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# ENERGY

## Fact Sheet Series for Key Stage 4 and A-Level

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*1999 (updated 2002)*



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# 1. What is Sustainable Energy?

Sustainable development, according to the **Brundtland Report**, can be defined as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs”. Sustainable development should minimise environmental damage and take into account that some **non-renewable** fuels must be preserved for the future, whilst promoting **renewables** as the way forward in energy production.



The issue of sustainable energy has become increasingly important, as concern about the effects of economic growth on natural resources and the environment have been noted. Since the **Industrial Revolution**, national wealth has been immediately linked with access to **fossil fuels**. In the 18th Century coal became crucial in Britain and soon throughout the world. Oil became vital with the introduction of the automobile, and natural gas as a cleaner domestic and industrial fuel.

Energy efficiency, in its role in reducing the threat of climate change, is the main building block of any sustainable policy. **Greenhouse gases** in the atmosphere, which absorb heat released or radiated from the Earth, are responsible for the natural greenhouse effect. Energy production increases the levels of these gases, which include **carbon dioxide** (CO<sub>2</sub>) and **nitrous oxide** (N<sub>2</sub>O), enhancing the natural greenhouse effect. This may cause **global warming**.

Most countries believe that an international framework must be used to prevent man-made global warming. If this is not successful, then rapid changes in climate could have damaging effects on crops and natural **ecosystems**, as well as causing drought and flooding in parts of the world, spreading disease and slowing economic development.

## 2. Energy Consumption in the UK

### Introduction

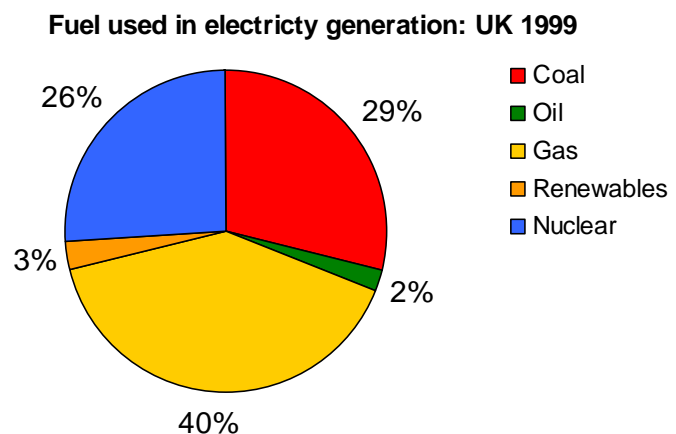
The average energy consumption per person in the UK in 2000 was about 3.6kW (**kilowatts**); this figure was similar throughout Western Europe and Japan. This compares to 1kW per person used in the **developing countries** of the world. The UK pattern of energy use is typical of an **industrialised** country. About 18% of all energy consumed in the UK in 2000 was for the purposes of electricity generation.

### Fuel Used in Electricity Generation in the UK

As shown by the pie chart, coal burnt in power stations accounts for the largest amount of electricity consumed in the UK. Nuclear and gas power stations are also major generators of electricity . It can be seen that renewables provide a very small proportion of our energy needs.

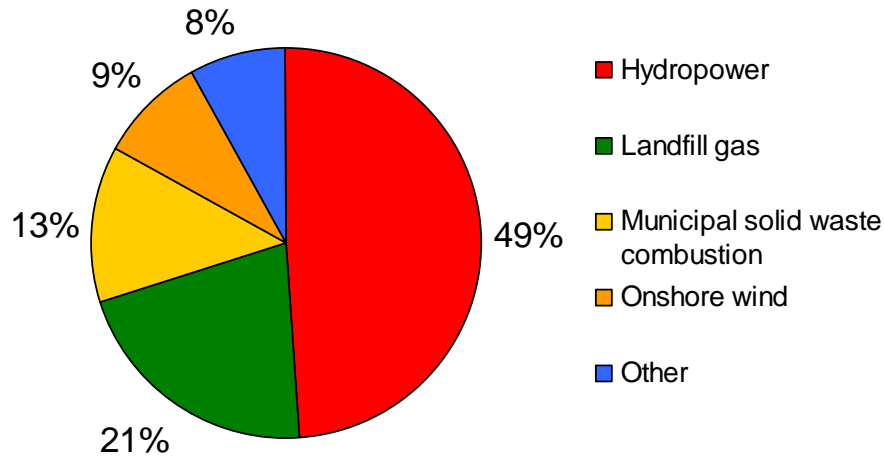
### Renewable Sources Used to Generate Electricity

The pie chart on the following page illustrates the proportion of the various renewable energy sources used in the UK. It can be seen that hydroelectric power (HEP) provides the



largest amount of renewable energy, followed by landfill gas *municipal solid waste combustion*.

