Teachers' Support
Energy

Contents:

Introduction

Energy is the ability or the potential of something to "do work". Therefore, all matter is considered to be a potential form of energy. Today, scientists convert energy into matter – and matter into energy – as allowed by Albert Einstein's formula. In 1905, at the age of 26, Einstein proposed the world-famous equation in physics, known as $E=mc^2$. Einstein's discovery of the link between matter and energy has paved the way for the peaceful use of nuclear power.

Energy and Climate Change

Fossil fuels contain carbon and when these fuels are burned, the carbon is released into the atmosphere and combines with oxygen to make carbon dioxide, one of our main greenhouse gases. See "Future Actions" section below for an elaboration on links with climate change. For further information also click on:

Websites for Climate Change and Energy

Student Activities

For further student activities click on:

'Switched On' Booklet

Energy- Student Activities

For an example of a lesson plan integrating three learning areas and values click on:
Integrated Lesson Plan This lesson plan is for *Mission Cosy House.*

Forms of Energy

What are the forms of energy?

Energy is found in many forms, such as light, heat, sound and motion. All energy forms can be classified into two categories, *kinetic energy* and *potential energy.*

A summary table of 'forms of energy' is available by clicking:

Forms of Energy.

Ref: http://www.worldofenergy.com.au/factsheet_energy/07_fact_energy_forms.html

1. Kinetic energy is energy in motion, such as waves, electrons, atoms, molecules, substances and objects. Different kinds of kinetic energy include:

- Electrical energy is the movement of electrical charges. Everything is made of tiny particles called *atoms.* Atoms are made of smaller particles, known as *electrons, protons* and *neutrons.* Applying a force can make these electrons move. Electrical charges moving through a wire is called *electricity.* Lightning is another example of electrical energy.

- Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

- Thermal energy**,** or heat, is the internal energy in substances – the vibration and the movement of atoms and molecules within substances. *Geothermal energy* is an example of thermal energy.

- Motion energy is the movement of objects and substances from one place to another. Objects and substances move when a force is applied to them, according to Isaac Newton's Laws of Motion. Wind is an example of motion energy.

- Sound is the movement of energy through substances in longitudinal waves. Sound is produced when a force causes an object or substance to vibrate – the energy is transferred through the substance in a wave.

2. Potential energy is stored energy and the energy of position, known as *gravitational energy.* There are several forms of potential energy:

- Chemical energy is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

- Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

- Nuclear energy is energy stored in the nucleus of an atom – the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called *fission.* The sun combines the nuclei of hydrogen atoms in a process known as *fusion.*

- Gravitational energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy. One of the best gravitational wave detectors in the world was built at the University of Western Australia in the 1980s. Now, gravity waves are investigated at the Gravity Discovery Centre near Gingin. Visitors will enjoy viewing the Western Power Foucault Pendulum at the Gravity Discovery Centre. This pendulum is one of the most simple and elegant ways to prove that the earth rotates. This phenomenon was discovered by Leon Foucault in 1848 and the first Foucault pendulum was built for the 1850 Paris Exhibition. For more information about the Gravity Discovery Centre, go to: www.gdc.asn.au

The above forms of kinetic and potential energy are governed by the *law of conservation of energy* (the first law of thermodynamics). Under this law, energy cannot be created or destroyed. When we use energy, it doesn't disappear. We can change energy from one form to another form, but the total energy remains the same.

Sources of Energy

Sources of Energy	
Non Renewable	**Renewable**
Oil (petroleum)	**Solar**
Natural gas	**Wind**
Coal	**Geothermal**
Uranium	**Biomass**
	Hydro
	Ocean

We use many different energy sources to do work for us. On average, every person in the industrialised world uses about six times the amount of energy as every person in the developing world. Primary energy sources are classified into two groups - *non-renewable* and *renewable***.**

- Non-renewable energy sources include coal, natural gas, petroleum (the three *fossil fuels*), uranium (a source of nuclear energy) and propane. These energy sources are called non-renewable because their supplies are limited, they draw on finite resources that will eventually dwindle. Petroleum, for example, was formed millions of years ago from the remains of sea plants and animals.

  We cannot make petroleum in a short time. These non-renewable energy sources are used to make electricity, to heat our homes, to move our cars and to manufacture all kinds of products.

- International competitiveness relies on access to competitively renewable energy sources include solar power, solar thermal, wind turbines, hydro power, wave and tidal power, biomass-derived liquid fuels, biomass-fired generation and geothermal energy. These energy sources are called renewable because they are constantly replenished and they do not run out.

Our national wealth depends upon reliable, safe and high-quality energy supplies in Australia. The energy sector encompasses the identification and development of primary energy sources such as coal, gas, oil and uranium, as well as renewables like hydro-electricity, wind, solar and biomass. Australians spend about $50 billion on energy a year. Energy exports - including coal, natural gas, oil, petroleum products and uranium - earn about $24 billion a year.

Energy is a significant input for major industries such as aluminium, steel, cement and pulp and paper; their priced, reliable energy. The energy sector directly employs about 120,000 Australians while energy-intensive industries employ hundreds of thousands more people. The aluminium, cement and paper industries alone employ 35,000 people.

Australians continue to demand more energy to meet our electricity needs. Over the past 30 years, Australian energy consumption has more than doubled from 2,700 petajoules (PJ) to more than 5,500 PJ a year. One petajoule (PJ) of energy approximates to 278 gigawatt hours (GWh). Energy consumption in Western Australia has risen by an average rate of four per cent each year.

Fossil fuels are the primary sources for supplying our energy needs. The electricity generation sector accounts for about 30 per cent of total energy consumption. Coal provides about four-fifths of Australia’s electricity needs. Renewable energy sources contributed to five per cent of energy used in electricity generation in 2004/2005.

However, the use of natural gas and renewable energy is increasing significantly throughout Australia.

Electricity has traditionally been generated from coal – a fossil fuel.
But with growing environmental concerns over the effect of greenhouse gases, we are starting to produce energy using natural or renewable sources such as wind, the sun and water.

Generating electricity using coal

Mining Coal

Coal is mined at open cut or underground mines, then crushed, washed and transported to power stations to be stockpiled and used as fuel.

The Boiler
For efficient combustion, the coal is ground to the consistency of talcum powder in pulverising mills before being blown into the boiler furnace chamber in a stream of pre-heated air. The pulverised coal is burned at very high temperature, converting water circulating in the boiler tubes into high pressure steam.

