Energy

1. Energy in food

Energy stored in food can be released by combustion (burning) or by respiration in our cells. The labels on packets of food show how much energy is available from the food. In some instances food energy is measured in kilojoules - mostly by the scientific community - though some food packaging also gives kilojoule (kJ) values. 1 kilocalorie = 4.2 kilojoules.

2. Energy stores and transfers

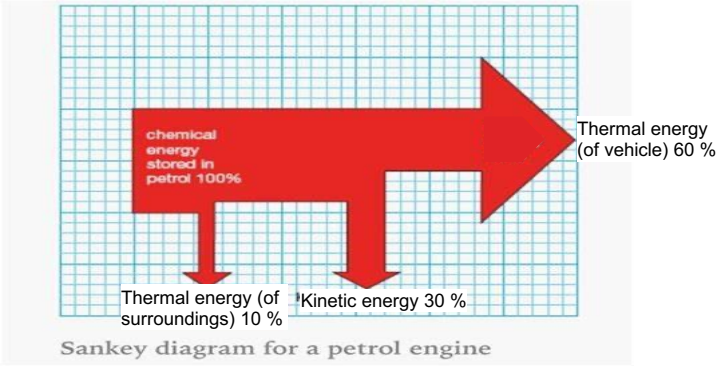
Energy Store	Definition
Kinetic energy	All moving things have kinetic energy. The amount of kinetic energy an object has depends upon: • the mass of the object • the speed of the object. 
Thermal energy	**Thermal energy** is energy possessed by an object or system due to the movement of particles. The faster the movement of the particles the greater the thermal energy and temperature.
Elastic potential energy	Some objects can change shape reversibly, e.g. rubber balls, springs and elastic bands. When a rubber ball is stretched or squashed, it can regain its shape again. Elastic potential energy is stored in stretched or squashed materials.
Gravitational potential energy	When an object is moved higher, it gains gravitational potential energy. The amount depends upon: • the mass of the object • the extra height it gains • the gravitational field strength (on Earth this is 9.81 m/s². it is often rounded to 10 m/s²). 
Electrostatic	Some objects carry electrical charges and create electric fields. These charged objects can exert forces on each other. You get an electric current when charged particles move through a wire.
Magnetic	Some objects can be magnetised and create magnetic fields. They can exert forces on other magnetised objects, or on magnetic materials.
Chemical	The energy contained in a chemical substance, such as food, petrol or a battery.
Atomic	The energy contained in a nuclear substance, such as stars, nuclear weapons and fuel for nuclear power stations.

3. Heat and temperature

A thermometer is used to measure the temperature of an object
The temperature of an object is a measure of the average kinetic energy per particle of the object. It is measured in degrees Celsius. Note that the unit of temperature is written as °C, (not °c or oC).
All objects contain internal energy. Some of this is due to the movement of the particles in the object. When an object is heated, its particles move more vigorously and its internal energy increases. Unless the object changes state (e.g. melts or boils), its temperature will increase.

4. Conservation of energy.

Energy can be stored or transferred, but it cannot be created or destroyed. This means that the total energy of a system stays the same. Sankey diagrams show the conservation of energy and how energy stores empty and fill.



The total amount of energy never changes, it just changes the type of store it is in.

Energy Transfer	Definition
Heating (by particles)	Energy is transferred from a hotter object to a cooler one. This can be done by conduction or convection.
Working Mechanically	Energy can be transferred mechanically through the movement of the parts in machines, and when the motion or position of an object changes. Sound waves and seismic waves (formed during earthquakes) are mechanical waves that transfer energy through materials and from place to place.
Working Electrically	Energy is transferred when an electrical circuit is complete.
Heating (by radiation)	Visible light, infrared light, microwaves and radio waves are forms of radiation. They are carried by waves (although unlike sound, these are not mechanical waves and can travel through empty space).

7. Power

Power is the rate at which energy is transferred.
The unit of power is the watt, which has the symbol W. 1 W is 1 J per second.

$$power\ (W) = \frac{energy\ (J)}{time\ (s)}$$

$$energy\ (kWh) = power\ (kW) \times time\ (h)$$

The cost of the energy used can be calculated: $cost = energy\ (in\ kWh) \times cost\ of\ 1\ kWh$

8. Work Done

By doing "work" you are transferring energy

$$work\ done\ (J)\ =\ force\ \ (N) \times distance\ (m)$$

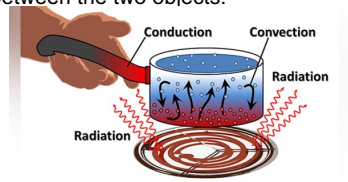
When a force causes a body to move, work is being done on the object by the force. Work is the measure of energy transfer when a force (*F*) moves an object through a distance (*d*).
So when work is done, energy has been transferred from one energy store to another, and so:
energy transferred = work done
Energy transferred and work done are both measured in joules (J).

4 & 5 Thermal equilibrium

If there is a difference in temperature between two objects, energy is transferred from the hotter object to the cooler one. This will continue until both objects are at the same temperature. When they are at the same temperature, we say that they are in thermal equilibrium, and there is no overall transfer of energy any more between the two objects.

