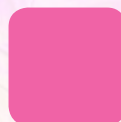
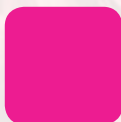
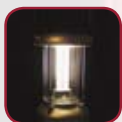
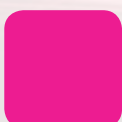
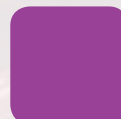


national science week

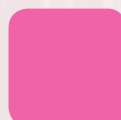
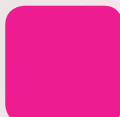
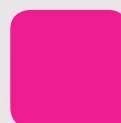
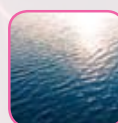
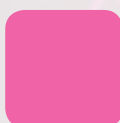
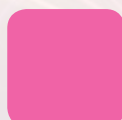
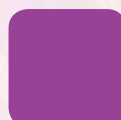
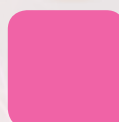
11-19 August 2012 • www.scienceweek.net.au



ENERGY EVOLUTION



A resource book of
ideas for teachers



National Science Week is proudly supported by the Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education in partnership with Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Broadcasting Corporation (ABC) and the Australian Science Teachers Association (ASTA).


An Australian Government Initiative


Inspiring
AUSTRALIA

Minister's Foreword

Australia, like the rest of the world, is faced with the enduring challenge of energy and the move away from fossil fuels to renewable, clean forms of energy.

In 2012, we will join more than three quarters of the world's advanced economies who, in the quest to deliver a clean energy future, have introduced schemes to help reduce pollution and greenhouse gas emissions.

The Gillard Government knows we need to bring our brightest and best minds to the global challenges of the 21st century like climate change and sustainable energy.

Young Australians need to be encouraged to delve into the fascinating world of science from an early age and our teachers need to have the necessary resources to inspire them.

This year, as part of the National Science Week celebrations, it is my pleasure to commend the Australian Science Teachers Association (ASTA) teacher resource book, Energy Evolution.

Energy Evolution celebrates the United Nations 2012 International Year of Sustainable Energy for All and will be a great resource for all Australian classrooms. It contains a wealth of information, resources and innovative activities designed to engage students in the energy challenges facing the world as well as science more broadly. The book has been written by an experienced team of teachers and links to the new Australian Curriculum: Science F-10.

There are many ways to reduce our environmental footprint and this year ASTA is doing its bit—for the first time in 27 years the annual teacher resource book will be available only as a digital publication. This edition of Energy Evolution is published as a full colour eBook and is freely available for all online.

National Science Week celebrates its 15th year in 2012. Millions of Australians have taken part in National Science Week since its inception in 1998 and, this year, it is expected that trend will continue with more than 1000 events, activities, talks and shows taking place around the country. National Science Week highlights what we have achieved in science and looks towards the scientific possibilities of the future. It is designed to engage all Australians and is especially successful at igniting the interest of school children.

I am confident that the 2012 Science Week celebrations, along with this excellent teacher resource book, will inspire a new generation to get involved in science.



Chris Evans
Minister for Tertiary Education, Skills, Science and Research



President's Message

The Australian Science Teachers Association (ASTA) is pleased to bring you *Energy Evolution*, the 2012 teacher and community educator resource book for National Science Week. The schools theme for National Science Week, and the resource book, are generally related to the United Nations' International Year – 2012 being the *International Year of Sustainable Energy for All*.

After 26 years of printing a teacher resource book, ASTA has moved to providing the book as an electronic resource. A web-based digital book or an eBook will be the way ASTA produces this type of resource in the future.

ASTA acknowledges the funding support for this resource from the Australian Government through the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE). I would also like to acknowledge the significant contribution of the many people who contributed to the writing, editing and production of this electronic resource.

I would also like to thank each of ASTA's eight member Science Teacher Associations, through their National Science Week Representatives, for encouraging schools to be involved in the many activities available during National Science Week.

The electronic format of the National Science Week resource is a major step forward, providing wider access to the ideas contained within it. Finally, I'd like to encourage all teachers of science across Australia to use this electronic resource to promote science, and to promote and encourage the sustainable use of the energy resources we have available in Australia.

Dr. Stephen Zander
ASTA President



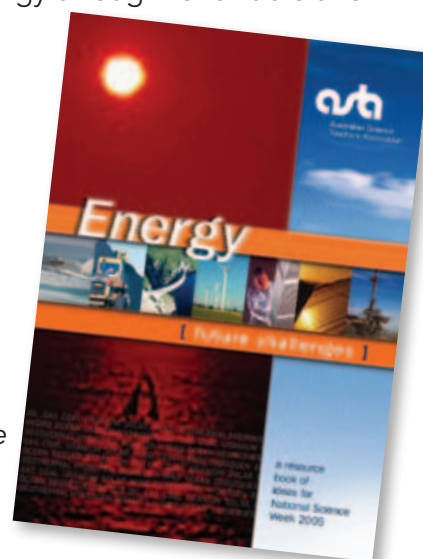
ASTA president Stephen Zander in Antarctica

Introduction

2012 is the UN declared International Year of Sustainable Energy for All (IYSEFA). *Energy Evolution* was chosen as the schools theme for National Science Week 2012 to not only celebrate this international year but to provide Australian teachers and community science educators with information and activities for students on a very topical issue facing all Australians.

Energy Evolution looks specifically at renewable energy resources and energy efficiency, two of the themes of IYSEFA. The main objective in targeting these themes is to encourage students to make informed decisions about the significant social, environmental and economic issues that are associated with the generation of energy through renewable and sustainable means.

In 2005, the Australian Science Teachers Association published *Energy: Future Challenges – a resource book of ideas for National Science Week 2005*. This book provides information on both renewable and non-renewable energy sources and can be used as a companion book to *Energy Evolution*. *Energy Evolution* has been written in a similar layout to help facilitate this. A few of the activities/experiments in *Energy: Future Challenges* have been included in *Energy Evolution* since they are still the best way to demonstrate certain scientific concepts.



Energy: Future Challenges is available as a digital book on the ASTA website <http://www.asta.edu.au/>

How to use this book

Energy Evolution has been structured to provide opportunities for teachers and students to develop an understanding of the latest developments in renewable energy production and initiatives in sustainable living. All topics are self-contained, so teachers can select information and activities to fit their lessons. Each topic contains scientific background information, some Australian industry case studies (where appropriate) and the latest innovations in the field, activities and experiments for students and additional weblinks and resources for teachers.

Try This!

Activities and experiments, written for students, are included in every topic. An indication of the year levels that each activity suits is included. This is just a guide for teachers and you are encouraged to read across all the activities for ideas that are appropriate to, or could be adapted for, your students' specific talents, interests and levels of conceptual development.

Case Study

Where appropriate, Australian renewable energy industry case studies have been included. These illustrate the latest innovations in the field. Weblinks to further information enable teachers to do further research if required.

Teachers' corner

Additional websites and resources for teachers and activities for students have been suggested to enable you to access further information about the topics. All websites were active at the time of publication. It cannot be guaranteed that all websites will continue to be available into the future.

Did you know?

Interesting, short facts about the topics for both teacher and student audiences.

Curriculum Guidelines

This resource book is intended to enrich teaching across a wide range of school and outside-school hours programs. Whilst activities are not specifically curriculum linked, consideration has been taken to consult with the Australian Curriculum v 3.0 documents provided by the Australian Curriculum, Assessment and Reporting Authority (ACARA) to identify key learning areas that would be addressed during the implementation of activities.

The activities are based within the Science Curriculum, with the key strands being identified as Science Understanding and

Science as a Human Endeavour, as these are often interrelated. Some activities also address Science Inquiry Skills. The Science Curriculum emphasises inquiry-based learning and it has been the aim of this digital book to provide students with engaging activities that promote exploration around a broad spectrum of curriculum outcomes.

The Science Understandings are drawn mainly from the Physical Sciences and Earth and Space Sciences strands that focus on children gaining knowledge and understanding of energy and energy sources and the Earth's resources being renewable or non-renewable. Students draw on the concept that scientific knowledge is used to inform personal and community decisions and to solve problems that direct people's lives. Students also identify that science knowledge helps people to understand the effect of their actions. These concepts draw directly from the Science as a Human Endeavour strand that examines the nature and development of science, and its uses and influences.

Some Science Inquiry Skills identified in activities include concepts such as making predictions about investigations, communicating ideas and findings using a variety of representations, safely using materials and equipment and working effectively in teams. Many activities also draw on the general capabilities identified in the Science Curriculum documents such as addressing literacy, numeracy, Information and Communication Technologies and critical and creative thinking.

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

Safety Awareness

All experiments included in *Energy Evolution* have been designed or selected to minimise hazards. However, there is no guarantee that a procedure will not cause injury. Teachers and community educators need to be aware

of the special considerations surrounding practical activities in the classroom and ensure that students are suitably clothed for outdoor experiences. Teachers and community educators should test all activities before

using them in class and observe the OH&S requirements of their own state or territory. All necessary safety precautions should be outlined clearly to students prior to the commencement of any activity.

Tell us what you think of Energy Evolution!

Each year we are continually trying to improve the National Science Week resource book and would like your feedback on Energy Evolution. As 2012 is the first year of a digital version of the resource book your feedback is greatly appreciated.

Please take a few minutes to complete the brief online questionnaire at

<http://tinyurl.com/SW2012feedback>

Many thanks.





An Australian Government Initiative



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What is energy?

What is energy?

Energy makes things happen. It is the ability to do work.

Did you know?

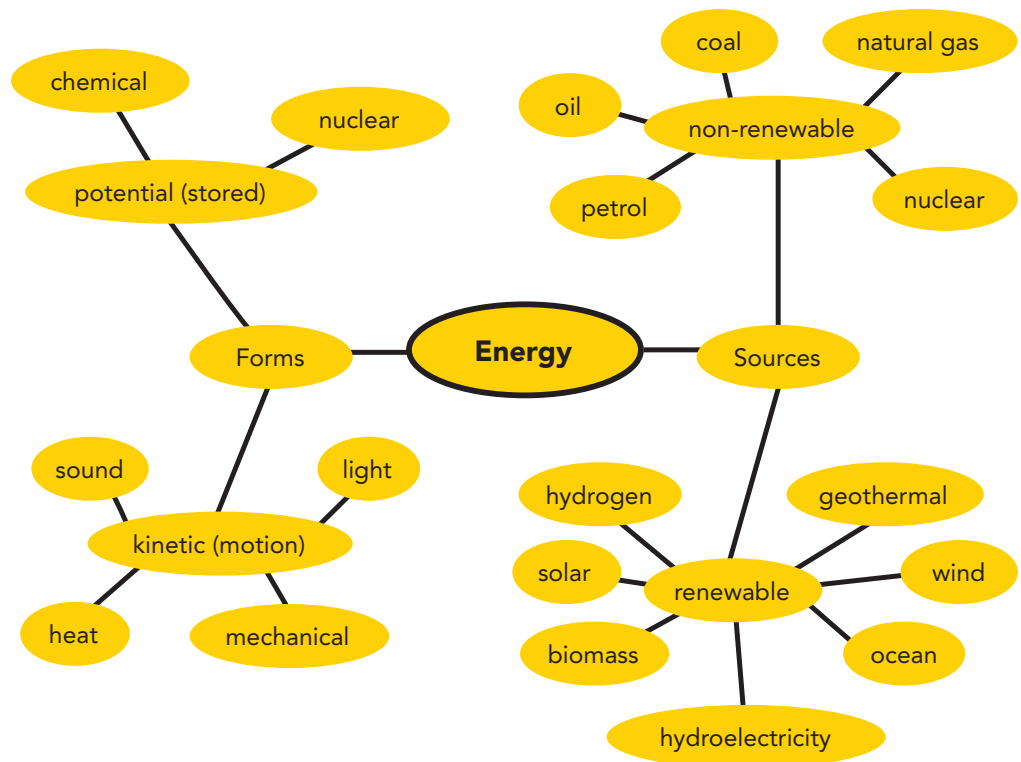
Energy cannot be created nor destroyed but can change from one form to another. This is known as the *Law of conservation of energy* (1st law of thermodynamics).

Energy is all around us and we use it everyday from using energy to work and play to using energy to turn on lights and to cook dinner. While energy can come in many different forms such as heat, electrical, solar, wind, there are two main types of energy: potential (stored) and kinetic (movement).

Try This! Years 4-7

Stretch a rubber band between your thumb and finger. How long can you keep the rubber band stretched? What do you notice about your fingers after a while? Why did this happen? What happens if you release the rubber band from your fingers?

You may have noticed that your fingers were starting to get tired after a while. This is because the stretched rubber band has stored energy and your fingers were becoming aware of this stored energy. When you released the rubber band, it used its stored energy to do work, that is, to return to its original shape.



Try This!

Energy quizzes

Years 6-10 - <http://www.originenergy.com.au/energysavers/students/quiz>
<http://www.abc.net.au/science/games/quizzes/2008/cleanenergy/>

Years 3-4 - http://www.ecokids.ca/pub/eco_info/topics/energy/quiz/index.cfm

Energy can be generated by two main sources: non-renewable energy sources and renewable energy sources.

What is non-renewable energy?

Non-renewable energy is energy that is taken from the sources that are available on the Earth in limited quantity and will vanish. They are called non-renewable because they cannot be re-generated within a short span of time. These energy sources exist in the form of fossil fuels, natural gas, oil and coal.

Non-renewable energy sources include:

- petrol
- coal
- oil
- natural gas
- uranium (used in nuclear energy)

What is renewable energy?

The term renewable energy refers to any source of usable energy intended to replace fuel resources without the undesired effects or consequences of the replaced fuels. This means that sources of renewable energy come from natural sources that are naturally replenished. Renewable energy is therefore

sustainable as it is obtained from sources that are inexhaustible, meaning that it can be relied on for the long-term.

Try This! Years 4-6

Watch a series of slideshows on renewable energy and natural resources on the Scholastic — StudyJams website:

Natural resources — <http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/natural-resources.htm>

Fossil fuels — <http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/fossil-fuels.htm>

Renewable fuels — <http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/renewable-fuels.htm>

Renewable energy is generally considered clean, non-polluting, energy and cost-efficient. Many renewable energy sources do not emit any greenhouse gases or waste in the process of producing of electricity.

Try This! Years 6-10

Watch an animation guide on carbon emissions from 800,000 years ago to the present day, presented by the BBC News and listen to environmental correspondent Richard Black's audio.

<http://www.bbc.co.uk/news/science-environment-15887129>

Try This! Years F-2

- Download a copy of the Renewable Energy colouring book!

http://www.energy.ca.gov/teachers_resources/books.html

- Play 'Hungry Mice' — When most mice are hungry they look for bacon and cheese. Not these mice! They're hungry for a different type of energy food. Help them eat the non-renewable energy sources in this game.

<http://www.sciencemuseum.org.uk/energy/site/EIZGame4.asp>

Renewable energy sources include:

- solar
- wind
- hydropower
- geothermal power
- ocean
- biomass
- biofuels

Try This! Years 6-10

Modelling the greenhouse effect

This activity models what effect increasing the gases in the atmosphere would have on the Earth's temperature.

You will need:

- 1 plastic container with lid (ice-cream container is quite suitable) and 1 extra plastic lid or 2 sheets of cardboard,
- 2 thermometers.

The researchable question:

What happens to the air temperature when we cover the thermometer with a container?

Make a prediction about what you think will happen.

Procedure:

1. Place each lid (or piece of cardboard) in a sunny position or under desk lamps.
2. Place a thermometer on each lid.
3. Record the temperature on both thermometers.
4. Cover one thermometer with an upturned container and seal the lid.
5. Continue to record the temperatures of each thermometer at regular intervals.
6. Graph each thermometer's temperature.

Questions to think about:

Compare the temperature differences between the covered and uncovered thermometers.

What did you notice?

How does this model the greenhouse effect?

What does the container represent?

What are some advantages and disadvantages of renewable energy sources?

Advantages:

- Sources such as the Sun, wind, geothermal and ocean energy are abundant and free to use.
- Renewable sources of energy have low carbon emissions.
- Renewable energy helps to stimulate economies by creating job opportunities.

Disadvantages:

- Not all renewable energy source infrastructures are cheap at the initial outlay or set-up.
- Solar energy can be used during the day but not through the night or rainy seasons.
- To use wind energy for example, you have to rely on strong winds. You therefore have to choose suitable sites to operate wind turbines.

Try This! Years 4-10

- Conduct a compare and contrast of the different sources of renewable energy. Examine the production and running costs, environmental impacts and energy savings.
- Alternatively, conduct a comparison between renewable and non-renewable energy sources. Examine the advantages and disadvantages of both.

Try This! Years 4-10

Conduct a debate on the best type of resource for your state or territory or for your local area, by examining the advantages and disadvantages.

Dictionary definitions:

Renewable energy: (noun)

- Able to be renewed.
- A source of energy (such as water, wind or solar power) that is not depleted by use.

Electricity: (noun)

- Electric current, especially when used as a source of power.
- A form of energy that results from the existence of charged particles, either statically as an accumulation of charge or dynamically as a current.

Fossil fuel: (noun)

- Any carbon containing fuel derived from the decomposed remains of prehistoric plants and animals. E.g. coal, peat, petroleum and natural gas.

Greenhouse gas: (noun)

- One of a number of gases found in the atmosphere that contribute to the greenhouse effect.
- A gas that contributes to the greenhouse effect by absorbing infrared radiation. Carbon dioxide and chlorofluorocarbons are examples of greenhouse gases.

Non-renewable energy: (noun)

- a fuel or energy source existing in finite quantity.

Replenish: (adjective)

- To supply or to fill again, renewable.

Teachers' corner

Are you interested in livening up your science resources?

Try these commercial sources that provide great kits, models and equipment to assist you in implementing fun and engaging activities on energy!

- Professor Bunsen — has a range of kits and ideas for renewable energy activities including mini wind turbines, wind pitch turbine kits, solar modules for racing cars, insects, solar cookers and hand generators.

<http://www.profbunsen.com.au/shop/category/renewable-energy>

- LEGO — have Renewable Energy kits and parts to power a number of their LEGO systems including the Green City Challenge Kits for LEGO Mindstorms.

Find them at Modern Teaching Aids

<http://www.teaching.com.au>

or at Moore Educational

<http://shop.mooreed.com.au/store/index.shop>

Looking for more information on renewable energy?

The Green Cross Australia project — *Future Sparks* is a great resource on clean energy. Enter your class into the learning journey and video competition about saving energy. The site provides activities, games, video clips plus more!

<http://www.futuresparks.org.au/>

The Department of the Environment, Water, Heritage and the Arts provides maps of proposed and operational renewable energy generators across Australia.

<http://www.agso.gov.au/renewable/>

Australian Government — Geoscience Australia website provides information on a number of renewable and non-renewable energy sources.

<http://www.ga.gov.au/energy/other-renewable-energy-resources.html>

Wikipedia — Renewable energy in Australia

http://en.wikipedia.org/wiki/Renewable_energy_in_Australia

Resources from United Nations:

UN-Energy

<http://www.un-energy.org/>

International Renewable Energy Agency

<http://www.irena.org/home/index.aspx?PriMenuID=12&mnu=Pri>

UN Industrial development organisation

<http://www.unido.org/>

2012 International Year of Sustainable Energy for All**Did you know?**

2012 is the International Year of Sustainable Energy for All.

Find out more about Sustainable Energy for All by visiting <http://www.sustainableenergyforall.org/>

Today, there are still large numbers of people in our world who rely on non-renewable energy sources. This is unsustainable and inequitable in today's global economy. Waste from inefficient energy use is still a problem in industrialised countries and contributes to the warming of our planet.