Steam Turbine

The steam produced by the boiler is injected at very high pressure into the turbine, spinning the fan-like blades mounted along the main drive shaft. This shaft continues like an axle from one end of the turbine to the other.

The turbine is divided into three stages with different levels of pressure and different sized blades. *Stage 1* is a high-pressure cylinder where the fan blades are smallest in diameter. Once the steam has passed through Stage 1, for maximum efficiency, it is reheated in the boiler as some of its energy has been spent.
The steam is then passed to *Stage 2*, which is an intermediate pressure cylinder with larger fan blades. As the heat and pressure lessen, the steam passes through *Stage 3* of the turbine, which has two low-pressure cylinders and the largest blades.
Once the spent steam leaves the turbine, it is cooled back to water as it passes over a series of condenser tubes through which cold water from the cooling system is circulated. The *reclaimed* water is then recirculated to the boiler to produce more steam.

Electrical Generator

The generator consists of two main sections - the revolving section called the *rotor*, which is directly coupled to the steam turbine's drive shaft, and the *stator*, a series of wire coils which form a cylinder around the rotor. The rotor, which is really an electro-magnet, revolves at high speed to generate electricity (alternating current) in the stator. A separate *static exciter* energises the wire coils of the rotor.

Transmission

Electricity is produced in modern generators at 23,000 volts. It then passes through a transformer that increases the voltage to as high as 500,000 volts. Then it passes into the adjacent power station switchyard where transmission lines carry it to where it is needed, via a vast network of interconnected high voltage transmission lines called a grid.

Alternative Energies

Our energy demand is projected to increase by 50 per cent by 2020. The energy industry has estimated that at least $37 billion in energy investments will be required by 2020 to meet the nation's energy needs. Western Australian electricity utilities are confident they will meet the growing energy demands in an environmentally safe way, while working to minimise greenhouse gas emissions.

Fossil fuels contain carbon and when these fuels are burned, the carbon is released into the atmosphere and combines with oxygen to make carbon dioxide, one of our main greenhouse gases. Energy production and energy use contributed to 68 per cent of Australia's greenhouse gas emissions in 2003. This is expected to rise to 72 per cent by 2020.

Due to the growing focus on the environmental impact of energy use and the depletion of increasingly expensive fossil fuel resources, the use of renewable energy will continue to rise in Western Australia. In 2005/2006, renewable energy accounted for 3.2 per cent of the state's electricity generation, nearly half of which is produced by wind power. Western Australian electricity businesses have been actively working to significantly reduce greenhouse gas emissions and there are a number of State and Federal Government programs to meet this goal.

As part of these programs, state electricity businesses have been committed to meeting stringent government requirements to generate additional electricity from renewable energy sources. Both State and Federal Government grants have assisted Western Australian energy utilities and other local industry members to research and develop renewable energy technologies. Verve Energy has developed a wide range of renewable energy sources, including Solar Energy **,** Wind Energy **,**
Water Energy**,** Biomass Energy and Fuel Cells **.**

For more information go to:
www.verveenergy.com.au

Future Actions

In May 2007, "Making Decisions for the Future of Climate Change", The Premier's Climate Change Action Statement was published which outlines the actions being taken to reduce Greenhouse emissions from the generation of electricity.

The following actions were detailed:

- Replacing diesel fired power stations in Broome, Derby, Halls Creek and Fitzroy with stations which generate energy using LNG.
- Commissioning the $400m NewGen Kwinana power station which provides power using gas technologies. This is expected to reduce emissions by 50% compared to traditional coal-fired power stations.

- Implementing policy to secure the Gorgon LNG project and future LNG projects for domestic use
- Requiring the Gorgon LNG project to store carbon. The CO2 content of the gas is to be reinjected underground into permanent geological storage. (This will be the largest carbon capture in the world.)
- November 2006 – the Cervantes wind farm opened (80MW capacity)
- Cervantes wind power being used to run the Kwinana desalination plant which provides drinking water for Perth (17% or 130 m.lites per day), which avoids 220 000 tonnes of greenhouse emissions annually. Wind farms have low impact on existing land use as stock can graze beneath them.

The goal is to reduce emissions to 60% of the 2000 levels by 2050. Total emissions were 66.6 m tonnes in 2005 – so needs to be reduced to 26m by 2050 to meet the target.

<u>Solar Energy</u>

The sun is a star which provides energy for life on earth. It is also the primary source of energy for the fossil fuels - oil, gas and coal. In one year, the amount of solar energy reaching the earth's surface is ten times greater than the world's total fossil fuel energy resources.

Some of the solar energy reaching earth is transformed into wind, hydro and wave energy. The sun also contributes, along with the moon, to tidal movements, which can be a significant source of renewable energy. Solar energy is transformed via photosynthesis into trees and crops which can be used to provide energy (bioenergy). And animals eat plants and themselves produce wastes (such as dung), which are then used by humans to provide us with energy in one form or another.

We can use the heat (or thermal energy) from the sun for practical purposes including:

- Solar hot water;
- Passive solar heating of buildings; and
- Crop drying, salt production etc.

Also, solar energy can be transformed into electricity in two main ways. Firstly the sun's heat energy can be used in various solar thermal systems. Secondly, the high energy part of the solar spectrum can be captured by special devices known as photovoltaic cells to produce electricity directly.

It is estimated that enough sunlight falls on the earth's surface every hour to meet world energy demand for an entire year. Although the sun's energy is free, special technology is required to transform it into other energy forms, such as electricity. The cost of the technology, for example photovoltaic cells, can be quite expensive. Large amounts of energy from the sun are used around the world, but solar power provides less than 0.1 per cent of the world's electricity. In the United States, more than 10,000 homes are powered entirely by solar energy.

Renewable sources contributed to five per cent of energy used in Australia's electricity generation in 2004/2005. In Western Australia, solar energy accounted for about 0.4 per cent of electricity generation in 2005/2006. Instead, Western Australia predominantly relies on fossil fuels - coal, petroleum and natural gas – for our energy needs.

