergent, baking soda, vinegar - a tablespoon.

Method: Place modelling clay around a small bottle to represent a mountain. Fill the bottle with warm water and place on the pie tin. Add 2 or 3 drops of red food colouring, 5 or 6 drops of liquid detergent and 2 tablespoons of baking powder to the warm water in the bottle. Pour vinegar into the bottle until the suds begin to rise to the top of the bottle and flow down the sides.

ACTIVITY - Thermal energy put to work

Aim: Can thermal energy be made to do useful work?

Cool a balloon and a 1 litre bottle in the freezer for 5 minutes. Fill a bowl with hot water. Put the balloon over the mouth of the bottle making sure that the air has been squeezed from the balloon. Place the bottle into the hot water. The air inside the bottle should expand and inflate the balloon. After it is inflated, put the bottle in the bowl of ice water and observe the balloon deflate. Design a device to convert this expansion and contraction into usable work such as lifting a rock.

Extension: Can you think of devices that convert thermal energy into motion? Can you think of a way to convert thermal energy into electrical energy? Research internal combustion engines and turbine generators.

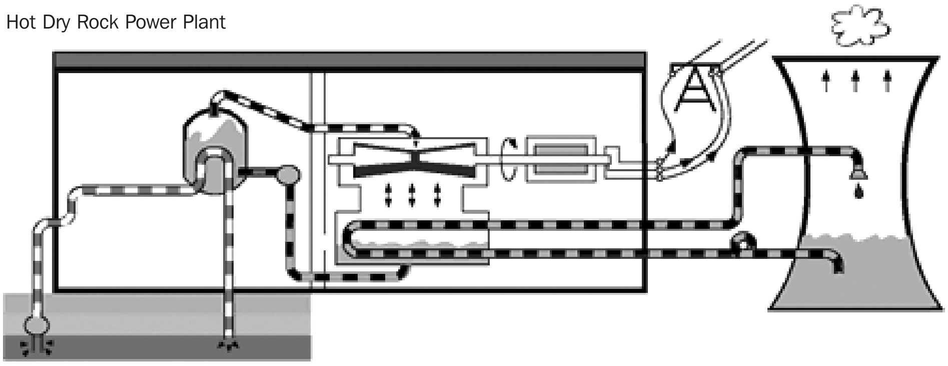
Geothermal power plant at Wairakei, New Zealand.
(Image courtesy of International Geothermal Association)

[Geothermal]

Geothermal energy for electricity

In geothermal power plants steam, heat or hot water from geothermal reservoirs provides the force that spins the turbine generators and produces electricity. The used geothermal water is then returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir.

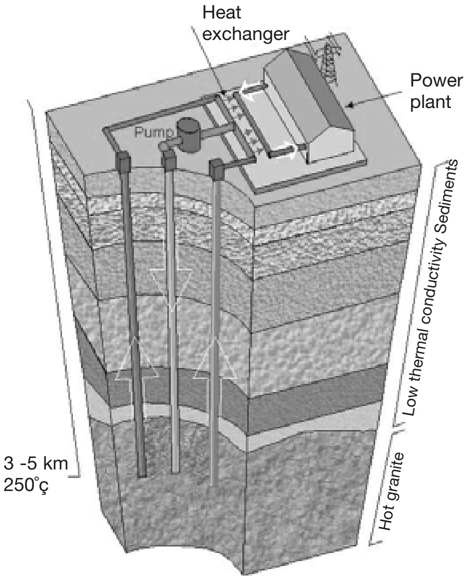
Hot Dry Rock Power Plant



Hot dry rocks (HDR)

In Australia, the potential sources of geothermal energy are hydrothermal reservoirs and hot dry rock (HDR). HDR is a heated geological formation usually composed of granites at depths of three to five kilometres below the earth's surface. HDR power is a relatively new discovery in Australia – for many years it was thought that no active volcanoes or geysers meant no geothermal potential. In fact, Australia has several thousand cubic kilometres of identified high heat producing granites and buried low-grade uranium bearing mineralisation having the potential to meet the total electricity demand of the country for hundreds of years.

At present there are two HDR projects in Australia – one in the Cooper Basin in South Australia and the other in the Hunter Valley in New South Wales.



HDR formation

Source: www.hotrock.anu.edu.au/

Case Study

HDR project in the Cooper basin, SA.

www.greenhouse.gov.au/renewable/recp/hotdryrock/one.html

Future Challenges

Whilst Australia's geothermal HDR potential is enormous there are several factors inhibiting its development: economics, geological risks, legislation restrictions and how to get the energy source to potential customers.

The main challenge facing geothermal use in Australia is the location of a large enough concentration of the right kind of hot rock in the right geological setting. For geothermal energy to be a truly feasible alternative energy solution in Australia, new drilling innovations are needed. This will result in greater extraction efficiency as well as reduction in the cost of exploration, leading to a decrease in the price of geothermal-generated electricity per kilowatt hour. Only then will this energy source be able to potentially compete with more affordable, coal-generated power.

A ACTIVITY - Make your own geothermal power plant

Link: www.energyquest.ca.gov/projects/geothermal-pp.html

What are the economic and social implications of harnessing HDR energy for electricity?

What are the potential risks to the environment of drilling for geothermal energy? If there is enough geothermal energy in the Cooper Basin "to rival 50 times the Snowy Mountains Scheme" and to "power the whole nation for more than 100 years with greenhouse gas-free emissions" why isn't it yet available to the consumer?

Link: www.abc.net.au/ra/innovations/stories/s1159367.htm

Www.

History of geothermal energy
iga.igg.cnr.it/geo/geoenergy.php

Information about geothermal energy
www.sustainable.energy.sa.gov.au/pages/advisory/renewables/types/geothermal/using_geothermal.htm:sectID=46&tempID=52
www.re-energy.ca/t_otherclean.shtml

Information about direct use of geothermal energy
www.nrel.gov/clean_energy/geodirectuse.html
geothermal.marin.org/GEOpresentation/sld003.htm

News story in the Yemen Times outlining details of HDR discovery and potential in Australia
www.yementimes.com/article.shtml?i=802&p=health&a=1

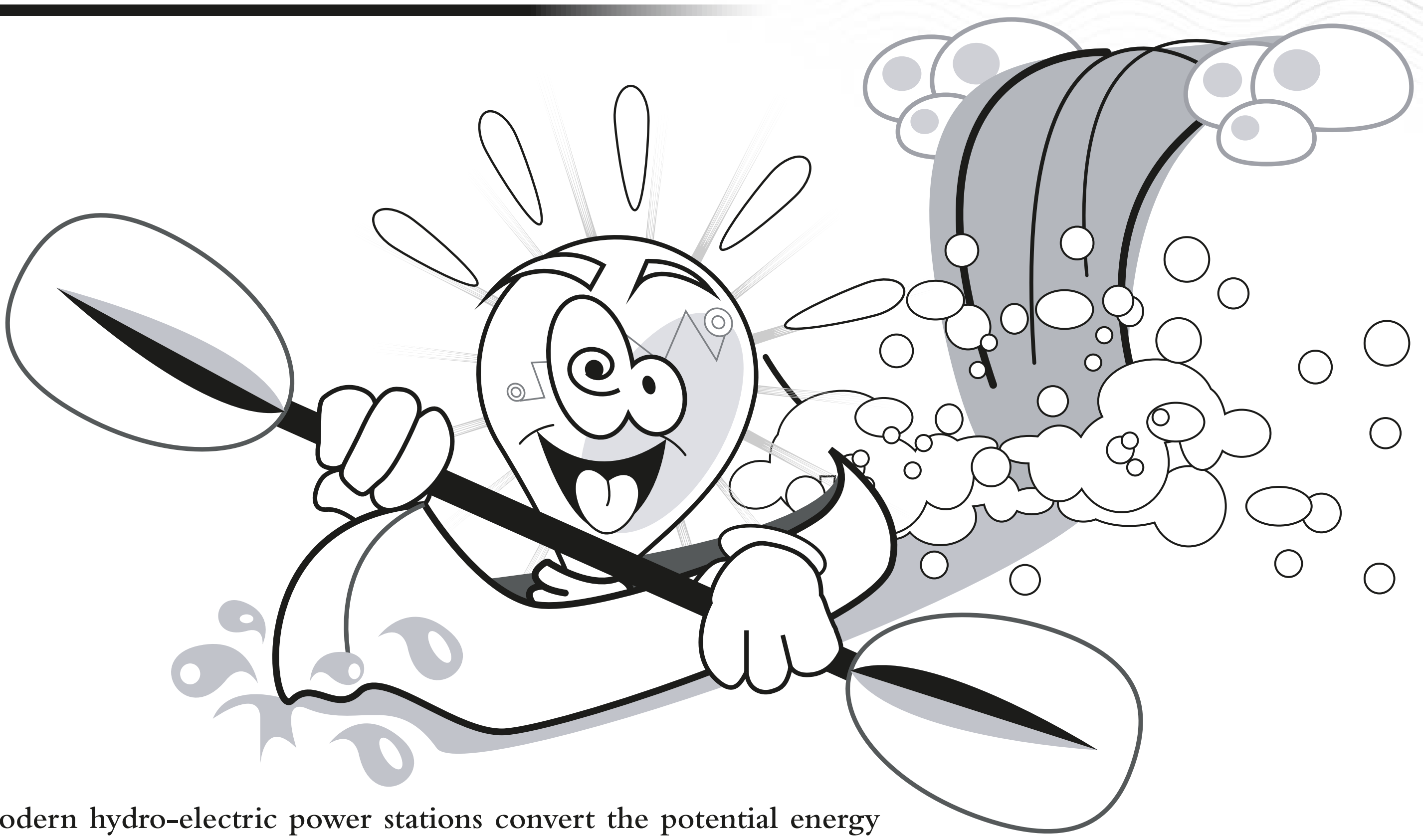
Interactive display of generation of electricity from HDR
www.geodynamics.com.au/IRM/content/02_hotdryrock/02.html

