WJEC (Eduqas) Physics GCSE

1.2: Conservation, Dissipation and Global Energy Sources

Detailed Notes

(Content in **bold** is for higher tier **only**)

Energy Transfer

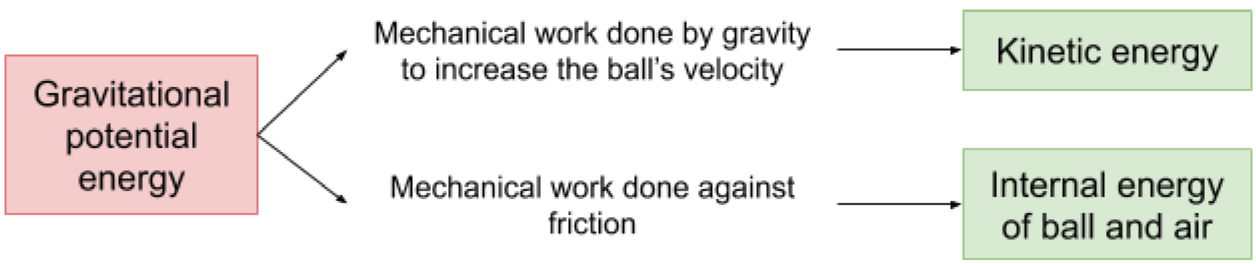
The law of the **conservation** of energy states that energy **cannot be created or destroyed**, **only transferred** between stores. Whenever there is a change to a system, there is a transfer of energy. There are **four** main methods of energy transfer between stores that can all occur at different rates.

Energy Flow Diagrams

Energy transfers can be shown using **energy flow diagrams**. These can show the starting energy store, transfer process and end stores as **transfer** diagrams or **Sankey** DIagrams.

Transfer Diagrams

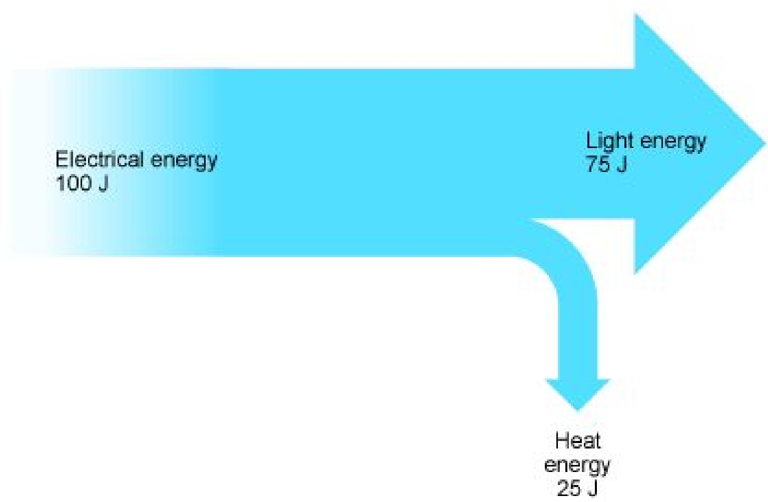
These diagrams show the **start** and **end** energy sources as well as a brief description of the **energy transfer**.



Example transfer diagram showing energy transfers for a falling ball.

Sankey Diagrams

These diagrams show the different **energy transfers** that take place and can also be used to **estimate efficiency**. Sankey diagrams are drawn **'to scale'** meaning a bigger line represents a greater value than a smaller line.



Example sankey diagram showing energy transfers (pintrest.com).

The input electrical energy is mainly transferred to light energy and a small amount to heat energy. This is typical of a light bulb where the heat energy is **wasted energy**.

Heat Transfers

The transfer of thermal energy can take place via **conduction, convection** or **radiation**.

Conduction

Conduction is a form of energy transfer that takes place in **solids**. As one end of a solid is heated, the particles **gain kinetic energy** causing them to **vibrate more**. In a solid, the close proximity of the particles means **collisions** occur, passing on the vibrations from one atom to the next. This passing on of vibrations means the solid will gradually heat up.

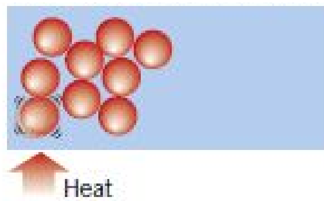


Diagram showing the transfer of heat via conduction (revisionscience.com).

