

Sources of Energy

Why Conservation of Energy?

Energy and its sources

- Energy is the ability to do work or the total power derived from our natural resources. The energy exists in many forms and can be converted from one form of energy into another. Energy in usable form is dissipated to the surroundings as less usable form.
- Energy is mainly derived from natural sources like the sun, oceans, fossil fuels, wind etc and is converted into electrical energy that we consume for our daily needs and benefits.

What Is a Good Fuel?

A good source of energy

- Sources can be classified as renewable and nonrenewable sources of energy.
- Any source of energy that does not get depleted or gets exhausted is considered a good source of energy and are usually called as renewable.

Good fuel

A good source of energy/fuel should be:

- Easily available
- (Easy to store and transport
- Able to perform large amounts of work per unit mass and volume
- Economical

Fossil Fuels and Thermal Energy

Conventional sources of energy

- Sources of energy that have been in use for a very long time or have been used extensively worldwide are known as conventional sources. Eg: wood as a common source of heat energy or the usage of coal after the Industrial Revolution.
- Examples: Fossil Fuels, Hydro Power

Fossil fuels

- Fossil fuels are formed due to compression of dead organic matter over millions of years, buried deep under the earth. Eg. coal or natural gas.
- We rely heavily on fossil fuels for most of our work.
- Fossil Fuels are non-renewable sources of energy as they have limited reserves and hence finding alternative sources is essential to avoid an energy crisis.

Disadvantages of burning fossil fuels

- Fossil fuels also produce byproducts due to combustion which causes air pollution.
- Burning coal and petroleum produces harmful oxides of carbon, nitrogen, and sulphur which pollute the air leading to acid rain and greenhouse effect.
- Gases emitted by the combustion of fossil fuels are the main contributor to global warming.

Thermal power plants

- Thermal power plants use steam produced by burning fossil fuels (mainly coal) to move the turbines to generate electricity.
- The burning of coal heats up the water and forms steam that is used to run the turbine.
- Usually, Thermal power plants are located near coal or oil fields as it is easier to transmit electricity than transport coal.

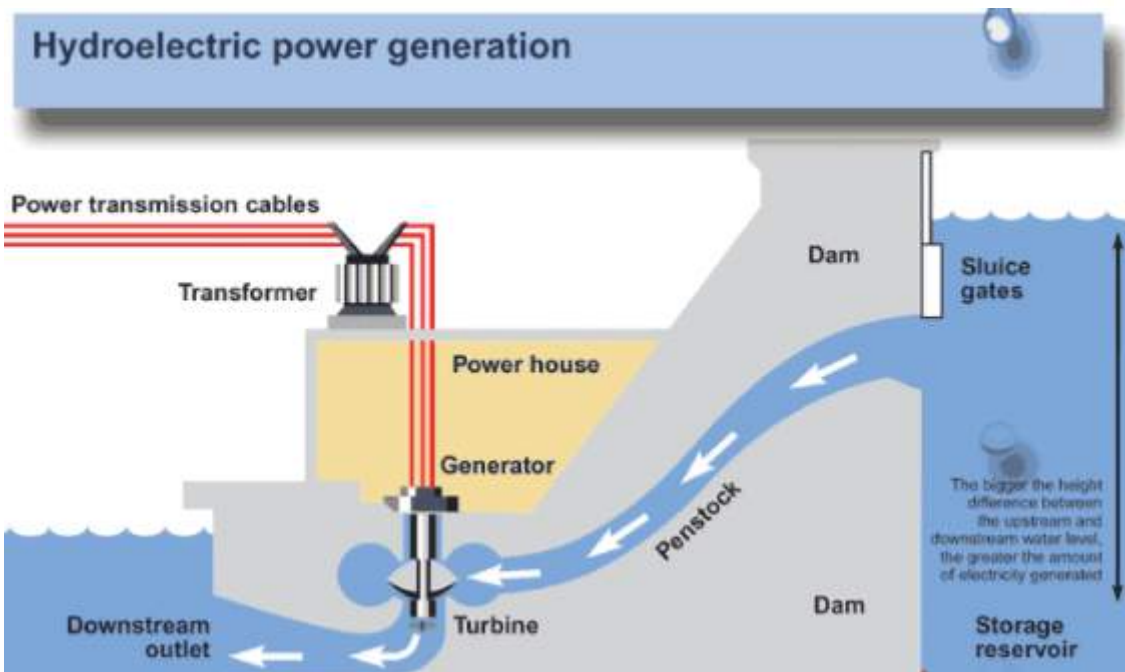
Hydropower Plants

Turbines

- A turbine is a rotatory mechanical device that extracts kinetic energy in various forms and converts it into useful work. It uses a dynamo to convert this mechanical energy into electrical energy.
- Various uses of this have been implemented in power plants where the shaft of the dynamo is made to rotate by mechanical means.