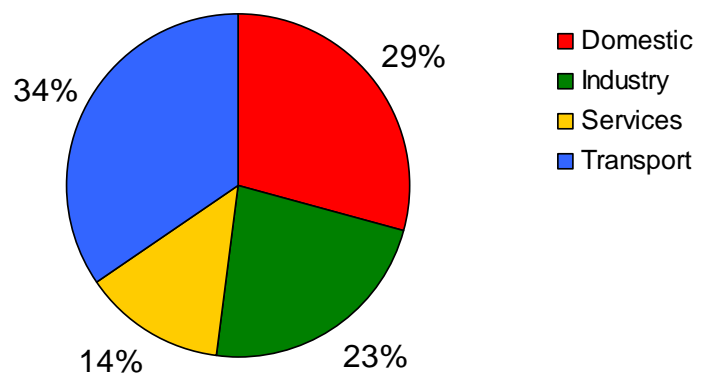
Electricity produced by renewable sources: UK 2000



### ***Energy Consumption by Final Users***

Transport accounts for the largest end usage for energy produced in the UK. This has increased greatly since the 1960s, when transport accounted for 17% of the energy used.

Energy consumption by final user: UK 2000



Transport usage is closely followed by domestic (home) and industrial usage. Domestic usage has remained at similar levels to those in the 1960s, whereas industrial usage has decreased from 42% to 24%.

## 3. Fossil Fuels and Emissions

### Introduction

Fossil fuel burning in power stations for electricity releases gases into the atmosphere, which constitute air pollution.

### Coal

Coal is a solid fuel formed over millions of years by the **anaerobic** decay of vegetation. Coal is widely used in the generation of electricity as it constitutes a highly concentrated energy source.

It is, however, not a “clean” fuel in comparison to natural gas; when burnt it releases significant amounts of pollution into the atmosphere in the form of carbon dioxide (CO<sub>2</sub>), **sulphur dioxide** (SO<sub>2</sub>) and **oxides of nitrogen** (NO<sub>x</sub>). CO<sub>2</sub> is a greenhouse gas, and as mankind adds more to the atmosphere, it may be responsible for global warming. SO<sub>2</sub> and NO<sub>x</sub> are the major contributors to acid rain.



Air pollution from the burning of coal in the first part of this century led to huge **smog** problems in the UK, particularly in London. In response to the Great London Smog in 1952, during which 4,000 people died, the Clean Air Act of 1956 was introduced. This prevented the burning of coal in towns and cities and required factories and power stations to erect taller chimneys or stacks which disperse plumes of pollution high into the air.

## Oil

Oil is formed from the remains of marine **micro-organisms**. As they accumulate on the seafloor over millions of years they gradually infiltrate the microscopic cavities of the sea floor sediment and rock where they decay. The resulting oil remains trapped in these spaces, forming **hydrocarbon** reserves which can be extracted through large drilling platforms.



Many sites of major oil fields occur where **continental margins** have been created by the break-up and rifting apart of landmasses. It was in such areas that the majority of the world's oil was formed.

In the early 1970s, approximately 40% of global fossil fuel use came from oil, but during the 1990s this figure has decreased. The United States consumes about a quarter of all oil extracted around the world. Reports have shown that most of the developed nations would be unable to function efficiently under a severe oil shortage situation. Consequently, nations are looking to invest in alternative energy resources.

Improved energy efficiency has caused oil consumption to decline in many developed, industrialised countries, as well as shifts to other fuels such as natural gas and nuclear energy. Decreasing use of oil is also resulting from tougher environmental restrictions concerning its use in some regions.

## ***Natural Gas***

Natural gas is formed in the same way as oil, from the remains of marine micro-organisms, and is also found throughout the same regions of the world.