Volcano experiment
www.nashville.k12.tn.us/CurriculumAwards/First%20Grade%20Internet%20Expedition/projectinst.html

The cutting edge

1. Hot Dry Rock
   Links: www.hotrock.anu.edu.au/int_links.htm, www.geodynamics.com.au
2. New technologies in deep drilling.
   Link:www.oilfield.slb.com/media/resources/oilfieldreview/ors95/jan95/01950422.pdf
3. Low temperature power stations can use lower grade geothermal resources to produce electricity
   Link: www.epa.qld.gov.au/publications/p00834aa.pdf/Birdsville_geothermal_power_station.pdf

[Hydro-electricity]

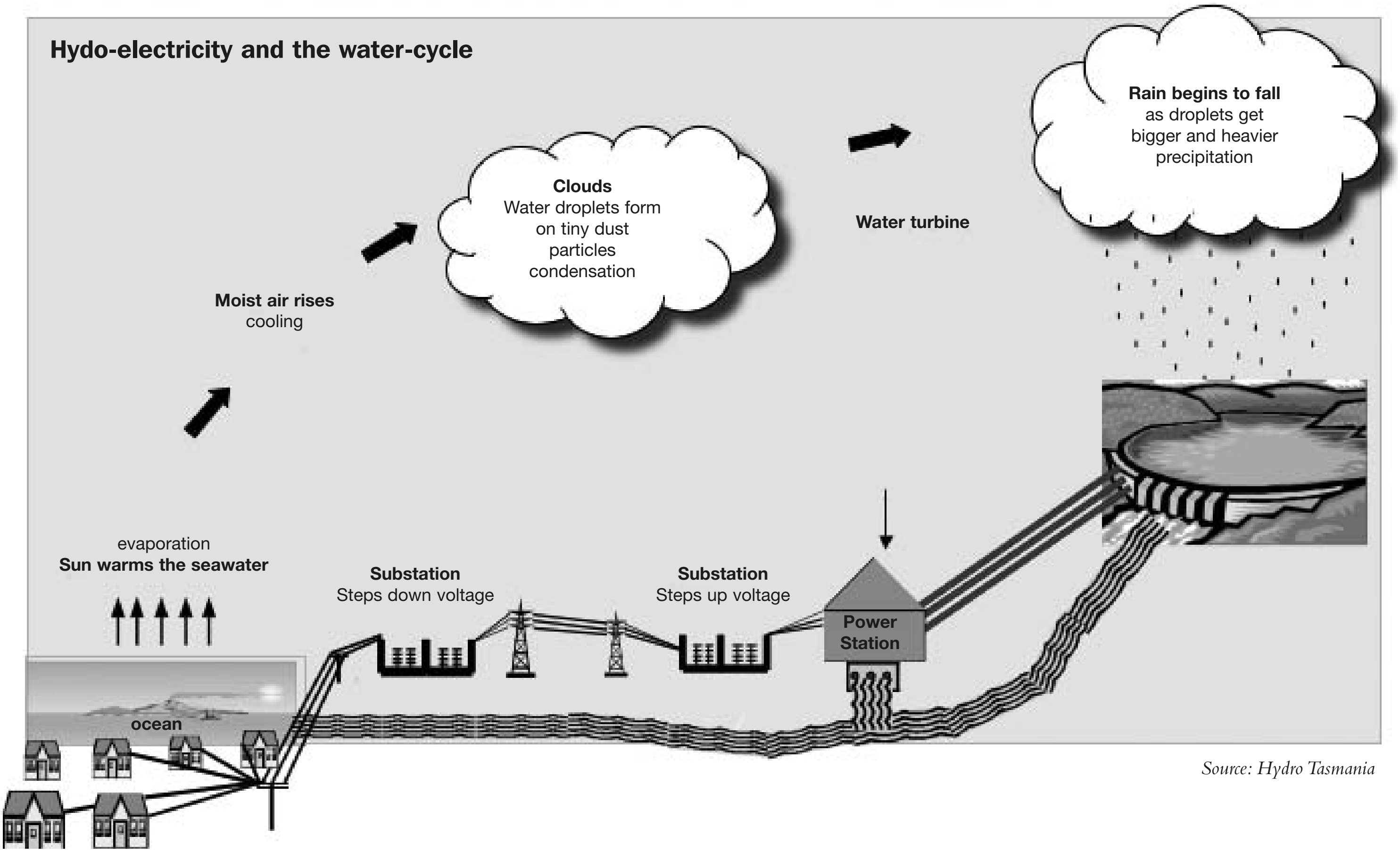


Modern hydro-electric power stations convert the potential energy of water stored at high elevation in dams or lakes to electrical energy. Hydro-electricity is renewable and produces no air pollutants and very few direct greenhouse gases in the generation process. Greenhouse gases are, however, produced in the building and development of the dams. Hydro-electricity is produced by utilising one of the earth's natural systems "the water cycle".

DID YOU KNOW?

The term hydro comes from the Greek word for water.

Hydo-electricity and the water-cycle



Source: Hydro Tasmania

[Hydro-electricity]

ACTIVITY - The water cycle

Design and build a model of the water cycle using readily available materials.

Hydro-electricity is unique among energy sources for its operational flexibility. That is, if there is an increased electricity demand, a hydro-electricity plant can respond almost immediately by releasing more water. When the demand is low, a hydro-electricity plant can conserve the water for future requirements.

DID YOU KNOW?

Hydro is the only renewable technology that can be used to store large quantities of energy in a clean environmentally friendly way. This is done by reservoir storage and pumped storage schemes.

Hydro-electricity in Australia

Hydro generation currently represents over 90% of Australia's existing renewable electricity generation capacity, and about 8% of Australia's total electricity generation. Most is generated from large dams in the Snowy Mountains Scheme near the NSW/Victoria border, from Southern Hydro's power stations in Victoria, and in various schemes run by Hydro Tasmania. Australia has limited additional hydro capacity.

Lake Bunbury, Tasmania. *Source: Hydro Tasmania*

DID YOU KNOW?

Hydro-power is one of the oldest sources of energy and was used thousands of years ago to turn a paddle wheel for purposes such as grinding grain.

How does it work?

Hydro-electricity uses the potential energy of water stored in lakes. The potential energy in the water is turned into kinetic energy when it flows down through the pipes and into the power station. The water is used to spin a turbine and run the generator.

Visit **www.fwee.org** to view an animated diagram showing how hydro-electricity works.

EXPERIMENT - The energy in falling water

Aim: To demonstrate the difference in the stored energy of water at different heights.

Set up a tray containing a shallow covering of flour. Use an eyedropper to drop water on to the flour from a range of different heights. What happens to the impression made in the flour as the dropper is held further away form the tray? What does this tell you about the energy in falling water? Explain the energy change in this process.

CHALLENGE - All about turbines

A water turbine is a wheel with blades or fins on it, somewhat like a windmill except it uses water. Water hits and rotates the turbine, and through the connecting shaft, turns the generator. Make a series of turbines, which can be run by blowing air through a straw. Find out which ones work best when blown with a straw from the top and which work best when blown from the end. Use materials available to you. These include aluminium cans, icypole sticks, plastic bottles, plastic spoons, milk cartons, cups, corks and wire.