2012 marks the International Year of Sustainable Energy for All.

The Sustainable Energy for All initiative launched by the United Nations is set to stimulate urgent global action to promote the use of accessible, clean and efficient energy that is reliable, sustainable and affordable. The initiative is set out to achieve the following objectives to stabilise climate change:

- Ensure universal access to modern energy services.

Did you know?

More than 1.4 billion people world wide have no access to electricity.

Try This! Years 3-6

Get involved in promoting a cleaner, more sustainable energy future by visiting:

<http://www.futuresparks.org.au/>

Did you know?

Over 80% of energy used on Earth comes from non-renewable sources such as fossil fuels – yet until the industrial revolution in the 19th century almost all the energy used was from renewable sources.

Try This! Years 4-10

Read stories that demonstrate how people across the world are working towards in achieving the three objectives.

<http://www.sustainableenergyforall.org/progress>



- Double the global rate of improvement in energy efficiency.
- Double the share of renewable energy in the global energy mix.

With these objectives, the UN General Assembly aims at increasing the awareness of addressing the issues of inefficient energy sources and use to create accessible energy for all that is cleaner and more efficient. The UN General Assembly is encouraging action at local, national, regional and international levels to address these issues and outcomes.

Try This! Years 3-6

View the different events around the world that are supporting the 2012 International Year of Sustainable Energy for All and mark the location of these events on a world map.

<http://www.sustainableenergyforall.org/events>

Teachers' corner

- **Lesson plans:** (upper primary/ high school) and activities on conservation of energy see: <http://www.thephysicsfront.org/static/unit.cfm?sb=5&course=3>
- **Learning object:** (Secondary) <http://phet.colorado.edu/en/simulation/energy-skate-park>
- **Website:** Science Safari: Energy resources <http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/energy.html>
- **Webquest:** Energy: Future Challenges – this is an internet treasure hunt designed by the University of New South Wales where students are given a series of 'Who am I' questions to solve. Could be used for individuals, pairs or as a class exercise http://sydney.edu.au/science/uniserve_school/quests/energyhunt.html
- **Fact Sheets:** From Power for a Sustainable Future. This is a good reference tool or can be used to enhance student note-taking strategies. You could do this by using questions to guide students to relevant information, providing students with key words to identify and define from the text, or by providing students with a concept map to complete. <http://www.sustainableenergy.eq.edu.au/html/factsheets.html>

solar energy

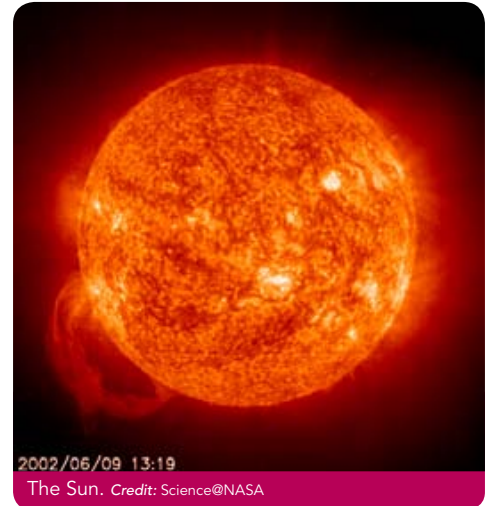
Sustainable energy

Solar energy

What is solar energy?

Solar energy is energy from the Sun. It is the most abundant form of energy on Earth that comes in the form of light and heat. Solar energy is a constant source of energy and can be transformed into wind, hydro-electricity and wave energy. Plants use the Sun's energy to store and make their own energy which in turn can be used as bioenergy (biomass).

Australia is well positioned in harnessing solar energy as Australia has the highest average of solar radiation per year. The desert regions in north western and central Australia are the highest solar radiation areas in Australia.



Try This! Years F-10

List the pros and cons of using solar energy.

Did you know?

Dark colours tend to absorb more heat than light colours?

Try This! Years F-5

See which colours absorb more heat

You will need:

- large cardboard sheet
- paper or fabric colour samples (white, black, red, blue, yellow)
- 5 thermometers

Procedure:

1. Attach the colour samples to the cardboard sheet like pockets (one opening left at the top).
2. Place one thermometer in each pocket.
3. Place the chart in a sunny position.
4. Leave the chart in the sunny position and take regular temperature recordings.

Try This! Years 3-10

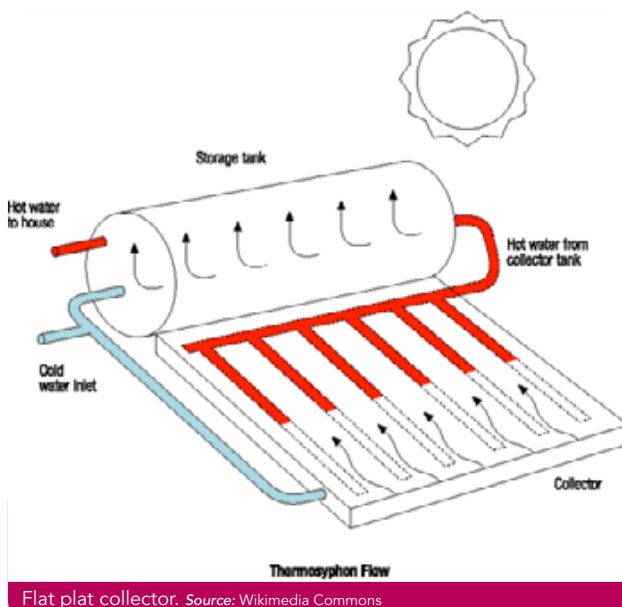
Solar cooker challenge — Design your own solar cooker. Remember reflectors and mirrors reflect solar energy, so use them to your advantage.

Solar thermal energy (heat)

Solar thermal energy is harnessing the heat energy from the Sun. It is used for solar hot water heating, generating steam to power a turbine to produce electricity and space heating in building designs.

Solar hot water

There are two types of solar hot water systems: *flat plate collectors* and *evacuated tube solar collectors*.



A Solarhart brand solar hot water panel and integrated tank on a house roof in Australia. Source: Fairv8, Wikimedia Commons

Flat plate collectors work on the basis of thermosiphons where darker colours absorb more heat and hot water rises. A water tank is located on the roof with a glass collector panel containing copper pipes. Cool water flows in to the dark, heat absorbent collector panel where the water is heated. The heated water rises back into the water tank and displaces the cool water into the collector panel. The greater the temperature difference between the cool and heated water, the faster the heating cycle is.

Evacuated tube solar collectors are more efficient than flat plate collectors. An insulated water storage tank is located at ground level and the collector panels are mounted on the roof. Inside the collector panel are evacuated glass tubes that absorb the Sun's radiation with minimal reflection to heat the water. The glass tubes are manufactured to create a vacuum inside the glass tubes to minimise heat transference, increasing the efficiency of water heating. Cool water is pumped from the storage tank to the collector panels using a circulator (pump) where it is heated. The heated water returns to the insulated storage tank, where it can stay heated for several days.

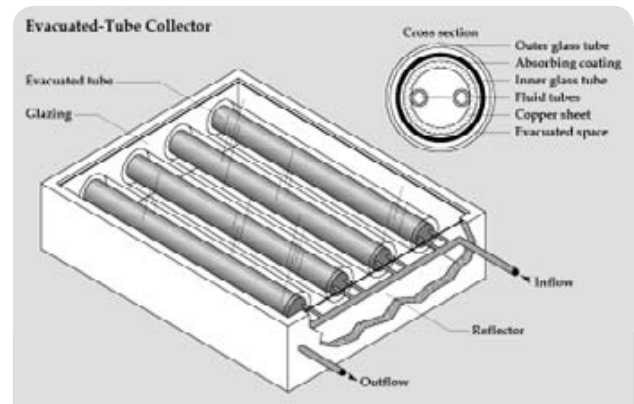


Diagram of evacuated tube solar collector. Source: Wikimedia Commons



Evacuated tube solar collector installed on a roof. Source: RaBoe/Wikipedia/commons.wikimedia.org/wiki/File:Vakuu-roehren-kollektor_01.jpg

Try This! Years 6-10

Estimate the difference solar cells could make to your home electricity usage.

1. Use the Bureau of Meteorology sunshine map (http://www.bom.gov.au/jsp/ncc/climate_averages/sunshine-hours/index.jsp) to find out the average hours of sunlight in your area each year.
2. Use the equation: $0.5\text{kWh} \times \text{hours of sunshine} \times 365 = \text{kWh per year}$
3. Find out your annual household energy consumption — talk to Mum or Dad about your power bill.
4. Work out the average contributions solar panels will make to your household by using the equation: $\text{Solar panel output} / \text{annual consumption} \times 100$.

Try This! Years 7-10

Make your own solar hot water heater. For instructions, visit:

http://www.solahart.com.au/downloads/file/SolarWaterHeating/SH416_SchoolingProject_Highres.pdf

Electricity generation using solar thermal energy

The Sun's energy is harnessed by using reflectors and mirrors. These reflect the Sun's energy to a focal point where a long tube

containing fluid is fitted. The fluid in the tube is heated and turned into steam. This rotates a turbine to generate electricity.

The Sun's thermal energy can also be used passively, without the use of equipment. Hanging clothes on a clothesline or sitting in the sun on a cold day are examples of passive solar thermal energy.

Did you know?

Light is made up of packets of energy called photons. When these photons collide with the surface of a photovoltaic material the ones that are absorbed are transformed into electrical energy.

Did you know?

Solar cells were first developed to power satellites in space. The first satellite to use solar power was the Russian Sputnik 3 satellite in 1957.

Did you know?

Different wavelengths of the solar spectrum contain various amounts of energy.

Did you know?

The average life of a solar panel is 25 years!



This is a parabolic trough solar thermal electric power plant located at Kramer Junction in California. Source: kjkolb/Wikimedia Commons

Photovoltaic solar

Solar photovoltaic cells (solar cells) convert light energy from the Sun to generate electricity. These cells are connected together electrically to form a module known as a solar panel. The panel is made from a semiconductor material, like silicon, that absorbs photons of light. These photons excite the electrons from the semiconductor material into a higher stage of energy to produce an electric current. This is known as the photovoltaic effect. The electric current, DC (direct current) from the cells passes through an inverter where the current is converted in AC (alternating current) where it can be used as electricity. Excess electricity supply from the cells can be directed to the electricity grid for other consumers by a two-way electricity metre. The more sunlight available, the more current is produced. An emergency phone can be powered by one single solar module, however, to power a house or power plant, multiple modules arranged in arrays are needed.



Two workers installing a tilt-up photovoltaic array on a roof.
Source: Labraun90/Wikimedia

Did you know?

Photovoltaic cells are named after Alessandro Volta (1745 – 1827) who pioneered the study of electricity. He also gives his name to a unit used to measure electricity – the volt!!

Case Study

Cloncurry Solar Farm

The Cloncurry district in Queensland is the site of a new solar farm. This solar farm is expected to produce 3,700MW using 7,600 solar panels. This should be enough to provide electricity to over 500 homes in the area. Find out more at <http://www.ingenero.com.au>

Case Study

Dye-sensitised solar cells

CSIRO is engaging in research of dye-sensitised solar cells that aim to develop:

- solar technology that is easily reproduced, efficient and reliable that can be used for various applications,
- transparent cells that can be used in building design, even replacing windows and light transmitting ceilings, and
- an increased use of solar power and to decrease the use of fossil fuels through the uptake of the dye-sensitised solar cells.

Dye-sensitised solar cells are different from first (silicon photovoltaic cells) and second (thin-film semiconductor) generation solar cells in the materials that are used to absorb the light; a light absorbing dye and a metal oxide semiconductor.

The advantages of dye-sensitised solar cells are:

- high cost-effective efficiency,
- continuous, stable energy generation under various light conditions,
- architectural appeal,
- simple production process,
- environmentally sustainable materials, and
- low cost with balance of system payback 0.8 years

Challenges include increasing the cell's photovoltaic response and the surface ability of the dye. This has lead research activities including:

- investigating sustainable organic and inorganic dyes for photovoltaic performance,
- determining the lifespan, stability and performance of cells in various conditions, and
- enhancing manufacturing to identify effective designs and processes.

For more information, visit:

<http://www.csiro.au/en/Outcomes/Energy/Renewables-and-Smart-Systems/dye-sensitised-solar-cells.aspx>

Case Study

The Bushlight project

The Bushlight project is an organisation that focuses on providing reliable electricity sources to remote communities in Australia using solar energy. The program asks the members of each community about their current electricity use, their future energy use and their environment before working with each community to ensure their energy requirements are met. Find out more about Bushlight at <http://www.bushlight.org.au> or www.catprojects.com.au

Try This! Years F-2

Solar powered calculator

1. Take a solar powered calculator out into the sun.
2. Enter a sum into the calculator (e.g. $5 + 5 =$). What did you observe?
3. Hold your fingers over the solar panel for 45 seconds.
4. Keep your fingers on the solar panel and retype the sum into the calculator. What did you observe? Why did this happen?

Try This! Years 7-10

What is the effect of the amount and wavelength of light on solar cells?

<http://www.solarschools.net/resources/pdf/Effect%20of%20Amount%20of%20Light%20and%20Wavelength%20on%20Solar%20Cells.pdf>

Teachers' Corner

- **Website:** For more activities relating to solar energy, visit <http://www.solarschools.net>
- **Website:** Find out how solar thermoelectric generator technology is being developed in Australia at <http://www.csiro.au/Organisation-Structure/Flagships/Energy-Transformed-Flagship/solar-thermoelectric-generator-EFT.aspx>
- **Website:** Download a solar colouring in book for full of fun pictures and interesting facts at http://www.energyquest.ca.gov/games/coloring_books/index.html
- **Podcast:** CSIRO has developed a new solar thermal field. Have a listen to find out what its, where it is and how it works at <http://www.csiro.au/Portals/Multimedia/CSIROpod/New-solar-thermal-field.aspx>
- **Activity:** A cloze exercise about solar energy can be found at <http://www.darvill.clara.net/altenerg/solarquiz.htm>
- **Website:** Information, videos and links to other websites can be found at <http://www.darvill.clara.net/altenerg/solar.htm>



Windorah's Solar Farm dishes taken from the roadside (Diamantina Developmental Road) on a hot summer day. Source: Aaronazz/Wikimedia Commons

Hydroelectricity

Hydroelectricity

What is hydroelectricity?

Hydroelectricity harnesses the energy of moving water to turn a turbine which operates a generator to produce electrical current. Many large hydroelectricity plants are located near dams that were built to provide water for communities. The water in the dam travels through pipes to the turbines of the hydroelectricity plant before being used for other purposes.

Did you know?

Hydroelectricity plants power up fast — it usually takes only 90 seconds for the plant to go from zero electricity generation to maximum electricity generation!

Did you know?

Some hydroelectricity dams pump their water back into the dam that feeds them, and reuse it.

Hydroelectricity plants are found in areas of Australia which have a good water supply such as Tasmania and Far North Queensland. Australia's most famous hydroelectricity plants are in the Snowy Mountains of New South Wales. The construction of the dams and pipelines for the Snowy Mountain Scheme was a huge project that began after the Great Depression of the 1930s. It provided jobs for a large number of people in a time of great poverty. You can see a newsreel from the building of the plant in 1949 at <http://aso.gov.au/titles/sponsored-films/snowy-hydro-snowy-mts-scheme/clip2/>

Did you know?

There are over 8000 hydroelectricity stations around Australia which supply around 5.5% of our electricity.

Did you know?

Small hydroelectricity generators can be used in stream and rivers — as long as the water is moving you have electricity which is a real bonus if you live in a rural area.

Hydroelectricity is a very cheap source of electricity and so industrial processes that need a lot of electricity such as the extraction and refinement of aluminium are usually located near a hydroelectricity plant.



Tumut 3 Generating Station is one of three hydroelectric power stations on the Tumut River in NSW. It is part of the Snowy Mountains Hydroelectricity scheme. Source: Image by Colin Henein/GFDL Wikimedia Commons

Did you know?

Workers from over 32 nations helped to build the Snowy Mountains scheme from 1949 to 1974. This hydroelectricity scheme has 16 dams, 7 power stations and a pumping station. It has over 145km of tunnels and 80km of aqueducts to carry the water back to the rivers after it's been used.

In fact over sixteen percent of the world's electricity is generated using hydroelectricity sources making it the largest renewable energy source on Earth.

Did you know?

The water pumped into a hydroelectricity plant is pumped out without becoming contaminated. It can be used to irrigate crops, returned to rivers and streams safely or pumped to water treatment plants to become tap water for household use.

Did you know?

Hydroelectricity is a zero-emission electricity source. In fact one megawatt of electricity from a hydroelectricity station saves one tonne of carbon dioxide emissions!

Try This! Years 7-10

Construct a hydroelectricity timeline using the Ecogeneration website: [http://ecogeneration.com.au/news/hydroelectricity in australia past present and future/055974/](http://ecogeneration.com.au/news/hydroelectricity%20in%20australia%20past%20present%20and%20future/055974/)

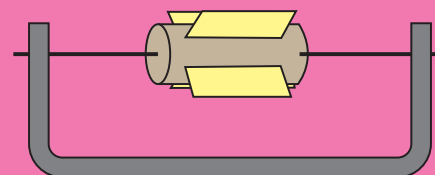
Try This! Years 3-8

Make a water wheel

Thousands of years before humans started using water power to generate electricity, the water wheel was used for other purposes, such as grinding grain. Water wheels were used to move water from rivers and creeks to irrigate crops. They were also harnessed to huge grinding stones and used to make flour from wheat. Make your own water wheel and try it out in your local creek or under a tap.

You will need:

- 2 pins
- 1 cork
- 1 craft knife
- 1 scissors
- empty plastic food container or carton
- empty aluminium food container



Procedure:

1. Cut 8 strips of plastic from the empty food container using your scissors. These should be slightly shorter than the cork and about 2cm wide.
2. Carefully use the craft knife to cut 8 slits down the length of the cork (**teacher supervision may be required**).
3. Put a strip of plastic into each cut.
4. Use the scissors to cut a strip of aluminium foil 2cm wide from the food container. It's best to cut it across the width of the food container – down one side, across the base and up the other side. Do this twice and you'll have a U-shape.
5. Push a pin through one end of the aluminium strip and into the top of the cork.
6. Repeat this on the other side to suspend your cork in the middle of the U-shape.
7. Gently push the cork to set it spinning.
8. Pick up your water wheel by the aluminium foil middle section which makes a good handle and suspend it in to a steady stream of water.

