Section 1 - Supply and Demand

Fossil Fuels

At present our main sources of energy are the **fossil fuels**. These are **coal**, **oil** and **gas**.

Fossil fuels are the remains of plants and animals that died millions of years ago.

The reserves of fossil fuels are finite (they will run out one day).

Renewable and Non-renewable Sources

Renewable energy sources are sources that will never run out. Such sources include wind, solar, wave, tidal, hydroelectric, geothermal and biomass.

Non-renewable energy sources will run out one day. These include coal, oil, gas, uranium and peat.

Conserving Energy

Since the reserves of fossil fuels are finite it is important to conserve (save) energy. This can be done in the following ways:

At home:	fitting insulation turning down the heating switching off unused appliances
In transport:	using public transport car sharing careful driving cycling for short journeys
In industry	using fans to circulate heat self-closing doors using low energy lighting fitting insulation

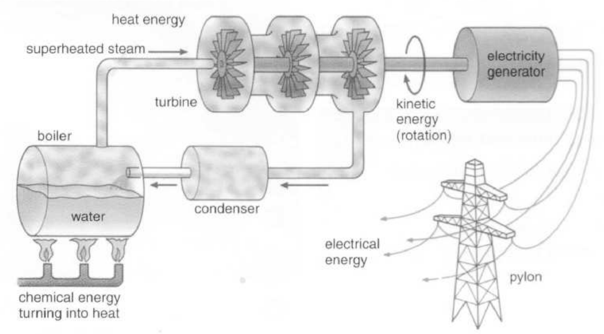
Comparing Renewable Energy Sources

Source	**Advantages**	**Disadvantages**
Wind	Cheap to run Clean	Not always windy Wind farms use a large area of land Wind turbines can be unsightly
Solar	Cheap to run Clean	Expensive to install Sun is not always shining
Wave	Cheap to run Clean	Wave size is variable Suitable sites are distant from the user Possible shipping hazard
Tidal	Cheap to run Clean	Expensive to set up Few suitable locations
Hydroelectric	Cheap to run Clean	Expensive to build Reservoirs use a large area of land Environmental damage
Geothermal	Cheap to run Clean	Expensive to set up Few suitable locations

Section 2 - Generation of Electricity

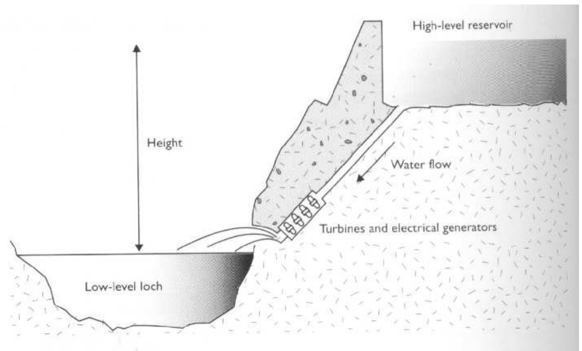
Thermal Power Stations

In a thermal power station fuel (coal, oil or gas) is burned in a **furnace** to produce heat (chemical to heat energy). This heat is then used to change water into steam in the **boiler**. The steam then drives the **turbine** (heat to kinetic energy) which in turn drives the **generator** to produce electricity (kinetic to electrical energy).



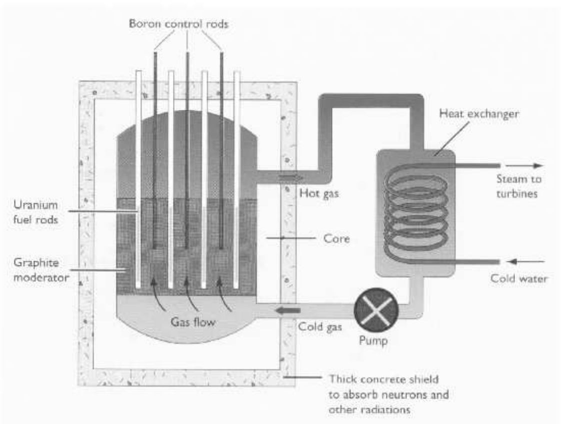
Hydroelectric Power Stations

In a hydroelectric power station water is stored behind a dam in a **reservoir**. This water has potential energy. The water then runs down pipes (potential to kinetic energy) to turn the **turbine**. The turbine is then connected to a **generator** to produce electricity (kinetic to electrical energy).