Experiment with: different paddle sizes, numbers of paddles per turbine, shapes of blades, size of the turbines. Decide on a set of criteria for assessing the performance of the turbines.

The amount of electricity produced by a hydro-electric power station is dependent on the water pressure on the turbine and the volume of water available. The greater the height (or head) of the water above the turbine the greater its pressure.

DID YOU KNOW?

A modern hydro turbine generator set can convert over 90% of the energy in the available water into electricity.

There are two main systems for the production of hydro-electricity - Run of River and Dam Storage. Dam Storage uses lakes or very large dams to store water to produce the power. The power stations used with the dam system are often located underground to increase the head. The alternative system uses the natural run of the river. The power station is located on the river and the flow of water runs in one side, through the turbine and out the other side. This system releases the same amount of water as went in so the flow of the river does not change. In some instances there are small dams built near the power station to temporarily hold and control the flow of the water.

Hydro Tasmania

Hydro Tasmania uses a combination of Dam Storage and Run of River systems. The environmental conditions and time of year influence how Hydro Tasmania runs both of these systems. During the winter months a lot of water is available in the large river systems which become very swollen from rain and melting snow from the highlands. The water in these rivers can't be "stored" and must be used when it is available. Any rain that is captured in the large lakes can be stored for summer production (when the Run of River stations have less water available). This ensures water is available for energy production throughout the seasons.

Visit **www.hydro.com.au** to learn about building a dam and the environmental issues to consider.

EXPERIMENT - The kinetic energy of falling water

Aim: To measure the effect of the water head on the kinetic energy of water.

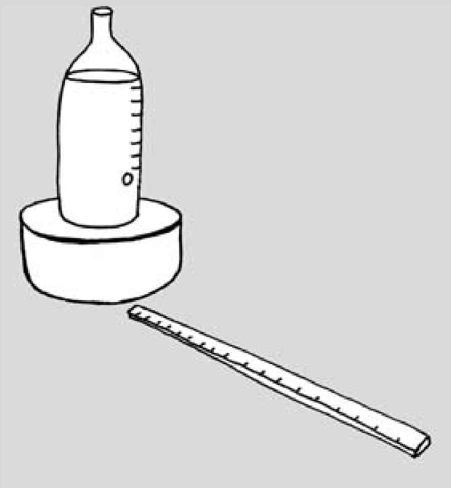
Facts to consider:

- Water falling through 100m can produce twice as much power as the same volume falling only 50m.
- The amount of power is directly related to the quantity of water – twice the volume produces twice the amount of power.

Set up an experiment to measure the effect of the height of the water head on the kinetic energy of the water as measured by the distance water is squirted from a hole near the bottom of a plastic bottle. You will need a number of different plastic drink bottles including at least one 1.25 litre bottle, two rulers, blu-tac, plasticine or tape, paper and pencils.

1. Make a hole at the base of a 1.25 litre bottle on the line just above the 'stand section'.
2. Mark the bottle each 2 cm to the 14cm mark.
3. Set the bottle on a brick with a ruler under the brick.
4. Plug the hole with Blu tac and fill the bottle to above the 14cm mark with water.
5. Read the water head aloud each time it passes one of the marks on the bottle.
6. Measure the distance water is 'squirted' at each of the two centimetre marks.
7. Record the distance of the squirted water.
8. Graph the water head in cm against the distance the water is squirted. What is the relationship between the water head and the average distance water is squirted?

Design a similar experiment to show how the amount of water is related to the amount of power produced.



Future Challenges

Advantages of Hydro-electric Generation

- Hydro-electricity is one of the cleanest and most efficient methods of producing electricity
- The water used for hydro-electricity generation can be used for other purposes. eg irrigation and recreational activities such as fishing, boating and rafting.

Disadvantages

- Hydro-electric schemes alter stream flows and change the environment
- The cost of installing a hydro-electric power station depends greatly on the site
- It is not available for use in all areas of Australia due to environmental and weather conditions
- There is little potential for future large-scale hydro developments.

ACTIVITY - Is Hydro the answer?

Is Hydro-electricity clean and green? Think about how you could overcome the disadvantages associated with hydro-electricity. Do the advantages outweigh the disadvantages? Do you think hydro-electricity could be set up somewhere near you? Would you be prepared to pay more for your power if it is more environmentally friendly?

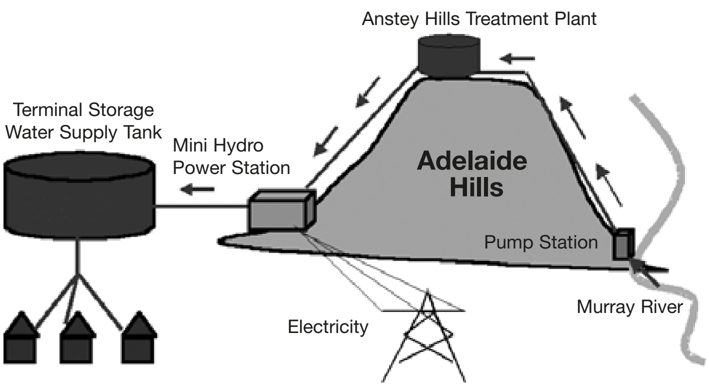
Link: www.hydropower.org/1_5.htm

The Cutting Edge

Case Study of Terminal Storage Mini Hydro Development in South Australia.

The Mini Hydro project (completed in Sept 2003) was a joint venture between Hydro Tasmania and South Australian Water.

This project is an example of how innovation was used to capture the wasted potential energy in the falling water. A small water turbine is used to generate clean renewable energy from water that already flowed through the Mannum/Adelaide pipeline providing fresh drinking water for residents in Adelaide.



Terminal Storage System layout. *Source: Hydro Tasmania*

www.

Australia's largest hydro-electric company with a fantastic education centre
www.hydro.com.au

Quick facts and the history of hydro
www.canhydropower.org

Kids activities and resource kits
www.snowyhydro.com.au

Make your own hydropower
www.fwee.org

Case studies
www.greenhouse.gov.au

Water education kit
www.sawater.com.au

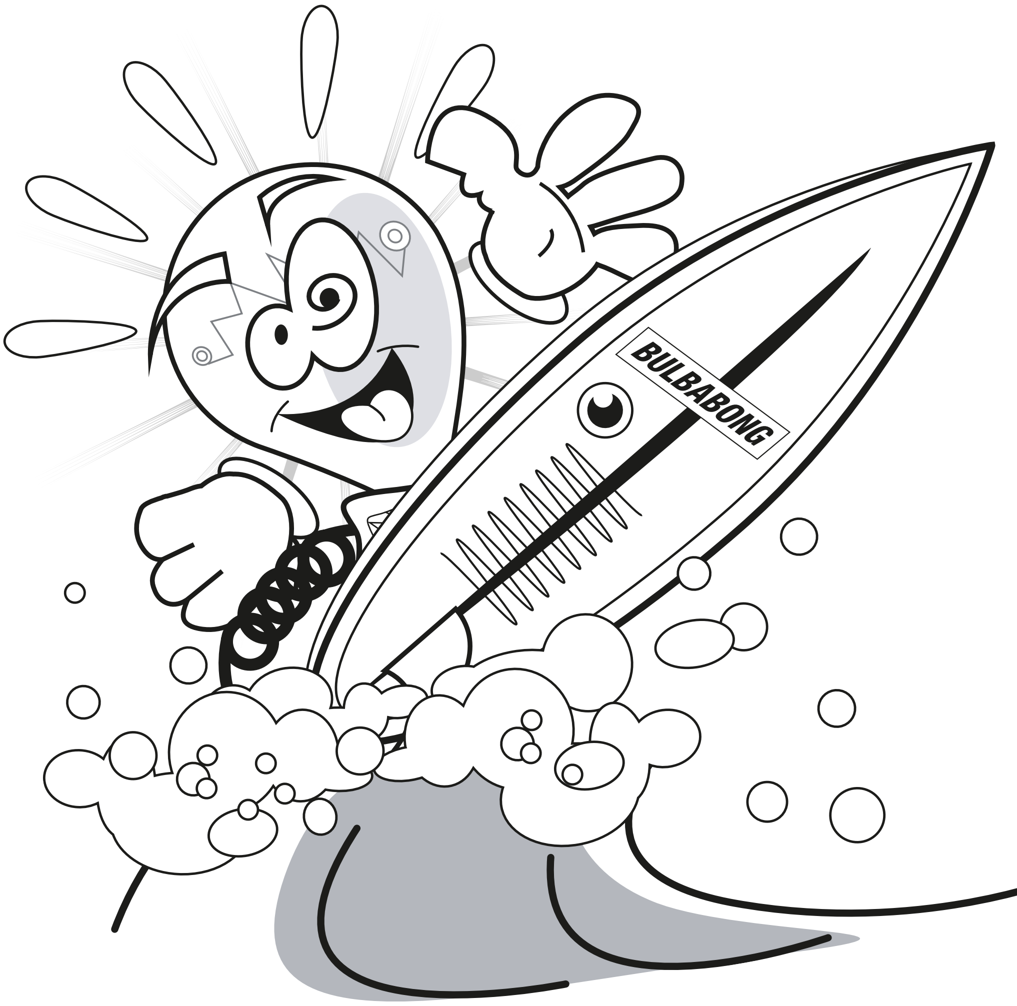
References

Scanlon A, The power of Nature available from www.hydro.com.au

Edom H, Science with Water, Usborne Publishing Ltd., England (1992)