Try This! Years 3-8

Make a water turbine

You will need:

- an empty juice carton (screw on lid variety, 600mL at least)
- string
- skewer or nail
- masking tape
- water in a jug or plastic bottle

Procedure:

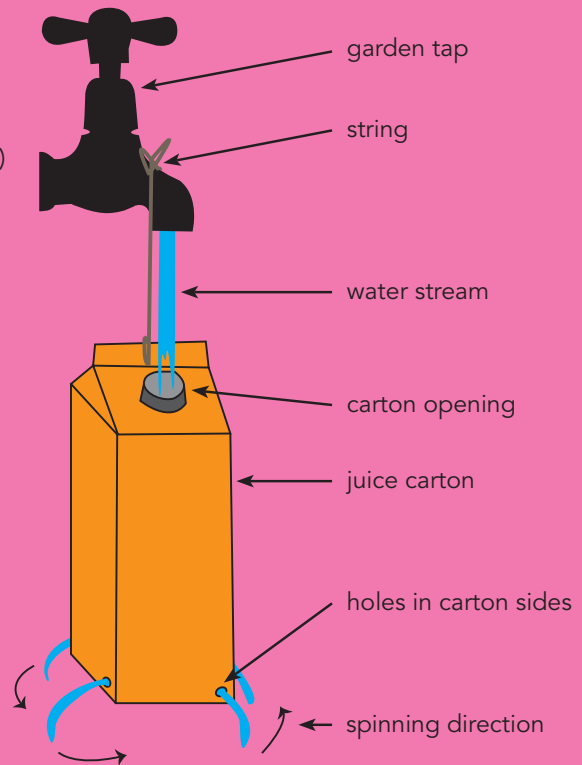
1. Carefully use the skewer to put a hole in the bottom right hand corner of each side of the carton
2. Cover each hole with masking tape
3. Put a hole in the top of the carton and thread the string through it.
4. Find a place outside where you can let water fall on the ground. A washing line or a tree branch could be the ideal spot
5. Hang the carton up and use the jug to fill the carton with water
6. Take the masking tape off the hole in one corner and step back!

What happens?

7. Top up the carton with water. Now take the tape off a second hole on the side directly opposite the first. How does the motion change?
8. Repeat step 7 for the other two holes. How does the motion change?

With all four holes open, the movement of the water pouring out through them should make the carton spin. Many water turbines work in the same way. They often have lots of small holes which make them spin very quickly.

Why does it work? A famous physicist Sir Isaac Newton discovered that for every action there is an opposite and equal reaction. This means that the force of the water moving out of the carton is balanced by a force that pushes the carton in the opposite direction. When it has holes on all four sides, where the water is moving through, the forces cause the carton to spin.



Try This! Years 4-8

The energy in falling water

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 from the tray? What does this tell you about the energy in falling water? Explain the energy change in this process.

Challenge - All about turbines (Years 5-10)

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.

Try This! Years 7-10

The kinetic energy of falling 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.

Procedure:

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.

Did you know?

The first ever hydroelectricity station was built in the 1870s in England.

Did you know?

Australia's first hydroelectric station was built in Tasmania in 1893 at the Mount Bishoff tin mine.

Teachers' corner

Websites:

- <http://www.energyquest.ca.gov/story/chapter12.html> - from *Energy Story*, EnergyQuest, Canada. Introduction to hydropower.
- <http://www.darvill.clara.net/altenerg/hydro.htm> from Andy Darvill's Science Site. Introduction to hydroelectric power and how it works.

Videos:

- *Hydro Power* — watch an animation on how hydro power works (Year 6, 7) <http://www.youtube.com/watch?v=g8DTiztIMFA>
- *How hydroelectricity works* — this video shows how a hydroelectric plant works (Year 8) <http://www.youtube.com/watch?v=rnPEtwQtmGQ>

Teacher resources:

- A cloze activity revising concepts associated with hydroelectric power can be found at <http://www.darvill.clara.net/altenerg/hydroquiz.htm>. It is recommended you read this before implementing to ensure your students have covered all the points raised. Suitable for Years 6 – 8.



Case Study

Parangana Mini-Hydro Project

The Parangana Dam was built in 1968 to divert water from the Mersey River into the Forth River valley in Tasmania. It holds up to 19,500 ML (mega litres) of water behind a 53m high rock fill wall. That's enough to fill your bathtub every night for 667,800 years!! Originally built to control water flow for irrigation, it became the site of a mini-hydro plant in 1999. This power station generates enough electricity to keep its local community supplied and also feeds excess electricity into a power grid for use by people on the mainland. Find out more about the Parangana Mini-Hydro electricity plant at <http://www.cleanenergycouncil.org.au/resourcecentre/casestudies/Hydro/Parangana.html>

Case Study

Koombooloomba Hydro Project

Koombooloomba Dam is located in Far North Queensland in the Wet Tropics World Heritage Area. When the dam was built in 1960 on the Tully River, the infrastructure for a hydroelectric power plant was included. It wasn't until March 2000 that the hydroelectricity power station began operating. This type of electricity source is ideal for the World Heritage Area as it produces no greenhouse gas emissions. In fact over its 40 year lifetime it is expected to save 840,000 tonnes of greenhouse gas emissions. The Koombooloomba Hydro Project typically generates 22,500 MWh of electrical power a year. Find out more about the Koombooloomba Hydro Project at <http://www.cleanenergycouncil.org.au/resourcecentre/casestudies/Hydro/Koombooloomba.html>

Ocean energy

Ocean energy

What is ocean energy?

Over 70% of the Earth is covered in water. Of that 70%, 96.5% is found in the Earth's oceans. The ocean has the ability to produce two types of energy: mechanical energy from tides and waves and thermal energy from the Sun's heat. With such a large energy resource available, how are scientists tapping into this large store of energy?

Try This! Years 3-4

Advantages and disadvantages of tidal energy:

<http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/advantages/>

Tidal energy

Tidal energy is a form of mechanical energy where the energy is harnessed from Earth's tides to generate electricity. Each day tides move large volumes of water over the Earth's surface. This periodic movement caused by the gravitational interaction between the Earth's rotation and the position of the Moon and Sun makes tidal energy a predictable renewable source of energy. Due to the predictability of tides, tidal energy is considered to be a reliable source of energy. There are two main technologies currently harnessing tidal energy.

Tidal stream generator (tidal energy converter)

Tidal stream generators function like underwater wind turbines called tidal turbines. The kinetic energy from the moving masses of water propels the blades of the turbine, creating electricity. This form of tidal power generation is the cheapest and least ecologically damaging.



SeaGen - world's first commercial tidal generator in Strangford Lough Northern Ireland. The strong wake shows the power in the tidal current.
Source: Fundy/Wikimedia Commons

Try This! Years 7-10

Research and build models of the different types tidal stream generators.

Did you know?

The Derby region in north west

Australia has some of the highest tides in the world.

Tidal barrage

Tidal barrages use the potential energy in the pressure head created between high and low tides. A tidal barrage is a dam-like structure built across an inlet subjected to tidal flows and is able to take advantage of both incoming and outgoing tides (hydro dams are one directional) to generate electricity.

Tidal barrages consist of a tidal fence with gates called sluice gates and tunnels that contain turbine systems that harness the energy in the tidal flows. The tidal flow is measured so the sluice gates can be controlled at key times of the tidal cycle. These gates are lifted during incoming tides to allow water to flow into a bay or river. On the outgoing tide, the gates are closed to form a pressure head and the water is forced to flow through the turbine system to generate electricity.

There are few tidal barrage sites around the world. This is because ideal sites need a tidal range of 7m or more, a narrow entry to the inlet and a great tidal flow. There needs to be a demand for electricity supply close-by otherwise the costs of storing and transporting the electricity outweighs the benefits of generating the electricity.

Try This! Years 7-10

Research possible sites for tidal barrages and mark them on a world map.

Try This! Years 9-10

Identify the cause and effect relationships that tidal barrages would have on a large ecosystem. Suggest possible solutions to the problems.

Wave energy

Waves are formed by wind transferring its energy to the ocean's surface. Wave height is determined by wind speed, wind duration and fetch length (the length the wind has been blowing over the water). In general, the larger the wave the more energy it has however, the amount of energy in a wave is also determined by wave speed, wavelength and water density. Energy from waves can be harnessed to generate electricity.

Did you know?

A CSIRO study in August 2010 showed that if less than 10% of the energy from waves around Australia was turned into electricity, it would meet half of Australia's current electricity needs.

Did you know?

The southern coastline of Australia has one of the strongest wave regimes in the world.

Visit: <http://www.abc.net.au/catalyst/stories/s1117412.htm> for more information about innovative wave energy alternatives.

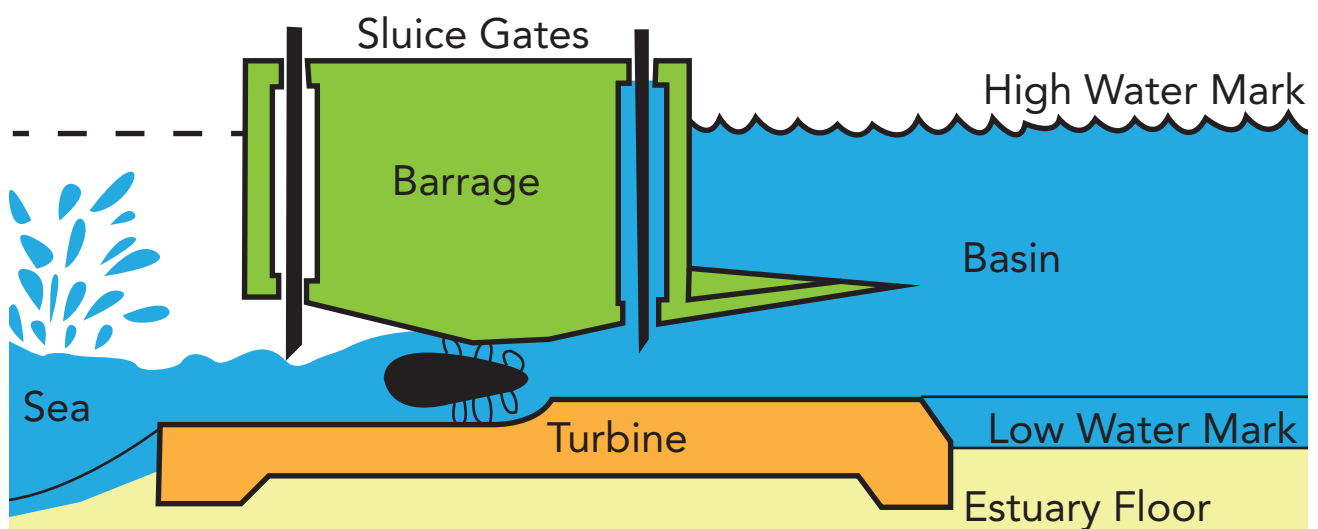
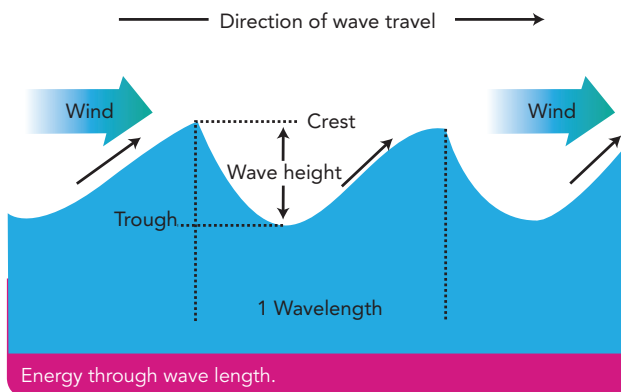


Diagram of a tidal barrage.



Try This! Years F-2

Make your own waves

You will need:

- large tray
- straw
- water

Procedure

1. Fill a large container with water.
2. Blow short and weak puffs of air through the straw onto the water. What did you observe?
3. Blow long and strong puffs onto the water. How were these waves different? Which waves do you think had more energy? Why?
4. Experiment with different types of air intensities and flows to compare the different waves.

Currently several technologies are being trialled to determine the efficiency of harnessing energy from waves. These include *attenuator* or *linear absorbers* and *point absorbers* that involve the use of floating devices to capture energy and terminators (including oscillating water column and overtopping device) harness energy by using passive devices, like a tapered channel.



A Pelamis wave energy converter (linear absorber). Source: Wikimedia



A Wave Dragon wave power facility. This is a example of an overtopping terminator. Source: Erik Friis-Madsen/Wikipedia

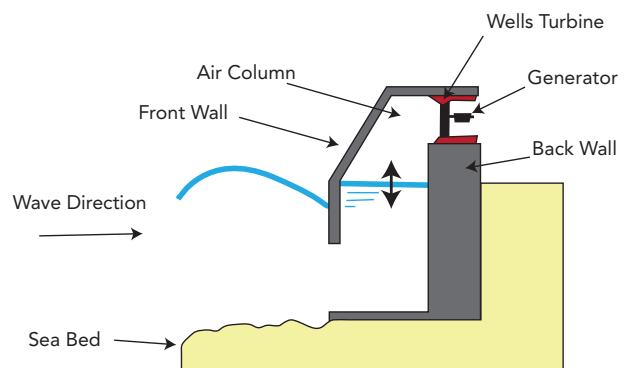


Diagram of an oscillating water column

Try This! Years 3-6

Wave energy in action!

You will need:

- 1 large deep container
- 1 electric fan
- 1 drinking straw
- 2cm x 1.5cm piece of tissue paper
- sticky tape

Procedure:

1. Fill the container with 2cm of water.
2. Tape the tissue paper to the top of the straw to cover the opening.
3. Place the straw in to the water on an angle with the tissue paper at the top.
4. Point the fan towards the water.
5. Turn on the fan so the air creates waves on the water towards the straw.

What do you notice about the tissue paper?

Why is this happening?



Wave energy power plant, Islay The LIMPET (Land Installed Marine Power Energy Transmitter) is the world's first commercial scale wave energy plant. It can supply up to 500kW and is connected to the national grid. Source: Claire Pegrum/Wikimedia Commons

Ocean thermal energy conversion

With 70% of the Earth's surface covered in water, the Sun's radiation is heating more surface water than land surface. This makes the ocean the world's largest solar energy collector and storage system. This results in a temperature gradient of warm surface waters and cool deep waters. Ocean thermal energy conversion is more efficient when the temperature variance is 20°C or greater and these conditions are found in the tropics.

Ocean thermal energy conversion technologies are emerging current systems include:

Closed-cycle systems use a fluid with a low boiling point (e.g. ammonia) turning it into a vapour using the warm surface water to rotate a turbine. Cooler water is pumped up through a pipe to cool the vapour into a liquid to be recycled.

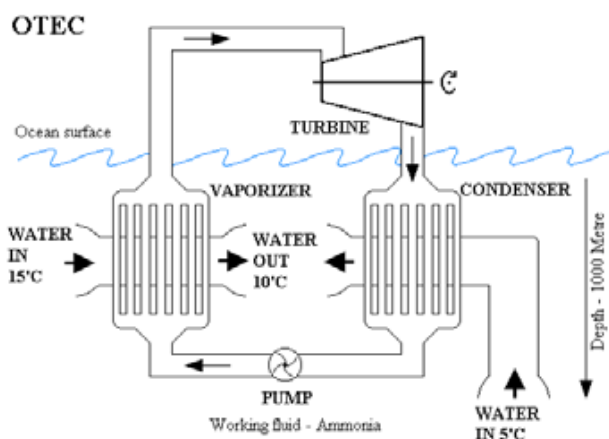


Diagram of a closed cycle ocean thermal energy conversion system. Source: Wikimedia Commons

Open-cycle systems use low pressure containers to boil the warm water where steam rotates a low-pressure turbine. By exposing the steam to the cooler water, it is condensed back into fresh water.

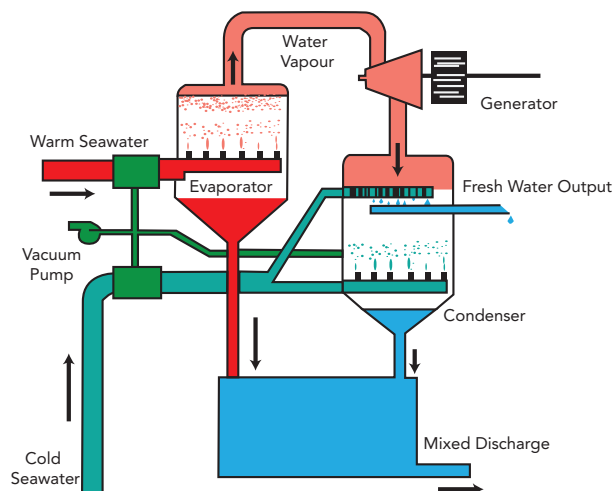


Diagram of an open cycle ocean thermal energy conversion system.

Hybrid systems use a combination of both the closed-cycle and open-cycle technologies.

Teachers' corner

- **Website:** Teacher notes on advantages and disadvantages of energy sources
<http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/advantages>
- **Factsheet** on renewable energy
http://www.westernpower.com.au/pluginkids/aboutelectricity/Renewable_energy.html
- **Factsheet** on renewable energy
http://www.energex.com.au/switched_on/power_up/index.html
- **Website:** wave energy projects in Australia
http://www.sustainableenergy.com.au/wave_energy.html
- **Activity:** A cloze activity covering concepts associated with wave energy <http://www.darvill.clara.net/altenerg/wavequiz.htm>

Geothermal energy

Geothermal energy

What is geothermal energy?

'Geo' means Earth and 'thermal' means heat, therefore, geothermal means 'Earth's heat'.

The Earth is made up of four layers, the inner core, the outer core, the mantle and the crust. Scientists believe that the heat from the Earth is generated deep inside, from the Earth's core. The Earth's inner core is made of hot, solid metal surrounded by an outer core of hot, liquid metal. The temperatures generated from the core are around 2000°. The Earth's mantle is made of molten rocks or magma. The magma is heated by the core and rises up to meet the crust. As it transfers heat energy to the crust, it cools and falls back down to the core where it is re-heated. This heat energy is transferred to the solid rock of the crust where it can be used as a source of geothermal energy.

Geothermal energy is the only renewable energy source that can be sourced all year round, regardless of climatic conditions or time of day.

Try This! Years 6-10

Make a model of the Earth – out of clay!

You will need:

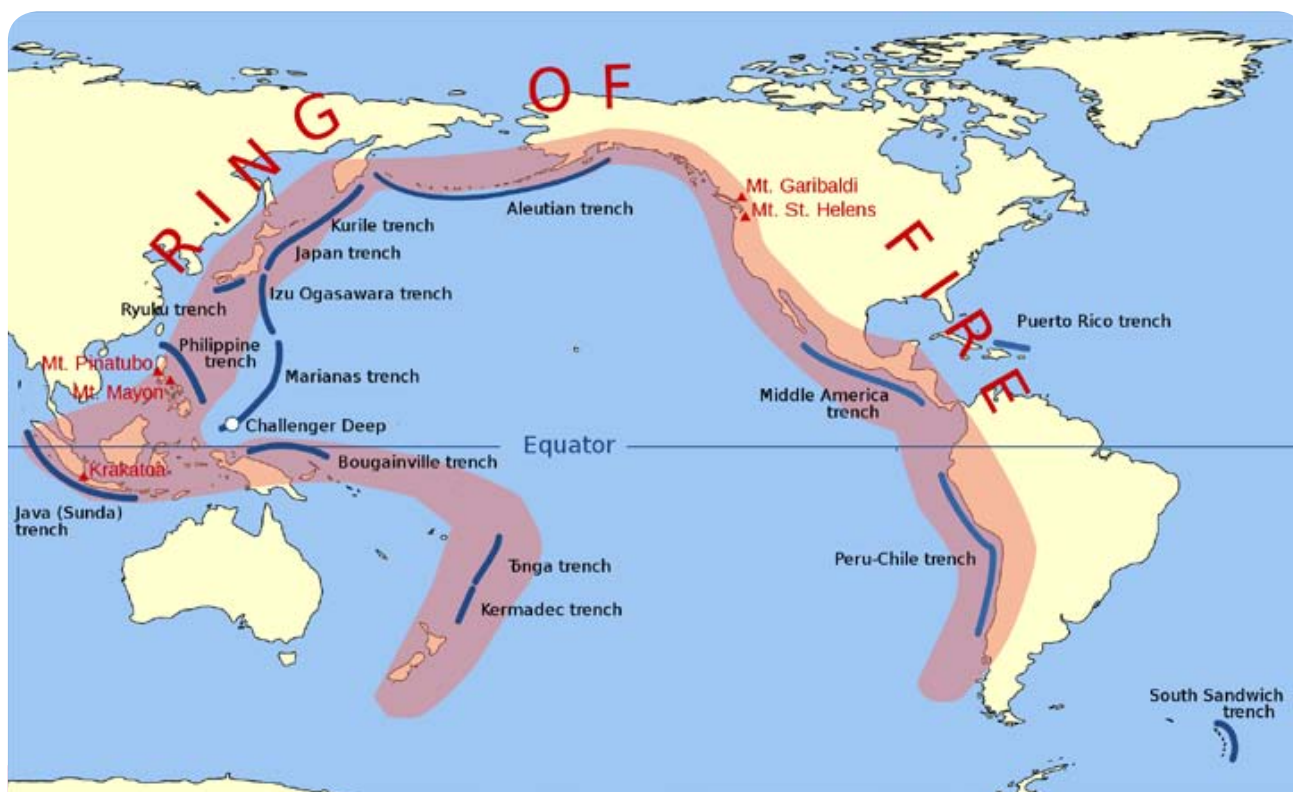
red, white, green and brown modelling compound.