Hydropower plants

- Another traditional source of energy is from the kinetic energy of flowing water or harnessing potential energy of water falling from a height.
- The falling/flowing water moves the turbine, which with the help of a dynamo converts mechanical energy into electrical energy.
- Hydropower plants are usually constructed near dams or waterfalls.



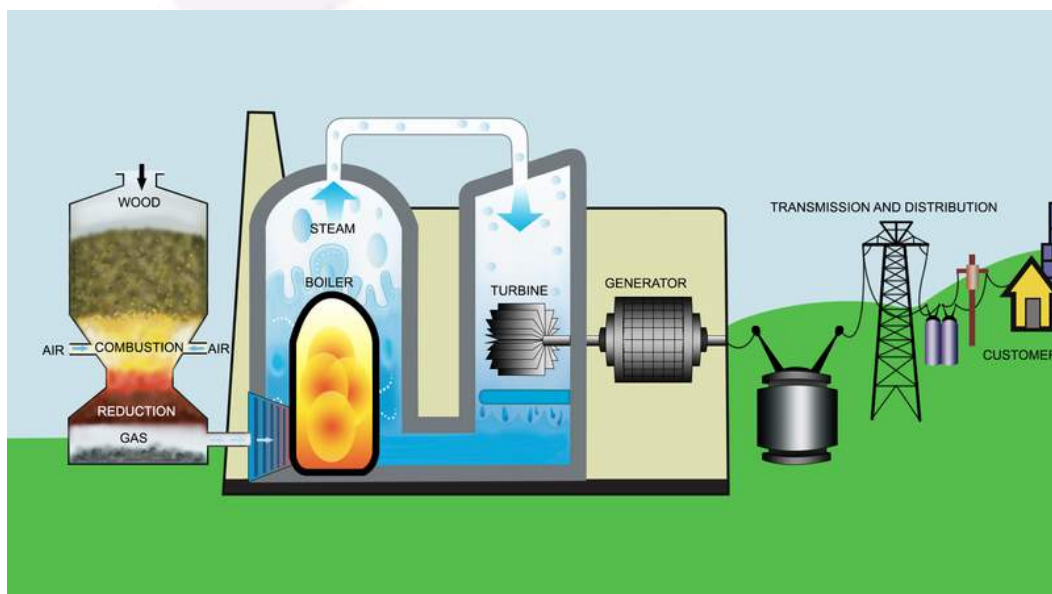
Dams

A dam is a barrier that impounds water or underground streams. The water is ejected upon requirement by the power plant to generate hydroelectricity.