From the mid-1960s, up until the present day, there has been a dramatic increase in the amount of proven reserves of natural gas. Consequently, natural gas has become the fastest-growing energy resource. The present global use of natural gas is approximately 20% of all fossil fuel use, and this figure is predicted to rise in the future. Natural gas provides an alternative to oil or coal in the provision of energy, and in terms of pollution it is a cleaner fuel.

In the mid-1990s it was predicted that global natural gas reserves would last only for the next 120 years, whereas economically recoverable coal reserves might last for another 1,500 years. However, if it becomes economically viable to tap less accessible reserves, then natural gas may possibly last for almost 400 years.

Leakage and losses of ***methane*** from distribution systems, including pipelines, oil/gas wells, and domestic use, contribute to the ***anthropogenic*** (man-made) emissions of greenhouse gases. Annual leakage rates are estimated to range between 1-5% of the total amount of natural gas used each year in Europe and North America, and up to 10% in countries such as the former Soviet Union.

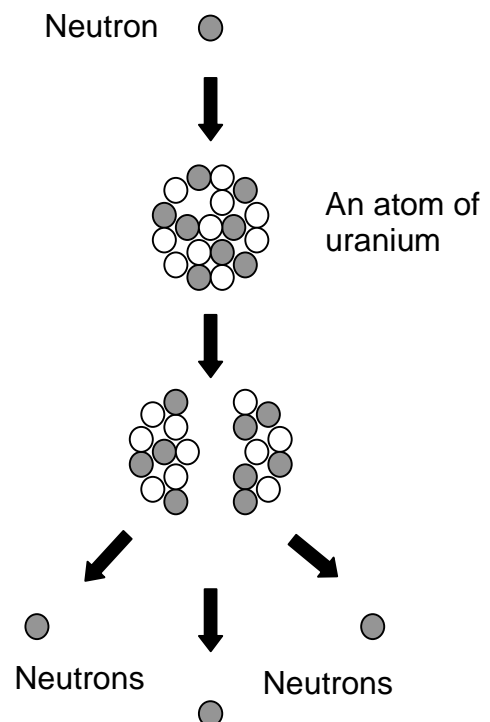
## 4. Nuclear Power

### *What is Nuclear Power?*

Nuclear power has a significant part to play in maintaining a balanced energy policy. It currently contributes to 26% of the UK's electricity generation and a great deal more in countries like France and Germany. Nuclear power generation does not emit pollution and can therefore help to reduce acid rain and global warming.

Nuclear power generation uses the fuel **uranium** to produce electricity. Uranium is a highly concentrated energy source that is available throughout the world in large quantities. 1 **tonne** of uranium can produce as much electricity as 2000 tonnes of coal. Once uranium has been used, it can be reprocessed and recycled to make more fuel. During the reprocessing, **plutonium** is given off as a by-product. The plutonium can then be used to generate power in **fast reactors**.

Electricity is generated in a nuclear power plant when an extra **neutron** is added to the **nucleus** of a uranium **atom**. This causes it to split apart and release heat energy. As the nucleus splits apart, several neutrons are released, which can then collide with another nucleus and cause further **fission**. This leads to a chain of reactions. The heat produced during fission converts water to steam, which then turns a turbine and generates electricity. In a power station, the amount of energy release is controlled to provide an even heat supply.



## ***Nuclear Waste***

Waste generated by the nuclear industry is **radioactive** and must therefore be disposed of with extreme care. The waste must be managed to present no hazard to humans or the environment. The radioactivity of waste will decay over time. All radioactive waste is managed according to its content. There are three classifications of radioactive waste:

### ***High-level waste***

High-level waste is made up of material separated from uranium and plutonium during reprocessing. This waste is very radioactive and must therefore be stored in large steel tanks, or made into solid blocks of glass in a process called **vitrification**. Although this waste is highly dangerous, the amount produced is very small.

### ***Intermediate-level waste***

Intermediate-level waste is made up of contaminated equipment and sludges from various treatment processes. It is far less radioactive than high-level waste.

### ***Low-level waste***

Low-level waste refers to paper towels, clothing and lab equipment which may have come into contact with radioactive materials. This waste has a very small radioactive content and is therefore disposed of deep underground.