Procedure:

1. Roll the red modelling compound into a small ball measuring approximately 1cm in diameter.
2. Use the white modelling compound to mould around the ball of red to make the ball now measure 3cm in diameter.
3. Use the brown modelling compound to make the next layer so the ball now measures 6cm in diameter.
4. Finally, use the green modelling compound to make the final layer. Make sure this layer is very thin — it represents the crust of the Earth.
5. Use a knife to cut the model in half through the centre so you can see the 'internal structures of the Earth'

Tectonic plates

The Earth's crust isn't one piece like, for example, the sugar coating on a 'Smartie'. It is in many large pieces called tectonic plates, which move about very slowly on top of the hot, liquid mantle layer of the Earth. Places on the Earth where these plates meet are often the locations where volcanoes occur. This is evident all around the Pacific Ocean leading



The Pacific Ring of Fire. Source: Wikipedia

geologists to call this area the 'Ring of Fire'. Indonesia is a country in this area, which has many dormant and extinct volcanoes and is an area where geothermal energy use is on the increase.

Try This! Years 6-10

Tectonic Plate Dessert

This delicious dessert shows how the mantle (jelly) interacts with the tectonic plates (biscuits).

You will need — glass bowl or dish, jelly, fork, square or rectangular biscuits.

1. Make the jelly following the directions on the packet.
2. Put the jelly into the glass dish or bowl and allow to set.
3. Once set, use the fork to rake the jelly into small pieces.
4. Place the biscuits carefully on top of the jelly.
5. Move the biscuits gently around on top of the jelly, pushing biscuits together.

What happens to the jelly as you move two biscuits together?

How do you think this activity demonstrates tectonic plate activity?

Did you know?

Indonesia has many extinct volcanoes that have water trapped as steam 1 – 3km below the surface. Scientists are looking for ways to use this steam to power turbines and generate electricity.

Try This! Years 3-4

Make a bicarbonate and vinegar volcano, stand back and watch it erupt!

<http://chemistry.about.com/od/chemicalvolcanoes/ss/volcano.htm>

What is a geyser?

Geysers are large, spurting gushes of scalding hot water and steam that rush out of the Earth's surface. The term comes from the Icelandic word 'Geysir' meaning 'gusher'. Some geysers send up these natural fountains regularly, while others bubble and spurt at irregular intervals. Geysers form from the heating of groundwater by hot rocks and magma deep under the Earth's surface. In the case of geysers, pressure builds up and is released out of these geothermal reservoirs through weak areas in the rock, sending up the hot water and steam. Many geysers can be found in New Zealand, and the most well-



'Old Faithful' geyser. Yellowstone National Park, Wyoming, USA.
Source: Wikipedia



Hot steam pool. Source: Deb Smith 2011

known is called 'Old Faithful' in Yellowstone National Park in Wyoming in the United States, which spouts off once every 70 minutes!

There are many geothermal reservoirs in countries around the world. Many of these areas contain several geysers, bubbling hot pools of water and even pools of boiling mud. A sure sign of geothermal resources!

It was the 'discovery' of these sources thousands of years ago that has led to the development of geothermal energy as it is today.



Steam geyser with sulphur coated rocks, Rotarua NZ. Source: Deb Smith 2011

The history of geothermal energy

Geothermal energy has been used for thousands of years, with humans tapping into geothermal sources from as early as the Stone Age! As early as 3,500 years ago people bathed in hot springs. The Romans used geothermal energy sources to bath in heated pools, treat skin and eye infections and heat buildings. Many cultures have used hot geothermal waters to cook food and heat homes.

During the 1800s and 1900s, the manufacture of boric acid and borax in Italy were a direct by-product of geothermal hot springs. Italy has also been at the forefront of providing electricity by geothermal energy. They had the first steam generated electricity plant in Larderello in 1904 and by 1913 were selling electricity to nearby communities. By 1943' this plant was providing electricity to 132,000 homes. Unfortunately, the power plants were all destroyed in World War II, however, the geothermal reservoir was undamaged and is again generating electricity today.

Using 'low temperature' geothermal energy

Geothermal water can range in temperatures and is classified into 'low temperature' and 'high temperature' use. How we use the water therefore depends on this temperature. Low temperature water is considered to be anything below 150°C and high temperature water can get as hot as 315°C!

Uses for low temperature geothermal water:

1. Geothermal aquaculture – farming of water-dwelling creatures such as fish and amphibians.
2. Therapeutic bathing – using warm water to heal and relax. This is popular across Europe (e.g. Belgium and Russia), Japan, Mexico, the United States and New Zealand.
3. Agricultural production – geothermal greenhouses are used in a variety of ways to help vegetables, flowers and other plants to grow better. Tuscany in Italy is renowned for using steam to heat fields of vegetables during winter!
4. Dyeing fabric – geothermal water is used in many Pacific countries for dyeing fabric.
5. Industry – manufacturers of paper and dried foods use geothermal steam to dry wood, fruits, vegetables and even pasteurise milk!
6. Heating homes – using geothermal heating systems to heat homes and buildings. These heating systems work by pumping geothermal water from beneath the Earth's surface through pipes to a heat exchanger that is then pumped to buildings. Some homes in Klamath Falls in Oregon in the United States even have their own geothermal wells in their front yards!

Because geothermal heating is a clean, economical way to heat buildings, many communities are now using this method to heat entire districts. The United States, France and Iceland all have large communities using geothermal water as their main system of heating. Boise, Idaho; Klamath Falls, Oregon; Jonzac and Soultz-sous-Fôrets, France and Reykjavik, Iceland all use geothermal energy.

Reykjavik used to be the most polluted city due to the pollution from burning fossil fuels to heat their homes. Now it is one of the cleanest cities in the world!

Try This! Years 6-10

Research countries around the world that use low temperature geothermal water to heat their communities. Reykjavik in Iceland is one city that utilises its geothermal sources to best advantage!

Other countries that use geothermal energy include:

- The United States of America
- Mexico
- Italy
- The Philippines
- New Zealand
- Japan

Try This! Years 6-10

Read about low temperature power stations that can use lower grade geothermal resources to produce electricity. The Birdsville Geothermal Power station is one such facility.

<http://www.ehp.qld.gov.au/register/p00834aa.pdf>

Using 'high temperature' geothermal energy

Generating electricity from geothermal reservoirs

Electricity has been produced from manufactured steam for long periods of time. These forms include the burning of coal, oil and methane gas, from nuclear reactors, biomass fuels and from the Sun.

The generation of electricity by geothermal energy is considered to be the most natural source. Geothermal reservoirs — areas of underground sources of hot rocks and heated groundwater — are used to generate this electricity. A well is drilled down to the reservoir and the boiling hot, steamy water

Did you know?

It takes less land to produce electricity from geothermal resources than from almost all other energy resources.

comes up the well and is directed through pipes in the power plant where it spins the turbines that in turn generate the electricity.

Did you know?

The geothermal water used in power plants is always sent back to into the geothermal reservoir so that surface water and fresh ground water stay clean and safe to use.

Generating electricity using HDR (hot, dry rocks)

Hot dry rock (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 mineralization, particularly the Eromanga Basin near the South Australia/ Queensland border and in the Hunter Valley in New South Wales where a pilot project is now underway. In fact, HDR have the potential to meet the total electricity demand of Australia for hundreds of years!

Try This! Years 6-10

Research HDR — the cutting edge of geothermal energy.

<http://hotrockenergy.com>

<http://www.geodynamics.com.au>

Geothermal electricity today

The geothermal electricity industry is a fast growing industry with many countries around the world, now implementing and investigating how they can use this renewable energy source. Currently, 5,700 megawatts of geothermal electricity is being produced,

which is the equivalent to over a hundred million barrels of oil per year! Italy, New Zealand, Japan, Indonesia, the Philippines, Central America, Mexico and the United States are all countries utilising their geothermal energy sources. There are many geologists doing exciting and innovative exploration around the world in order to increase the utilisation of this amazing resource.

Did you know?

In some places such as the Cooper Basin in South Australia and Eromanga Basin in Queensland, rock temperatures 4.5km below the surface of the Earth are up to 250°C! This is hot enough to melt some metal alloys such lead solder.

Did you know?

The first borehole drilled in the Cooper Basin to investigate hot rocks in the area is called Habanero 1 after the world's hottest variety of chilli!

Try This! Years 9-10

Make your own model geothermal power plant

A geothermal power plant uses steam to turn a turbine attached to an electricity generator. In the model, the pinwheel represents the turbine, the hot plate represents the hot rocks found in the Earth and the pot represents the reservoir of hot water that has been pumped through the hot rocks.

<http://www.energyquest.ca.gov/projects/geothermal-pp.html>

Try This! Years 9-10

Try discussing these questions:

1. What are the economic and social implications of harnessing HDR energy for electricity?
2. What are the potential risks to the environment of drilling for geothermal energy?
3. 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' then why isn't it yet available to the consumer?

Try This! Years 9-10

Ever wondered where geothermal energy would be best situated?

The South Australian Government's Department of Manufacturing, Innovation, Trade, Resources and Energy have a wealth of information about geothermal energy and current research happening in the state. South Australia is uniquely situated to facilitate geothermal exploration. Visit the website for more detailed information.

http://www.pir.sa.gov.au/geothermal/prospectivity/geothermal_provinces

Try This! Years 6-10

Want to learn more about this exciting energy resource?

The Australian Geothermal Energy Association Inc <http://www.agea.org.au> has information, FAQs and diagrams that explain this resource in detail.

Visit Wikipedia — Geothermal energy — http://en.wikipedia.org/wiki/Geothermal_energy for information on the history, sustainability and effects of geothermal energy.

Wind energy

What is wind?

Simply put, wind is air in motion. Wind is produced by the uneven heating of the Earth's surface by the Sun's energy. The Earth is made up of different types of land and water, so it absorbs the radiant energy from the Sun at different rates. This results in the energy being converted into heat. Wind is created, for example, when warm air over land near the coast expands and rises and heavier, cooler air over water rushes in to take its place. At night, changing temperatures cause winds to change direction, most often due to the sinking cool air pushing the warm air out of place.

Wind is affected by the shape of the land so different types of landscapes have different wind patterns. Wind is also affected by things like forests and buildings that make it slow down and change direction.

Wind speed

Wind speed is measured using an instrument called an anemometer. By using an anemometer scientists such as meteorologists can measure the speed of wind. In 1805, Francis Beaufort created a scale (called the Beaufort Scale) to determine wind speed, by looking at common things around him. It is still in use today.



Try This! Years F-10

Observing and measuring wind speed

- 1st — Make a ribbon wind sock to observe wind direction and speed (Years F-6)
http://alliantenergykids.com/wcm/groups/wcm_internet/@int/@aekids/documents/document/023062.pdf
- 2nd — Make an anemometer (Years 3-10)
<http://www.energyquest.ca.gov/projects/anemometer.html>
http://alliantenergykids.com/wcm/groups/wcm_internet/@int/@aekids/documents/document/022818.pdf
- 3rd — Research the Beaufort Scale (Years 3-10)
http://en.wikipedia.org/wiki/Beaufort_scale
- 4th — Measure the wind speed at various places (e.g. at home or at school) using both the anemometer and the Beaufort Scale.
- Last — Decide which method is the most accurate.

Image: Anemometer, a meteorological instrument used to measure the wind speed. Source: iStockphoto

What is wind energy?

Wind energy is a renewable energy source where the wind is harnessed to produce or generate power. Wind energy has been used in many forms throughout history with the earliest and simplest example being the use of sail boats.

Did you know?

That in 3200 B.C.E. the early Egyptians used wind to sail boats on the Nile River.

Later around the Year 0, the Chinese used kites during battles to signal their troops!

Did you know?

In the 1600s, the Dutch first began to use drainage windmills to pump water. The windmills dried out flooded land below sea level, doubling the size of the country!

Wind turbines

Wind turbines are used to capture enough wind speed to generate power. A turbine is a machine in which liquid or gas pressure act on the blades of a rotor to produce motion. This motion is then transformed into electrical or mechanical power.

Turbines are placed in high wind areas to provide the most efficiency, so the turbines can create more power. These locations vary around the globe with many found in high mountain areas or even in offshore locations like the Atlantic Ocean. One turbine will not provide a lot of power, so wind turbines are usually built in large groups known as wind farms. The turbines are placed evenly around the landscape and are then used to collect power.

Try This! Years F-10

View a video on a wind farm

Toora Wind Farm in South Gippsland, Victoria, Australia

<http://www.youtube.com/watch?v=72b51UO4mWo>

California San Geronio Pass Wind Farm, California, USA.

http://www.youtube.com/watch?v=IJ_bHVJfHrs



Whyalla wind farm SA. Source: Climate Change Denier/Wikimedia Commons

How do wind turbines work?

There are two types of wind turbines most commonly used. These are horizontal axis and vertical axis turbines. They work using similar methods; however there are differences in how they function as well. There are also special wind turbines that are designed to work in specific and unique conditions.

Wind turbines generally consist of a foundation, a tower, a nacelle (or a separate enclosure that contains the controlling equipment, gears and drive-train) and a rotor. Internal ladders are provided to allow access to the nacelle in case of malfunction. Because of their size, usually between 50 – 80 metres high, wind turbines are generally white or light grey in colour to lessen their visual impact.

Horizontal axis wind turbines

Horizontal axis wind turbines are the most commonly utilised of the types of turbines. These work by facing the horizontal blades into the wind. A large shaft holds up three-blades. The blades look like large propellers. The wind action causes the blades to spin, while the rotor shaft rotates with them. It is the motion of the rotor shaft that is used to generate electricity.

Vertical axis wind turbines

Vertical axis wind turbines work by having vertically placed blades arranged around the rotor shaft. The blades catch the wind by spinning the entire device in a circular motion.



Example of a horizontal axis wind turbine. Source: Wikimedia Commons

The blades are placed evenly around the rotor shaft, meaning they can catch the wind from any direction. The energy created by this action is used to generate electricity.



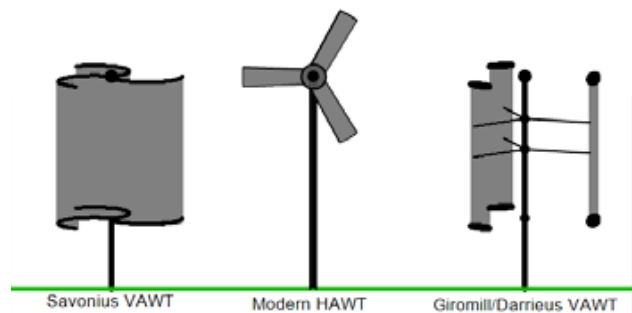
Example of a vertical axis wind turbine. Source: Lynne Kirton/Wikimedia Commons

Did you know?

In 1888, Charles F. Brush, a wealthy inventor and manufacturer of electrical equipment in Cleveland, Ohio, USA, built a giant windmill on his property. The windmill generated power for 350 lights in his mansion. In the basement a battery room stored 408 battery cells to store the electricity generated by the windmill!

How wind turbines generate electricity.

Wind turbines convert the kinetic energy of the wind into mechanical power. The energy in the wind turns the rotor blade that in turn spins the generator, which creates electricity. Once the electrical current is generated it is transferred through conductive wires directly to provide power for one home or building or is connected to an electricity grid to provide widespread electricity distribution to cities and towns. Battery banks can store power for later use. Small wind turbines can generate approximately 300 watts to 6 kilowatts of power; with large commercial wind turbines producing between 100 kilowatts to 5 megawatts of power.



The three primary types of wind turbine--Savonius and Darrieus vertical axis wind turbines (VAWTs) and a standard horizontal axis wind turbine (HAWT)--all with three blades. Source: Wikimedia Commons

Try This! Years 7-10

Research

From 2001 to early 2006, the main driving force for the establishment of wind farms in Australia was the Government's Mandatory Renewable Energy Target (MRET).

What is this and why is it important?

Did you know?

In order for wind turbines to generate power, wind speeds need to measure between 13 – 65 km/hr!

Try This! Years 3-10

View an animation of a wind turbine generating electricity. http://www1.eere.energy.gov/wind/wind_animation.html

Did you know?

There are approximately 295 wind turbines in Australia.

They produce enough energy to power more than all the homes in Canberra!

Try This! Years 6-10

Issues surrounding wind turbines

Many communities and groups have questions surrounding the efficiency, safety and environmental impacts of wind turbines. There are many points that people agree and disagree on.

Some of the questions raised include:

1. Are wind farms too noisy?
 2. Don't wind turbines just kill migrating birds?
 3. What happens when the wind stops blowing?
 4. Do wind farms affect the local weather and wind patterns?
 5. Does the expense to build a wind farm outweigh its energy output benefits?
- Conduct some research to find out your thoughts on these topics.
 - Don't forget to think critically about who is presenting the argument.
 - Come to your own conclusions, by looking at the scientific evidence.

Use these links to help you –

<http://www.cleanenergycouncil.org.au/technologies/wind.html>

<http://www.hi.com.au/resource/rfactsa.asp?kla=13&subtopicid=3510>

http://www.abc.net.au/science/news/enviro/EnviroRepublish_1227393.htm

Article: Community control 'key' to wind farms (News in Science, 25 July 2008)
Evaluates the use of community owned wind farms in Australia. <http://www.abc.net.au/science/articles/2008/07/25/2314473.htm?site=science&topic=latest>

WestWind Energy provides information, video clips and busts some myths about wind energy.

http://www.w-wind.com.au/WindEnergyInformation_FAQs.html

Try This! Years F-10

Constructing your own wind turbine

There are many types of DIY wind turbine models available to make and test.

The instructions for the following include written instructions, drawings and required resources.

Primary:

- Make a pinwheel wind turbine
http://alliantenergykids.com/wcm/groups/wcm_internet/@int/@aekids/documents/document/022821.pdf
- How to make a model of wind energy at home
http://www.ehow.com/how_12087638_make-model-wind-energy-home.html
- How to make a wind turbine out of straws
http://www.ehow.com/how_5082631_make-wind-turbine-out-straws.html
- Make your own turbine from a milk carton
http://alliantenergykids.com/wcm/groups/wcm_internet/@int/@aekids/documents/document/022820.pdf

Secondary:

- How to make an easy model of a wind turbine
http://www.ehow.com/how_5035549_make-easy-model-wind-turbine.html
- How to make a wind turbine model
http://www.ehow.com/how_7655334_make-wind-turbine-model.html

Teachers' corner

Looking for more information on wind power and energy?