These fuels have taken millions of years to form from fossilised plant and animal remains crushed deep below the earth's crust (although natural gas can also be of recent formation). Over a long period of time the combination of heat and pressure has caused the fossilised remains to become rich sources of heat energy which can be burned in power stations to provide electricity. And because plant and animal life are dependent on the sun's energy we can say that coal, petroleum and natural gas are the *indirect* results of solar energy – or solar energy stored up from long, long ago.

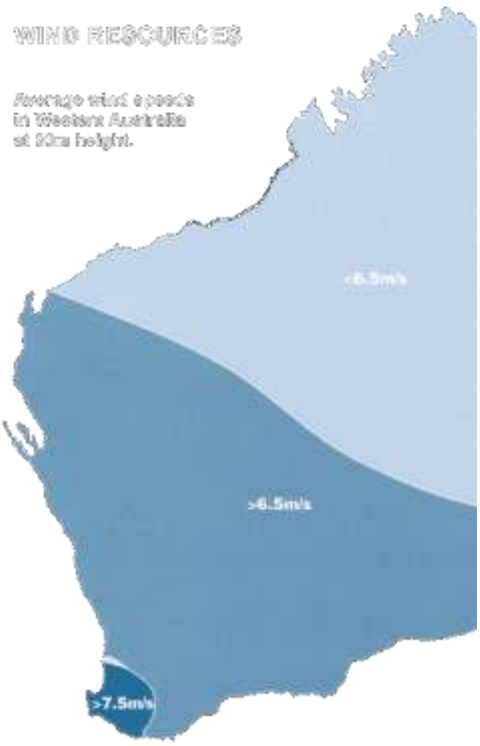
Planned Initiatives

- Solar Schools Program to have 350 primary and secondary schools using solar power by 2010; and
- Rebates for domestic solar hot water systems.

Wind Energy

What is wind energy?

Air is a low-density fluid. Air in motion is wind and wind contains kinetic energy (in fact, wind energy is a form of motion energy, which is the movement of objects and substances from one place to another). Water is another, more dense fluid that also contains kinetic energy when it is in motion. Wind is fundamentally an indirect form of solar energy. About two per cent of the solar radiation that the earth receives is converted to wind energy in the atmosphere. Winds are created when air moves. When air is heated, it becomes lighter in weight and moves upwards. Cooler air, which is heavier and therefore closer to the ground, moves into the space left by the rising warmer air and the wind is formed.



However, the air in the atmosphere is not heated directly by the sun's rays. Heat from the sun is first absorbed by the earth’s surface and the heated surface warms the air above it. As the surface of our planet varies (land, water, desert, forests, etc.) the amount of absorbed heat varies. This creates temperature differences causing the air to move from one place to another place.

The amount of sunshine received in a region depends on its geographical location, the season and the time of day. For example, in any given year the tropical regions receive an excess of heat energy, while the Polar Regions don't receive enough heat energy. However, the tropics do not get hotter from year to year nor do the poles get colder with time. This is because there is an exchange of heat – through wind breezes - across the latitudes. Breezes also occur between areas of land and water. Land and water along a coastline absorb heat differently (so do valleys and mountains). This creates the breezes.

The land surface becomes hotter more quickly during the day than the water body of the earth. During the daytime, the sea's temperature does not rise as rapidly as that of the land surface because much of the solar radiation is either absorbed by the water-body or consumed by evaporation. As a result, the lower layers of air above the land surface become warmer than the layers over the sea.

The heated air above the landmass expands, becomes lighter in weight, and rises while the comparatively cooler, heavier air over the water moves in to replace it. This process creates an on-shore or "sea" breeze. At night the breeze reverses direction. This is because at night the land surface cools more quickly than the water body, as the water holds heat from the sun longer and becomes the warmer surface. This in turn creates a warmer body of air above the water than over the landmass, causing a land or offshore breeze to form.

In the tropics the contrast between land and sea temperatures is quite marked. Consequently tropical sea breezes tend to be stronger. (Anyone who has experienced sea breezes up in the north of Western Australia will be aware of the force of winds in that region.)

A local and well-known example of a sea breeze is the refreshing wind welcomed by Perth people during the long, hot summer days. This is popularly known as the "Fremantle Doctor" and brings much relief to Perth people, particularly those working in the open, during the summer. This strong thermal breeze arrives in Perth most afternoons during the summer months. The good "Freo Doctor" reaches wind speeds up to 15 knots to 25 knots from October until March.

The advantages of wind energy include:

- Wind energy can offset the use of fossil fuels.
- It is available over a greater area than occurs with fossil fuels.
- There is no air pollution after manufacture.
- There is low environmental impact.
- Modern wind energy converter systems can be set up for individual houses, or as part of an electricity grid system interconnected with other types of generating plant.
- These are well proven and occupy a relatively small amount of land in proportion to their electrical output.

Planned Initiatives

- Wind farms are planned for Esperance, Hopetoun, Bremmer Bay, Exmouth, Denham, Kalbarri and Rottnest Island.
- Three cyclone proof turbines at Coral Bay are planned to provide 40% of needs.

Geothermal Energy

Introduction

"Geothermal" derives from two Greek words – "geo" means the earth and "therme" means heat. "Energy" also originates from a Greek word - "ergon" - which means work. Geothermal energy is a form of thermal energy, which is the internal energy in substances – the vibration and movement of atoms and molecules within substances. This form of energy provided less than 0.5 per cent of the world's electricity in 2005 because the practical development of geothermal energy is still relatively costly.

Geothermal heat originates from the earth's fiery consolidation of dust and gas more than four billion years ago. At the earth's core, which is 6,400 kilometres deep, the temperatures may reach more than 4,982 degrees Celsius. This geothermal heat is continuously flowing outwards from the earth's core. The heat transfers (conducts) to the surrounding layer of rock, known as the mantle. When temperatures and pressures become high enough, some mantle rock melts, becoming magma.

To enlarge image - click here.

http://www.worldofenergy.com.au/factsheet_geothermal/fact_sheets_7_pic1.html

The magma is lighter than the surrounding rock and it rises up towards the earth's crust, carrying the heat from below. When the magma reaches all the way to the earth's surface, it becomes lava. When the magma remains below the earth's crust, it heats the nearby rocks and water, which reach up to 371 degrees Celsius. Some of this hot water rises through faults and cracks and reaches the earth's surface as *hot springs* and *geysers* (which discharge jets of steam and water intermittently). Otherwise, the hot water stays deep underground, trapped in cracks and porous rock. This natural collection of hot water is known as a *geothermal reservoir***.**

http://www.worldofenergy.com.au/factsheet_geothermal/fact_sheets_7_pic2.html

We can make use of the hot water and steam originating from the earth's core, and turn them into practical energy, known as geothermal energy. The ancient Romans used hot springs to heat their baths and homes. This "magic water" was also used for medicine and cooking purposes. In 1864, a hotel in Oregon, USA, heated rooms using geothermal energy from underground hot springs.