Fuels

Biomass

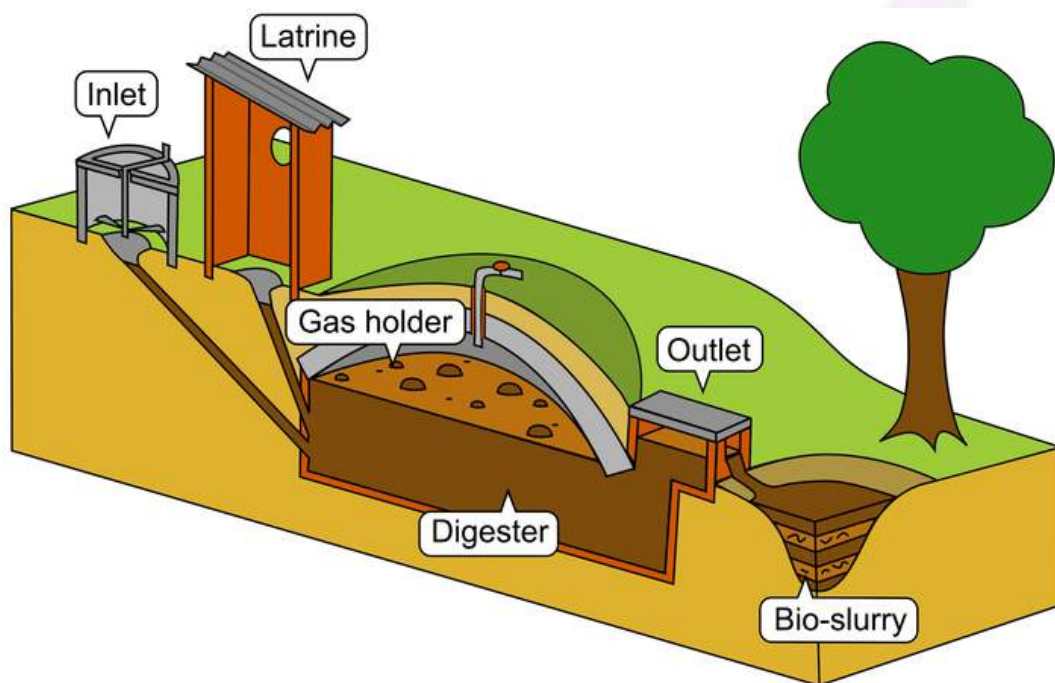
- Biomass is the source of energy derived from living things (organic matter). For a long time, we relied on wood for the source of heat energy. In India, we make fuel out of biowaste such as cow dung due to the availability of a thriving population of livestock.
- When wood is burnt in a limited supply of oxygen and water until volatile materials are removed, the residue left behind is charcoal. Charcoal has good heat generating efficiency. It also burns without flames.



Electricity generation through biomass

Bio-gas plant

- In India cow dung, sewage waste, plant matter are decomposed in absence of oxygen to produce biogas. Since it has cow dung it is often termed as gobar gas.
- A biogas plant is a dome-like structure built with bricks where cow dung and other biowaste are mixed with water to form a slurry and put into a digester.
- The digester is a sealed chamber with anaerobic bacteria which breaks down the slurry.
- This decomposition process releases gases like methane, CO_2 , hydrogen sulfide and hydrogen.
- These gases are drawn via pipes which are transmitted to a turbine for the production of electricity.



Bio-gas plant

Wind Energy

Wind energy

- Environment-friendly efficient source of energy.
- Wind is the natural phenomenon caused by pressure differentials due to unequal heating of land and water masses on the surface of the earth. It is harnessed in the form of kinetic energy.

Windmill

- Wind Energy is harnessed by rotatory structures known as windmills.

They have huge blades or fans attached very high on a rigid support that is attached to turbines that rotate due to high speeds of wind and generate electricity.

- A single windmill has a low output and therefore, the wind farms are built that comprises of several windmills.

Advantages and limitations of wind energy

Advantages: Environment-friendly, efficient, renewable source, with no recurring cost for production of electricity.

Limitations:

- Wind speeds should be constant and $> 15 \text{ km/h}$.
- Must have back up storage facilities like cells.
- Requires large land area.
- High initial cost and regular maintenance are required.

Solar Energy

Solar energy

- Light energy and heat energy from the sun are known as solar energy.
- Sun has been radiating energy from the past 5 billion years and will continue to do so at the same rate for another 5 billion years or more.
- We must find ways to harness the energy with maximum efficiency, although only a small fraction of the solar energy reaches the earth's surface.

Solar cooker

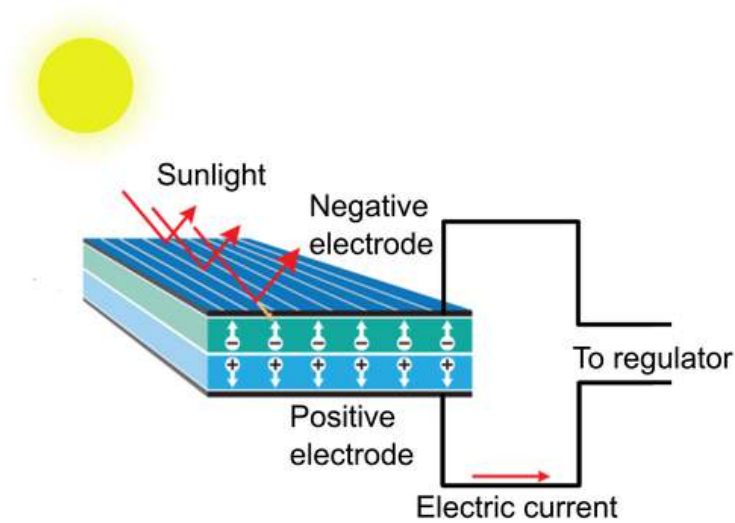
- Solar cookers and water heaters use solar energy to operate.
- Black surfaces absorb more energy than other surfaces and solar cookers use this property by coating their insides black.
- They use reflecting surfaces like mirrors to focus the sun's rays.
- The device is covered with a glass plate thereby establishing the greenhouse effect by trapping heat inside the cooker.