Ardley N, Science for Kids Hot and Cold Dorling Kindersey Ltd, England (1992)

[Ocean]



An abundant resource. **Ocean energy results from energy transmitted from wind to the ocean surface or from the thermal heating of the ocean. Ocean energy is abundant and non-polluting. Australia's coastline is an excellent wave energy resource conveniently close to the major population centres.**

DID YOU KNOW?

The total power of waves breaking on the world's coastlines is estimated at 2 to 3 million mW.

How do waves work?

Waves are seen to move through an ocean, yet the water always returns to its rest position. Energy is transported through the medium, however the water molecules are not transported.

ACTIVITY - How do waves work?

Place a small floating ball/ fishing float in a tub of water noting exactly where it is located in the tub. Make some waves and observe what happens to the position of the floating object (it should bob up and down but stay in the same place).

EXPERIMENT - Thermal currents

Aim: To demonstrate thermal currents.

Place a beaker of water over a Bunsen burner. When the water begins to heat up, put a few drops of food colouring in the water. Describe the movement of the food colouring. Move the Bunsen so it is only heating one side of the beaker. Add some more food colouring. You will be able to see a current in the water. This is how currents work.

EXPERIMENT - Temperature differences

Aim: To demonstrate the movement of currents due to temperature differences

Measure the temperature in different areas of an aquarium. The temperature will be roughly the same everywhere. Tape a thermometer to each end of the aquarium. Place a row of ice cubes at one end of the aquarium (about 5cm from the edge). Record the temperature every minute on both thermometers. Which end of the tank cools down more quickly? Why is this the case? Check the movement of the currents by adding food colouring to the aquarium. Make sure there are no fish!

What is ocean energy?

Ocean waves are a tertiary form of solar energy, in that unequal heating of the Earth's surface generates wind, and wind blowing over water generates waves. The energy contained in the ocean is a huge renewable resource and can be harnessed through three different paths - wave energy, tidal energy and ocean thermal energy.

ACTIVITY - Amplitude and energy of waves

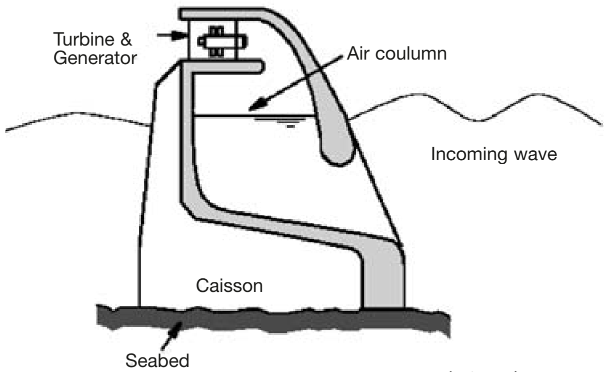
What does amplitude mean? Visit this website to learn about how amplitude is related to the energy in the wave. How does this equation help organisations design wave energy systems?

Link: www.physicsclassroom.com/Class/waves/U10L2c.html

Wave Energy

For wave energy conversion, there are three basic systems: channel systems that funnel the waves into reservoirs, float systems that drive hydraulic pumps, and oscillating water column systems that use the waves to compress air within a container. The mechanical power created from these systems either directly activates a generator or transfers to a working fluid, water, or air, which then drives a turbine/generator. In Australia Energetech has developed a system called an Ocean Wave Converter (OWC). Visit **www.energetech.com.au** to interact with animations showing how electricity is harnessed from waves and to learn about the OWC about to start work in Australia.

Outline and operating principles of an OWC

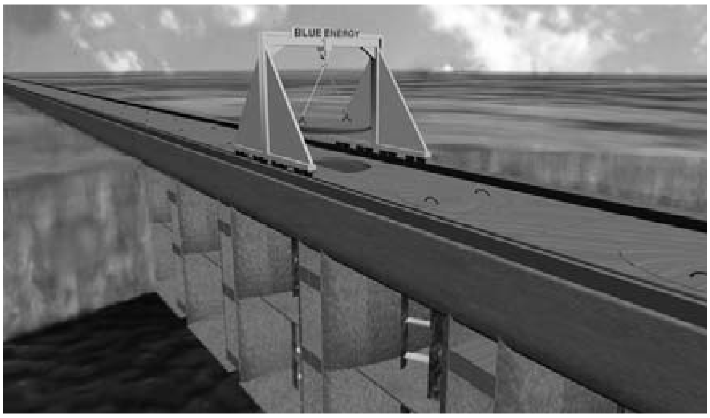


Source: Energetech Australia Pty Limited

Tidal Energy

Tidal power requires large tidal differences. The flow of water is used to turn a turbine to create electricity. Strong flows tend to occur within straits, between islands, and at entrances to large bays and harbours.

Producing electricity form ocean currents involves using a tidal turbine that works like an underwater wind turbine and drives a generator. The tidal currents need to be fast flowing which often occurs in areas which have a narrow or shallow constriction. Visit **www.bluenergy.com** to see how an Ocean Energy Turbine works.



Tidal fence. *Source Blue Energy*

ACTIVITY - Wave energy around the world

Visit the Ocean Power Delivery site **www.oceanpd.com/Resource/Worldresourcemap.html** to see the map showing world wave resources. Which countries have the potential to set up wave energy production systems?

ACTIVITY - The cost of electricity from wave energy

"Good wave climates should produce power at a cost of under 10 cents per kWh, while ideal wave climates will allow power to be generated for under 5 cents per kWh. This is a very favourable comparison with other alternative power sources. For example, wind power costs between 6 and 25 cents per kW, while solar power is usually more than double at over 50 cents per kWh." Find out how much it costs to produce a kWh of electricity using coal, oil and natural gas. **(www.energetech.com.au)**

Ocean Thermal Energy Conversion (OTEC)

With oceans covering 70% of the earth's surface, more solar radiation is falling on and heating the surface levels of oceans than on land. The technology for generating electricity from different ocean temperatures is known as "ocean thermal energy conversion," or OTEC. OTEC makes use of the difference in temperature between the warm surface water of the ocean and the cold water in depths below 600 metres to generate electricity. As long as a sufficient temperature difference (about 4.5˚C) exists between the warm upper layer of water and the cold deep water, net power can be generated. Visit this website to learn more about the different types of electricity conversion using OTEC. **www.hawaii.gov/dbedt/ert/otec_hi.html#anchor349152**

DID YOU KNOW?

According to the World Energy Council, the global energy available from wave energy conversion is 2000 TWh/yr. Tapping just 0.2% of this energy would satisfy the current global demand for electricity.
N.B. 1TWh = 1,000,000,000kWh

The cutting edge

Energetech Australia Pty. Ltd. has received a grant from the Australian Greenhouse Office to construct a 300 kW wave power generator on the breakwater at Port Kembla. Energetech's core patented technology is an onshore Oscillating Water Column (OWC) device based on the established science of wave energy. Energetech will launch this system early in 2005. Energetech has combined this with a system of desalinating water which could provide up to one billion litres of fresh water per annum.

Ocean Power Technologies (Australasia) Pty Ltd has built a 20 kW pilot scale prototype PowerBuoy™, to be moored to the sea-bed several kilometres off the Victorian coast near Portland. The buoy floats underwater and its up-and-down motion drives a hydraulic cylinder and generates power.