The process of conduction is much **faster in metals** than in non-metals. This is because metals consist of atoms and **free (delocalised) electrons** that can move much more **freely** throughout the metal, passing vibrations on more easily.

Convection

Convection is a form of energy transfer that takes place in **liquids and gases (fluids)**. In fluids, the particles are **free to move** around. Convection occurs when these particles with a lot of heat energy move to take the place of particles with less heat energy.

Fluid particles **move faster** when heated and **expand** to take up a greater volume. Therefore hot fluids are **less dense** than cold fluids meaning the hot fluids move into the colder areas. As a result, convection currents are set up, transferring heat around a volume. Convection can take place on many scales, from water within a beaker, to global weather systems.

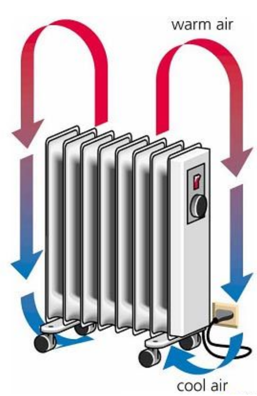


Diagram showing a convection current of air around a heater (revisionscience.com)

Radiation

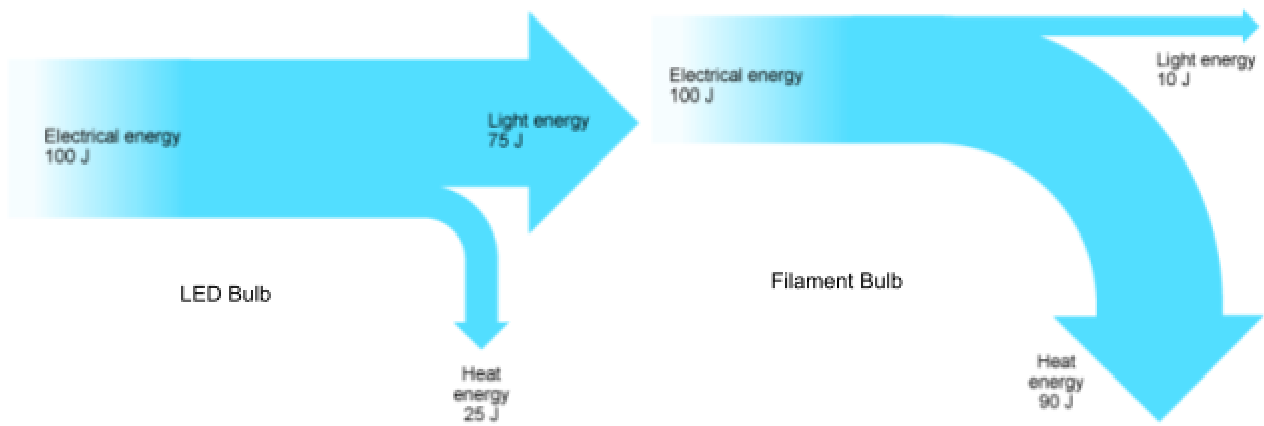
Radiation is a form of energy transfer that **doesn't require particles** and instead uses **infrared electromagnetic (EM) radiation** to transfer energy. This type of EM wave can transfer energy in a vacuum as it doesn't require particles, explaining how energy from the sun can be felt here on Earth having been transferred through space.

Difference surfaces are better at **radiating** heat or **absorbing** radiation than others. **Black, matt** surfaces make good emitters and absorbers of radiation whereas **light, shiny** surfaces make poor emitters and absorbers of radiation.

Energy Dissipation

Sankey diagrams make it clear to see the **proportion** of energy that transfers to **useful** or **wasted** energy, allowing **efficiency** to be calculated. Wasted energy is often referred to as **dissipated energy** as it is lost to the surroundings.

Common examples of dissipated energy come as a result of **mechanical or electrical work**. In both cases, **heat** is generated as the wasted energy. In **electrical systems** this is due to the **wires heating up** when current passes through them whereas in **mechanical systems**, heat is generated from **friction** between moving parts.