Solar cell

- A device that converts solar energy into electricity is known as a solar cell.
- A typical solar cell produces a voltage of 0.5 V and 0.7 W of electrical power. A large number of such cells can combine to form a solar panel which can generate power large enough for practical uses.
- Advantages: (i) no moving parts (ii) require little maintenance (iii) can be set up in remote areas without the hassle and expenses of transmission lines.

Disadvantages: (i) Requires a special grade silicon which is not easily available (ii) Usage of silver for interconnections makes it expensive.

- Uses: traffic signals, calculators, artificial satellites and space probes.



Cross section of a solar cell

Energy From the Sea

Energy from sea

The seas and oceans and other water bodies are a source of kinetic and potential energy due to the immense volume of water and the motion of waves.

Tidal energy

- Tides are variations in the level of water due to the gravitational pull of the moon.
- The phenomenon of rise and fall of water level or high and low tide gives tidal energy.
- Tidal energy is obtained by constructing dams near the narrow openings of the sea. When the tide sets in, it moves the turbine which directly produces electricity.
- It is limited to places near the sea.

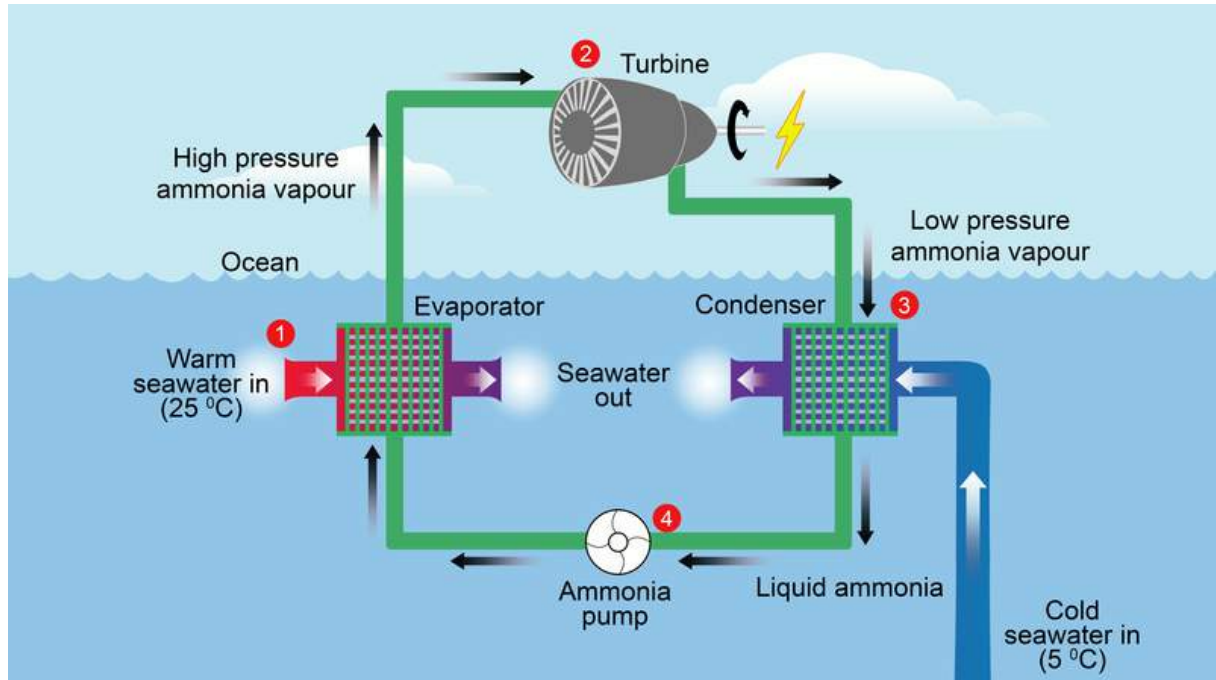
Wave energy

- Waves possess a lot of kinetic energy that can be harnessed to produce electricity.
- Waves are produced by strong winds blowing over the sea.
- Limited to places with strong winds. Devices have been designed to capture this energy.