Nuclear Power Station

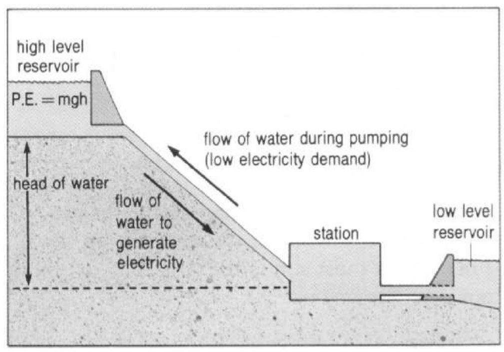
In a nuclear power station nuclear fuel (uranium) is reacted in the **reactor** to produce heat (nuclear to heat energy). This heat is then used to change water into steam in the **boiler**. The steam then drives the **turbine** (heat to kinetic energy) which in turn drives the **generator** to produce electricity (kinetic to electrical energy).



Pumped Storage Hydroelectric Station

A pumped storage hydroelectric station is one where, at night, when there is excess energy being produced by other power stations, water is pumped back into the reservoir. This stores energy and during the day the water can be allowed to flow back down to produce electricity just like a normal power station.

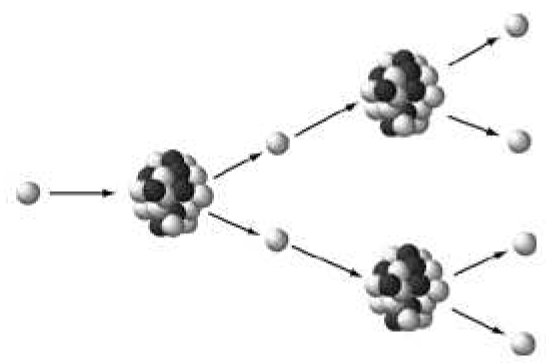
Such a system saves energy and also can be turned on quickly at times of peak demand.



Nuclear Reactors

The main advantage of nuclear fuel is that the energy output from 1 kg of fuel is millions of times greater than that from 1 kg of coal.

Energy is released from nuclear fuel in the reactor by a process known as a **chain reaction**. In a chain reaction a neutron hits uranium nucleus causing it to split. This generates heat and 2 or 3 more neutrons which can then go on to hit further uranium nuclei.



The main disadvantage of nuclear reactors is that they produce radioactive waste, which needs to be stored for thousands of years before it is safe.

Energy Transformations

During an energy transformation energy can neither be created nor destroyed. However energy can be **degraded**, that is there is less useful energy after the change than there was before. This is because some of the original energy has been changed into heat and lost to the surroundings.

Efficiency

J

$$\text{efficiency} = \frac{\text{energy output}}{\text{energy input}} \times 100\%$$

J

Energy Calculations

Useful equations for energy calculations in power stations include:

Gravitational potential: $E_p = mgh$

Kinetic energy : $E_k = \frac{1}{2}mv^2$

Electrical power: $P=IV$

Also, for all forms of energy: $E=Pt$

Section 3 - Source to Consumer

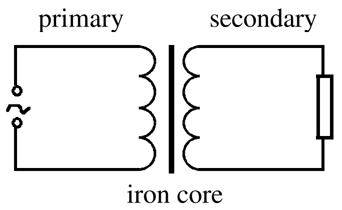
Induced Voltage

A voltage is induced in a conductor when ever the conductor moves in a magnetic field, or, if the conductor remains stationary, the magnetic field changes.

Transformers

A transformer can be used to change the magnitude of an a.c. voltage.

A transformer consists of two coils of wire (called the primary and secondary) wrapped around a soft iron core:



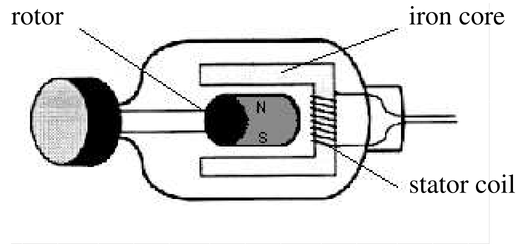
The voltages and number of turns on each coil are related by the following equation:

$$\frac{V_s}{V_p} = \frac{N_s}{N_s}$$

where: V_s = voltage on secondary
V_p = voltage on primary
N_s = number of turns on secondary
N_p = number of turns on primary

A.C. Generators

Simple a.c. generators are called **dynamos**. The main parts of a dynamo are:



In a dynamo the rotor is a permanent magnet. When this rotates there is a voltage induced in the stator coil.

The size of the induced voltage depends on:

- strength of the magnetic field
- number of turns on the coil
- relative speed of motion

In a full-sized generator the rotor uses an electromagnet instead of a permanent magnet to produce a stronger magnetic field. The stator also consists of several coils in order to generate large currents.

Electrical Transmission

Transformers are used to reduce power losses in electrical transmission. This is done by operating the transmission lines at a high voltage.

In the **National Grid** step-up transformers are used to increase the voltage from the power station. Overhead lines then carry electricity round the country. Step-down transformers are then used to reduce the voltage to suitable levels for industries and homes.