For more information on wind energy visit the Clean Energy Council's website. <http://www.cleanenergycouncil.org.au/technologies/wind.html>

The Environmental Protection Agency of Queensland, Australia provides information on wind energy. <http://www.derm.qld.gov.au/register/p00401aa.pdf>

The Australian Wind Energy Institute promotes awareness, conducts research and works in an advisory capacity to the clean energy generation industry. <http://australianwindenergyinstitute.com/>

Australian Government — Geoscience Australia provides information on wind energy. <http://www.ga.gov.au/energy/other-renewable-energy-resources/wind-energy.html>

Wikipedia — Wind power in Australia http://en.wikipedia.org/wiki/Wind_power_in_Australia

Biomass

What is biomass?

Biomass is the name for materials made by plants or excreted by animals. Plants capture the energy of the Sun and store it in the bonds between atoms that make up molecules. The more atoms in the molecule, the more energy it can store. This is called chemical potential energy. When we eat or burn plant materials we transform that chemical potential energy into different forms of energy that can be used for a wide range of purposes. When you eat, the chemical energy from digesting your food provides energy for your cells to keep you healthy, allows you to move and keeps you warm. If we burn plant material most of the chemical potential energy is transformed into heat and kinetic energy which can be transferred to liquids to turn them into gases. Many electricity generators work this way – the heat from burning plant materials is used to turn water into steam which is used to move turbines and generate electricity.

Did you know?

You are a good source of biogas – you make methane from the food you eat.

What are biofuels?

Solids like manure, liquids like ethanol and gases like methane can all be used as biofuels. All of these improve the environment as they provide a use for materials that would otherwise be used in landfills. Animal wastes are a good energy source and can be easily used as a starting material for producing methane which can be used to cook food, heat water, provide heating, cooling and lighting and improve the quality of life of thousands of people living in poverty.

Did you know?

Biomass is carbon neutral when the rate at which it is used is the same as the rate at which it is grown.

Ethanol

Ethanol is a liquid fuel that is made from the breaking down of sugar molecules usually by yeast or similar organisms. In Australia, ethanol is currently being used as an additive to motor vehicle fuels to reduce greenhouse gas emissions. In fact, Henry Ford the designer and constructor of the first Ford car actually designed his first engine to run solely on ethanol because he knew it would provide more energy with less pollution than petroleum.

Plant wastes

Plant wastes from the agricultural, forestry and sugar cane industries are also full of energy just waiting to be used either in biogas electricity generator plants, or steam turbine electricity generators. Often these wastes were burned, their energy transformed to heat energy which was not used, releasing greenhouse gases such as carbon dioxide, nitrous oxides and sulphur dioxide. New biofuel technology harnesses this energy and reduces the emissions. In fact, if plant-generated biomass is used to generate energy at the same rate at which it grows, its carbon footprint is zero. This is achieved when for every tonne of carbon released into the atmosphere from the use of biomass, there are enough plants using carbon from the atmosphere in photosynthesis. This removes the carbon from the atmosphere so it no longer contributes to the greenhouse effect. Like everything else – using biomass is all about balance!

Did you know?

In 2008, over 93% of the energy used in the Democratic Republic of Congo came from solid biomass.

Try This! Years 9-10

Plant 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: <http://www.aboutbioenergy.info/definition.html> to use the biomass energy calculator.

Try This! Years 7-10

Producing 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?

Did you know?

Dr. Victoria Haritos leads a team of researchers at the CSIRO who are investigating how chemicals called enzymes break down plant materials like wood, leaves and straw to produce biofuels like ethanol. Enzymes are chemicals used by living organisms to increase the rate of the chemical reactions that take place in cells. Most enzymes are specialised and only effect one specific chemical reaction. Dr. Haritos' team is investigating ways of using enzymes to make the production of biofuels more efficient and so more economical. Find out more about Dr. Haritos and her team at <http://www.csiro.au/Organisation-Structure/Divisions/Ecosystem-Sciences/VictoriaHaritos.aspx>

Try This! Years 7-10

Biodiesel challenge

Imagine this – you have 25 hectares of land near your house to use for biomass crops to supply your energy needs. The land is divided into two distinct areas – half has been used for growing crops and the other half has been left as native scrubland. What would you plant to get the best biomass? How would the climate and water supply affect your choices? How much land would you plant? How long will it take for your crop to reach maturity? How will you ensure a continual crop over 10 years? It's up to you – how will you use your land to meet your electricity needs?

Did you know?

Dr. Tom Beer and his team are part of the CSIRO Energy Transformed Flagship. They have developed technology that uses algae to make biodiesel. The process Dr. Beer and his team have pioneered produces biodiesel at the same cost as extracting and refining fossil fuel. How do they do it? Check it out at <http://www.csiro.au/Organisation-Structure/Divisions/Marine-Atmospheric-Research/Biodiesel-from-algae.aspx>

Try This! Years 7-10

Methane from manure

You will need:

- 2 heavyweight plastic bags with closures (elastic bands or similar)
- duct tape
- permanent felt marking pen
- large bucket (with volume measurements)
- water
- 2 cups fresh manure
- rubber gloves
- thermometer
- data sheet for recording

Procedure:

Prepare the bags - on one plastic bag (Bag 1), place an 8cm 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 – using rubber gloves 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?

Dr. Deborah O'Connell is a systems analyst who leads a team of researchers investigating ways to improve the efficiency of the production and use of biofuels in Australia. Dr O'Connell is an articulate advocate of the use of biofuels and with her team has presented many reports and articles in this area. You can read a transcript of an interview with Dr O'Connell at <http://www.abc.net.au/landline/content/2006/s2009826.htm> and read more about her team and their research at <http://www.csiro.au/Organisation-Structure/Divisions/Ecosystem-Sciences/DeborahOConnell.aspx>

Case Study

Berrybank Piggeries: there's more to pig waste than smell!!

Did you know that half of what a pig eats ends up as waste products? That's a lot of pig poo when you run a piggery which has hundreds of animals chomping through pig feed every year. The Berrybank Piggeries have turned their waste into electricity and use it to run the piggeries, saving them money and reducing their impact on the environment. Find out about their solution to this smelly problem at http://newwww.ballarat.edu.au/projects/ensus/case_studies/piggery/index.html

Try This! Years 7-10

Make a biogas generator like the one in methane from manure. Use it to investigate factors that impact on the production of gas including:

- the type of plant matter or manure used.
- the amount of water in the manure or plant.
- the temperature of the generator.

Case Study

New South Wales Sugar Industry: renewable energy generation

In northern New South Wales, over 30,000 hectares of farming land is devoted to growing sugar cane. Once the sugar has been extracted from the plant canes there is an awful lot of left over plant material to be disposed of. This sugar cane residue is called Bagasse and can be burned in a boiler to produce steam which is used to drive turbines to generate electricity. In 1978, the New South Wales Sugar Milling Cooperative was formed by over 600 growers with the view of improving the sugar industry practices in the area from harvesting the cane through to its refining and packaging by implementing new technology and machinery. They also saw a use for all that left over plant material – find out what it is at http://newwww.ballarat.edu.au/projects/ensus/case_studies/sugar/index.html

Case Study

Ipswich Renewable Energy Facility

This facility in South East Queensland is located on the site of the Ipswich City Council's Whitwood Road Landfill. This has turned a smelly dump into a source of biogas that can be used to generate electricity. The methane gas produced naturally by the decomposition of organic wastes is harvested and used to generate electricity which is sold to the local electricity grid. By doing this, the facility reduces greenhouse gas emissions by an estimated 46,000 tonnes every year — that is equivalent to removing over 9,000 cars from the road! Find out more about the Ipswich Renewable Energy Facility at <http://www.cleanenergycouncil.org.au/resourcecentre/casestudies/Landfill-Gas/Ipswich.html> and about other projects that harvest methane gas from landfill around Australia at <http://www.cleanenergycouncil.org.au/resourcecentre/casestudies>

How many are near you?

Case Study

B E Bioenergy: biodiesel from canola oil

Inspired by a television chef using vegetable oil to make biodiesel, Steven Hobbs developed a process to make his own biodiesel. Steven is a farmer in Victoria who wanted a way to reduce his farming costs by making biodiesel to replace the diesel fuel used in his machinery. Not only does he achieve this, the by-products of the process are also used on his farm. These include press cake - a high protein food for cows and sheep – lubricants, degreasers, soaps, fertiliser and cosmetics. Read more about Steven and the impact biodiesel has had on his farm at http://newwww.ballarat.edu.au/projects/ensus/case_studies/biodiesel/pdfs/biodiesel_printable.pdf

Teachers' corner

Teacher resources

- **Article:** *Biomass — the growing energy resource* is a concise introduction to the use of biomass as an energy source which can be used to develop students note taking and summarising skills. It can be accessed at <http://www.science.org.au/nova/039/039key.htm>
- **Fact sheet:** *About Bioenergy* is a fact sheet from the Clean Energy Council containing basic information and a schematic diagram of a small biogas generator used in Australia. This and other resources can be found at <http://www.cleanenergycouncil.org.au/education>.
- **Website:** The United States Department of Energy website http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics has extensive resources for students and teachers.
- **Activities:** The National Renewable Energy Laboratory http://www.nrel.gov/learning/student_resources.html has extensive resources for students and teachers at all levels including a student handbook which contains a selection of literacy and experimental activities for Middle School students. The pages 13-21 features a scaffolded experimental investigation and can be accessed at http://www.nrel.gov/education/pdfs/educational_resources/middle_school/biomass_student_handbook.pdf
- **Information, videos and links to other websites:** see <http://www.darvill.clara.net/altenerg/biomass.htm>

CONTINUES ›

- **A cloze activity:** Covers concepts associated with biomass energy sources can be found at <http://www.darvill.clara.net/altenerg/bioquiz.htm> biogas energy source at <http://www.darvill.clara.net/altenerg/biogasquiz.htm> and biofuel at <http://www.darvill.clara.net/altenerg/biofuelquiz.htm>
- **Fact Sheet:** *What is biomass?* is a fact sheet from the Australian Institute of Energy which includes sources of biomass, biomass applications and electricity generation.
http://aie.org.au/Content/NavigationMenu/Resources/SchoolProjects/FS8_BIOMASS.pdf
- **Information:** *Alternative transport fuels* from the Australian Government Department of Resources, Energy and Tourism focuses on information about the production and use of biofuels in Australia
http://www.ret.gov.au/resources/fuels/alternative_transport_fuels/Pages/AlternativeTransportFuels.aspx
- **Information:** *Biomass energy* provides a brief introduction to biomass energy including the use of bagasse in steam turbine power stations from the Queensland Department of Education.
http://www.sustainableenergy.eq.edu.au/fact/factsheet_10.html
- **Class debate:** *Biofuels: prospects, risks and opportunities* (Food and Agriculture Organization of the United Nations) can be used as a stimulus for a discussion or class debate about the pros and cons of biofuels. It includes an overview of biofuel types, production and uses in chapter two.
<http://www.fao.org/docrep/011/i0100e/i0100e00.htm>
- Wood residue as an energy source for the forest products industry (Australian National University) presents an overview of the energy value of wood, conversion technologies, combustion technologies and possible future uses for Australian forest products. <http://fennerschool-associated.anu.edu.au/fpt/nwfp/woodres/woodres.html>

Websites

- Find out more about biomass in Australia at <http://www.originenergy.com.au/2042/Biomass>
- So how is biogas produced and harvested at a Waste Management facility? Take this virtual tour of a waste to energy plant in Baltimore and find out. Hop onto the tour at http://www.eia.gov/kids/energy/cfm?page=RESCOE_Plant
- *What is Biomass?* contains information, links to experts in the field and a biomass to fuel converter so you can compare the amount of energy in your biomass to that in wood or oil.
<http://www.aboutbioenergy.info/definition.html>
- Interested in biogas production? Read this article by Ron Shannon an expert in the field.
<http://permaculturewest.org.au/ipc6/ch08/shannon2/index.html>
- One source of biomass is algae — microscopic one celled plants that can be grown in ponds using land that is unsuitable for other crops. Scientists at the CSIRO are investigating different species of algae and processes for using them as a source of biodiesel. Find out more at
<http://www.csiro.au/en/Portals/Multimedia/CSIROpod/Algae-biodiesel-gets-green-light.aspx>

Videos

- How does a biogas plant work? Find out how a biogas generator works in this animation at <http://www.youtube.com/watch?v=3UafRz3QeO8>
- Biogas technology can be used in small portable generators which use plant materials or animal manure. These are easy to use and maintain and can supply enough biogas for a family's cooking, heating and lighting needs. This makes them the ideal energy source for people in remote areas or who are impoverished. Access to biogas can also mean a healthier, more hygienic lifestyle as water can be easily boiled to purify it, food can be cooked more thoroughly and hot water can be used to clean and sterilise cooking implements and crockery. Find out about the benefits biogas can bring to poor communities in India and South Africa by watching Biotech India domestic portable biogas plant <http://www.youtube.com/watch?v=3th2bcqHbsk> and Biogas technology benefits Africa's poor <http://www.youtube.com/watch?v=OVclKRemXD8>

Energy options for the future

Nanotechnology

Nanoparticles are microscopic particles which behave differently in small groups than in large macroscopic groups. A nanometre (nm) is one billionth (1/1,000,000,000th) of a metre. Working at this small scale, scientists position atoms in precise locations to form structures that are used for specific purposes.

Many fuels such as natural gas, coal, biogas, and ethanol release carbon dioxide when they are used. What if you could turn the carbon dioxide back into methane gas? That's right, take the carbon dioxide and convert it to methane. Burn the methane to light a house, generate electricity or heat a room and capture the carbon dioxide released to reuse making methane. Too good to be true? Scientists at the Massachusetts Institute of Technology have been researching this problem and have designed and tested nanoparticles to do just that!

If you put copper and gold together in a mixture and add carbon dioxide nothing happens. But if you carefully put atoms of copper with atoms of gold together to form a structure less than 100nm, then add carbon dioxide in air and presto – methane gas! Find out more about nanotechnology by reading *Hybrid copper-gold nanoparticles convert CO₂* at <http://web.mit.edu/press/2012/hybrid-copper-gold-nanoparticles-convert.html>

To find out about nanotechnology and its possible applications for energy harvesting and use, watch this video

The Future of nano-electric power generation <http://www.youtube.com/watch?v=8wHGh2eRbLE>

Piezoelectric energy harvesting

The piezoelectric effect is the conversion of mechanical strain into electrical current. The strain may come from acoustic noise, low level seismic activity or even human body motion. This effect has been investigated since the late 1990s as a way to power small devices such as wristwatches, TV remote controls, door bells, even mobile phones. The medical uses of this energy source include wireless monitoring and diagnostic sensors that could monitor patients heart rate, blood pressure or body temperature. Industrially, piezoelectricity could be used to power sensors that could monitor the stress on engine components or buildings, and the temperature of braking elements in trains, planes and cars. Dr. Zhong Lin Wang and his team have developed a series of nano brushes which can be woven into clothing. These harvest energy from arm or leg movements and convert it into electricity which can be stored in a battery for later use.

Teachers' corner

Websites

- CSIRO electrical shirt to give soldiers a buzz on the battlefield. <http://www.itnews.com.au/News/95948,csiro-electrical-shirt-to-give-soldiers-a-buzz-on-the-battlefield.aspx>
- Professor Zhong Lin Wang's Nanoscience research group. <http://www.nanoscience.gatech.edu/zwang>
- Japan: Railway passengers to electricity at train stations. <http://www.orgismo.com/2006/08/02/japan-railway-passengers-to-generate-electricity-at-train-stations>

Video

- CC430 Energy Harvesting http://www.youtube.com/watch?v=aT67dfl_WnY
- Energy harvesting and Vibration control of buildings www.youtube.com/watch?v=f7e0ivDw_Po
- Energy harvester could change how we get power www.youtube.com/watch?v=2z4ApY8grD4

Thermoelectrics

The thermoelectric effect occurs when there is a difference between the temperatures of conducting materials. Effectively this means that electricity is generated by converting heat energy to electrical energy. Thermoelectric (sometimes called pyroelectric) materials can be used as heaters, coolers, and generators called TEGs (thermo electric generators). Small TEGs can be used to convert body heat to electricity, while larger ones can be used in nuclear reactors to convert the heat generated by nuclear fission into electricity.

The advantages of thermoelectrics include the lack of moving parts, they do not need to be replenished and they can be used for heating or cooling. In fact, one company claims that thermoelectric are capable of 100,000 hours of use before they need any maintenance. Currently thermoelectrics have a very low energy conversion rate of around 10%. Research is focused on improving this by using materials that conduct electricity well over a temperature gradient but do not conduct heat well. Scientists are also investigating ways to transform wasted heat like that from a car engine into electricity.

Try This! Years 7-10

Electricity from candles

You will need:

- 2 candles – pillar candles are best
- 2 nails
- matches
- small light bulbs or LEDs
- 2 leads with alligator clips
- strong magnet
- paper clip

Method:

1. Push a nail into the side of each candle. It should be about halfway through.
2. Rub the surface of the nail with the magnet to magnetise it. Remember to only rub the nail in one direction, not backwards and forwards. Use the paperclip to check it is magnetised
3. Clip a lead onto each nail, and attach the free end of the nail to the light bulb
4. Light the candles and observe what happens

Teachers' corner

Websites

- Thermoelectric power generation and refrigeration systems <http://Web.me.unr.edu/me372/Spring2001/> Look for the Thermoelectric Power Generation and Refrigeration.pdf in left column.
- Thermoelectricity explained <http://web.mit.edu/newsoffice/2010/explained-thermoelectricity-0427.html>
- Thermoelectrics <http://www.its.caltech.edu/~jsnyder/thermoelectrics/history.html>
- Pyroelectricity: from Ancient Curiosity to Modern Imaging Tool <http://www.slac.stanford.edu/grp/arb/tn/arbvol5/AARD459.pdf>
- New Pyroelectric Device Transforms Heat into Electricity with 30% Efficiency www.greenoptimistic.com/2011/05/17/scott-hunter-pyroelectric/

Videos

- Basic history of thermo electricity <http://m.youtube.com/#/watch?v=t53LGmpWLA>
- How do thermoelectric generators work? <http://www.thenakedscientists.com/HTML/podcasts/scrapbook/show/20120210/>
- Joule thief thermal electric generator energy harvesting from a candle. <http://www.youtube.com/watch?v=Ev3GnbhzFzY>

Electrostatic (capacitive) energy harvesting

This technology uses the motion of magnets to convert kinetic energy into useable electricity which can be stored in batteries. A team of CSIRO researchers lead by Dr. Adam Best have designed a jacket that keeps the wearer warm, is lightweight and flexible but which has micro generators, electrical fibres and flexible batteries embedded in it. As the wearer moves, the magnets are moved around, generating electric currents that are harvested and stored. These allow the wearer to be able to power a torch, radio or other small electrical appliance without having to carry other batteries. Find out more about these flexible integrated energy devices at <http://www.csiro.au/Outcomes/Energy/Storing-renewable-energy/flexible-integrated-energy-device.aspx>

Teachers' corner

Websites

- Current from magnets - this is a virtual experiment which will require Flash
<http://www.absorblearning.com/physics/demo/units/DJFPh055.html#Amovingwire>
- Harnessing kinetic energy
www.technologyreview.com/Energy/19777/

Metabolic sugar energy harvesting

Animal metabolic sugar harvesting

Sugars are an energy source your body uses every day. Researchers have been looking for ways to use blood sugar to power devices such as heart pacemakers and sensors that can measure heart rate, blood pressure, blood sugar levels and hormone levels without the need for invasive procedures such as needles and surgery. Already a team of scientists from Clarkson University in New York have found a way to use the blood sugar of snails to generate electricity, and are beginning research into repeating this using larger animals.