Ocean thermal energy

The difference in surface temperatures of water and water at a certain depth in oceans is exploited to harness this form of energy.

- Temperature difference must be 20° between the surface and water up to depths of 2 km.
- Warm water is used to boil volatile ammonia to form vapours that move the turbine. Cold water is used to condense the vapour back to liquid.

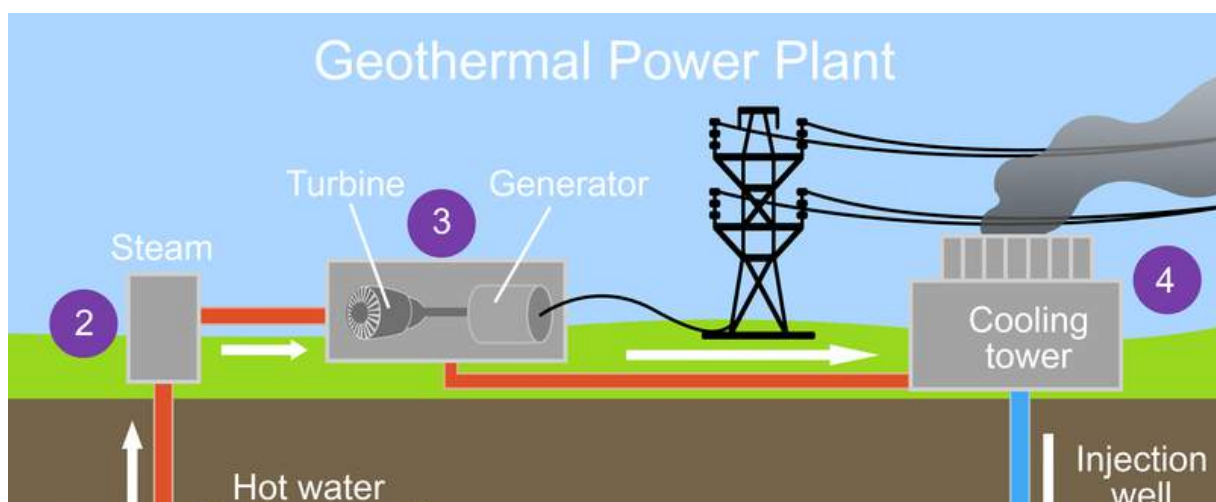


Extraction of Ocean thermal energy

Geothermal Energy

Geothermal energy

- There is a huge amount of heat trapped inside the earth. Molten rocks from Earth's core sometimes come up due to geological changes and get trapped in hotspots. Harnessing this heat energy is called geothermal energy.
- Any underground water present gets heated due to the hotspots and gets converted to steam which escapes from the surface of the earth as hot springs.
- This steam is used to rotate turbines and generate electricity.