Future Challenges

Ocean technology has not yet been adopted widely in Australia as the research is still being refined and it has been difficult for organisations to find investors to support such a new technology. There are also issues to be considered such as the fact that because the best wave power potential lies in the deep ocean, the transmission of energy from these sites to the user could be quite expensive. Other problems encountered in the generation of wave power include the survival of equipment in extreme wave conditions, and the maintenance of equipment in the salt water environment, as well as the potential impact on maritime navigation.

www.

Hands-on wave activites
www.wavegen.com

An interactive model
www.oceanpd.com

A fantastic education kit
www.energyforkeeps.org

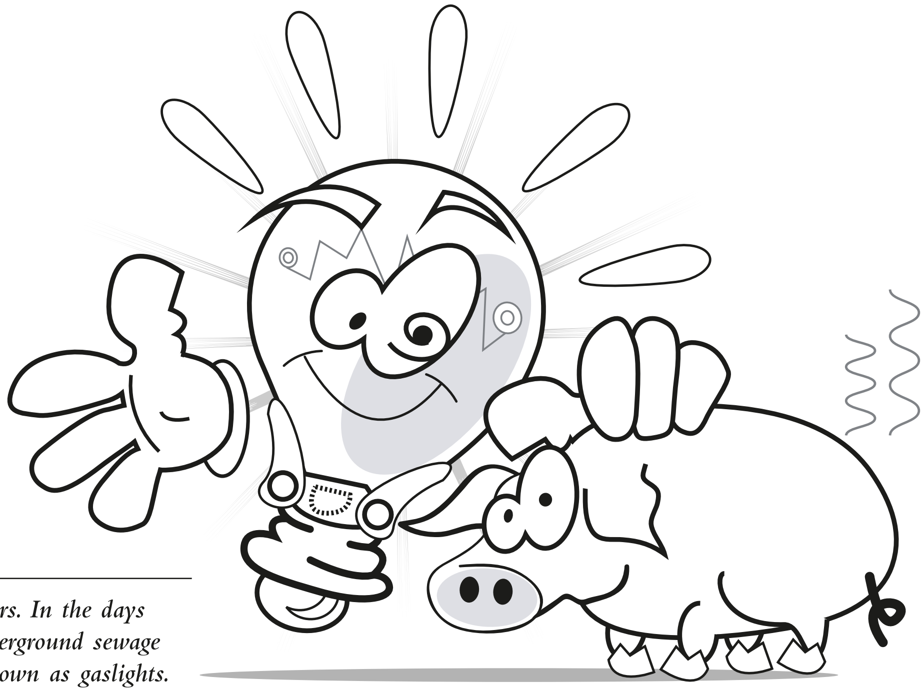
Tidal energy information
www.bluenergy.com

Information about ocean thermal energy
www.hawaii.gov/dbedt/ert/anchor349152

Latest research
www.powerinc.org

[Biomass]

Manure to power your house.
Biomass is material produced by photo-synthesis or an organic by-product from human or animal waste. It includes materials such as forestry and agricultural wastes and residues such as rice husks and cotton trash, urban tree trimmings, food processing wastes, woody weeds, oil-bearing plants, animal manures and sewage.



DID YOU KNOW?

People have been using biogas for over 200 years. In the days before electricity, biogas was taken from the underground sewage system in London and used for street lamps known as gaslights.

Plant Biomass

The use of the cropping biomass system results in a net zero increase of greenhouse gases. Biomass is a renewable resource if the organic material used is not harvested faster than the resource can be regenerated.

Animal Biomass

The use of animal manure and sewage has many environmental benefits. Sewage can be used as energy; some sewage treatment plants capture the methane given off by sewage and burn it for heat and power. This reduces air pollution, emissions of global warming gases, and nuisance odours, while producing useful energy.

Biomass in Australia

About 9% of stationary energy needs are obtained from biomass. The majority of biomass used in Australia is bagasse (the fibrous residue of the sugar industry) or black liquor (a by-product of wood processing.)

Biomass	MW produced in Australia (Warren Centre)
Sugar cane bagasse	368
Landfill gas	103
Black liquor	77
Sewage gas	26
Wood waste	9

DID YOU KNOW?

Humans produce biogas when they digest food. The human biogas is methane.

DID YOU KNOW?

Effluent from a 1000 sow piggery could supply enough power for 50 homes!

A EXPERIMENT - Plant biomass

Aim: To determine which plants produce the most biomass.

Different plants produce different amounts of biomass in the same amount of time. Design a controlled experiment to determine this using different grass seeds, same size pots and a grow lamp. Record growth of plants over a set period of time. At the end of this time measure the fresh and dry weight.

Which plant has the most and least biomass?

Which might be the most suitable for producing energy?

Discuss the economic advantages and disadvantages from using these grasses for bioenergy.

Remember that the amount of biomass is not directly proportional to the amount of available bioenergy.

As an extension activity visit:
www.aboutbioenergy.info/definition.html to use the biomass energy calculator

Biomass Uses

Biomass is used for: heating or cooking (eg.wood), electricity generation (eg. sugar cane waste) and transportation (eg. ethanol).

The term 'bioenergy'is used for biomass energy systems that produce heat and/or electricity and 'biofuels' is used for liquid fuels for transportation. Ethanol and methanol formed from the fermentation of cellulose are examples of bioliquids.

DID YOU KNOW?

Ethanol is burnt in the engines of formula one cars as it burns more cleanly and provides more power than petrol.

DID YOU KNOW?

When Henry Ford designed the Model T, it was his expectation that ethanol, made from renewable biological materials, would be a major automobile fuel.

EXPERIMENT - Producing ethanol

Aim: To demonstrate the production of ethanol.

Place a cup of water, 1/4 a cup of sugar and a packet of dry yeast into a bottle. Shake the bottle and place a funnel in the top of the bottle. Place a balloon over the mouth of the funnel and observe the results after one hour. Check again after 24 hours and then again after 48 hours.

Why is the balloon inflating?

Biomass for electricity

Biopower, or biomass power, is the use of biomass to generate electricity. The main biopower production systems are: direct-fired, cofiring, gasification, anaerobic digestion, pyrolysis and small modular systems. For a detailed explanation of each of these biopower production systems visit :
www.aboutbioenergy.info/index.html

Direct-fired biopower systems are the most common. The biomass is used to produce steam which runs a turbine and converts into electricity using a generator. An example of a direct-fired system is a paper mill that uses wood waste to produce electricity.

Cofiring involves using a biomass source as a supplementary energy source. Some coal-fired power plants use cofiring systems (burning two or more fuels together) systems to significantly reduce emissions, especially sulfur dioxide emissions.

Gasification systems use high temperatures and an anaerobic environment to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas then fuels a gas turbine.

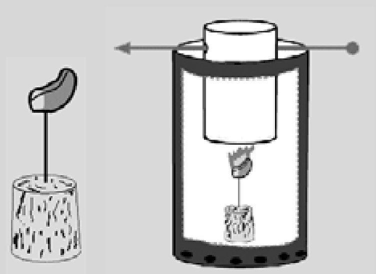
EXPERIMENT - Nut Power

SAFETY WARNING: Nuts are used in this experiment. Some students may be allergic to nuts.

Aim: To show how heat energy can be released from an almond.

Set up the equipment as shown.

Pour half a cup of water into the small can and let it sit for half an hour. Record the temperature of the water. Light the almond and place the can over it. When the almond has finished burning, record the temperature again. Has it changed? How many almonds do you think it would take to boil the water to produce steam? Try the experiment with other nuts. Adapted from:
http://www.energyquest.ca.gov/projects/peanut.html

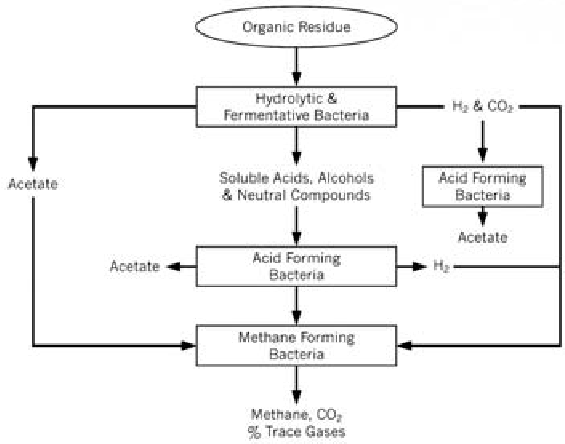


ACTIVITY - Anaerobic decomposition

What biomass could you find around the school to use to produce methane gas? Design a system to process organic matter and collect methane by anaerobic decomposition. Try different types of organic matter and varying temperatures and see which ferments more quickly. **Links: www.re-energy.ca/t-i_biomassbuild-2.shtml or www.sustainableenergy.qld.edu.au/activity/activity10_1.html**

See Experiment - Methane from manure Page 11

Anaerobic decomposition (refer to the diagram below)



DID YOU KNOW?