## 5. Combined Heat and Power



During electricity generation, a large amount of low-grade heat is produced as a by-product. In conventional power stations this heat is lost. In combined heat and power (CHP) systems the heat produced during electricity generation is recycled rather than wasted, thereby increasing the efficiency of the system. CHP is usually only used as a supplement to grid mains electricity supply for boiler produced steam/ heat.

High capital and maintenance costs deter individual users from investing in CHP, and therefore CHP schemes are more likely be used by the public, industrial and commercial sector. The main markets tend to be those requiring a great deal of heat, for example leisure centres, hospitals and industrial sites with process heating requirements, especially the chemical, brewing and paper industries. Sewage treatment works sometimes use CHP, fuelled by **biogas**.

The increased fuel efficiency of CHPs gives them a potentially useful role in helping to combat global warming, by decreasing carbon dioxide emissions. This reduction can be between 13-57%, depending on the fuel being replaced by CHP. Acid rain can also be reduced by the use of CHP, by cutting emissions of SO<sub>2</sub> and NO<sub>x</sub>. However, one disadvantage of a CHP plant that is close to the point of use is the increased noise level.

The UK Government is promoting CHP through the Energy Efficiency Office's Best Practice Program, and through the Energy Saving Trust. The aim is to double current CHP capacity by 2010. CHP currently provides about 4% of the UK's electricity.

## 6. Impacts of Power Generation

### *Air Pollution*

The term air pollution describes any harmful substances in the air we breathe. The largest sources of air pollution in the UK are transport and industry (including power generation).

Power stations are responsible for releasing large amounts of harmful pollutants into the air. The world emits approximately 69 **tonnes** of sulphur dioxide (SO<sub>2</sub>) and 24 million tonnes of nitrogen oxide (NO<sub>x</sub>) into the atmosphere each year. SO<sub>2</sub> and NO<sub>x</sub> can cause respiratory disorders, with children and **asthmatics** being particularly vulnerable.

In the past, air pollution was dominated by thick black smoke, which was emitted from the burning of coal by power stations, industries and homes. The famous London Smog of December 1952, which caused thousands of deaths, prompted the introduction of the 1956 Clean Air Act. This created smokeless zones, where no pollution from the burning of coal could be produced. The Act focused on reducing smoke pollution, but the measures taken helped to reduce SO<sub>2</sub> levels at the same time. Air pollution in cities dramatically reduced in the following ways:

- domestic emissions reduced due to smokeless zones;
- electricity and gas usage increased and the use of solid fuels decreased;
- cleaner coals were burnt, which had a lower sulphur content;
- taller chimney stacks were used on power stations to help the pollution disperse;
- there was a continuing decline in heavy industry.

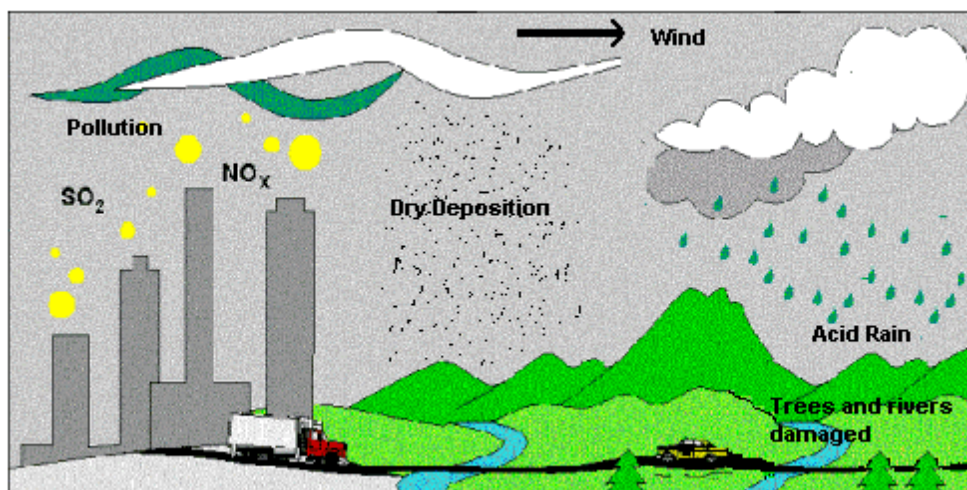


## Acid Rain

Acid rain is the term used to describe the acidity of wet and dry deposition. This includes acidity falling as rain, snow, sleet, hail, mist or fog (wet deposition) and the dry deposition of gases and particles. Rain water is naturally acidic as a result of carbon dioxide (CO<sub>2</sub>). However, **anthropogenic** (man-made) emissions of pollutants make acid rain a large problem.

