CHAPTER 2

ENERGY AND ENVIRONMENT

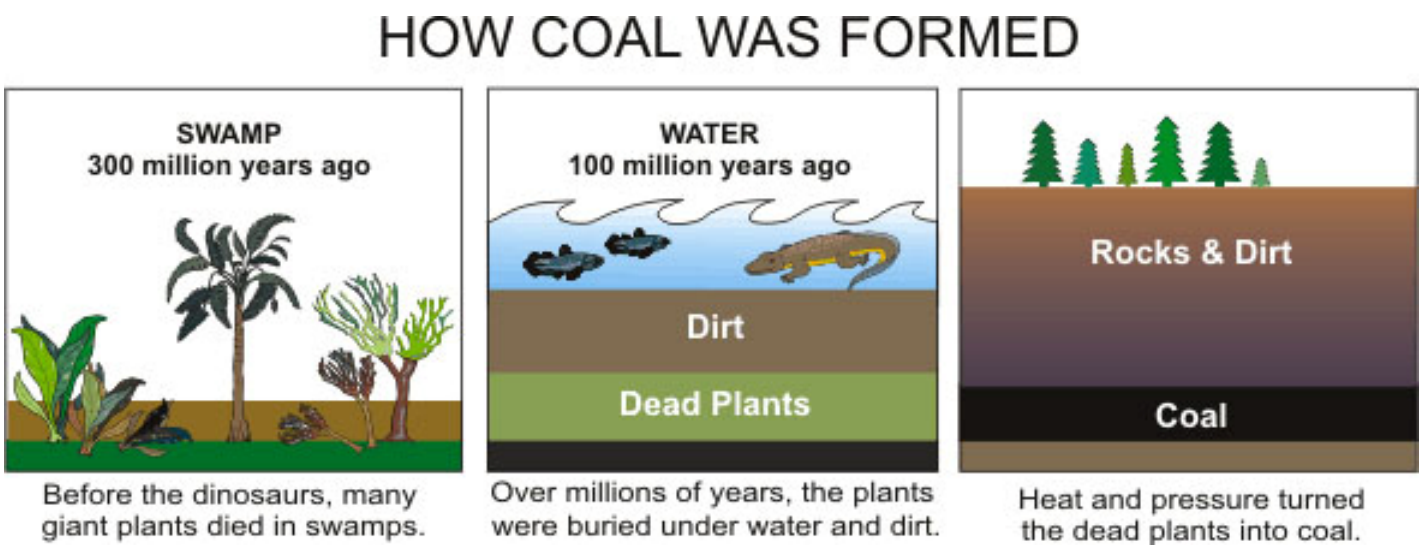
Fossil fuel formation

• Fossil fuels: carbon-based fuels, formed over many millions of years ago from the decay of living matter.

• Coal: formed from plants.

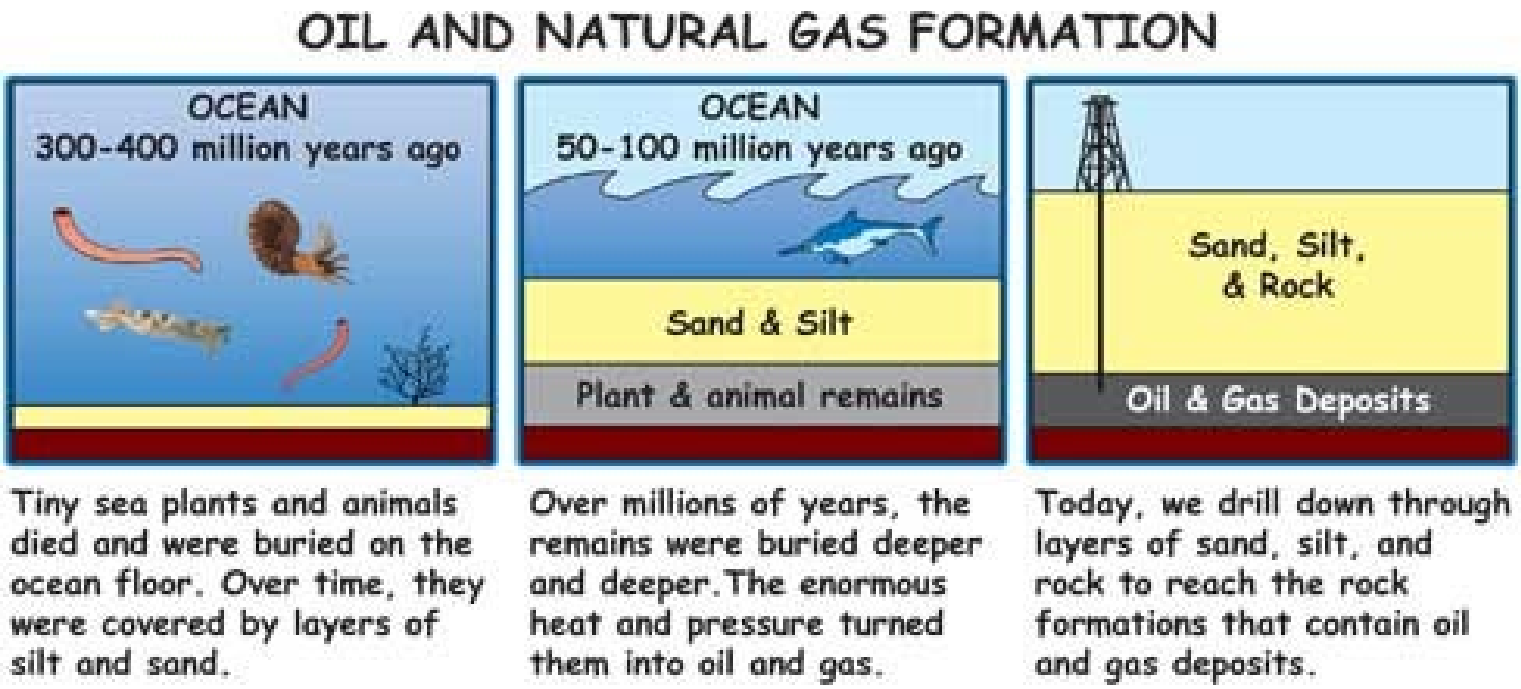
• Oil and natural gas: formed from sea creatures.