Try This! Years 7-10

Electrostatic energy

You will need:

- compass
- strong bar magnet with a North and South pole
- 4m insulated copper wire
- cardboard alfoil or paper wrap tube cut in half
- pliers or wire cutters
- ruler

Procedure:

1. Remove about 2 cm of insulation from each end of the wire using the pliers.
2. Starting at the top (North) end wrap the wire five times in a clockwise direction around the compass so the needle is covered.
3. Extend the wire out from the magnet about 60cm.
4. Wrap the wire around the cardboard tube at least 5 times – be careful to keep a distance of about 60cm between the compass and the cardboard tube.
5. Connect the two ends of the wire together by twisting them.
6. Move the bar magnet in and out of the cardboard tube, with the north end of the magnet going into the tube first. What happens to the needle of the compass? If nothing happens, increase the number of loops of the wire around the cardboard tube.
7. Try step 6 again but with the south end of the magnet entering the tube first.

The movement of the magnet causes the electrons in the copper wire to move. This results in a charge being moved around the wire to the compass where it makes the compass needle move away from its North position. Can you light up an LED light this way? Investigate this for yourself and see how many turns of wire around the cardboard tube you need to make the LED shine.

Try This! Years 7-10

Find out more about how biofuel cells generate electricity from the human body by visiting: <http://electronicsbus.com/implanted-biofuelcells-generate-electricity-human-body/>

Biomimicry

Biomimicry uses examples from nature to provide ideas to solve problems. When the engineers building the high speed bullet train in Japan were trying to reduce the amount of

strain on the front of the train they found their solution in the beak of the kingfisher. This bird dives into water at high speed, subjecting its beak to large amounts of strain. By modelling the front of the train on the beak design, engineers reduced the impact of the strain and streamlined the train so it moves faster at high speed.

Plants are the ultimate harvesters of solar energy. The design and position of their leaves ensure that the maximum amount of sunlight is captured and converted from solar to chemical potential energy that is stored in the bonds within sugar molecules. Researchers are using trees as exemplars to design energy harvesting trees. In particular, they are investigating the evaporation of water from leaves by making nano leaves which contain layers of microscopic channels. The leaves are attached to a metal 'stem' using metal charged plates. The movement of water through the leaves is interrupted by bubbles which generate an electric current.

Teachers' corner

Websites

- Glass leaf 'sweats' to generate electricity <http://www.newscientist.com/article/dn17538-glass-leaf-sweats-to-generate-electricity.html>
- Energy harvesting trees <http://www.ubergizmo.com/2009/02/energy-harvesting-trees/>
- Ask Nature <http://www.asknature.org/>
- Biomimicry Institute http://www.biomimicryinstitute.org/case_studies.php

Video

- Biomimicry solarbotanic energy from nature <http://www.youtube.com/watch?v=7BhNHlhv7OM>

Electroactive polymers

Polymers are large molecules in the plastics in shopping bags, the polyester and nylon in your clothes and probably the chair you are sitting on. Some polymers are electroactive, that is they change shape when exposed to electricity. This change in shape or size can be used to generate electricity which can be harvested using piezoelectric devices. Currently this technology is being used to develop materials for robotics and sensors.

Teachers' corner

Websites

- Focus issue on biomimetics using electroactive polymers as artificial muscles http://iopscience.iop.org/1748-3190/2/2/E01/pdf/1748-3190_2_2_E01.pdf
- Electroactive polymers (EAP) as artificial muscles (EPAM) for robot applications www.hizook.com/blog/2009/12/28/electroactive-polymers-eap-artificial-muscles-epam-robot-applications

Video

- Artificial muscles power new devices <http://www.youtube.com/watch?v=hyycT2IMONk>

Plant metabolic energy

They may not look like it but plants move quite a lot and not just in the wind either. Plants open and shut pores called stomata on their leaves, move water to their leaves and foods like starch to their roots. They turn their leaves to harvest as much solar energy as they can. These processes are often slow so we don't notice them. Plants also use sugars and starches as energy sources which can be converted into electricity. By using this as a power source, heat detecting sensors can be attached to trees to warn of bush fires. These sensors have no need for batteries as they use the metabolic energy of the trees.

Teachers' corner

Websites

- Bioenergy Harvester <http://voltreepower.com/bioHarvester.html>
- Voltree Power makes trees sensitive <http://www.slashgear.com/voltree-power-makes-trees-sensitive-1018868/>

Noise harvesting

Sound is a form of kinetic energy we experience all day, every day. It is a constant source of energy which as yet is not used on a large scale. This is mainly because noise needs to be loud and continual to enable it to be harvested. When compared to solar energy, the energy density of sound is much lower, making it less economical to harvest for most applications. One use for sound energy could

be recharging mobile phones. This would involve converting the vibrations from the sound of conversations into electricity, which is stored in the phone's battery for later use. Ideally your battery should never go flat again, because every ring, buzz, beep and word will generate the electricity to keep it going.

Teachers' corner

Websites

- Can sound be converted to useful energy? <http://engineering.mit.edu/live/news/1809-can-sound-be-converted-to-useful-energy>
- Parametric generators could power your watch with street noise <http://www.techcrunch.com/2010/23/parametric-generators-could-power-your-watch-with-street-noise/>
- Mini generators make energy from random ambient vibrations <http://www.ns.umich.edu/new/releases/7585>

Magnetic bacteria

Magneto tactic or magnetic bacteria are bacteria which have a microscopic crystal of magnetite in their cell. What's magnetite? It's a mineral containing iron that is used in compasses. These bacteria were first discovered in 1975 despite them being very common in fresh and salt water. But it took a 16 year old student Kartik Madiraju who demonstrated that these bacteria can be used as an energy source.

Teachers corner

Websites

- Power Up With Magnetic Bacteria <http://www.wired.com/science/discoveries/news/2006/05/70882>
- Generating electricity from magnetic bacteria www.ecofriend.com/entry/generating-electricity-from-magnetic-bacteria

Better ways of using non-renewable energy resources

Better ways of using non-renewable energy resources

Coal seam gas

If you could look very closely at coal it would look like a sponge with lots of gaps, holes and folds. The methane gas trapped in these spaces is called coal seam gas. The gas is 'adsorbed', that is, attracted to the surface of the coal where held in place by water that has been soaked up by the porous coal 'sponge'. The water keeps the gas trapped preventing it from being easily extracted. Removing the water reduces the pressure keeping the gas adsorbed, and it travels with the water out of the coal and to the surface.

To extract the coal seam gas, wells are drilled between 300 – 1,000m below the surface and the water is pumped to the surface, carrying the coal seam gas with it. At the surface the coal seam gas is separated from the water, purified, compressed and piped to consumers.

The water can be treated and used for a wide variety of uses from human consumption to irrigation, or recycled and returned to the coal seam. The amount of water removed from the natural underground reservoirs can vary from a few thousand litres to hundreds of thousands of litres daily. This can be a huge amount of water and has led to concerns about the possible long term consequences of moving this amount of water out of underground reservoirs even if it is pumped back. Researchers already know that as water moves up to the surface from these reservoirs it carries salt deposits with it and can lead to increased salinity in water and soil.

Try This! Years 4-9

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.

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

Did you know?

Using coal seam gas to generate electricity produces around half the greenhouse gas emissions of black coal and 70% less than brown coal. This makes it a candidate for use as an interim energy source while renewable energy sources and technologies are developed.

Did you know?

It took a 120m layer of plant material and over 200 million years to make a 1m thick coal seam!!

Try This! Years 5-9

How solid is a rock?

Divide students into groups. Each group should collect five rocks. Provide each group with samples of sedimentary rocks e.g. 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.

Did you know?

It has been estimated that Queensland has enough coal seam gas resources to power the whole state for 10,000 years!

Did you know?

In Queensland, harvesting coal seam gas brings around 20,000L of water to the surface, carrying minerals and salts as well as the gas. What impact will this have? Researchers are still looking into this aspect of coal seam gas extraction.

Fossil fuels

Since the Industrial Revolution the use of fossil fuels has grown to be the most common energy source used for transport and generating electricity. Fossil fuels are economical to extract and use, provide easily accessed energy and have resulted in the technology and lifestyle Australians currently enjoy. Many of the plastics, polymers and other modern products are the results of the extraction and refining of crude oil.

The down side of fossil fuel use is the emissions that are produced when fossil

Teachers' corner

Websites

- The advantages and disadvantages of extracting coal seam gas are being debated in Australia at the moment. This topic can be an ideal one for teaching evaluation of secondary information sources which could culminate in a class debate or persuasive presentations. The CSIRO and *Future Sparks* websites both have good quality information at a level appropriate for middle school students. <http://www.csiro.au> and <http://www.futuresparks.org.au>
- The ABC website 'Coal Seam Gas by the Numbers' has articles, graphs and statistics presenting both sides of this debate at a level suited for upper and middle high school <http://www.abc.net.au/news/specials/coal-seam-gas-by-the-numbers/>
- The Australian Government Department of Sustainability, Environment, Water, Population and Communities website presents information from a range of government departments outlining the current legal requirements and statistics about coal seam gas mining as well as links to other state government departments and organisations <http://www.environment.gov.au/epbc/coal-seam-gas/index.html>
- What is coal seam gas? How is it made? What is its impact on the environment? These are all questions the Queensland Government Department of Environment and Resource Management has information on. Check out http://www.derm.qld.gov.au/environmental_management/coal-seam-gas/index.html
- The CSIRO has scientists investigating ways of harvesting coal seam gas efficiently and minimising its environmental impact through a wide range of different projects. Find out about them at <http://www.csiro.au/Portals/Publications/Brochures--Fact-Sheets/coal-seam-gas.aspx>
- How can the water from coal seam gas harvesting be managed? These CSIRO scientists are investigating different ideas <http://www.csiro.au/news/coal-seam-gas#FactSheets> See *Coal seam gas-produced water and site management pdf*.

Video

- *Gas land - Australia* is a 2011 Oscar Nominee: Best documentary short film about coal seam gas extraction in Queensland. <http://www.gasland.com.au>
- *Myths about coal seam gas* from the Queensland Department of Resources and Mining addresses some of the questions about how the coal seam gas mining industry is regulated and controlled in Queensland http://www.derm.qld.gov.au/environmental_management/coal-seam-gas/vodcast.html

fuels are burned. Fossil fuels were formed over millions of years from the remains of prehistoric animals and plants. This means that they contain similar chemicals to those your body contains. When these chemicals are burned they form nitrous oxides, sulphur dioxide, carbon dioxide, water and methane gas. All of these have been identified as contributors to climate change.

Australia is committed to lowering our emissions of these gases dramatically in the coming years. Australia's strategy to achieve lower greenhouse gas emissions includes developing more efficient and less polluting technology for the use of fossil fuels while continuing the development and use of renewable fuels. This is one of the major focuses of the CSIRO who have researchers working in the areas of hydraulic fracturing, reservoir engineering, wells and deep sea technologies, drilling geomechanics, gas processing and conversion. Find out more at <http://www.csiro.au/Organisation-Structure/Divisions/Earth-Science--Resource-Engineering/Petroleum-engineering.aspx>

Did you know?

Did you know that coal, natural gas and crude oil are all stored solar energy from the Sun?

Case Study

Dr. Karen Kozielski leads a team of scientists and engineers at the CSIRO investigating new materials for use in pipelines carrying crude oil and gas from oil rigs in the oceans off the coast of Australia. This team is researching ways to maximise extraction of oil and gas while reducing their environmental impact, especially in the case of leaks and spills from the piping. You can read about Dr. Kozielski's team and their achievements at <http://www.csiro.au/Organisation-Structure/Divisions/Earth-Science--Resource-Engineering/KarenKozielski.aspx>

Did you know?

Petroleum bearing rock is porous – it has microscopic spaces which liquids can seep into. The mass of most petroleum bearing rock contains between 5-25% oil and gas.

Try This! Years 7-10

Find out how gas and oil are made at this interactive website <http://www.adventuresinenergy.org/>

Did you know?

There are over 21,000km of natural gas pipelines in Australia.

Try This! Years 3-6

Use this interactive map to track emissions from the power plants in your area.

<http://www.forteachersforstudents.com.au/NPI/Interactives/spike-map.php>

Case Study

Dr. Hua Guo is a mining engineer with over 30 years of operational and research experience who leads the CSIRO's Coal Production theme. He was the initiator of an integrated research approach into issues such as safety, deep coal mining and coal mine methane extraction and use. Find out more about Dr. Guo and his team's research and collaboration with International groups interested in the same issues at www.csiro.au/Organisation-Structure/Divisions-Earth--Resource-Engineering/Hua-Guo.aspx

Try This! Years 3-6

Visit Ollie's World and find out more about energy from fossil fuels at <http://www.olliesworld.com/planet/aus/info/info/energ04.htm> before playing some of the games.

Case Study

Dr Jane Hodgkinson is a geologist who is currently researching how the shift to renewable energy sources is impacting on the operations and lives of staff working in fossil fuels. She is also interested in ways of storing carbon dioxide gas underground. This process is called geosequestration and you can find out more about it and Dr. Hodgkinson at <http://www.csiro.au/Organisation-Structure/Divisions/Earth-Science--Resource-Engineering/JaneHodgkinson.aspx>

Try This! Years 6-10

Watch an animation about oil at 'Energy source oil' <http://www.eon-uk.com/EnergyExperience/351.htm>

Teachers' corner

- **An interactive map:** Details of the locations of fossil fuel power stations in Australia can be found at http://www.oresomeresources.com/interactives_view/resource/interactive_fossil_fuel_power_stations_in_australia_map/section//parent//category/oresome_interactives
- **Lesson plans and resources:** for teaching about coal fired electricity power stations can be found at http://www.oresomeresources.com/interactives_view/resource/interactive_coal_fired_energy_plant/section//parent//category/oresome_interactives
- **Quiz:** How much do your students know about fossil fuels? Invite them to show off their knowledge with this quiz http://www.ecokids.ca/pub/eco_info/topics/energy/quiz/index.cfm
- **Lesson plans:** Learning about fossil fuels - for younger students. Contains a series of lesson plans and resources for teaching middle to lower primary students about fossil fuels <http://www.fe/doe/gov/education/energylessons/index.html>
- **Fact sheets:** Easy to read fact sheets about fossil fuels for middle primary school students can be accessed for
 - coal <http://www.depweb.state.pa.us/justforkids/cwp/view.asp?a=3&q=472755>
 - oil <http://www.depweb.state.pa.us/justforkids/cwp/view.asp?a=3&q=472741>
 - and gas <http://www.depweb.state.pa.us/justforkids/cwp/view.asp?a=3&q=472748>

Websites

- BrainPOP Jr has teacher resources and links to helpful websites for upper primary students at <http://www.brainpopjr.com/science/conservation/naturalresources/grownups.weml>
- Where are Queensland's natural gas and oil fields? Have a look at this map http://www.oresomeresources.com/interactives_view/resource/interactive_oil_gas_and_methane_gas_in_queensland_map
- *Petroleum Systems: our energy, our future.* Find out about the future of Australia's petroleum resources <http://www.csiro.au/Outcomes/Energy/Energy-from-oil-and-gas/Petroleum-systems.aspx>
- Read about the innovating procedures CSIRO scientists are developing to maximise the efficiency of oil and gas mining:
 - Enhanced oil recovery: getting every last drop <http://www.csiro.au/Outcomes/Energy/Energy-from-oil-and-gas/EOR.aspx>
 - Flow assurance: A smooth ride for oil and gas <http://www.csiro.au/Outcomes/Energy/Energy-from-oil-and-gas/Flow-Assurance.aspx>
 - Gas Processing and conversion: fuel for Australia's future <http://www.csiro.au/en/Outcomes/Energy/Gas-Processing-Conversion-Fuel-Future.aspx>

Efficient energy management

Electricity transmission

Most electricity is generated kilometres away from where it is used. When it is generated, the electricity usually has a voltage of around 25,000 volts. It travels through thick wires to transformers. Most materials resist the movement of electricity through them. Even metals which are good electrical conductors have a small degree of resistance. This is why electricity is transformed from 25,000 volts to about 400,000 volts before being transmitted long distances. The electricity passes through substations where this process is reversed at step down stations before it goes to be used in households, businesses and industries.

Did you know?

The National Electricity Market links all of the electricity grids of the Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania and Victoria. This means electricity from Tasmania can be used in Queensland! The 290km link between Tasmania and Victoria is one of the longest submarine power cables in the world!

The further the electricity travels from the generator, the lower the amount of useable energy available for appliances. About 2.5% of the electrical energy is transformed into heat energy which is absorbed by the transmission wires' insulation or transferred to the air. Another 1-2% is transformed into magnetic energy, 3-5% is lost at the transformers and the step down, so in all between 8-15% of the electricity generated doesn't get to its users. New technology to make the transmission of electricity more efficient include high efficiency transformers, superconducting transformers, high temperature superconductors, direct current transmission, and ultrahigh voltage transmission in both A.C. (alternating current) and D.C. (direct current) modes.

Try This! Years 5-9

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.

Try This! Years F-6

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?

Around 9.5% of electricity generated in Australia is 'lost' on the journey from the generator to the user.

Case Study

High efficiency transformers

Traditional transformers have iron cores which become magnetised when electricity flows through them. High efficiency transformers avoid this by using iron, boron, silicon and carbon mixtures in their cores which do not form crystals when they solidify. Although more expensive than traditional transformers they are much more efficient often reducing electricity losses by up to 70%. Find out more about transformers by watching:

- How does a transformer work?
<http://www.youtube.com/watch?v=5LmJjklXvw>

Case Study

Superconducting transformers

Superconductors are materials that conduct electricity without transforming any electrical energy to other forms of energy. Typically this occurs at temperatures between -269°C and -135°C which are reached by immersing the material in a coolant such as liquid nitrogen. A serious disadvantage of these transformers is the need to keep them at low temperatures which means that disruptions such as lightning strikes and power surges can cause serious damage.

For more information check out:

- Superconducting transformers for the grid
<http://www.scitechstory.com/2010/01/31/superconducting-transformers-for-the-grid>
- Superconducting transformers will complement greener smart grid technology
<http://www.digitalcommunities.com/articles/Superconducting-Transformers-Will-Complement-Greener-Smart.html>

Teachers' corner

Websites

- Power Sleuth (<http://www.powersleuth.org>) is a website from the Maine Mathematics and Science Alliance with lesson plans, worksheets, power points, videos, virtual tours and links to online resources for primary school teachers and students.
- *Using Electricity* is a BBC Bitesize revision site focusing on the transmission of electricity through the British National Grid. This can be useful to revise concepts and as a model for the transmission system in Australia.
http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/energy/
- Explore the different ways used to produce electricity commercially <http://www.energyquest.ca.gov/story/chapter06.html>
- How is electricity transmitted? <http://www.enmax.com/Corporation/About+Enmax/Electricity+101/How+is+Electricity+Transmitted.htm>
- *Energy Story — Electricity Transmission System*
<http://www.energyquest.ca.gov/story/chapter07.html>
- *Transmitting electricity* has lots of information and activities with a good glossary to help you understand the way electricity is transmitted to your home <http://powerup.ukpowernetworks.co.uk/over-11.aspx>
- *How Electricity Gets To Your House.* Follow the journal from the power plant to your door at this website <http://www.alliantenergykids.com/EnergyBasics/AllAboutElectricity/index.htm>

Videos

- What is the smart grid?
<http://www.youtube.com/watch?v=-8cM4WfZWg>
- How does the electric grid work?
<http://www.youtube.com/watch?v=38EEemWHI0C8>
- How power gets to your home?
<http://www.youtube.com/watch?v=pXasvq1ivnw>

Did you know?