The main pollutants responsible for acid rain are sulphur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>). Both are produced from the burning of fossil fuels for power generation. Once emitted, they combine with water in the atmosphere to form **sulphuric** and **nitric acid**. The acid then falls to the Earth's surface, causing damage to plants and animals.

Emissions of SO<sub>2</sub> and NO<sub>x</sub> in the UK contribute significantly to problems of acid deposition in other parts of Europe, e.g. Scandinavia. This occurs because the pollutants remain suspended in the atmosphere, where they can travel long distances before falling back to the ground.



To reduce the problem of acid rain throughout the world, it is necessary for all countries to work together in reducing their pollutant emissions.

## ***Global Warming***

Greenhouse gases such as water vapour, carbon dioxide (CO<sub>2</sub>), methane, and nitrous oxide (N<sub>2</sub>O) keep our planet warm. They exist naturally in the atmosphere, heating it by trapping energy that originally came from the Sun. This process is called the greenhouse effect. Without the greenhouse gases, the surface of the Earth would be about -18°C, rather than the typical surface temperature of about 15°C.

Increasing ***concentrations*** of the greenhouse gases trap more ***terrestrial radiation*** in the lower atmosphere (***troposphere***), enhancing the natural greenhouse effect. Over the last 200 years, mankind has increased the amount of greenhouse gases in the atmosphere through processes such as fossil fuel burning. Fossil fuels are made up of carbon and hydrogen, which are changed to water and CO<sub>2</sub> when they are burned.



By the end of the 21<sup>st</sup> century, global average temperatures could be several degrees higher than today. In an effort to reduce or remove the threat of global warming, nations around the world have adopted the Framework Convention on Climate Change. The objectives of this framework are to prevent “dangerous interference with the climatic system”. The aim is to reduce global greenhouse gas emissions by 5.2% from 1990 levels by 2012.

Renewable and nuclear power are alternative energy resources that do not produce CO<sub>2</sub> and may therefore be used to reduce the threat of global warming. As the world aims towards a sustainable energy future, the use of renewables will increase and hence pollution from the burning of fossil fuels will reduce.

# 7. Renewable Energy

## ***Introduction***

Renewable energy refers to power generated by a renewable source. When the energy is generated, the resource is not depleted or used up. They are naturally replenished, and can either be managed so that they last forever, or their supply is so enormous humans can never meaningfully deplete them. Unlike fossil fuels, renewable energy sources do not release carbon dioxide as a by-product into the atmosphere. As the amount of fossil fuel resources on Earth decreases, it is becoming increasingly important to find and utilise alternative fuels.

Examples of renewable resources include:

- wind power;
- solar power;
- biofuels;
- hydro-electric power (HEP);
- geothermal energy;
- tidal power and
- wave energy.

## ***Wind Power***

Air moves around the Earth because of the differences in temperature and atmospheric pressure that exist. Wind turbines harness the movement of air to produce energy. The wind turns the blades which turn a rotor shaft; the resultant mechanical power is used to drive an electricity generator. Wind turbines are often grouped together in wind farms.



Wind power has very promising potential in the UK as we live in the path of Atlantic depressions (low-pressure systems), which bring windy weather. The UK currently has over 70 onshore wind farms and it is thought that wind power could be supplying 10% of the UK's electricity by the year 2025.

Wind farms provide a clean source of energy, but they do have some disadvantages. To some, they have a detrimental visual impact, and can be noisy in windy conditions. Suitable locations for wind farms are often in areas of scenic beauty and so careful consideration needs to be given before they can be built.

It is estimated that the UK has a very large offshore wind resource. Increasingly, it is now becoming financially viable to build offshore wind farms. Currently there are 13 offshore windfarm in UK waters, most off the coasts of East Anglia, Lancashire and Cumbria.