Formation of coal:



- Huge forests grew millions of years ago covering most of the Earth.
- The vegetation died and formed peat.
- The peat was compressed between layers of sediments to form lignite (low-grade coal).
- Further compression formed coal.

Formation of oil and natural gas:



- Small animals and plants die and fall to the bottom of the sea.
- Their remains are covered by sediments.
- As the sediments start forming layers, they start to change into sandstone as the temperature and pressure increase.
- The heat and pressure turn the remains into crude oil and natural gas.
- They separate and rise through the sandstone, filling in the pores.
- The rock above the oil and gas is impervious (non-porous).
- So, they get trapped underneath it.

Energy resources and the generation of electricity

- The demand for energy is increasing worldwide due to:

  - Increasing population size.

  - Increasing industrialisation and urbanisation.

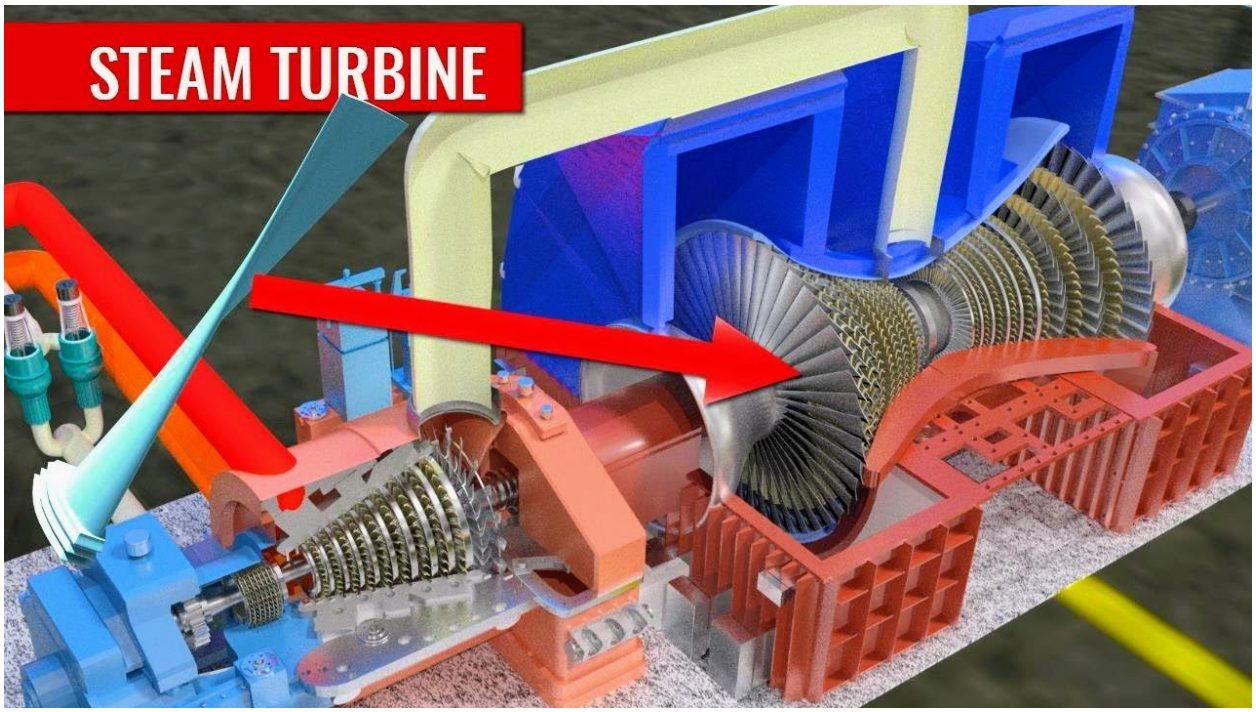
  - Improvements in standards of living and expectations.