Example sankey diagrams showing energy transfers and dissipated energy for a filament and LED bulb (pintrest.com)

Modern **LED bulbs** produce more light energy compared to heat energy as they are **more efficient** than older filament bulbs that produce more wasted heat energy than light. Therefore filament bulbs **dissipate more energy** to the surroundings.

Measures can be taken to **reduce** the amount of energy dissipated in a system in order to **improve efficiency**, this includes the use of **lubricants** in mechanical systems.

Efficiency

The efficiency of a device is measured as the proportion of the energy supplied that is transferred into **useful** energy. It can be calculated as a percentage of the input energy:

$$\%\ efficiency = \frac{useful\ energy\ (power)}{total\ input\ energy\ (power)} \times 100$$

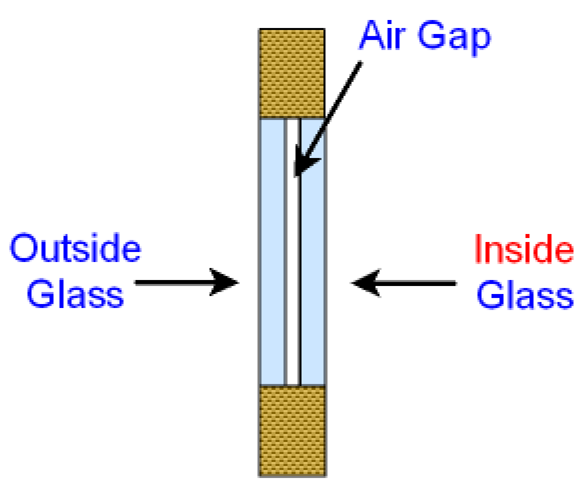
The **greater** the percentage, the **more efficient** the device and therefore the more useful energy produced. This demonstrates how reducing the amount of energy dissipated to the surroundings will increase efficiency of the energy system.

Improving Domestic Efficiency

Heat energy can be lost from buildings via the roof, windows, walls, floors and through any gaps around windows and doors, however, these losses can be reduced by considering the method of heat transfer involved. Reducing this heat loss is **good for the environment** as it means less energy is required to heat the house.

Double Glazing

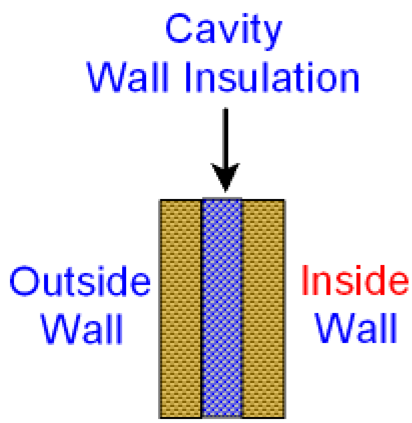
Heat loss via **conduction** through windows can be reduced by using double glazed windows. These windows contain a layer of **air or a vacuum** between two panels of glass. This insulating layer reduces conduction to almost zero. Air is a **poor conductor** and use of a vacuum also prevents any heat loss via convection too.



A double glazed window (gcsescience.com)

Cavity Wall Insulation

Heat loss via **conduction** through walls can be reduced by using cavity wall insulation. This is when an insulating material is placed in the gap between the outer bricks and the inside wall of a house. The insulating material is made up of lots of **little fibres**, meaning it contains **pockets of trapped air** which reduces conduction and **convection**. It can also reduce convection on the outside walls of the building.



A layer of cavity wall insulation between two walls (gcsescience.com)

A thin layer of **silver foil** can be added to the cavity wall insulation in order to reduce any additional heat loss via **radiation**. Instead, it is reflected back into the building.

Loft Insulation

Heat loss via **convection** and **conduction** through the roof can be reduced by installing loft insulation, which works in a similar way to cavity wall insulation.