## ***Solar Power***

Solar power is the term used to describe energy derived directly from the Sun. The Sun provides the basis of energy for all living things. Sunlight has been utilised by humans for drying crops, and heating water and buildings for millions of years. Solar energy is free and will never run out. We can use solar panels to turn the Sun's

energy into useful energy. There are a number of different ways that we can utilise the Sun's energy.

### ***Passive solar heating***

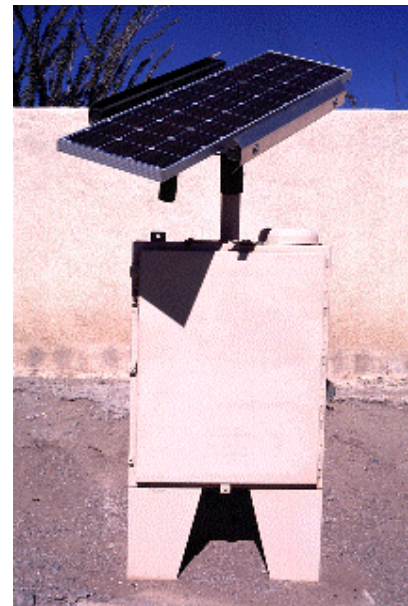
Houses can be designed with large windows in the south facing walls and small windows in the north facing walls. This would allow natural light and heat from the Sun to be used to its full potential and reduce the need for electricity.

### ***Active solar heating***

Solar power can be used to heat large bodies of water mainly for domestic hot water systems, but also swimming pools

### ***Photovoltaics***

Photovoltaics allow the direct conversion of solar radiation into an electric current by the interaction of light with the electrons in a semiconductor cell. As development in solar technology has increased, it has become much cheaper and the UK is starting to invest in the technology.



### ***Biofuels***

This is the term used to describe plant material and animal waste, which can be burnt to produce energy. In terms of energy production, "biomass" refers to using tree and grass crops, and forestry, agricultural, and urban waste. It is the oldest source of renewable energy known to humans. Biomass is considered to be a renewable energy source because the energy it contains comes from the Sun.

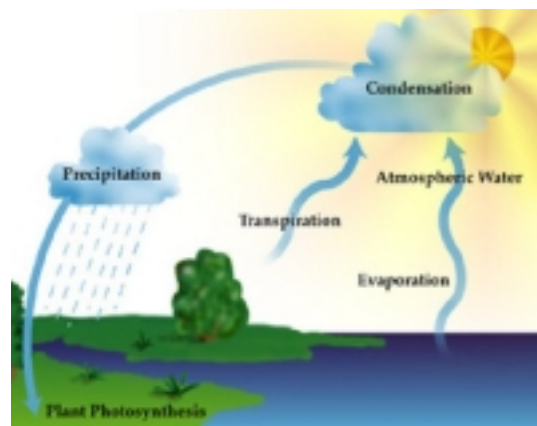
Unlike other renewables, biomass energy does release carbon dioxide, but it is only returning to the atmosphere as much as was removed through **photosynthesis** during the plant's lifetime. Burning fossil fuels, by contrast, returns carbon dioxide to the atmosphere that has been locked away in the Earth's crust for millions of years.



Crops can be grown with the purpose of being burnt to produce energy, e.g. willow and oil seed. We can also extract **methane** from waste landfill sites and burn it to generate electricity. Methane is a powerful greenhouse gas, and burning it would help to reduce the amount of methane in the atmosphere.

### ***Hydro Electric Power (HEP)***

On the Earth, water is neither created nor destroyed, but is constantly moved around. Water **evaporates** from the oceans, forming clouds, falls out as rain and snow, collects into streams and rivers, and flows back to the sea. This is known as the water cycle.



All this movement provides an enormous opportunity to create useful energy. Hydroelectric power (HEP) uses the force of moving water to create electricity. However, HEP stations often require large dams, which can disrupt **ecosystems** and displace people.



There are a number of large-scale HEP stations currently in operation throughout Britain. In Scotland they are responsible for providing a significant amount of energy. Unfortunately there is little room for the future development of large scale HEP stations in Britain and so

the potential of small-scale HEP stations is now being investigated.