The hottest underground reservoirs are always in parts of the world where the earthquake activity (or seismic activity) is greatest. The *seismic belt* runs around the edge of the Pacific Ocean (known as the "Pacific Ring of Fire"). Countries along the belt include New Zealand, the Philippines, Japan, Russia (Siberia) and the countries of the western seaboards of North and South America.

http://www.worldofenergy.com.au/factsheet_geothermal/fact_sheets_7_pic4.html

Future Possibilities

Geothermal energy as an alternative to nuclear and fossil fuels. Australia has several extensive hot, dry rock resource sites available.

Water Energy

What is water energy?

Water is the most abundant substance on the surface of the planet. It's in constant motion due to the actions of the sun and the moon. The sun drives the water evaporation cycle while the moon is largely responsible for the ocean tides. When we talk of water energy, we tend to think of using the *mechanical energy* in stored or moving water. Water also possesses *kinetic energy* (which is the energy possessed by moving masses) as well as *thermal energy* (which is energy pertaining to heat or temperature) when the water has been warmed by the sun or the earth.

The total energy generating potential of waves breaking on the world's coastline is estimated to be about 2 to 3 million megawatts (MW), according to the U.S. Department of Energy. Renewable energy analysts believe there is enough energy in the ocean waves to provide up to two terawatts of electricity. A terawatt is equal to a trillion watts. Electricity can be generated from water energy, whether the source is ocean-based or river-based. Worldwide, water is the most commonly used renewable energy resource, providing enough power to meet the needs of 28.3 million customers. Ocean-based sources include wave energy, tidal energy and thermal energy. River sources are primarily hydro-electric schemes of varying sizes, many of them associated with irrigation or flood mitigation schemes. About 20 per cent of the world's electricity is generated through the use of water, according to the Hydro Research Foundation.

However water is a very precious resource that is becoming scarcer in many parts of the world. For more information about global water scarcity, go to: http://www.unesco.org/water

Another significant challenge is that the practical development of water energy is still relatively costly. A balanced mix of non-renewable and renewable energy sources is needed to supply our electricity needs in Australia. Hydro sources accounted for seven per cent of Australia's electricity generation in 2004/2005, according to the Energy Supply Association of Australia.

Refer to website for further fact sheets

Biomass Energy

The Facts About Biomass Energy

Imagine if all Australian farmers planted vegetable crops which could be processed to become fuel for power stations, as well as for our cars, trucks, buses, trains and aircraft. And imagine what a tidy world it would be if we could recycle all our rubbish and turn it into energy and other useful products. The idea of using plant and animal wastes, vegetable crops and rubbish (generally called “biomass”) to produce various forms of energy is not new.

For centuries the people of India have used dried cow dung to fuel their fires, and in Turkey remote villagers mix animal dung with straw, dry it and use it as a fuel. However, the world is still heavily dependent on fossil fuels – petroleum, coal and natural gas – to produce electricity and other forms of energy.

But as the demand for these limited fossil fuels increases, their prices will escalate. During the mid-1970s there was a dramatic increase in the price of petroleum in nearly all countries, including Australia, although the effect was not as bad here because we can supply much of our own needs. However, Australia’s ability to supply most of its own needs is decreasing. Since the 1970s, Australian scientists have investigated natural sources to generate electricity and other forms of energy.

Narrogin Bioenergy Demonstration Plant

The Narrogin Bioenergy Demonstration Plant uses locally grown mallee trees. The Integrated Wood Processing Demonstration Plant generates enough electricity for 1000 homes, produces activated carbon for use in air and water filters and eucalyptus oil. The mallee tree stores carbon. Mallee tree branches can be harvested every second year indefinitely, without felling the tree or the need to replant.

Landfill gas in Western Australia:

Western Australia has a successful history of developing landfill gas generators which convert methane into electricity. Ten landfill gas generators were operating in Perth in June 2006 and they were contributing 24MW of power to the main grid, enough to supply 33,000 households with electricity.

The latest landfill gas generator, known as the Henderson Renewable Energy Facility and located in Henderson, was opened on 7 June 2006. It is expected that the 2.1MW landfill gas generator will reduce greenhouse gas emissions by more than one million tonnes over the next 16 years. The facility is owned and operated by Waste Gas Resources.

In the Perth metropolitan region, nine other landfill generators are located in Redhill, Mt Claremont, Canning Vale, Kalamunda, Baldivis, Gosnells, Tamala Park, Noranda and South Cardup.

Landfill Gas and Power Pty Ltd (LPG) has built four landfill power stations and they are located in Tamala Park (commissioned in 2004), Kalamunda (1996), Canning Vale (1995) and Redhill (1993).

Planned Initiatives

Capturing methane (a greenhouse gas) from landfill sites. This methane could be contributing 19m tonne or 2.5% of Western Australia’s total emissions. Landfill sites will be required to capture and destroy or use the methane. It could be used to generate electricity.

Petroleum

Introduction:

http://www.worldofenergy.com.au/

Petroleum is energy, stored deep in the earth by nature. The word, petroleum, comes from two Latin words: “petra”, a rock; and “oleum”, oil. This is a *non-renewable energy source* because petroleum supplies are limited and they draw on finite resources that will eventually dwindle. Petroleum includes crude oil, condensate and natural gas. They are forms of *chemical energy*, which is energy stored in the bonds of atoms and molecules.

Since early times, man has collected petroleum. More than 2,000 years ago, the Chinese used bitumen (a form of petroleum) to build the Great Wall of China. Around the same time, Ancient Egyptians discovered that thick oil was useful to grease the wheels of their chariots.

During the European Middle Ages, the Venetian explorer, Marco Polo, wrote that there were “oil springs” at Baku, on the Caspian Sea, towards the end of the thirteenth century. Early European adventurers also detected “oil springs” in the American colonies. There are accounts of a Franciscan monk who said he visited oil springs near New York in 1632. Early settlers in Texas were disgusted by the black, filthy stuff they could do nothing with. The discovery and production of Texas oil occurred sporadically during the second half of the nineteenth century.