The volt, which measures the force used to push electricity around a circuit, was named after Alessandro Volta the Italian physicist who invented the first battery.

Case Study

High temperature superconducting cables

High temperature superconducting cables are more expensive than traditional electricity cables but have the advantages of being lighter, more compact and importantly reducing the loss of electrical energy to nearly zero. Although these are called high-temperature, they are actually cooled to around -203°C using liquid nitrogen or helium. Currently no electricity grid in the world uses superconducting cables, but there are plans to use them as the backbone for grids in North America and Europe which are harvesting solar and wind energy for transmission across countries.

Read these articles to find out more:

- Super-thin superconducting cables
<http://www.technologyreview.com/energy/32424>
- Superconductors to wire a smarter grid
<http://www.technologyreview.com/energy/23928>

Batteries

Batteries

What are batteries?

Batteries are cells that store chemical energy that can be converted into electrical energy when required. Batteries are a common power source used in many things including toys, television remote controls, watches, clocks, mobile phones, portable devices (e.g. laptop computers, music players, tablets, radios).

Did you know?

The first practical battery was invented in 1800 by Alessandro Volta.

Batteries consist of a series of cells. In a cell, a metal electrode, such as lithium and zinc, are placed in a conductive solution known as electrolyte. Atoms in the surface of the electrode exchange electrons with the electrolyte and the atoms in the electrode become charged (ions). The ions move freely from the electrode to the electrolyte, creating an electrode potential, where there is a difference between voltage in the electrode and electrolyte. Electrode potential depends on the atomic structure of the metal and can vary between different types of metals.

Each cell contains a positive electrode, where the process of reduction occurs (electrode gaining electrons) and a negative electrode, where the process of oxidation occurs (electrode losing electrons). When there is an external circuit attached to the electrodes, the electrons are able to flow between the electrodes that enable the reduction and oxidations reactions to continue, providing electrical energy. In the absence of an external circuit, the reduction and oxidation reactions continue until they become blocked by the build up of charged ions, storing energy until it is released.

Types of batteries

There are two types of batteries — primary and secondary batteries. Primary batteries are disposable batteries. Generally, primary batteries have higher energy densities and have a lower upfront cost than secondary batteries. As a result of the irreversible energy transformation, more waste is produced compared to rechargeable batteries.



Battery. Source: Stock Xchng

Secondary batteries are rechargeable batteries. Over the long term, secondary batteries are more cost-efficient due to their rechargeable ability; however, they have a lower energy density than primary cells.

Types of cells

Wet cell

Wet cells contain liquid electrolyte that covers all the internal parts in the cell. Both primary and secondary batteries can consist of wet cells. An example of a secondary wet cell battery is a car battery that contains a lead-acid electrolyte. Over time with extend use; wet cell batteries eventually lose their ability to generate electricity due to corrosion of the electrodes.



Vehicle batteries are an example of a wet cell battery.
Source: iStockphoto

Dry cell

Dry cell batteries contain a paste electrolyte and are the most common batteries used. The paste contains enough moisture to allow the flow of ions through it. An advantage to the dry cell battery is that the battery can be used without the risk of spilling the electrolyte. Dry cells can be primary batteries, like silver and mercury batteries or they can be secondary batteries like nickel/cadmium batteries.

Molten salt cell

Molten salt cells contain salt heated in a liquid form as the electrolyte. Salt in the liquid form allows the ions to flow. Batteries that use molten salt cells operate at high temperatures and must be well insulated for the heat to

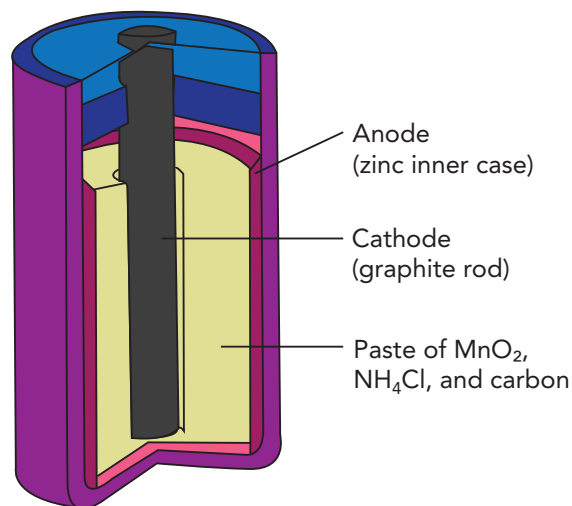


Diagram of a dry cell battery.

be retained. As a result of the energy and powder densities in molten salt cells, there is the potential for using these cells in electric vehicles.

Reserve cells

Reserve cells store the electrolyte and electrodes separately. This avoids the deterioration of the materials, as they are inactive when stored separately. Reserve batteries can be activated by assembling the internal parts together and provide a ready-charged battery. Reserve batteries are generally used in emergency situations.

Battery capacity

Battery capacity refers to the amount of electric charge that can be extracted from the battery under specific conditions. The amount of available electrical discharge from the battery is measured in ampere-hours (Ah). Discharge conditions, such as the magnitude of the current, temperature and allowable terminal voltage of the battery can influence battery capacity. Discharge rates can vary due to the rate of diffusion of ions through the electrolyte.

Try This! Years 7-10

List advantages and disadvantages of renewable and non-renewable batteries.

Case Study

CSIRO UltraBattery

CSIRO have developed a new, dynamic technology, UltraBattery that aims to:

- power low emission transport (hybrid electric vehicles), and
- provide solutions for renewable energy storage from wind and solar sources.

This technology uses a supercapacitor in conjunction with a lead acid battery to form a hybrid energy storage device which results in a high power discharge with the benefit of a long, low-cost life.

The benefits of the UltraBattery include:

- reliability
- stability
- load levelling
- remote area power supply
- emergency backup

For more information, see <http://www.csiro.au/en/Outcomes/Climate/Reducing-GHG/Ultra-Battery.aspx>

Teachers corner

Website:

Monkeysee Watch, Learn, Discover
<http://www.youtube.com/user/monkeyseevideos>
has a range of videos.

Activities:

How to make a battery:
<http://www.youtube.com/watch?v=ax3iMxqu3ks>

How to make a potato battery: <http://www.youtube.com/watch?v=FITxr6bJmd8>

How to make a battery out of a film canister:
<http://www.youtube.com/watch?v=FTEfZETJykM>

How to power a stopwatch with a homemade battery: http://www.youtube.com/watch?v=dszVJeh_fUI

Basic battery circuitry: <http://www.youtube.com/watch?v=umtgfFoVle0>

Try This! Years 3-10

Make your own batteries using:

Lemons

<http://www.csiro.au/helix/sciencemail/activities/lemonbattery.html>

http://www.education.com/activity/article/make_a_battery/

Potatoes

<http://www.miniscience.com/projects/potatoelectricity/>

Copper-zinc

http://quiz2.chem.arizona.edu/preproom/Demo%20Files/cu-zn_battery.htm

The future of energy storage

We know that once energy is generated it needs to be stored. Even renewable energy systems must have some form of storage in order to make them reliable and accessible all the time. Wind only blows intermittently, therefore there needs to be some form of storage for when the wind isn't blowing. The energy from the Sun is not available on cloudy or rainy days or during the night, so there needs to be some form of storage for when there is a lack of sunlight.

Scientists in industry are at the forefront of finding ways to store renewable energy to cope with the supply and demand of the world. There are many companies around the world addressing this issue in a number of ways.

Solar energy can be stored in salt!

The Sun's rays are concentrated using concave mirrors and the heat produced is then used to melt salt (molten salt). The molten salt is then moved into large tanks and the heat is used to power turbines to generate electricity day or night! This is already a well proven method of energy storage.

Case Study

Wizard Power based in Canberra, Australia is developing a project called SUMO — SUperheated MOlten Salt. Find out more about this technology by visiting their website:

http://www.wizardpower.com.au/index.php?option=com_content&view=article&id=37&Itemid=36

Advantages:

The temperature of the molten salt is very high, so it is very good for storing and recovering energy and because it can withstand much heat before it vaporises.

Disadvantages:

The solar fields needed to cope with the demand of heating the thermal tanks and running the turbines at the same time, have to be built extra-large within the plants. This results in increases in costs in capital, storage areas, material and labour.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in *Australian Science Illustrated*, September/October 2011, p. 37.

Compressed air

Another well proven method is the use of compressed air to store energy. Underground cavities are filled with air under high pressure. This is then used to drive turbines. There are only a few CAES (Compressed Air Energy Storage) systems in the world, but several are in development.

Advantages:

Due to being underground, compressed air plants do not present any 'visual pollution' to the surrounding areas. The power can be delivered very quickly, in a few minutes and the compressors can also utilise surplus power supplies to compress the air.

Disadvantages:

Finding suitable underground areas is difficult. Such areas need to be free of groundwater to prevent chemical changes to the water caused by the process of compressing the air.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in Australian Science Illustrated, September/October 2011, p. 38.

Using lakes to store water for power

In this well proven technique, used in conjunction with hydroelectric power stations, water is pumped into lakes located in high places, so that it can be stored for later use. The reservoir is located on a hilltop and stores energy in the form of water. When electricity demand is high, the water is released from the reservoir to power the turbines in the hydroelectric power station, generating electricity.

Advantages:

It has the potential to store large amounts of water and is relatively cheap to construct. It can also be used in conjunction with wind power plants for pumping the water into the storage areas.

Disadvantages:

Finding the right location can be difficult, as there needs to be suitable elevation and large enough lakes to store the large amounts of water required.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in Australian Science Illustrated, September/October 2011, p. 39.

Superconductors

What is a superconductor?

A superconductor is an element or an alloy (such as tin or aluminium) that will conduct electricity without resistance. Once started, electrical current will flow continuously in a closed loop of superconducting material. This means that superconductors are very energy efficient. This method of storing energy is still progressing as a technology.

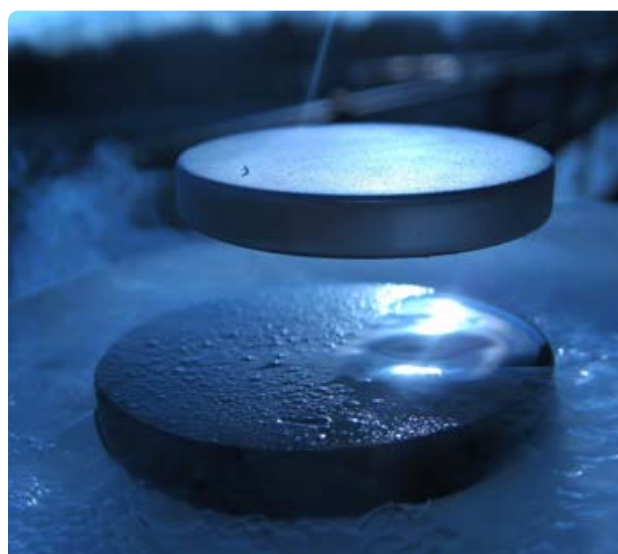
Advantages:

Electricity can be stored more or less without any loss and the current is instantly and efficiently available when needed.

Disadvantages:

Superconducting wires are very expensive, so there are only a few superconductor storage sites in the world. Energy is also consumed to keep the superconductor working at the correct temperature.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in Australian Science Illustrated, September/October 2011, p. 39.



Levitation of a magnet on top of a superconductor of cuprate type $\text{YBa}_2\text{Cu}_3\text{O}_7$ cooled at -196°C . Source: Julien Bobroff, Frederic Bouquet/Wikimedia Commons

Case Study

Zenergy Power in Wollongong, Australia is one of the leading specialists in renewable energy storage systems that use superconductors. Visit their website to read more about these technologies

<http://www.zenergypower.com.au>

Flywheels

What is a flywheel?

A flywheel is a rotating mechanical device that stores energy. Flywheels function like mechanical batteries. They generate and store energy by either increasing or decreasing the rotational speed at which it is turning. Flywheels are made of composite materials suspended by magnetic bearings. They can rotate up to 50,000 revolutions per minute! Read more about flywheels by visiting the website: <http://en.wikipedia.org/wiki/Flywheel>

Advantages:

Flywheels can be spun up and discharged thousands of times, meaning they can be used over and over again. New technologies are assisting in accelerating flywheels to top speed in just a few seconds.

Disadvantages:

Flywheels must be housed in very strong containers due to the speeds at which they rotate. Flywheels also only store moderate amounts of energy, so usually need to be set up in a series to store large amounts.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in Australian Science Illustrated, September/October 2011, p. 41.

Underground balloons

One method of energy storage that is about to undergo trialling is that of underground balloons that power turbines. This method is new, however an experiment conducted in Denmark (on a small scale) proved successful. This has prompted further investigation into construction on a larger scale.

A hole is excavated in the ground and a balloon is placed in the hole. The balloon is made of multiple layers of plastic. The soil that was removed from the hole is placed over the position of the balloon on the surface, creating a layer of earth approximately 25 metres thick. Water is then pumped into the balloon, expanding it underground. The soil from the surface presses down on the balloon, creating pressure. This pressure is used to drive a turbine.

Advantages:

Being a small-scale operation, there is little visual impact on the physical environment on the surface of the Earth. Grass could be

planted over the balloon, creating a hill that moves up and down! The water that could be used could be recycled, or even pumped in from the sea.

Disadvantages:

At this time the disadvantages are rather unknown due to the fact it has only been tested on a small scale. The major cost involved initially would be the large-scale excavation work required to construct the hole for the balloon.

Reference: LB Salomon, (2011) '10 methods to store clean energy', in Australian Science Illustrated, September/October 2011, p. 40.

Other technologies in the progress of being developed include:

1. Wind being stored as natural gas
2. Molten metal batteries
3. Groundwater reservoirs
4. Vanadium batteries storing wind energy
5. Combining different sources of energy in the one power plant

Try This! Years 6-10

Researching and discussing alternative storage solutions

- Conduct some research on the methods of storing energy discussed above.
- Write a list of advantages and disadvantages for each.
- Research the Australian energy companies at the forefront of these technologies — what other services and projects are they working on?
- Conduct a debate on how these new methods might impact on the environment.
- Underground balloons and compressed air — what else might the future hold? Think about what other options there might be out there.

Teachers' corner

Want to find out more information about energy storage? Try these websites.

Wikipedia — Energy storage
http://en.wikipedia.org/wiki/Energy_storage

The U.S. Department of Energy <http://energy.gov/oe/technology-development/energy-storage>

CSIRO Article 'Smarter energy storage for solar and wind power' <http://www.csiro.au/Organisation-structure/Divisions/energy-Technology/SmarterEnergyStorage.aspx>

Living sustainably

Living sustainably

What is living sustainably?

Living sustainably is the ability of a system to function without destroying itself. This means living within the Earth's limits, meeting our needs without damaging or depleting the Earth's environmental, economic or social resources without impacting future generations.

Why should we live sustainably?

Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our Ancestors, we borrow it from our Children. Native American Proverb — Oglala Sioux

Our actions today have implications for the future environmentally, economically and socially by creating pressure on the environment and problems for resource use and population growth. If we continue to exploit the Earth's resources, they will become exhausted creating demands on the environment, driving up resource costs that lead to unprofitable production. This will impede economic growth, limiting the growth of the human population. To sustain our current population we need nearly three Earths. If we continue to use Earth's resources at the current rate, by 2050, we would need at least four Earths to sustain the projected population of 9 – 9.5 billion people. The issue of sustainability is not one only for governments and international organisations, but for every person in the world.

Try This! Years F-10

Take the up2me for kids challenge on how to live more sustainably. Visit <http://www.up2meforkids.com.au/> for more information

Sustainable Homes

IMPROVING OUR SUSTAINABILITY

Sustainable Homes

Take action for living greener!

Many people think that saving energy or becoming sustainable is too difficult or expensive or they just don't know where to start. Becoming more aware of how you live at home and how you work and travel are the first steps in working towards becoming energy efficient.

What you can do at home

Here are some ideas to help you save energy, help the environment and maybe even get healthy!

- Use your car less
- Switch to efficient lighting
- Get a home assessment
- Buy a fuel efficient car
- Re-use and recycle
- Improve heating and cooling at home
- Install a rainwater tank
- Install solar power
- Ride a bicycle or walk to work or school

Try This! Years 3-10

Make a list of all the actions that you think would help save energy.

Share your list with a partner and see how well you compare!

On the Australian government's, *Living Greener* website there is a list of 41 actions that you can take. Check out the list and see how many actions you included or missed!

<http://www.livinggreener.gov.au/take-action?category=Energy>

Think about all the things you do at home that are energy efficient and match them to those actions on the website.

How do they compare? Are you as energy efficient as you think?

Try This! Years 6-10

Carbon footprint

Your carbon footprint measures how much your lifestyle is impacting on the climate around you. Find out what yours is by taking the quiz at

<http://www.powerhousemuseum.com/online/bigfoot/>

Try This! Years F-6

Energy use collage

How many different ways do you use energy at home? Create a collage showing your family's energy uses from magazine and advertising material. Talk to your family about ways they could change their energy uses.

What is a home energy audit?

One major way that you can start to save energy and live greener is to get a home assessment of your energy use and requirements. A great way to do this is to conduct a home energy audit.

A home energy audit is an examination of the energy use, processes and equipment you use at your home. By using a checklist and moving from room to room in your home, you are able to assess the way you use energy. The checklist even helps to identify areas that you can make changes to the way you use energy and not only save money, but help to save the planet as well!

Try This! Years 3-6

Powercor Australia provides an excellent home audit checklist that is easily downloadable and used for this purpose. It only takes one hour to determine what your energy use is and where you can make changes. Give it a go at your house!

Home energy audit checklist — Powercor Australia
<http://www.powercor.com.au/docs/pdf/Community%20and%20Environment/Home%20Energy%20Self%20Audit.pdf>

Try This! Years 3-10

Join the Smarty Pants – The Queensland Government's ClimateSmart Home Service is a service provided for Queenslanders where they can get information on how to become more energy aware at home.

<http://www.climatesmarthome.com/faq.html>

Another way that the Australian government recommends we become more energy efficient at home, is to buy household electrical items that have an energy efficiency star rating or an energy rating label.

What is an energy rating label?

Energy rating labels or ERLs are labels that are placed on household electrical items that indicate how much electricity an item uses, by an indicated star rating system. The label enables consumers, when purchasing electrical household appliances to consider and compare appliances according to their electrical efficiency. By choosing an appliance with a high star rating and therefore, energy efficient rating, consumers can not only save money on their electricity bills, but assist in reducing the amount of greenhouse gas emissions expelled into the environment!

Teachers' Corner

Want to learn more about sustainable housing?

Websites:

Queensland Government – Department of Local Government and Planning
<http://www.dlgp.qld.gov.au/sustainable-housing/>

EnviroCottage <http://www.envirocottage.com.au/>

New South Wales Government – Environmental Sustainability <http://www.housing.nsw.gov.au/About+Us/Environmental+Sustainability.htm>

Sustainability Victoria <http://www.sustainability.vic.gov.au/www/html/1517-home-page.asp>

Sustainable Living – Tasmania
<http://www.sustainablelivingtasmania.org.au/>

Northern Territory Government – Department of Housing, Local Government and Regional Services
<http://www.dhlgrs.nt.gov.au/>

The Sustainable Mandurah home – Western Australia <http://www.sustainablemandurah.com.au/>

Want to know more information about living sustainably?