## ***Geothermal Energy***

Rocks under the Earth's crust contain naturally decaying ***radioactive*** materials like ***uranium*** and ***plutonium***, producing a continuous supply of heat. The amount of heat within 10,000 metres of the Earth's surface contains 50,000 times more energy than all the oil and gas resources in the world.

Geothermal energy is power generated by the harnessing of heat beneath the Earth's surface. Wells are used to pipe steam and hot water from deep within the Earth, up to the surface. The hot water is then used to drive turbines and generate electricity. The regions with highest underground temperatures are in areas with active or geologically young volcanoes. These "hot spots" often occur around the Pacific Rim. This area is also known as the "Ring of Fire" due to the large number of volcanoes.

In the UK at a depth of about 1500 - 3000 metres below the surface there are some aquifers that contain water at very high temperatures. This water can be pumped up to the surface and used in heating schemes.



## ***Tidal Power***

The idea of tidal power is very similar to HEP. A dam-like structure is constructed across an estuary to trap a high tide of water and then let it pass through turbines to generate electricity. The water flow can generate electricity on the falling tide only, or on the falling and rising tide. The Rance Estuary in France (Brittany) is an example of a successful tidal plant. The UK has the potential to widely use tidal power with the Severn and Mersey estuaries being possible sites.

## ***Wave Power***



Ocean waves are a form of wind energy that is concentrated. Friction develops between air and water as wind blows across the water, and waves are produced as energy is transferred between these two elements. Taking the motion of the waves, and

translating it into mechanical or electrical energy, generates energy from waves.

The UK is situated in the path of strong winds from the Atlantic, creating large waves. There is therefore the potential to exploit a great deal of energy from wave power. Further financial investment is necessary to aid the future development of wave energy.

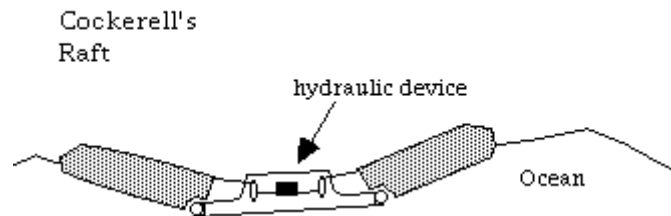
There are 2 types of instruments that can generate electricity from wave energy: floaters and sitters. Salter's Duck and Cockerell's Raft are examples of floaters and Vickers 'Duct' is an example of a sitter.

***Salter's Duck***

This design can extract approximately 90% of the energy from a wave. It is made up of a chain of about 25 floats. As they bob up and down on the water a pump is driven and electricity is generated.

***Cockerell's raft***

To generate electricity, lines of rafts are placed at right angles to the wave front. Between the rafts are hydraulic motors or pumps, which convert the energy to high pressure that then drives the turbines.

***Vickers 'Duct'***

Water goes up and down a submerged tube and as the pressure changes water is squirted out and electricity generated

***Use of Renewable Energy***

Compared to the use of fossil fuels, the harnessing of energy from renewable sources for mass consumption is still limited. Large scale HEP contributes about 20% of the world's electricity needs. In the UK however, energy from renewables currently contributes only 3% to the total energy consumed. Most of this comes from HEP, and the potential to increase this resource in the future is limited. In the UK, the Government is trying to encourage the uptake of renewable energy through the Non-Fossil Fuel Obligation, which requires energy suppliers to purchase some of their electricity from renewable sources. The Government has set a target for 10% of the UK's electricity to be supplied from renewable energy by 2010.

## 8. Energy Efficiency

### *Improvements in Energy Supply*

More efficient usage of electricity would enable reductions to be made in the amount of energy resources which are required to produce the same unit of electricity by less efficient means. Greater utilisation of Combined Heat and Power (CHP) would theoretically enable the supply of fuel to a power plant to be reduced.

CHP utilises heat that is produced as a by-product of electricity generation. In conventional generation, a mere 30-50% of the energy consumed is converted to electricity. The fuel efficiency of an industrial CHP plant can be more than 80%, and losses from transmission and distribution are minimised by locating plants on site.