However, it was in Pennsylvania USA that the first commercial petroleum well was drilled in 1859.

In the United States, bores that were used for water began producing crude oil. People soon found that this crude oil could be used to make lamp oil, lubricants, gas for lamps and paraffin wax. At that time, petroleum was called coal oil. The discovery of petroleum eventually closed the nineteenth century whale-oil industry. The Industrial Revolution in England, Europe and the United States had depended on whale oil to lubricate factory machines. You could say that the oil and gas industry has helped to save the whale!

For more information about the modern petroleum industry, go to:
www.answers.com/topic/history-of-the-petroleum-industry

Now, petroleum literally turns the wheels of industry. Hundreds of products are made from petroleum. Petroleum is found in three forms: as a *solid*, called bitumen; as a *liquid*, which is usually called crude oil or condensate; and as a *gas*, such as methane and ethane. The list is astonishing - and it gets longer every year. Petroleum includes liquefied gases; motor, aviation and tractor fuels; jet aviation fuel; kerosenes; distillates (diesel fuels and light heating oils); lubricating oils and greases (more than 1,000 kinds); rust preventives; transformer and cable oils; and asphalts, for road making. Both liquid oil and natural gas are generally found together.

Whether a discovery becomes an oil or a gas field depends solely on whether there is more of one fossil fuel or the other fossil fuel in the area. Crude oil and natural gas are made up of the same molecular building blocks. Both are a mixture of *hydrocarbons*, which are combinations of hydrogen and carbon. There are hundreds of hydrocarbons in petroleum. There are also small amounts of nitrogen, oxygen and sulphur. So petroleum and natural gas are parts of the same group of chemical compounds. But gases have smaller molecular structures and petroleum liquids have larger molecular structures.

Natural Gas

Gas is defined as an air-like substance, a completely elastic fluid, which does not become liquid or solid at ordinary temperatures. It is a form of *chemical energy*, which is energy stored in the bonds of atoms and molecules.

There are many substances that can be classified as gas. For example, both steam and oxygen are different forms of gas. Wherever we happen to be outdoors, gas is all around us. The air we breathe is a gas. It is made up of oxygen and nitrogen and tiny quantities of other gases. We breathe in oxygen and breathe out carbon dioxide and some water vapour.

Air is the most obvious gas around us but there are many more gases in our world. The word “gas” is generally used to describe the form of energy that provides hot water, warms up homes, cooks meals and is used by industry and commerce as an economical and reliable fuel for manufacturing and other processes.

Generally, people burn gas to produce heat. This heat energy can in turn be converted into *mechanical energy* and *electrical energy.*

Natural gas is often found with oil but it is also found with little or no associated oil. The cost of oil and gas exploration is high, especially when deposits are concentrated beneath the sea-bed. Although measuring instruments can detect likely areas to explore, the only certain way to confirm deposits is to drill a test well. Drilling is an expensive gamble. There is only a slim chance that an exploration well (a "wildcat") will reveal a major find.

Western Australia's sedimentary basins along the Continental Shelf may provide high yields of gas and some oil, but gas and oil deposits are difficult to find. Geologists working on these basins use seismographs (instruments for measuring and recording movement in the earth's crust) to locate folds in the subterranean rock which might contain oil or natural gas. Energy pulses (e.g. strong vibrations or compressed air “pops”) are created on the earth's surface and the resulting shock waves are measured on seismographs. From the readings, geologists can trace possible oil or gas fields.

For more information about the drilling and exploration of natural gas fields, go to: http://www.naturalgas.org/naturalgas/exploration.asp

Today natural gas plays a major role in the energy market. It is the most important gas and the one used by most Western Australians. Our state possesses abundant fossil fuels, particularly natural gas and coal. They are both *non-renewable energy sources* because their supplies are limited and they draw on finite resources that will eventually dwindle.

In 2007, black coal accounted for around 50 per cent of the total fossil fuel resources in the state. At this time, natural gas accounted for around 40 per cent and it was growing as more resources were being identified. According to the Western Australian Office of Energy, it is expected that natural gas will last around 164 years at the current levels of production in our state. Throughout Australia, there is more than a century’s supply of natural gas in reserve at current rates of usage, according to the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Natural gas accounted for about 22 per cent of the world’s energy mix in 2005. In Australia, natural gas is expected to be the fastest-growing energy source – which accounted for about 18 per cent of our 2005 primary energy needs.

http://www.worldofenergy.com.au/factsheet_natgas/fact_sheets_13_pic1.html

Natural gas is formed continuously and naturally**.** It is a fossil fuel formed by decaying plant and animal remains, trapped beneath layers of sands, silt and rock over millions of years. It is stored at great pressure beneath layers of mud and rock. Large resources of this fossil fuel can make huge gas development and supply projects worthwhile. (Next time you light your gas room heater, remember that the fuel keeping you warm is millions of years old, and took millions of years to make.)

Natural gas is a combination of gases, consisting mainly of methane ($CH4$) with small amounts of ethane, propane and butane as well as nitrogen, carbon dioxide and traces of other gases. The proportions of the components can vary widely from gas field to gas field.

Natural gas has minimal pollution problems. Once treated to remove unwanted substances it can't be tasted, seen or smelt. The burning of natural gas to generate electricity releases fewer greenhouse gas emissions than the burning of coal or diesel oil. Gas structures around the world contain widely varying proportions of carbon dioxide ($CO2$). However, it is estimated that the burning of natural gas emits around 30 to 50 per cent less carbon dioxide than coal and oil, as well as less sulphur dioxide.

Nuclear Energy

What is nuclear energy?

http://www.worldofenergy.com.au/

Nuclear energy comes from releasing energy locked inside the nuclear structure of molecules. In the nuclear structure, an atom is made up of an extremely small, positively charged nucleus which is surrounded by a cloud of negatively charged electrons.