Geothermal Power Plant

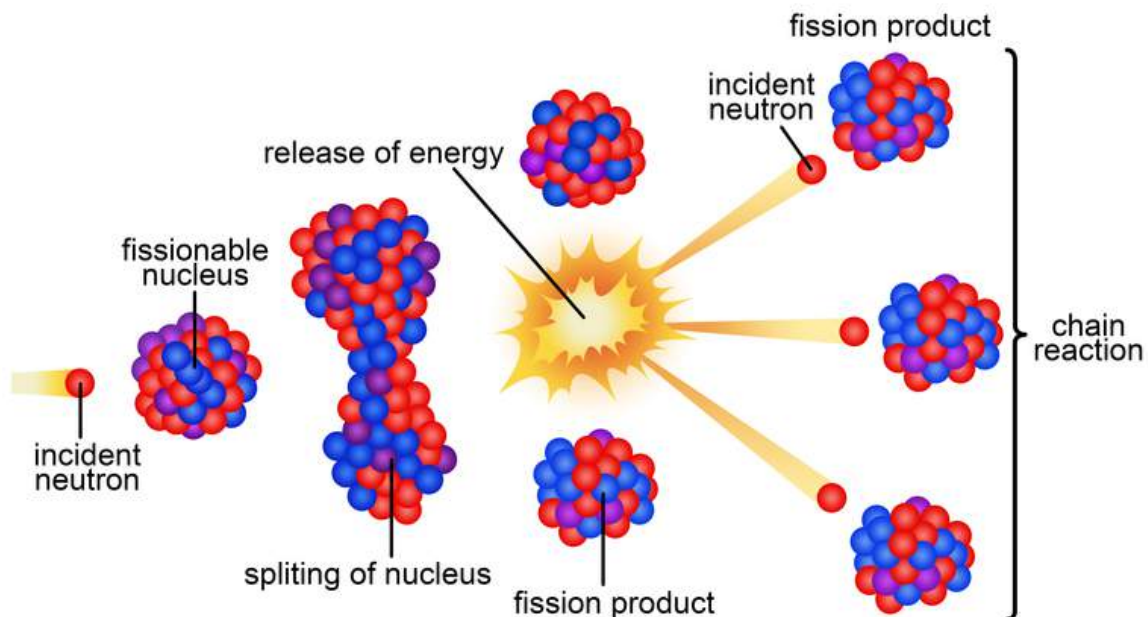
Nuclear Energy

Nuclear energy

- Nuclear energy can be used to generate electricity by means of nuclear fission.
- In a nuclear reactor, the nuclear fuel is used to carry out sustained fission chain reaction to produce electricity at a controlled rate.

Nuclear fission

Nuclear fission is the process where a heavy atom (uranium or plutonium) is bombarded with neutrons that split the atom to give lighter nuclei. This process releases tremendous amounts of energy. For example, Fission of 1 atom of uranium gives 10 million times the energy of combustion of 1 atom of carbon from coal.



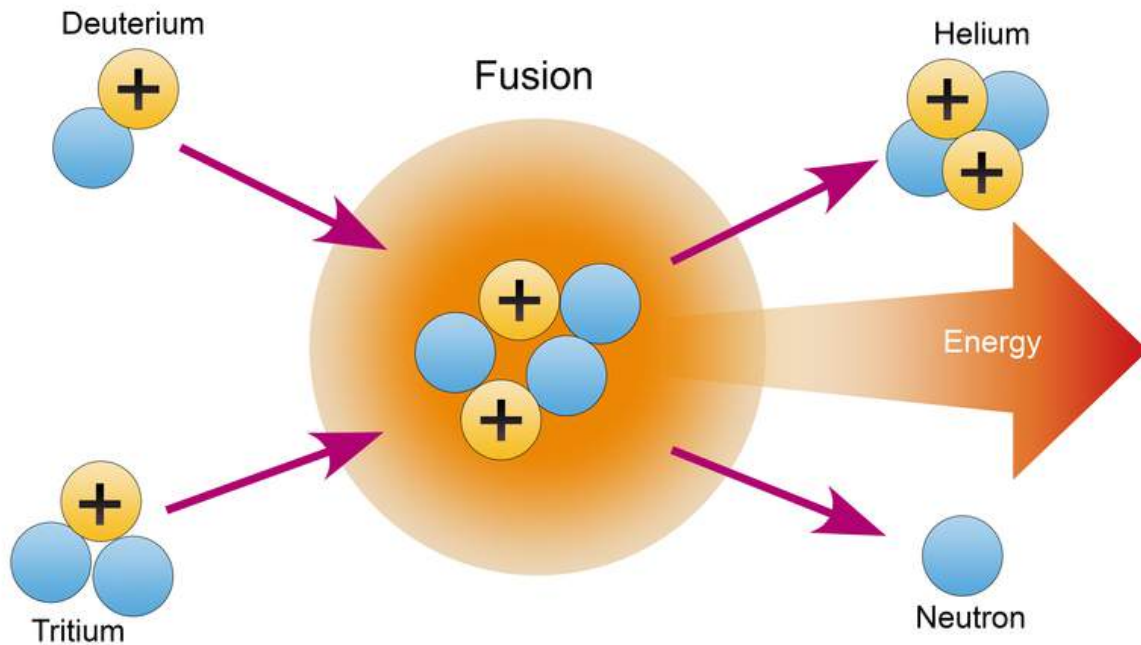
Nuclear Fission

Disadvantages of using nuclear energy

- Nuclear waste is hazardous as heavy atoms decay into harmful subatomic particles.
- High setup and maintenance cost
- Limited availability of uranium
- Can be used for destructive purposes

Nuclear fusion

- Fusion means combining lighter nuclei to produce a heavier nucleus, usually hydrogen or hydrogen isotopes to create helium.
- It releases a huge amount of energy. The mass deficit between the product and reactants are given by Einstein's equation. $E = mc^2$



Nuclear Fusion