Energy can be transferred from a hot object to a cooler one by:

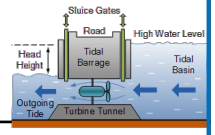
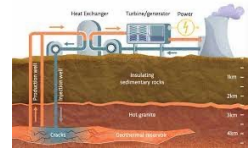
- conduction
- convection
- radiation



Type of heat transfer	Description	Useful information
Conduction (if the particles are in fixed positions)	When a substance is heated, its particles gain internal energy and move more vigorously. The particles bump into nearby particles and make them vibrate more. This passes internal energy through the substance by conduction, from the hot end to the cold end.	A substance that transfers energy easily from the hot part to the cold part is called a conductor. Metals are good conductors. A substance that does not transfer energy easily from the hot part to the cold part is called an insulator. Air and plastics are insulators.
Convection (if the particles are free to move)	The particles in liquids and gases can move from place to place. Convection happens when particles with a lot of thermal energy in a liquid or gas move, and take the place of particles with less thermal energy. Thermal energy is transferred from hot places to cold places by convection.	Convection cannot happen in a solid as the particles cannot move. Lava lamps work via convection; the cold lava with a greater density sinks in the water and the less dense, hotter lava rises.
Radiation	All objects transfer energy to their surroundings by infrared radiation. The hotter an object is, the more infrared radiation it gives off. No particles are involved in radiation, unlike conduction and convection.	Radiation is how we are warmed by the Sun, even though it is millions of kilometres away in space Infrared cameras give images even in the dark, because they are detecting infrared light, not visible light.

Energy is transferred from warm homes to the outside by: conduction through the walls, floor, roof and windows, and radiation from the walls, roof and windows. Insulation such as double glazing, carpets and reflective foil reduce the energy transferred.

6. Energy resources

Power station	Fossil Fuel	Renewable	How do they generate electricity?	Positives	Negatives
Coal, Oil and Gas	Yes	No	Energy from the burning fuel is used to boil water. The steam turns turbines, and these turn electrical generators.	Relatively cheap Reliable Provide large amounts of energy.	Releases pollution, including: carbon dioxide, which is a greenhouse gas and increases climate change; sulphur dioxide and nitrogen oxides, which cause acid rain.
Nuclear 	No	No	The main nuclear fuels are uranium and plutonium. The energy released is used to boil water. Steam spins turbines, which then drive generators.	Nuclear fuels do not produce carbon dioxide or sulphur dioxide.	Large amounts of radioactive material could be released into the environment. Nuclear waste remains dangerously radioactive for thousands of years. It must be stored safely.
Wind Turbine	No	Yes	As the wind blows, it transfers some of its kinetic energy to the blades (turbine), which turn and drive the generator.	There are no fuel costs and no harmful polluting gases.	Noise pollution and visual pollution They are not reliable. The amount of electricity generated depends on the strength of the wind.
Wave generator	No	Yes	The water in the sea rises and falls because of waves on the surface. Wave machines use the kinetic energy in this movement to drive electricity generators.	There are no fuel costs and no harmful polluting gases are produced.	They are not reliable. The amount of electricity generated depends on the strength of the wind creating the waves. Difficult for wave machines to produce large amounts of electricity.
Tidal barrage	No	Yes	A tidal barrage is a barrier built over a river estuary to make use of the kinetic energy in the moving water. The barrage contains turbines inked to generators, which are turned by the water flowing through the barrage.	Very reliable and can be easily switched on. There are no fuel costs and no harmful polluting gases produced.	Tidal barrages destroy the habitats of estuary species, including wading birds. Only available for about 10 hours per day. 
Hydro-electric power	No	Yes	Hydroelectric power stations use the kinetic energy in moving water. The water high up behind the dam has a lot of gravitational potential energy. This is transferred to kinetic energy as the water rushes down through tubes inside the dam. The moving water rotates turbines which drive electrical generators.	Very reliable and can be easily switched on. There are no fuel costs and no harmful polluting gases are produced.	Dams flood farmland and push people from their homes. The rotting vegetation underwater releases methane, which is a greenhouse gas.
Geo-thermal	No	Yes	Some rocks contain radioactive substances such as uranium. These release energy, which warms up the rocks. Cold water pumped down. The water runs through cracks in the rocks and is heated up. It returns to the surface as hot water and steam. Here the steam can be used to turn turbines to drive generators.	There are no fuel costs and no harmful polluting gases are produced. The hot water and steam can be used to heat buildings directly.	Most parts of the world do not have suitable areas where geothermal energy can be exploited. 
Solar Cells 	No	Yes	Converts light energy directly into electrical energy. Some pocket calculators use solar cells, and you may have seen large panels of solar cells on house roofs.	There are no fuel costs and no harmful polluting gases are produced.	Solar cells are expensive and inefficient, so the cost of their electricity is high. Solar cells are not reliable as they do not work at night and not as well when it is cloudy.