Refer to the “atomic diagram” at the website:
http://www.lbl.gov/abc/Basic.html

The nucleus consists of positively charged protons and electrically neutral neutrons, which are held together by a strong nuclear force. The atomic mass of an element is the sum of the protons and neutrons in its nucleus. The atomic number of an element is equal to the number of protons in its nucleus. At present, there are 112 known elements (each with a different atomic number), ranging from the lightest element, which is hydrogen (with an atomic number of 1 and an atomic mass of 1), to iron (atomic number 26, atomic mass 56) to uranium (atomic number 92, atomic mass 238) and beyond. Elements above atomic number 96 generally do not exist naturally on earth. They have been synthetically produced, often having only the briefest existence before decomposing into other particles.

The Facts About Nuclear Energy

What is nuclear fusion?

Right - An illustration demonstrating fusion at work. http://www.worldofenergy.com.au/

Nuclear fusion reactions have been releasing massive amounts of energy in our galaxy for billions of years. This is a process where, in the extreme conditions of space, two very light atoms combine to form another larger atom while releasing enormous energy from the nuclear forces of the fusing nuclei. This is the same process by which a star such as our sun produces its solar energy. Whenever we feel the warmth of the sun, and when we can see by its natural light, we are observing the products of nuclear fusion in the galaxy.

When a star is created, it initially consists of hydrogen and helium formed from the “Big Bang”, the process that created our universe.

For more information about the Big Bang theory, go to:
http://map.gsfc.nasa.gov/m_uni/uni_101bb1.html

What Is nuclear fission?

Above - An illustration demonstrating fission at work.

http://www.worldofenergy.com.au/

Like nuclear fusion, the process of nuclear fission has been occurring in the universe for billions of years. During nuclear fission, a heavy or large nucleus (such as uranium) naturally splits into lighter nuclei after colliding with a neutron. The collision releases a great amount of energy from the splitting nucleus, as well as neutrons that can go on to collide with another large nucleus, so continuing the process.

The energy that is released from a single fission comes from the fact that the fission products and the neutrons, together, weigh less than the original uranium atom. The difference in weight is converted directly to energy at a rate governed by the equation $E=mc^2$, a famous outcome of Albert Einstein's Theory of Relativity which explored the relationship between mass and energy.

Einstein (1879-1955) discovered that energy (E) equals mass (m) times the speed of light (c) squared. With the speed of light being 186,000 miles per second we now understand, thanks to Einstein, how a small amount of mass can be converted to a phenomenal amount of energy.

For more information about Einstein and the theory of relativity, go to: science.howstuffworks.com/relativity.htm

Nuclear energy and electricity:

During the past 50 years, we have applied the fission process in nuclear power stations to generate energy to meet our everyday needs. The first commercial nuclear power stations started operating in the 1950s. The heart of a nuclear power station is the nuclear reactor. Uranium "fuel" of the right composition to undergo fission naturally is assembled into bundles and immersed in water. The energy released by the fission is absorbed by the water, turning it into superheated steam which is then used to drive a turbine and generator in much the same way as in power stations fuelled by fossil fuels such as coal and gas.

The fission reactor rate (and in turn the steam production rate) is controlled by lowering rods of neutron-absorbing material into uranium bundles. As the rods are lowered and more neutrons are absorbed, the fission reaction slows as it is starved of neutrons. Fully inserted, the control rods will stop the fission reaction completely, allowing the reactor to be cooled for maintenance.

To view a diagram of a nuclear power station, go to:
http://pro-resources.net/nuclear-power-plant.html

The Greenhouse Effect

What are the greenhouse gases?

http://www.worldofenergy.com.au/

The principal greenhouse gases are:

- Carbon dioxide (also known as CO_2 – this is the main greenhouse gas in terms of the amount in the earth's atmosphere.)
- Water vapour (H_2O).
- Methane (CH_4).
- Nitrous oxide (N_2O).
- Chlorofluorocarbons (CFCs).
- Ozone (O_3).

Other greenhouse gases include some solvents and the air pollutants resulting from the burning of fossil fuels to run cars and equipment.

All gases can be weighed. One kilogram of carbon dioxide would fill a large family fridge. One tonne of carbon dioxide would fill a family home. Carbon dioxide is colourless and odourless so it cannot be seen or smelt.

Some greenhouse gases are stronger heat absorbers than others. For example, 1kg of methane captures as much heat as 21kg of carbon dioxide. And only 1kg of nitrous oxide captures as much heat as 310kg of carbon dioxide.

The energy sector depends on fossil fuels – oil, gas and coal – as the main sources of energy. Fossil fuels contain carbon and when these fuels are burned to produce usable energy, the carbon combines with oxygen to make carbon dioxide which is released into the atmosphere. These fossil fuels are vital for the generation and supply of electricity and gas to people's homes and businesses. It is believed that we have been burning so much fossil fuel that there is now 25 per cent more carbon dioxide in our atmosphere as compared with 200 years ago.

Most greenhouse gases are produced at the point where the fossil fuels are burned. During electricity generation this is at the power station, while for gas it is at the point of use (e.g. cooking a meal or heating a room at home). Smaller amounts of greenhouse gases are also released in producing the fossil fuels for use. These include methane released from coal seams during some black coal mining operations and greenhouse gases emitted during oil and gas production.

Not all energy extracted from coal, oil and gas reaches our homes – some is lost during processing and transporting. Energy is lost in the generation of electricity and its transmission from the power station to our homes. Similarly, some gas is consumed in pumping the gas through supply pipelines as a small amount leaks from some gas pipelines.

Energy industries – and electricity generation in particular – account for the largest proportion of Australia's greenhouse gas emissions. Since 1990, the energy sector has experienced the largest increase in greenhouse gas emissions of any Australian industry sector.

Energy production and energy use contributed 68 per cent of Australia's greenhouse gas emissions in 2004. This is expected to rise to 72 per cent by 2020. Electricity consumption, due to the burning of fossil fuels, contributed to 45 per cent of Australia's emissions. In fact, the use of coal in electric power generation is the largest, single contributor to Australia's emissions. The burning of coal accounted for about 38 per cent of total emissions.

Click here to find out about Australia's greenhouse gas emissions Inventory 2004 at:
www.greenhouse.gov.au/

Who generates greenhouse gases?

Household activities:

Australian households are believed to be responsible for almost one fifth (17.5 per cent) of the nation's greenhouse gas emissions. This occurs through a family's everyday activities such as household energy use and vehicle use (transport). Additionally, when food scraps, organic materials, garden wastes and paper are dumped into landfills they decay, generating carbon dioxide and methane.