Retrofitting

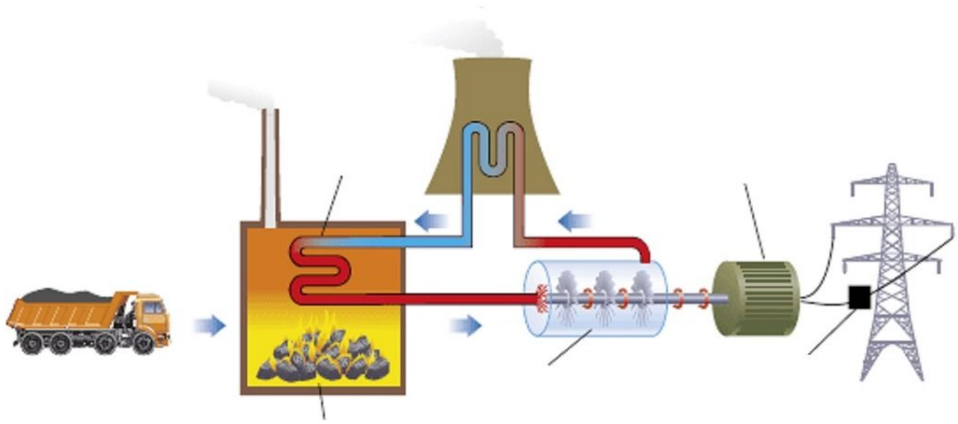
Some simpler methods of reducing heat loss can be **retrofitted** (installed afterwards) to reduce heat loss. These include fitting carpets, curtains, draught excluders reflective foil in the walls.

Global Energy Sources

Over the last 200 years the demand for electricity has **increased exponentially** as the world has become more developed. This electricity is mainly produced from **non-renewable** sources, however, as stores of these become **depleted**, we require more **renewable** energy sources to supply the electricity required.

Non-Renewable Sources

These energy sources will eventually **run out** as they are not being replaced at a fast rate. Coal, oil and gas are common non-renewable resources known as **fossil fuels**. When burned, fossil fuels transfer stored **chemical** energy into **heat** energy that produces steam to drive turbines for generating electricity.



Process of burning fossil fuels to generate electricity (gcsephysics.tumblr.com)

Fossil fuels are good energy sources as they **release a lot of energy** when burned and a lot of the world's infrastructure is built to rely on them. However it is **not sustainable** to rely on them to this extent and they are also **harmful** for the environment as they release **carbon dioxide** and other **greenhouse gases** into the atmosphere.

Renewable Sources

These energy sources are **replaced** at a much faster rate or are **infinitely available**. Common renewable sources include wind, solar and tidal power. They are much more **sustainable** but can be **difficult to harness** to the extent required and produce energy at a much slower rate.

Wind

Currents in the Earth's atmosphere can be used to turn **wind turbines** that directly turn an **electrical generator.** Without wind, no electricity can be generated and often, many turbines are required to generate the electricity required.

Solar

Energy released from **nuclear fission** in the sun can be harnessed to generate electricity. Solar cells (**photovoltaic** cells) transfer light energy into electrical energy whereas solar panels use heat energy to **heat water** that can then be used in a domestic setting. They are good for **small scale** energy generation but require direct sunlight to work well.

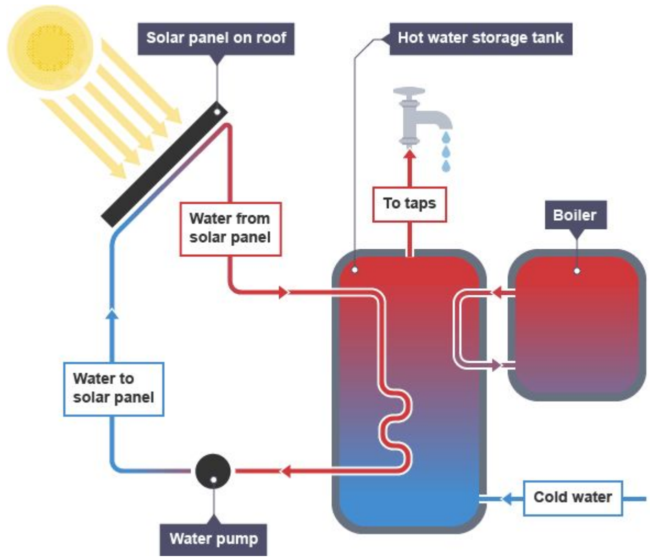


Diagram showing how solar panels can be used to heat water (bbc.co.uk)

Water

Kinetic energy from moving waves can be harnessed and used to **drive turbines** that generate electricity. **Hydroelectric power** (HEP) is generated when water with gravitational potential energy is dropped from an elevated store through a dam. The potential energy is transferred to kinetic energy as turbines are used to generate electricity.