The process of anaerobic fermentation in an artificial digester is the same process as in the stomach of a ruminant animal such as a cow.

Pyrolysis is the process used to heat biomass under anaerobic conditions to form a liquid. The liquid is called pyrolysis oil, which can be burned like petroleum to generate electricity.

The Future Challenges

The use of plant biomass energy has the potential to greatly reduce our greenhouse gas emissions. The net emission of CO_2 will be zero as long as plants continue to be replenished for biomass energy purposes. There are, however, some issues to consider before biomass becomes widely used in Australia:

- The use of irrigation water to grow the crops
- The need to use biomass at a rate no faster than it grows
- The management of waste from the system
- Vast areas of land are needed to grow sufficient crops to make any significant contribution to electricity generation.

The cutting edge

Australia has a great range of options for biomass and has been at the forefront of bioenergy innovation, with projects including a 1.5 MW macadamia nut shell power plant in Gympie, Queensland and an integrated wood processing plant at Narrogin, Western Australia which, when complete, will generate electricity, with co-products of eucalyptus oil and activated carbon.

Case Study

Rocky Point Cogeneration Plant
www.stanwell.com/sites/locations.asp

For a comprehensive list of case studies visit:
www.greenhouse.gov.au or **www.stanwell.com**

www.

Extensive education site – lots of facts and figures and interactive sections
www.aboutbioenergy.info

All about bioenergy in Australia
www.bioenergyaustralia.org

Summary of biomass
www.re-energy.ca

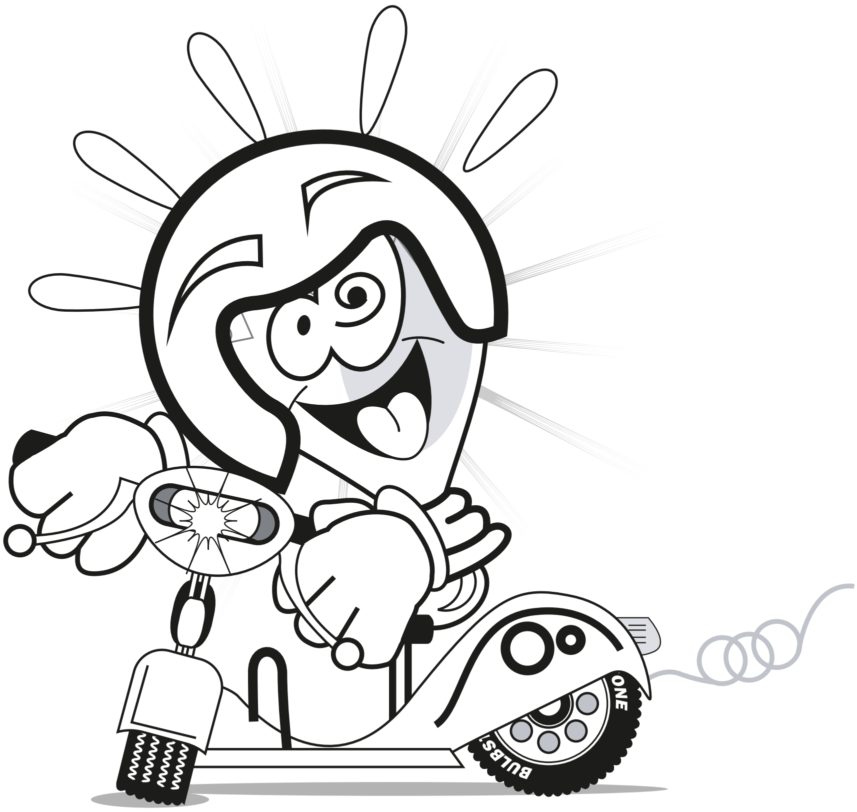
Kids activites and fact sheets on all forms of energy
www.sustainableenergy.qld.edu.au

Learn all about the Agstar program – using methane for power on farms
www.epa.gov

[Hydrogen]

Hydrogen: the element. Hydrogen is the most abundant element in the universe. Despite its abundance, hydrogen rarely occurs naturally on earth as a gas, it is usually combined with other elements. To obtain hydrogen, it is therefore necessary to extract it from other substances using energy.

Hydrogen can be burned as a fuel in the combustion engine of a car or it can be used to create an electric current using a device called a fuel cell. It is clean, does not produce CO_2 or any other greenhouse gases when it is burnt and provides another way of storing and regenerating electricity when it is needed.



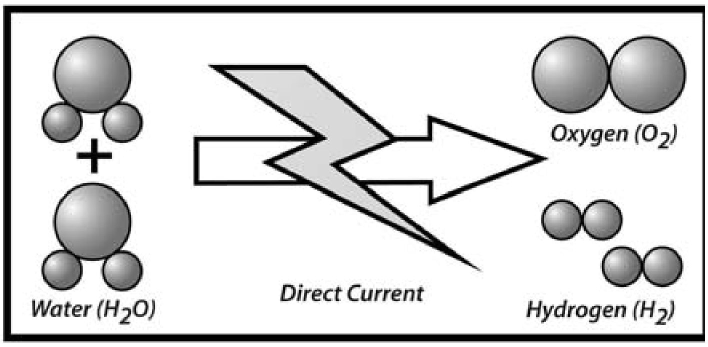
DID YOU KNOW?

In 1776 a British scientist, Henry Cavendish, discovered that hydrogen was given off (produced) after sulfuric acid was poured over metals.

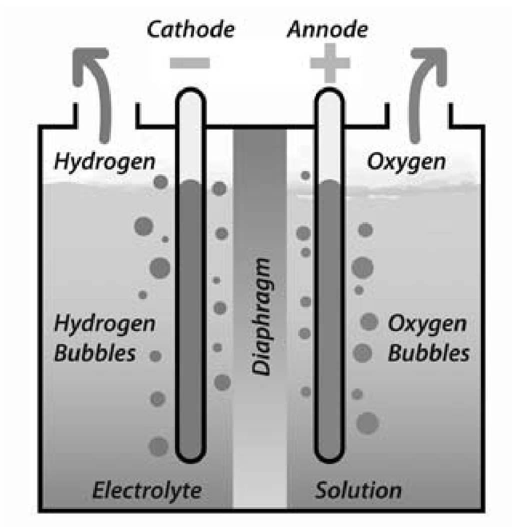
How is it produced ?

Hydrogen can be extracted from a variety of fossil fuels, including natural gas and coal, by using high temperature steam to separate the hydrogen from the carbon atoms – a process called steam reforming.

This process uses fossil fuels and produces some greenhouse gases.



Electrolysis. *Source: Hydro Tasmania*



Electrolysis. *Source: Hydro Tasmania*

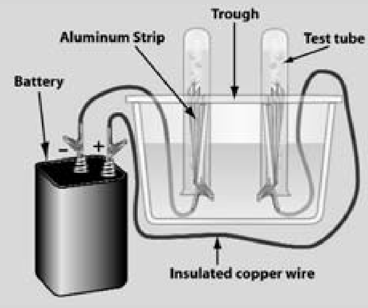
Hydrogen can also be extracted from water by a process called electrolysis. By passing an electric current through water, it is possible to split the water (H_2O) molecule into hydrogen, gas and oxygen. This process produces pure hydrogen and is by far the cleanest way of producing hydrogen gas, provided the electricity used in the electrolysis process comes from non-polluting clean renewable energy sources. Eloctrolysis is currently prohibitively expensive.

EXPERIMENT - Electrolysis of H_2O

Aim – To use electrolysis to split water into hydrogen and oxygen.

Set up equipment as shown. Add a tablespoon of vinegar to the water to allow water to conduct the electricity more effectively. Both of the electrodes should start to produce gas. What gas is produced? How could this activity be extended to test what gas is produced? Write the chemical equation for this activity.

Source: www.eere.energy.gov



How is hydrogen used as a fuel?