In fact, an average Australian household will generate about 15 tonnes of greenhouse gases a year from these activities. Excluding energy used for personal vehicles and public transport, each Western Australian household produces around six tonnes of greenhouse gases every year.

More efficient use of energy in the home could reduce these greenhouse gas emissions by up to 30 per cent. For every kilowatt hour of electricity saved in the home, about 1.2kg of greenhouse gas emissions are saved.

For more information about greenhouse gases generated by Western Australian households, go to:
www1.sedo.energy.wa.gov.au

Who generates greenhouse gases?

Farming and other agricultural activities:

Above - Farming and agricultural activities add to greenhouse gases.

In 2004, agricultural activities accounted for 16.5 per cent of Australia's greenhouse gas emissions. Plants absorb carbon dioxide from the air. Land clearing releases the carbon dioxide that is contained in plants. Animals, particularly cattle and sheep, produce methane when food breaks down inside them. Rice production also generates methane, while some fertilisers release nitrous oxide.

For more information about greenhouse gases which are generated by Australian

agricultural activities, go to:
http://www.greenhouse.gov.au

Who generates greenhouse gases?

Transport:

For every litre of fuel that we use in our vehicles, almost 3kg of carbon dioxide is pumped into the atmosphere. Transport contributed 76.2 million tonnes, or 13.5 per cent, of Australia's net emissions in 2004. Transportation is one of the biggest contributors to emissions growth in our country. In 2002 in Australia, cars contributed 43 million tonnes of carbon dioxide or equivalent greenhouse gases, which is 8% of total national emissions. Trucks and light commercial vehicles contributed 24 million tonnes of carbon dioxide. Together these vehicles represented 13 per cent of Australia's total emissions, and since 1990 this figure has increased by 28 per cent.

Planned Initiatives

- The Southern Railway (opened Dec 2007) expected to take 25 000 cars off the road.
- Build more cycle networks and pathways.
- Implement the Travel Smart Program to encourage alternative travel.
- Gradually replace diesel buses with gas buses.
- Trial hydrogen fuelled buses.
- Trial the use of biodiesel in 78 buses.

For more information about the greenhouse gases which are generated by Australian transport use, go to:
www.greenhouse.gov.au/transport/index.html
www.greenvehicleguide.gov.au

Who generates greenhouse gases?

Industrial processes:

Cement and aluminium production and some other processes involve chemical reactions which produce greenhouse gases. These industrial processes account for 5.3 per cent of Australia's greenhouse gas emissions in 2004.

For more information about the greenhouse gases which are generated by Australian businesses and industries, go to:
http://www.greenhouse.gov.au/inventory/2004/

Why we should care:

Above - We can all make a difference.

If we do not act to stop global warming, scientists predict that the following disturbances could happen:

- By 2100, the earth's temperature will increase by a maximum 5.8 degrees Celsius.
- Oceans will expand, glaciers will melt and the sea level will rise by 9cm to 88cm by 2100.
- Mankind will experience complicated changes in weather patterns including severe droughts, torrential floods and higher rainfall intensity.

As a result of these dramatic weather changes:

- Some animals and plants will not be able to adapt and they will become extinct. In other words, there would be changes to the earth's biodiversity.
- A rise in sea temperatures may upset the delicate balance of marine life and put pressure on fisheries.
- The farming sector will be affected by increased weeds, pests, droughts and soil erosion.
- Properties and lives will be endangered by more frequent storms and floods.

For more information about the possible impacts of global warming , go to:
http://www.climatehotmap.org

For a summary of the Stern Review on the Economics of Climate Change, go to:
http://news.bbc.co.uk/
http://en.wikipedia.org/wiki/Stern_Review

Energy Efficiency

The modern lifestyle is a costly one. Most people spend their money on the cost of running a home, a car and buying food. Their remaining income is devoted to "fun" things – fashion clothing, sports, social events, holidays and other recreational activities.

Whatever they deem to be the most important item in their lives, they will want as much money as possible to spend on this favourite activity so that they get the maximum enjoyment possible.

To really enjoy the important things in their lives, people need to plan their expenditure. How they choose to spend their income is basic economics – this much for rent, this much for the car and this much for food etcetera. It is called "the domestic budget".

The largest expenses after housing costs (rent or mortgage) and food are usually energy costs – the electricity and gas consumed in the home and the fuel for the car. These forms of energy are important whatever lifestyle you choose, because they:

- Heat your water.
- Warm your home in winter and cool it down in summer.
- Keep your food cool and fresh to eat.
- Cook your food.

- Give light at night-time.
- Provide energy for entertainment (stereo, TV).
- Clean (vacuum cleaner, washing machine).
- Help make things (food mixer, electric drill).
- Provide convenient transport (to work or to leisure activities).

The household electricity and gas costs are referred to as the “energy accounts”. In fact, these two forms of energy – electricity and gas - are so important that they are generally called *essential services*.

As our homes and lifestyles have become more sophisticated so our energy accounts have tended to rise but the consequence is not just monetary cost. Consumption of vehicle fuel, electricity and gas all result to some degree in the emission of greenhouse gases and scientists are now concerned that the build-up of these gases in the global atmosphere could cause significant climate change with serious social and economic consequences.

So although energy use is essential to our well-being, we need to use it wisely to not adversely affect our environment. Just about every time we switch on the light or turn on an appliance, we’re contributing to greenhouse gas emissions. On average, each Western Australian household produces around six tonnes of greenhouse gases every year. It is important that we all realise the implications of our energy use. Wasting electricity harms the environment as well as hurting the bank account.

So in the last decade there has been increasing focus on energy conservation and energy efficiency so that we don’t use energy unnecessarily and when we do use it, we do so effectively – even at home.

<u>The energy efficient home:</u>

The design and location of your home will affect the size of your family’s energy accounts and your general comfort. Therefore if your family is planning to build a new home, think about one of the big running costs – heating and cooling.

By carefully choosing the building block, house design and garden layout, your home could use a lot less energy for heating and cooling. You have probably experienced homes that you would describe as cool in summer or warm in winter. These instances are not just a matter of luck. A home is naturally cool in summer or warm in winter because of its favourable design features. Similarly, homes that are described as “hot boxes” in summer or “ice boxes” in winter have unfavourable design features and they cost a lot of money to heat or cool.

It is important to consider “energy efficiency” before a family buys a block of land and chooses a house design. A crucial decision is the direction that the house faces. North-facing windows and walls receive maximum winter sun and warmth.

