

GCSE Topic 1 AQA Physics: Energy

Energy:

Energy changes in a system, and the ways energy is stored before and after such changes:

Energy Stores and Systems:

A system is an object or a group of objects. When a system changes, the energy stored within the system also changes.

The Main Energy Stores:

Energy Store	Description	Example
Chemical	Energy stored in chemical bonds.	Batteries, fuels, food.
Kinetic	Energy due to an object's motion.	A moving car, thrown ball.
Gravitational Potential (GPE)	Energy stored in an object raised above the ground.	A lifted weight, rollercoaster at the top of a hill.
Elastic Potential	Energy stored when an object is stretched or compressed.	A stretched spring, a drawn bow.
Thermal (Internal)	Energy of particles in an object – related to temperature.	Hot water, fire.
Magnetic	Energy stored when magnetic poles are pushed together or apart.	Magnets repelling.
Electrostatic	Energy due to charges attracting or repelling.	Static electricity, charged particles.
Nuclear	Energy stored in atomic nuclei.	Nuclear reactors, stars.

1.1.2 Changes in Energy:

Calculating Kinetic Energy:

$$E_k = \frac{1}{2}mv^2$$

- Where E_k is the kinetic energy (J)
- Where m is the mass (kg)
- Where v is the velocity (m/s)

Calculating Elastic Potential Energy:

$$E_e = \frac{1}{2}ke^2$$

- Where E_e is the elastic potential energy (J)
- Where k is the spring constant (N/m)
- Where e is the extension (m)

Calculating Gravitational Potential Energy:

$$\textit{gravitational potential energy} = mg\Delta h$$

- Where m is the mass (kg)
- Where Δh is the change in height (m)

Energy Changes in Systems:

$$\Delta E = mc \Delta \theta$$

- Where ΔE is the change in thermal energy (J)
- Where m is the mass (kg)
- Where c is the specific heat capacity (J/kg °C)
- Where $\Delta \theta$ is the temperature change (°C)

Power:

Power is defined as the rate at which energy is transferred or the rate at which work is done.

$$\textit{Power} = \frac{\textit{Energy Transferred}}{\textit{Time}} = \frac{\textit{Work Done}}{\textit{Time}}$$

An energy transfer of 1 joule per second is equal to a power of 1 watt.

Efficiency:

The energy efficiency for any energy transfer can be calculated using the equation:

$$\text{efficiency} = \frac{\text{Useful Energy Output}}{\text{Total Energy Input}}$$

Efficiency may also be calculated using the equation:

$$\text{efficiency} = \frac{\text{Useful Power Output}}{\text{Total Power Input}}$$

Conservation and Dissipation of Energy:

Energy Transfers in a System:

Energy Transfers Between Stores

Energy can be **transferred** by:

- **Mechanically** (forces doing work)
- **Electrically** (currents transferring energy)
- **By heating** (thermal transfer)
- **By radiation** (light, sound waves, infrared)

Example:

A pendulum — GPE ↔ Kinetic energy transfers as it swings, with some energy lost as heat due to air resistance.

Energy can be transferred usefully, stored, or dissipated.

Reducing Unwanted Energy Transfers

Reducing Thermal Energy Loss

Energy can be lost through **heating** – e.g., from hot objects to the surroundings.

Ways to reduce this:

Method	Explanation
Insulation	Materials with low thermal conductivity reduce heat transfer.
Thicker walls	Slower transfer of heat through walls.
Cavity wall insulation	Air gap reduces conduction.
Loft insulation	Prevents convection currents in the roof space.
Double glazing	Two layers of glass with trapped air in between reduce conduction.
Draught excluders	Stop convection currents around doors and windows.

Thermal Conductivity

Definition:

The rate at which heat energy passes through a material.

- **Low conductivity = good insulator** (e.g., wool, foam).
- **High conductivity = good conductor** (e.g., metals).

Energy Resources

Energy resources are used to generate electricity, provide heating, and power transport.

Non-Renewable Energy Resources

Resource	Main Use	Advantages	Disadvantages
Coal	Electricity generation	Reliable and abundant	Produces CO ₂ and sulfur dioxide (acid rain)
Oil	Transport fuels	High energy output	Produces CO ₂ and risk of oil spills
Natural Gas	Heating, electricity	Cleaner than coal/oil	Still releases CO ₂
Nuclear Fuel (Uranium/Plutonium)	Electricity generation	No greenhouse gases	Risk of radioactive waste and accidents

These are **finite** — they will run out and contribute to **global warming**.

Renewable Energy Resources

Resource	Description	Advantages	Disadvantages
Solar Power	Converts sunlight to electricity	Renewable, no pollution	Weather-dependent, expensive panels
Wind Power	Turbines turned by wind	No fuel cost, renewable	Noisy, unreliable, affects landscape
Hydroelectric Power	Falling water drives turbines	Reliable, quick to start	Dams destroy habitats
Tidal Power	Uses tides to turn turbines	Predictable	Expensive, affects marine life
Wave Power	Energy from surface waves	Renewable	Unreliable, visual pollution
Geothermal	Heat from underground rocks	Reliable, clean	Only available in certain locations
Biofuel	Energy from burning organic material	Carbon neutral (in theory)	Can use land needed for food

1.7 Main Energy Uses

Sector	Examples of Use
Transport	Petrol/diesel vehicles (non-renewable), electric vehicles (renewable electricity).
Heating	Natural gas for homes, electric heating, geothermal systems.

Electricity generation

Fossil fuels, nuclear, renewables like wind and solar.

Environmental Impact

- **Fossil fuels** → CO₂ → global warming.
- **Coal and oil** → sulfur dioxide → acid rain.
- **Nuclear waste** → long-term radioactive hazard.
- **Renewables** → lower emissions but can cause **habitat destruction** (e.g., dams, wind farms).

Trends in Energy Use

- **20th century:** heavy reliance on fossil fuels.
- **21st century:** increasing use of renewables due to:
 - Climate change awareness.
 - Falling costs of renewable tech.
 - Government incentives and international agreements.

However:

- Renewable energy can be **intermittent**.
- Infrastructure change takes time.
- Energy demand continues to rise.