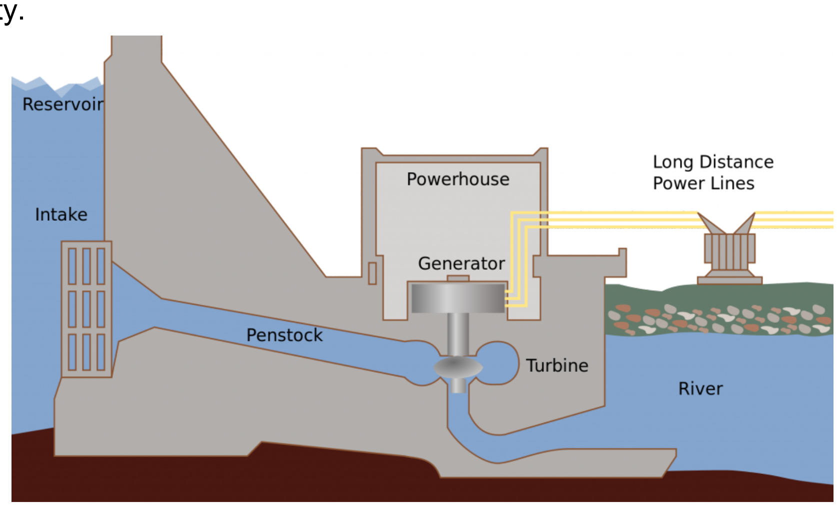


Diagram showing a hydroelectric dam system (studyrocket.co.uk)

A few energy sources are considered to be both **renewable and non-renewable**, such as **biomass**, where decaying organic material is burned to generate heat or electricity. Trees can be grown and felled to produce material for burning.

Nuclear Power

Nuclear power stations use **unstable (radioactive) elements** such as plutonium and uranium undergoing **nuclear decay (fission)** to heat water. This water produces steam which can turn electricity generators. Overall, nuclear energy is converted to heat, then kinetic energy before electrical energy is produced.

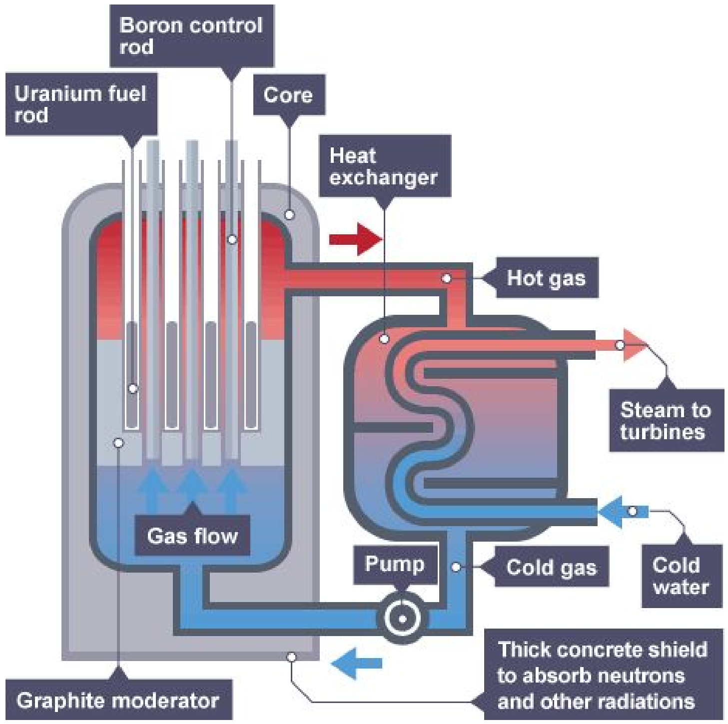


Diagram showing the components of a nuclear reactor system (bbc.co.uk)

Nuclear energy sources are **very efficient**, producing a lot of energy from just a small amount of material with no harmful gases. However a lot of **nuclear waste** is produced that remains **radioactive and harmful** for a long time. This material could be catastrophic if released into the environment through a nuclear reactor accident.