Transformer Efficiency

Transformers are not quite 100% efficient. Energy can be 'lost' for the following reasons:

- heat losses in coils - reduced by using low resistance wire (e.g. copper)
- magnetising/demagnetising losses - reduced by using a soft iron core
- eddy currents in the core - reduced by using a laminated core
- sound losses - reduced by good design

To calculate the efficiency of a transformer first calculate the input and output power using the formulae:

$$P_{in} = I_p \times V_p \quad \text{and} \quad P_{out} = I_s \times V_s$$

Then calculate the efficiency using:

$$\text{efficiency} = \frac{P_{out}}{P_{in}} \times 100\%$$

Transmission Line Efficiency

Energy is lost as heat in a transmission line due to the resistance of the line. The energy lost can be calculated using the power, current and resistance formula.

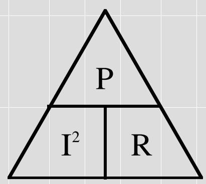
To reduce the current, and therefore the power losses, the voltage is stepped-up

Power, Current and Resistance

Ω

power = current^2 x resistance

W A



$$P = I^2R$$

$$I^2 = \frac{P}{R}$$

$$R = \frac{P}{I^2}$$

Section 4 - Heat in the Home

Heat and Temperature

Heat is a form of energy that is measured in joules (J).

Temperature is how 'hot' or 'cold' an object is and is measured in degrees Celsius (°C)

Heat Loss

Heat always moves from from hot objects to cold objects

The rate of heat loss depends on the temperature difference between the two objects.

Heat Transfer

Heat can be transferred by three main methods:

Conduction - The vibrations of hot particles are passed to their neighbours. Takes place in solids.

Convection - Hot fluids are less dense then cold fluids and so they can rise while the cold fluid falls setting up a convection current. Takes place in liquids and gases.

Radiation - Energy in the form of electromagnetic rays (Infrared rays). Only method through a vacuum.

Reducing Heat Loss

Heat loss from the home can be reduced in the following ways:

Loft insulation -	Reduces heat loss by conduction through the ceiling.
Double Glazing -	A vacuum between the panes of glass reduces heat loss by conduction.
Draught Excluders -	Reduce heat loss by convection.
Foil-backed Plasterboard -	Reduces heat loss by radiation from the walls.
Foil-backed Radiators -	Reflects heat back into room and so reduces heat loss by radiation.
Cavity Wall Insulation -	A foam filling between the walls prevents heat loss due to convection.
Carpets -	Reduces heat loss by conduction through floor.

Changing Temperature

The same mass of different materials require different quantities of energy to raise their temperature by one degree Celsius.

The quantity of heat energy required to raise the temperature of 1 kg of a material by 1 °C is called the **specific heat capacity**, c, of a material. Specific heat capacity has the units J/kg/°C. For example water has a specific heat capacity of 4,200 J/kg/°C.

Changing State

When a material changes state energy is either lost or gained.

During a change of state the temperature of a material does not change.

The quantity of heat energy required to melt 1 kg of a material is called the **specific latent heat of fusion**, l_{fusion}, of a material. (This is the same as the heat energy given out by 1 kg of a material as it freezes.)

The quantity of heat energy required to evaporate 1 kg of a material is called the **specific latent heat of vaporisation**, $l_{vaporisation}$, of a material. (This is the same as the heat energy given out by 1 kg of a material as it condenses.)

Specific latent heat has the units J/kg.

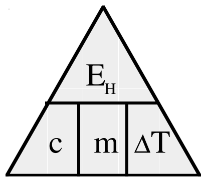
Applications involving a change of state include refrigerators and picnic box cooling packs.

Energy, Mass, Temperature Change and Specific Heat Capacity

kg

Energy = s.h.c. x mass x temperature change

J J/kg/°C °C



$E_H = cm\Delta T$

$c = \dfrac{E_H}{m\Delta T}$

$m = \dfrac{E_H}{c\Delta T}$

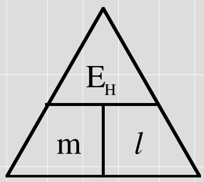
$\Delta T = \dfrac{E_H}{cm}$

Energy, Specific Latent Heat & Mass

kg

energy = mass x specific latent heat

J J/kg



$E_H = ml$

$m = \dfrac{E_H}{l}$

$l = \dfrac{E_H}{m}$

Energy Calculations and Conservation of Energy

During any energy change *energy can neither be created nor destroyed*. However some energy is usually 'lost' as heat to the surroundings.

Useful equations for energy calculations involving temperature change include:

Electrical power:	P=IV
Heat energy:	$E_H = cm\Delta T$
Also, for all forms of energy:	E=Pt