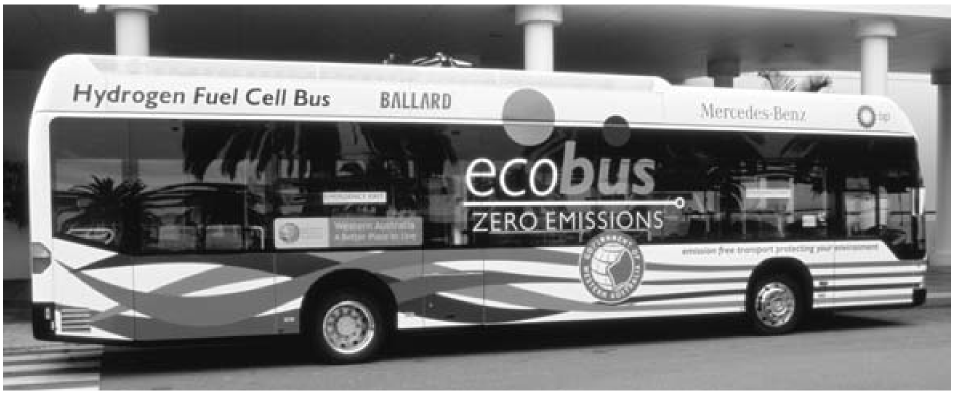
Hydrogen can be combined with petrol, ethanol or natural gas to increase performance and reduce pollution in an internal combustion engine. Burning hydrogen at high temperatures in an engine however, is not as clean or efficient as running hydrogen through a fuel cell.

How is hydrogen used to produce electricity in a fuel cell?

A fuel cell is an electrochemical device which allows hydrogen gas and oxygen to be fed into a cell where they recombine, producing pure water, electricity and heat. A fuel cell will continue to produce an electric current as long as hydrogen gas and oxygen are fed into it. To power an electric car, a number of fuel cells can be stacked together and fuelled by hydrogen from an onboard storage tank with oxygen being supplied from the surrounding air. This arrangement provides enough power to turn electric motors on each of the wheels of a passenger vehicle or bus. For an animation of how a fuel cell works, go to
www.humboldt.edu/~serc/animation.html

A ACTIVITY - Hydrogen to power a community

Imagine that you are one of a group of highly talented people who have been given the task of introducing hydrogen as a new clean fuel to a small town or community. Your task is to lay out a plan for the local community to show them how they and the environment will benefit from using new hydrogen technologies to power their cars, houses and businesses. You will have to produce the hydrogen somehow and transport it safely to refuelling stations. Come up with a creative way to present your report to the community.



Hydrogen fuel cell bus. *Source: Hydro Tasmania*

Hydrogen scooter. *Source: Hydro Tasmania*

The Cutting Edge

Research into hydrogen is progressing rapidly in virtually every developed country including Australia. The University of Tasmania's School of Engineering has set up the first fully dedicated laboratory for applied hydrogen research in Australia. The facility is investigating hydrogen applications in automotive technology, electrical engineering and remote area power systems.

Case Study

Hydro Tasmania and the University of Tasmania are developing a proposal for a remote area power system on a small island to the northeast of Tasmania. The power system includes a number of wind turbines which will produce electricity for the community. During the day when demand is high, the wind turbines will produce most of the energy requirements for the community. At night, when demand for power is low, the wind turbines will be used to produce hydrogen using a device called an electrolyser. Hydrogen collected in this way can be stored and used at times when demand for electricity is high or in times of low wind speeds.

Additional research projects at the University of Tasmania include looking at ways to:

- reduce emissions from existing diesel fuels by mixing diesel with hydrogen
- convert a postie bike to run on hydrogen gas using a small combustion engine.
- design and build a fuel cell powered scooter.

Future Challenges

Fuel cell bus trials are currently operating in many countries including Europe, the US, Iceland, Japan and Perth (Western Australia) to determine the feasibility of running hydrogen powered transport systems and to assess the related social, economic, and engineering issues which accompany new technologies of this kind.

It has been predicted that mobile phones powered by tiny fuel cells will become a reality within five years and fuel cell powered cars will be available to the public within 12–15 years.

Some of the challenges facing scientists and engineers include:

- producing sufficient quantities of hydrogen using clean renewable energy sources
- reliability of operation and durability of fuel cells
- safe storage, transport and distribution of hydrogen
- educating the public and regulatory authorities about the benefits of hydrogen technologies
- bringing down the cost of hydrogen production.

Www.

All about energy
www.eere.energy.gov

How fuel cells work
www.fuelcells.org

Fuel cell animation
www.humboldt.edu/~serc/animation.html

The latest hydrogen research
www.hydrogenus.com

Hydrogen scooter
world.honda.com/products

Fuel Cell Models
www.fuelcellmodel.com

[CO_2 Capture and Storage - Geosequestration]

Geosequestration is the capture, transport, injection and deep, geological storage of CO_2, the most common greenhouse gas. It is one of a number of solutions to reduce greenhouse gases including increasing energy efficiency; switching to less carbon-intensive fuels; enhancing natural carbon sinks (vegetation); and harnessing renewable energy.

How can geosequestration address climate change?

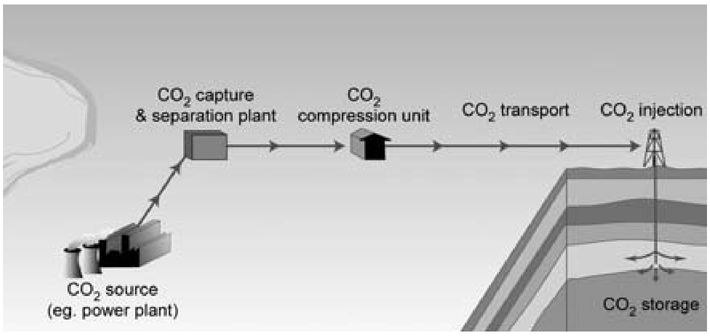
The benefit of geosequestration is that it can make large reductions in the amount of CO_2 in the atmosphere by storing CO_2 emissions from industrial sources such as power stations.

? DID YOU KNOW?

Almost half of Australia's CO_2 emissions come from large stationary energy sources and could potentially be stored.

Geosequestration comprises four main steps:

1. Capturing the CO_2 at the source, such as a power plant or industrial facility and compressing it to a liquid-like state.
2. Transporting the captured CO_2, typically via a pipeline, from the source to a safe geological storage site.
3. Injecting the CO_2 deep underground into a geological reservoir.The compressed CO_2 is injected at least one kilometre underground where it will be stored for thousands of years.
4. Storing the CO_2 in the geological reservoir. Stringent monitoring activities at all stages of the process will enable the scientists to track the migration of the CO_2 underground.



Steps of Geosequestration. *Source: CO2CRC*

Geology and CO_2

There are a number of options for the storage of the CO_2. The CO_2 can be injected into:

1. depleted oil and gas fields
2. saline reservoirs
3. deep unmineable coal deposits.

The CO_2 can be held in the rock in the same way that oil and natural gas is stored. For more information visit : **www.co2crc.com.au**

Www.

All about CO_2 sequestration
www.ga.gov.au/image_cache/GA5536.pdf

Australian research
www.co2crc.com.au

Chemistry of CO_2
mattson.creighton.edu/CO2

Energy Bulletin
www.energybulletin.net/2908.html

Geosequestration around the world
www.cslforum.org

CO_2 experiments and activites
www.CO2science.org

Report on CO_2 Geosequestration
www.ipcc.ch/index.html

A ACTIVITY - CO_2 as a liquid?

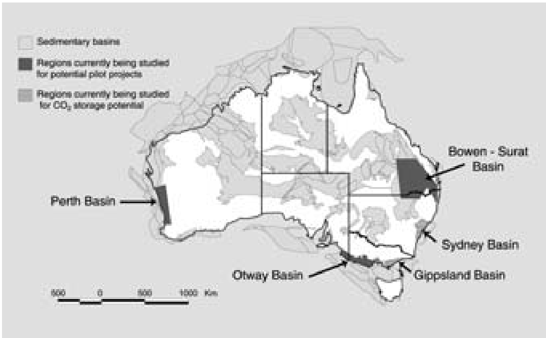
Gases can be converted to liquids. In geosequestration the CO_2 is compressed into a supercritical state, similar to a liquid. Do you think the issues of storing a liquid would be different to storing a gas? How could you liquefy CO_2? Find out what a supercritical gas is. What about dissolving CO_2 in water? Can you think of any other ways of storing CO_2? To learn more about CO_2 mattson.creighton.edu/CO2/

Read the section of Aus Geo News about storing CO_2 in rock. www.ga.gov.au/image_cache/GA5536.pdf

EXPERIMENT - Liquids stored in rock

Aim: To determine how much liquid can be held in a rock

Collect samples of rocks such as granite or sandstone or use bricks. Weigh each of the rocks and record the weight. Soak the rocks in water. At the end of each day remove the rocks from the water and weigh. How much water does the rock hold. To illustrate porosity – dip a sugar cube into a glass of coloured water and watch the absorption rate.