### *Using Energy More Efficiently*

As an individual, we have very little influence on how our energy is produced, e.g. by coal or gas fired power stations, or alternatively by wind or solar power. However, the individual does have control on how they use that available energy. Through the use of simple measures, we can effectively bring about a reduction in energy consumption, thereby reducing the need for energy production.



This would in turn lead to reductions in the price of fuel bills.

There are a number of different things we can do to reduce our energy use, including:

- using energy saving light bulbs;
- draught proofing doors;
- insulating lofts;
- external wall insulating;
- fitting a hot water jacket to the water tank;
- having showers instead of baths when possible;
- not placing a fridge/freezer next to the cooker;
- lowering temperature setting of the central heating down by just 1°C will save 10% on heating bills and;
- fitting double-glazing.



# Glossary

**Anaerobic:** in the absence of oxygen.

**Anthropogenic:** man-made.

**Asthmatics:** people who have asthma, a respiratory disease, causing breathing difficulties.

**Atom:** the smallest part of a chemical element that can take part in a reaction.

**Biogas:** a gas produced by the action of bacteria on organic matter.

**Brundtland Report:** a report by Gro Harlem Brundtland of the United Nations, outlining the actions needed to be taken for sustainable development to be achieved globally.

**Carbon dioxide:** a molecule formed from one atom of carbon and two of oxygen. Carbon dioxide is a greenhouse gas of major concern in the study of global warming.

**Concentration:** a measure of the atmospheric content of a gas, defined in terms of the proportion of the total volume that it accounts for.

**Continental margins:** part of the Earth's crust at the edges of continents.

**Developing country:** a poor country that is seeking to develop its resources by becoming industrialised. Previously known as a Third World country

**Ecosystem:** a system involving the interaction between a community of plants and animals and its non-living environment.

**Fast reactors:** used in nuclear energy production.

**Fission:** the splitting of atoms, for example of uranium to generate nuclear energy.

**Fossil fuels:** any hydrocarbon deposit that can be burnt to produce heat and power.

**Global warming:** the recent and projected increase in temperature at the Earth's surface.

**Greenhouse gases:** gases that trap heat energy in the atmosphere.

**Hydrocarbon:** an organic substance containing carbon and hydrogen.

**Industrial Revolution:** the rapid growth of industry seen in Britain and subsequently the rest of the developed world in the late 18<sup>th</sup> and 19<sup>th</sup> centuries.

**Kilowatts (kW):** one thousand watts. A Watt is a unit of power.

**Methane:** a greenhouse gas consisting of 4 molecules of hydrogen and one of carbon.

**Micro-organism:** an organism, such as a bacterium, protozoa or virus, of microscopic size.

**Municipal solid waste combustion:** the burning of waste collected from homes for energy production.

**Neutron:** a particle found in the nucleus of an atom.

**Nitrous oxide:** a colourless, non-flammable, slightly soluble gas containing nitrogen.

**Nitric acid:** a component of acid rain formed when nitrogen and oxygen pollution mixes with moisture in the air.

**Non-renewable:** a finite resource, such as coal and oil.

**Nucleus:** the core of an atom, consisting of neutrons and protons.

**Oxides of nitrogen (NO<sub>x</sub>):** compounds of oxygen and nitrogen.

**Photosynthesis:** the generation of food resources and energy by plants utilising sunlight, water and carbon dioxide.

**Plutonium:** a highly toxic and radioactive metal.

**Pollutants:** substances that cause harm or damage to the environment.

**Radioactive:** a material emitting radiation from an atomic nucleus.

**Renewables:** energy sources which will not run out, e.g. wind power, solar power.

**Sulphur dioxide (SO<sub>2</sub>):** a colourless gas, consisting of molecules of sulphur (1) and oxygen (2) atoms, it is given off during the burning of fossil fuels.

**Sulphuric acid:** a component of acid rain formed when sulphur dioxide pollution mixes with moisture in air.

**Terrestrial radiation:** radiation or energy released from the Earth once it has been received by the Sun.

**Tonne:** a unit of mass equal to 1000 kg.

***Troposphere:*** the lowest layer of the atmosphere, about 18km thick.

***Uranium:*** a silvery-white metallic element that is radioactive.

***Vitrification:*** the conversion of a substance to a glassy substance.

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