See
http://www.worldofenergy.com.au/factsheet_efficiency/07_fact_efficiency_home.html
for details of summer and winter sun angles and solar pergolas. (interactive map)

Another significant way to reduce energy is to install insulation in ceilings and walls. Ceiling insulation is remarkably effective and it can reduce your family’s winter heating bill by up to 30 per cent.

For more information about energy efficient home design and home insulation, go to:
www1.sedo.energy.wa.gov.au/pages/energy_smart_homes.asp

Water Heating

Water heating accounts for nearly one third of the total energy used in a typical Western Australian household. The domestic hot water system is one of the most expensive appliances to install in a home. It is also the most costly appliance to operate. Any savings that you can make in this area will impact significantly on your total energy use.

There are two main types of water heater – instantaneous and storage

Instantaneous water heaters are either electric or gas. They are *reduced-pressure systems.* This is because the flow of water from the main supply is reduced and this allows the instantaneous heating of the water as it passes through the water heater. These water heating systems can be installed either inside or outside a house. However gas water heaters are mainly installed outside.

Electrical and standard gas instantaneous water heaters have a reduced flow of water and they can normally supply only one tap with hot water at any one time. These systems are not recommended for large homes.

Storage hot water systems:

Hot water is stored in an insulated tank ready for use throughout the day. These water heaters are either electric or gas. They are mains pressure systems and so they do not have a reduced flow of water. Mains pressure means they are capable of supplying more than one tap at a time and therefore, they can be suitable for homes with two or three bathrooms.

Both electric and gas water heaters can go either inside or outside a home. However, outside installations are usually the best because these units are much larger than instantaneous systems and they take up considerably more space. Storage water heaters come in different sizes and the correct size needs to be chosen for the number of people living in the home. Each person uses about 50 litres of hot water each day on average.

These hot water systems are suitable for larger homes and they have a higher flow of water than instantaneous units. This means that you can fill up your bath, sink and washing machine much more quickly with a storage hot water system. But the higher water flow rate can be very costly in the shower.

When taking a shower, you normally need only five litres of hot water per minute mixed with cold water. Instantaneous water heaters supply this amount as a normal function. However, the storage system can supply a massive 13 to 15 litres of hot water in a shower at one time! It may seem fun to stand under a piping hot waterfall on a chilly day but what about the cost? It is certainly much more expensive than an instantaneous water heater.

In Western Australia, it is recommended that families should install a "flow control valve" or valves in bathrooms. The flow control valve will reduce unnecessary excess water flow in a hot shower. These valves reduce the water flow down to a sensible level in showers. However, it is not necessary to install a flow control valve in places where a fast water flow is useful, such as sinks and baths. The valves are cheap to purchase and you will significantly reduce energy costs. You will also save water, a precious resource in Western Australia.

To reduce the cost of running your water heater:

- Take shorter showers.
- Fix leaky hot water taps as soon as possible.
- Don’t leave hot water taps running (not even a little bit).
- Ask your mum or dad to set the thermostat to 60 degrees Celsius on storage hot water systems and 50 degrees Celsius on instantaneous systems.
- Install a AAA rated water efficient showerhead (or a flow control valve) if you have a storage hot water system.
- Turn off the hot water system when you go away on holidays

For more information about hot water systems, go to:
www1.sedo.energy.wa.gov.au/
For more money-saving hints about saving hot water at home, go to:
http://www.synergyenergy.com.au

Warming up and cooling down:

There are many types of heating and cooling systems available for homes. One of the most efficient systems is a reverse cycle air-conditioner. The main advantage of the reverse cycle air-conditioner is that it provides the combined effects of a home air-conditioner and a heater.

The main types of air-conditioners are:

- Evaporative (cooling);
- Refrigerative (cooling and dehumidifying).

The main types of heaters are:

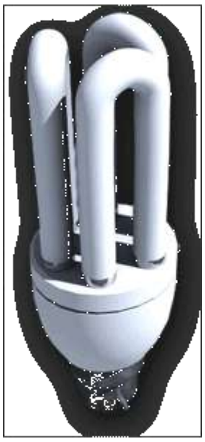
- Reverse-cycle refrigerative;
- Electric fan heaters;
- Electric bar radiators;
- Oil-filled column heaters;
- Flat panel or film electric radiant heaters;
- Electric floor heaters;
- Convection gas heaters;
- Radiant gas heaters;
- Combination convection/radiant gas heaters;
- Kerosene heaters.

When your family is ready to buy a new heating or cooling system, it is important to calculate the overall energy costs. The following factors are worth considering:

- The energy star rating (the more stars, the more energy efficient).
- The size of the area to be cooled.
- The direction that your room faces; whether the room is insulated; and the size of the windows in that room.
- The amount of time that you will use the appliance each day.

- The cost of the appliance.
- The installation costs.
- The running costs, usually expressed in terms of cents per energy unit used (kWh).
- How long you expect the appliance to last.

For more information about efficient heating and cooling systems, go to:
http://www.synergyenergy.com.au



More smart ways to save electricity:

Electrical appliances will account for a significant portion of your family's household energy costs. Keeping your food cold can be a major area of energy use. This is mainly because your fridge/freezer runs for a large part of the day, everyday. The kitchen is one area where simple actions can usually be taken to reduce energy use at no extra cost. Other ways to conserve energy include the installation of more efficient lighting and other electrical appliances.

Useful references:

- Synergy website at:
  www.synergyenergy.com.au
- Sustainable Energy Development Office website at:
  www1.sedo.energy.wa.gov.au/
- The Australian Greenhouse Office website at:
  www.greenhouse.gov.au
- International Energy Agency website at:
  www.iea.org/
- Research Institute for Sustainable Energy at:
  www.rise.org.au/info/Tech/house/index.html
- Horizon Energy website at:
  www.horizonpower.com.au
- Verve Energy website at:
  www.verveenergy.com.au
- "Western Power" website at:
  www.westernpower.com.au
- "The Energy Kids' Page" website at:
  www.eia.doe.gov/kids/index.html
- "Energy Western Australia" published by the Office of Energy, 2003:
  www.energy.wa.gov.au
- International Energy Agency website at:
  www.iea.org/
- The ResFiles website at:
  www.rise.org.au/info/Res/index.html