Potential Regions for geosequestration. *Source: CO2CRC*

Geosequestration in Australia

Areas currently being evaluated for geosequestration in detail include the Otway, Perth and Bowen-Surat Basins where either natural deep subsurface accumulations of CO_2 occur, or where major power stations exist which have large CO_2 emissions. Area of interest in future work will include the Gippsland Basin and the Northwest Shelf region. For information about why these sites have been chosen visit: **www.co2crc.com.au/DOWNLOADS/FS/Factsheet3.pdf**

A ACTIVITY - How can we stop climate change?

How does geosequestration help to stop climate change? Do you think geosequestration is an environmental, social, economic and political solution to the greenhouse problem in Australia? Compile a newspaper article discussing the benefits and future use of geosequestration.

Consider issues such as: Could the CO_2 contaminate the fresh water supply? How long will the CO_2 be trapped underground? Could a hydrocarbon seal leak? Why is geosequestration not being used commercially in Australia yet?

[Comparison of energy sources]

SOURCE	APPLICATION	CURRENT STATUS	ADVANTAGES	DISADVANTAGES
Conventional Coal	Coal is burned in a furnace to raise steam which drives a turbine.	Provides 85% of Australia's and 38% of the world's electricity.	The most abundant and widely distributed fossil fuel and the lowest cost form of electric power.	High greenhouse gas emissions.
Clean Coal Including IGCC and CO_2 Capture and Storage.	Coal is reacted with oxygen and water to produce a hydrogen-rich gas which is then combusted in a turbine. CO_2 is captured and permanently stored underground.	Both IGCC and CO_2 capture and storage have been demonstrated. Further research and development is required to reduce costs	Maintains access to abundant, low cost energy from coal with lower or zero greenhouse emissions.	Higher cost than conventional coal, but potentially less costly than most alternatives.
Natural Gas	Gas is burned directly in a turbine.	Provides 17% of the world's electricity.	Proven technology and lower cost than alternatives apart from coal.	High, greenhouse gas emissions. Less abundant and higher cost than coal.
Nuclear	Uranium is used in a nuclear fission reaction to produce heat.	Provides 16% of the world's electricity.	No greenhouse gas emissions.	The safety of reactors and the difficulty of dealing with resulting radioactive waste.
Solar	The energy of the sun is trappedby solar cells to heatwater (solar thermal) or produce electricity directly (photovoltaics).	Provides less than 0.1% of the world's electricity.	Renewable and low greenhouse gas emissions.	High cost. Intermittent-only works when the sun is shining.
Wind	Wind striking propeller blades is used to drive turbines.	Provides less than 0.5% of the world's electricity.	Low greenhouse gas emissions.	Lower cost than solar but higher than coal and gas. Intermittent–only works when sufficient wind is present.
Hydro	Water stored in reservoirs falls through pipes via gravity and turns a turbine.	Provides 17% of the world's electricity.	Relatively low greenhouse gas emissions (but may be significant while flooded vegetation in new dams decomposes).	Large scale application requires major interruptions to natural watercourses and large areas of land. Suitable sites limited.
Geothermal	Water is pumped deep underground where it passes through hot geological formations. The resulting steam returns to the surface to drive a turbine.	Provides less than 0.5% of the world's electricity.	Uses the natural heat of the Earth's core to produce theoretically limitless energy with no greenhouse gas emissions or other pollutants.	High costs and technological barriers still to overcome for large scale applications.
Ocean	The natural movement of tides and waves or changes in the oceans temperature is used to drive a turbine.	Less than 0.1% of the world's electricity.	Renewable energy free of greenhouse gas emissions and other pollutants.	High cost and suitable sites are limited.
Plant Biomass	Biomass (plant material such as agricultural or forest wastes) is burned to raise steam to drive a turbine.	Provides less than 1% of the world's electricity.	Renewable and greenhouse gas neutral provided the crops used are regrown each year.	Requires very large areas of land to produce sufficient plant material.

[Glossary]

Anaerobic digestion – fermentation process for producing gas from biomass in a wet, oxygen-free environment.

Amplitude – the maximum displacement of a periodic wave.

Bagasse – the fibrous residue of sugar milling that is used as a fuel to raise steam in the mills.

Base load – That part of electricity demand which is continuous, and does not vary over a 24-hour period. Approximately equivalent to the minimum daily load.

Bioenergy – energy generated as a result of conversion of a biomass (organic matter) resource.

Biofuel – any solid, liquid or gaseous fuel produced from organic matter.

Biogas – gas produced from biomass.

Biomass – Material produced by photosynthesis or an organic by-product from a waste stream.

Biopower – electricity generated from biomass.

Breakwater – a barrier that protects the harbour or shoreline from waves.

Carbon sequestration – The capture and secure storage of carbon (generally in the form of carbon dioxide) that would otherwise be emitted to the atmosphere.

Carbon sinks – A reservoir that absorbs carbon released from another part of the carbon cycle eg, plants and the ocean.

Cofiring – Burning two or more fuels together (e.g. coal and biomass) in the boiler of a power station.

Cogeneration – the production of electricity and useful heat together from the same power plant. Sometimes called 'combined heat and power'.

Combined cycle – a power station that generates electricity by means of one process (e.g. gas turbine) and then uses the waste heat from that process to generate more electricity from another process (e.g. waste heat boiler plus steam turbine).

Energy crops – field crops grown specifically for combustion to produce energy.

Fuel cell – An electrochemical system that converts hydrogen and oxygen into water, producing electricity and heat in the process, thereby providing a high efficiency means for converting the energy in a fuel(hydrogen) directly to electricity.

Fugitive emissions – Greenhouse gas emissions not resulting from the combustion of fossil fuels, but rather from mining, transmission, distribution and storage of fuels.

Generator – machine that generates electricity when the magnet turns around the shaft inside a coil of wire.

Geosequestration – The capture of CO_2 gas from a large point source, such as a power station, and its storage deep underground.

Geopressured brines – Geopressured hot brine saturated with methane, is a geothermal resource found in large, deep aquifers under high pressure.

Grid – Network of electricity powerlines.

Hot dry rock (HDR) – Hot dry rock is a heated geological formation used as a renewable energy source.

Hydrothermal reservoir – a hydrothermal reservoir arises when hot water and/or steam is formed in porous rock beneath the Earth's surface (heated by molten rock). This water or steam penetrates the Earth's surface to be harnessed as a renewable energy source.

Integrated gasification combined cycle (IGCC) – Combined cycle power station that gasifies solid fuel before burning it.

Microturbine – A very small gas turbine that can be used to generate both useful heat and electricity at the point of use in commercial and (possibly in the near future) in residential buildings.

Nacelle – The portion of a wind electric turbine that houses the electricity generating equipment.

Nuclear reactor – equipment that is capable of maintaining and controlling a nuclear reaction for the purpose of producing electricity.

Photovoltaic (PV) cell – An electronic device that converts solar energy directly into electricity without any moving parts (apart from the electrons).

Primary fuel – Fuel that is extracted directly from the natural environment, such as coal, natural gas, crude oil, uranium, wood, bagasse, wind, solar energy.

Pyrolysis – One of several thermochemical methods for converting biomass or coal into a gas or liquid, involving heating the biomass or coal within a closed chamber in the almost complete absence of oxygen.

Secondary fuels – Fuels produced from primary (or other secondary) fuels by conversion processes to produce the fuels commonly consumed: e.g. thermal electricity, coke and refined petroleum products.

Shale – sedimentary rock formed by the deposition of successive layers of clay.

Spent fuel – fuel assemblies removed from a reactor after several years use.

Stationary Energy – energy supplied to consumers mainly as electricity and gas, i.e. NOT for transport or the mobile equipment used in agriculture, mining and construction.

Supercritical – New kind of boiler used in coal-fired power stations which operates under higher steam pressures and temperatures and so gains higher thermal efficiency.

Synthetic gas (syngas) – Synthetic gas (principally carbon monoxide and hydrogen) made by the gasification of organic matter.

Thermal efficiency – (of power station) Electrical energy sent out divided by energy input, sometimes expressed as a percentage. In the case of thermal power stations, the energy input is the chemical energy stored in the fuel.

Tidal turbine – uses currents in the water to produce electricity (similar to a windmill).

Turbine – A motor whose central elements are a series of blades attached to a shaft that rotates, usually within a chamber.

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