Australian Government
<http://australia.gov.au/topics/environment-and-natural-resources/environmental-sustainability>

The Australian Government offers information, how-to's and rebates for sustainable living. Explore the website for more ways that you can take action to live greener
<http://www.livinggreener.gov.au/home>

Plan for Education for Sustainability
<http://www.environment.gov.au/education/publications/pubs/national-action-plan.pdf>

Sustainable schools

State governments around Australia are looking at ways schools can become more energy efficient and environmentally aware. Many programs are in place to assist schools in investigating and implementing solar energy, saving water and reducing their carbon footprint.

The National Solar Schools Program was a national initiative for schools to implement solar power and reduce their reliance on traditional electrical power that produces greenhouse emissions. Many schools took up the challenge and installed solar panels to power tuckshops and labs.

Some schools are able to access data programs that log how their solar panels are working, how much energy they are producing and how they are saving the planet.

School energy monitoring through Solar Schools, have approximately 1500 schools connected and monitoring their solar energy generation. Visit <http://www.solarschools.net/> to see how schools are saving greenhouse gases!

Try This! Years 6-10

Join in the School Energy Savings

If your school is currently not involved, try investigating how you can incorporate solar energy into your school. Schools Energy Savings provide schools with ways to conduct school energy audits, school heating reviews and a school environment tracking system.

<http://www.schoolenergysavings.com.au/>

Try This! Years 6-7

Are you interested in doing more for your school or organisation?

Do you enjoy helping the environment? Do you want to help save the planet?

Set-up an environmental team or club in your school or organisation!

Give yourselves a cool name and help make your school or organisation more energy efficient and sustainable.

- Conduct an energy audit
- Introduce or refine your recycling processes
- Introduce a compost heap to your school grounds
- Create a garden or habitat to help local plant and animal species
- Advocate a walk to school day
- Report to your school the new and exciting ways your school or organisation is helping to save the planet

Try This! Years 3-6

Conduct a school/organisation energy audit

Just like the home energy audit – only at school!

Take a walk around your school or organisation and assess your energy usage and requirements using an audit tool.

In what way could you change the way your school or organisation operates?

Write a list of ideas for your school or organisation to get started on saving money, energy and the planet!

Try This! Years 7-10

Have you ever thought about the amount of fuel used to grow, harvest and transport an apple to your house? Most of our food is grown many kilometres from our homes. This can mean that your orange from California or kiwi fruit from Italy could be more travelled than you!

How much energy is used to do this? How is this impacting on the environment? Use the resources at <http://learning.cat.org.uk/en/resources> to determine the real impact of importing fruit and vegetables.

Try This! Years F-6

Become a 'nude lunch' school!

No! This doesn't mean eating your lunch naked!

Becoming a nude lunch school means lunches and snacks are not wrapped in plastic! The aim is to for all students to reduce the plastic waste they produce from bringing their lunch to school.

Bring your lunch to school in containers that you can take home, wash and use again. Try re-useable lunch boxes that seal and protect your lunch but don't add to the waste already produced in schools.

Ideas include:

- Replace popper juice boxes with juice in a re-useable bottle.
- Place small biscuits or pieces of fruit in small containers.
- Don't buy snack packs of chips or biscuits that are in small plastic packets – if you do, open them at home and place them into small containers.
- Replace individual yogurt tubs and disposable spoons with containers and spoons you can take home and fill your container with yogurt from a large tub in the fridge!

Trial being 'nude' for one week and look at how the plastic waste and litter is reduced!

Try This! Years 3-6

Light and heat

We all use light bulbs every day, but have you ever thought about how energy efficient they are? When you use a light bulb you are transforming electrical energy into light energy and heat energy. You use the light energy to help you see but what happens to the heat energy? How much of this non-useable energy does a light bulb produce? Do all light bulbs produce the same amount? Is there a difference between the heat produced by incandescent and fluorescent light bulbs? Which produce the most useful light and the least useful heat in your house? Find out in this investigation.

You will need:

- a table lamp
- different light bulbs types and wattages
- thermometer
- ruler or tape measure
- A3 piece of white paper
- watch or clock
- paper and pencil to record your results

Procedure:

1. Place the paper on a flat surface, like a table. Put the lamp at the end of the paper.
2. Place the thermometer on the paper where the light bulb will shine directly on it. Use your pencil to draw around the thermometer.
3. Measure the distance from the bulb of the thermometer to the lamp socket (this is where the light bulb sits). Record this distance.
4. Make sure the lamp is unplugged and insert the light bulb with the smallest wattage. (You may need an adult to help with this).
5. Record the temperature of the thermometer – this is the starting temperature.
6. Plug the lamp in and turn the light on. Let it shine on the thermometer for 5 minutes. Turn the lamp off and record the temperature of the thermometer.
7. Let the light bulb cool before unplugging it to remove the light bulb and put in another globe.
8. Repeat steps 5 – 7 for each of the globes that you have.

Questions to think about:

Which light bulb gave out the most heat? Which light bulb gave out the least heat? Did you notice anything about the amount of electricity the light bulb used and the amount of heat it produced? Which light bulb would be the best for your bedroom light?

Case Study

1. Queensland state schools are installing solar panels and energy efficient lighting in their schools.

Many Queensland schools have instituted a SEMP or School Environmental Management Plan.

Read more about what a SEMP involves at: <http://www.sustainableschools.qld.edu.au/Default.aspx?tabid=153>

- Investigate how you can become involved in your state.

2. Victorian Schools are being resource smart.

Visit the ResourceSmart Australian Sustainable Schools Initiative Victoria (AuSSI Vic) website to see how Victorian students are working for their schools and saving the planet! http://www.resourcesmart.vic.gov.au/for_educators_2439.html

Teachers' corner

Oresome Resources provides free educational resources and teacher professional development to assist the teaching and learning of minerals and energy.

Access the website *Oresome Resources – Minerals and Energy Education* <http://www.oresomerresources.com/> for a myriad of information, interactives, curriculum activities, news and events surrounding our natural resources.

Energy efficiency fact sheets – http://www.oresomerresources.com/resources_view/resource/fact_sheet_energy_efficiency_in_homes/section/resources/parent//category/

Mining makes your house interactive –

http://www.oresomerresources.com/media/flash/interactives/mining_makes_your_house/

Images – Media Centre http://www.oresomerresources.com/media_centre/section/media

Professional development opportunities for teachers:

http://www.oresomerresources.com/teacher_education/section/teacher_education

CarbonKids: (www.csiro.au/Portals/Education/Teachers/Classroom-activities/CarbonKids/Investigating-CarbonKids.aspx) Provides units for students in Years F-10 containing a variety of learning resources and teaching strategies

How could you reduce your schools carbon footprint? Visit Eco'tude <http://ecotude.powerhousemuseum.com/> to find out how.

Games, information and activities for kids of all ages: Switched On from Energex .Visit www.energex.com.au/switched_on

What's in your lunch box? Explores the relationship between food production and consumption and the amount of energy this requires. It includes lesson plans and links to supporting resources which can be adapted from the Welsh context to Australian contexts. This resource is appropriate for Years F-8 and can be accessed at www.footprintfutures.org.uk/index.php?option=com_content%&view=article&id=56%3Awhats-in-your-lunchbox&catid=5%3Amodule-5-food&Itemid=65&lang=en

Resource books: *PowerDown Primary Toolkit* and *PowerDown Secondary Toolkit* are resource books that contain activities for student in primary and middle school students. These activities encourage students to become engaged in conserving energy and reflect on lifestyle choices. Although written for use in conjunction with the PowerDown kit and with the United Kingdom curriculum, these resources can be used in the Australian context. Both can be accessed at http://www.actionaid.org.uk/doc_lib/schools_powerdown_primary.pdf and www.actionaid.org.uk/doc_lib/schools_powerdown_secondary.pdf

Sustainable transport

Try This! Years 7-10

Rate your family's car using the *Green Vehicle Guide*:

<http://www.environment.gov.au/settlements/transport/fuelguide/index.html>

Sustainable transport minimises the impact on the environment whilst meeting the needs of individuals and societies to conduct everyday activities. This includes the use of non-motorised transport, including walking and bicycles, as well as motorised transportation, such as green vehicles, that have low fuel consumptions, low greenhouse gas and air pollutant emissions.

Did you know?

For every litre of petrol burned 2.3kg of carbon dioxide gas is released.

Green vehicles

Green vehicles are motor vehicles that produce less harmful impacts to the environment than the conventional internal combustion engine vehicles. Electric vehicles and hybrid electric vehicles use advanced vehicle technologies to reduce emissions and pollutants into the environment.

Electric cars

Electric cars, also known as electric drive vehicles, use one or more entirely electric or traction motors rather than internal combustion engine. The electric motor uses electrical energy stored in rechargeable batteries which power the controller. The controller is then able to power the electric motor. The rechargeable batteries are commonly charged by household electricity. Many electric cars also use regenerative braking technologies to recharge the batteries. Regenerative braking converts the kinetic energy when braking into electrical energy to store in the batteries.

The benefits of electric cars include the reduction of air and noise pollution, reduction of emissions and the reduction on the dependence of oil. Despite the benefits, electric



Smart Electric Drive ForTwo car charging. Source: iStockphoto

cars are more expensive to purchase than the conventional internal combustion engine hybrid cars, have a limited driving range, long recharge times and currently there is a lack of both private and public recharging infrastructure.



A closeup of an array of batteries inside an electric car. Source: iStockphoto

Hybrid vehicles

Hybrid vehicles, also known as hybrid electric vehicles, include cars, and simpler vehicle forms like mo-peds, electric bicycles and scooters. These vehicles are hybrids because they use two or more power sources. Hybrid electric cars combine a smaller conventional internal combustion engine with one or more electric motors and partially use electricity and fuel to power the car. Like the electric vehicles, modern hybrid vehicles make use of efficiency improving technologies by utilising regenerative braking to charge batteries. Some makes of hybrid electric cars generate electricity to recharge batteries or power electric drive motors by using the internal combustion engine to spin an electrical generator, known as a motor-generator. Another way hybrid electric cars reduce emission is by using a start-stop system where the internal combustion engine is shut down when the car is at idle and restarting the engine when required.

The benefits of hybrid cars include lower emissions compared to a conventional internal combustion engine vehicle and longer mileage range compared to an electric vehicle. Hybrid cars are more fuel-efficient than conventional cars, making it cheaper to run (on fuel), especially with the increasing

costs of oil. Despite lower running costs, hybrid cars are more expensive to purchase and weigh more as a result of the battery packs required for the electric motor.



Hybrid engine of a modern car. Source: iStockphoto

Try This! Years F-4

Survey other students and/or parents about the mode of transport they take to and from school/work.

Teachers' corner

- **Video** – Debate on gas cars v's electric and hybrid cars <http://www.youtube.com/watch?v=sk6eKX-AME>
- **Website** – New Scientist article *Electrified roads could power cars from the ground up* <http://www.newscientist.com/article/mg21128295.700-electrified-roads-could-power-cars-from-the-ground-up.htm>
- **Website** – ABC Science low-carb cars <http://www.abc.net.au/science/articles/2008/05/08/2238140.htm>
- **Website** – Catalyst *Future Car* <http://www.abc.net.au/catalyst/stories/2856325.htm>
- **Webquest** – Car Quest. This is a webquest activity designed for group work. Introductory work includes the design of an 'ideal car' and investigation of the possible environmental impacts of the cars in the school parking lot. The culminating webquest includes a set of guiding questions and web sources to guide groups' research. Groups share their results before each student writes a persuasive text to support their interpretation of the findings. This activity is from the World Wildlife Fund and can be accessed at <http://www.worldwildlife.org/climate/curriculum/WWFBinaryitem5970.pdf>

Sustainable buildings

We don't often think about our buildings when we think about sustainable energy, yet our buildings can be built out of materials that can minimise the amount of energy used in their construction and ongoing maintenance.

So what would a sustainable building be made of? Earth, mud and clay are all good building materials that provide insulation and sound proofing. Wood is a strong material that costs less to manufacture than steel. Using wood or other plant materials such as straw bricks also helps to reduce the buildings' carbon footprint by sequestering — or storing — carbon. Insulation made from hemp, straw and recycled papers have the same advantage.

In designing sustainable buildings the location and position of the building is important. The design of a building can promote passive solar heating where solar thermal energy is used to heat the air in daytime living areas. This is achieved by the design principles of northerly orientation of living areas, use of glass on northern facades, insulation and passive shading.

The efficiency of heating is increased through advanced glazing solutions of the glass, draught sealing and well-insulated walls. Passive shading in the form of well designed eaves help keep the building cool by excluding the higher angle summer sun.

Plants can act as shades to block sunlight and help us keep our homes cooler. In the summer, a tree with leaves will shade the home, decreasing the amount of sunlight striking the house and keeping it cooler. In the winter, when a tree drops its leaves, the sunlight is allowed to hit the home to assist in keeping it warm.

The colour your home is painted (especially the roof) can have an impact on heating and cooling it. Dark colours will absorb more sunlight while lighter colours will reflect the sunlight. So, if you paint a house and roof white or cream, the house will stay cooler in the summer.

Did you know?

You can grow a three bedroom house in three months. How? Plant a rugby oval with fast growing hemp, harvest the vegetation and use it to make bricks!!

Did you know?

Over half our energy use goes into our buildings. After they're completed we heat them, cool them, clean them and use lighting – all of which use energy.

Did you know?

Building a green building can reduce water and heating bills by 30 – 50%.

Did you know?

Over 65% of the soil types on Earth can be used to make bricks for building and paving.

Try This! Years F-5

Energy collage

How many different ways is energy used in buildings? Use pictures from magazines and advertising materials to make a collage of the different ways energy is used to build and maintain your house or school.

Try This! Years F-2

Shady Characters

Trees and tall shrubs can act as shades to block sunlight which helps to keep buildings cooler. In the summer a tree with leaves will shade the home, decreasing the amount of sunlight striking the house, keeping it cooler. In the winter, when a deciduous tree drops its leaves, the sunlight is allowed to hit the home to assist in keeping it warm. How much difference can this shade make? Do this activity to find out.

You will need:

- thermometer
- shoe box with lid

Procedure:

1. Put the box in a shady spot. Put the thermometer inside the box and put the lid on. Leave it for an hour before measuring the temperature.
2. Repeat step 1 with the box in a sunny spot. What was the difference in temperature? Will trees make a difference in temperature to your house?

Conduct a tree audit around your home. Count the number and types of trees. How long is your home shaded for every day? Would more trees help your home to keep its cool in summer?

Try This! Years 6-10

In some parts of Australia where the temperatures are extremely hot during the summer, houses are often built underground. Visit Earth Sheltered Houses (<http://www.shelterspace.com>) and Coober Pedy Underground Homes (<http://www.outback-australia-travel-secrets.com/coober-pedy-underground-homes.html>)

Try This! Years 3-4

Movement of heat

Energy, such as heat, can move from one spot to another. Sometimes we want this to happen, to warm us up, other times we don't. Some materials help heat to move from one place to another. These are called heat conductors – metal objects are usually good heat conductors which is why we use them for cooking. Other materials slow down the movement of heat and these are called insulators. These are the types of materials that we should use to keep a house warm in the winter and cool in the summer. What type of fabric do you wear in summer? Do you wear the same types of fabric in winter? We use insulating and conducting fabrics for our clothes, blankets, and curtains. Some are better for a purpose than others. In this experiment you will compare materials to see which are the best insulators and conductors

You will need:

- dirt or sand
- thermometer
- ice cream containers
- marker
- plastics cups – 2 more than the number of ice cream containers
- hot water
- cold water
- jug
- insulating materials such as newspaper, alfoil, leaves or mulch, plastic bags, clothes, towels, wool

Procedure:

1. Put a plastic cup into each ice cream container.
2. In one container carefully put the dirt around the cup, ensuring no dirt gets into the cup.
3. Repeat this process in each of the other containers but use the different insulating materials instead of the dirt.
4. Use the marker to draw a line around one of the remaining plastic cups. It should be about two thirds of the way up from the bottom of the cup.
5. Fill the jug with cold tap water. Pour water into the cup up to the mark. Carefully tip this into the cup surrounded by dirt. Repeat this process for the cups in each of the ice cream containers.
6. Measure the temperature of the water in the cups and record it.
7. Leave the containers for 15 minutes then check the temperature again. Repeat this for an hour. Use your results to decide which material was the best at stopping heat from entering the cups.
8. Empty the cups and replace them in their ice cream containers. Repeat steps 5 – 7 using hot water from the tap instead of cold water. Which was the best material to stop the heat from leaving the water?

Try This! Years 3-4

Hot colours

Have you ever worn a black outfit on a hot day? What happened when you did? What colours do you like to wear in summer? Do you like to wear different colours in winter? Do you think colours can make a difference to how hot you feel? Try this investigation.

You will need:

- thermometer
- different coloured cardboard
- shoe box
- table lamp

Procedure:

1. Place the thermometer in the shoe box and measure the temperature
2. Place a piece of coloured cardboard over the top of the box. Shine the lamp on the cardboard for 10 minutes. Check the temperature of the thermometer
3. Allow the thermometer to cool back to its starting temperature, before repeating step 2 with a different colour of card. Do this for all the colours you have

Questions to think about:

Which colour caused the largest increase in temperature? Did any of the colours reduce the temperature of the thermometer? How could you use your findings to suggest the best colour for a house in the desert? Would it be different for a house in a cold climate?

Try This! Years 6-10

Find out how the people in White Cliffs escape the heat of the desert in dugouts
<http://www.youtube.com/watch?v=sEqT46LSRNO>

Straw is easy to grow and harvest and is great to make into houses. Find out how at <http://www.oekofilm.de/index.php?id=20.33.0.0.1.0> Want to build your own cubby? Straw could be the answer – check it out at <http://www.youtube.com/watch?v=gUUBZW9jFM>

Try This! Years 6-10

At the Centre for Alternative Technology in Wales (<http://info.cat.org.uk>) you can explore a large number of building materials including mud bricks, straw bales and rammed earth buildings. Visit their gallery for more information and images at http://www.cat.org.uk/media/media_content.tmpl?subdir=media&sku=MEDIA_IL

Try This! Years 6-10

Many different people all over the world have used earth blocks for centuries. Find out how they are made at <http://www.earthblockinc.com/Block%20Making.html> You could watch a video about how to make them and then give it a go yourself. Don't forget to ask for permission before you start digging up the yard!

Try This! Years 6-10

Lime and hemp are traditional building materials in parts of the United Kingdom. Find out about them in this article 'Low Carbon Hemp House put to the test' <http://www.sciencedaily.com/releases/2010/09/100915205229.htm>

Try This! Years 6-10

Want to see a sustainable building being erected? Visit the website of the Centre for Alternative Technology and watch a timelapse video of the construction of a sustainable building at http://www.cat.org.uk/news/news_release.tmpl?command=search&db=news.db&eqSKUdataarg=38110&home=0

Teachers' corner

Websites:

Construct it Green is a European website with resources and information to support teaching about sustainable buildings. It includes information, explanations, photos, diagrams and animations and is primarily for a Year 9/10 audience but could be adapted for lower year levels.
<http://www.construct-it-green.org>

PowerPoint – A PowerPoint introducing Green Buildings for high school students is available at <http://www.authorstream.com/Presentation/umak-135632-green-building-education-ppt-powerpoint/>



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