Types of energy sources:

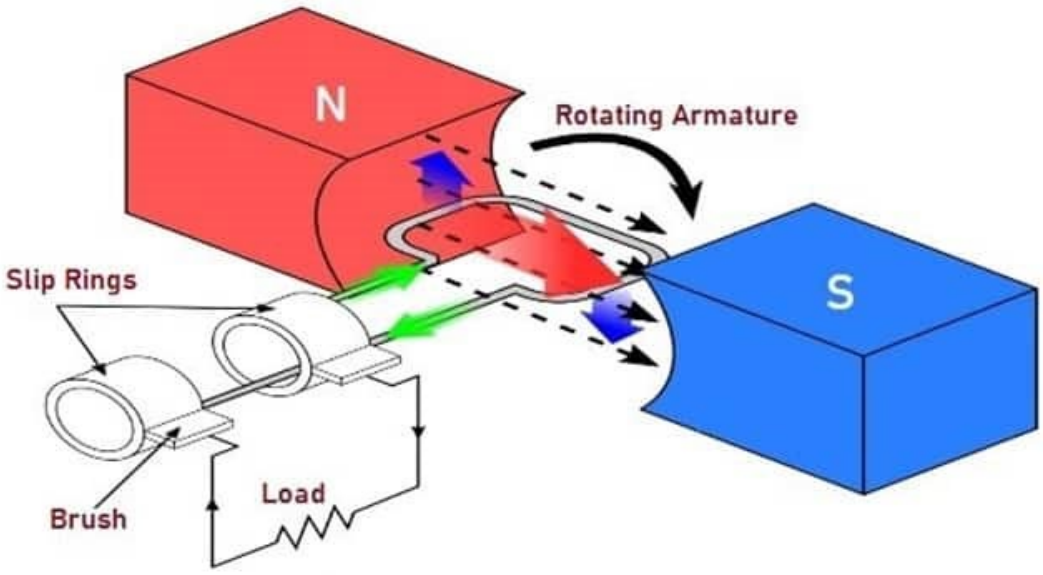
NON-RENEWABLE	**RENEWABLE**
Limited.	Can be used over and over again.
Take millions of years to get replenished.	Can be replenished in a short period of time.
•Fossil fuels (coal, oil and natural gas); • Nuclear power (using uranium).	•Geothermal power; • Hydro-electric power; • Tidal power; • Wave power; • Wind power; • Solar power; • Biofuels e.g. bioethanol, biogas and wood.

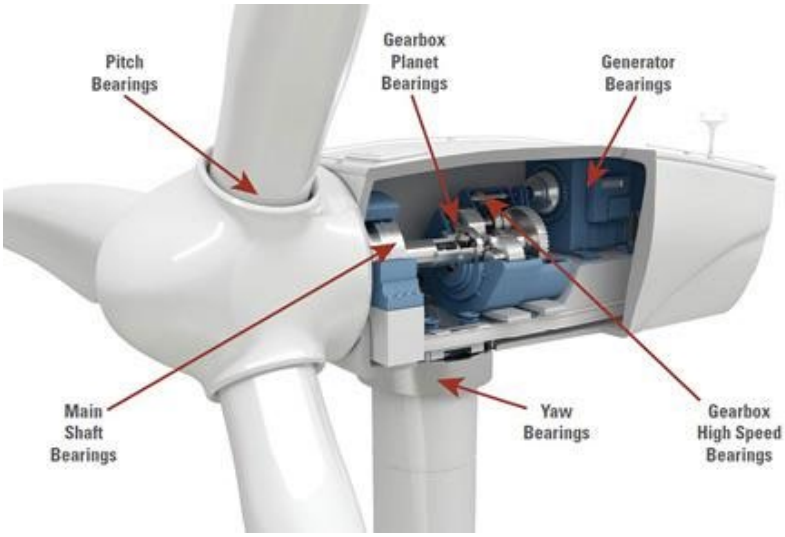
How energy sources are used to generate electricity:

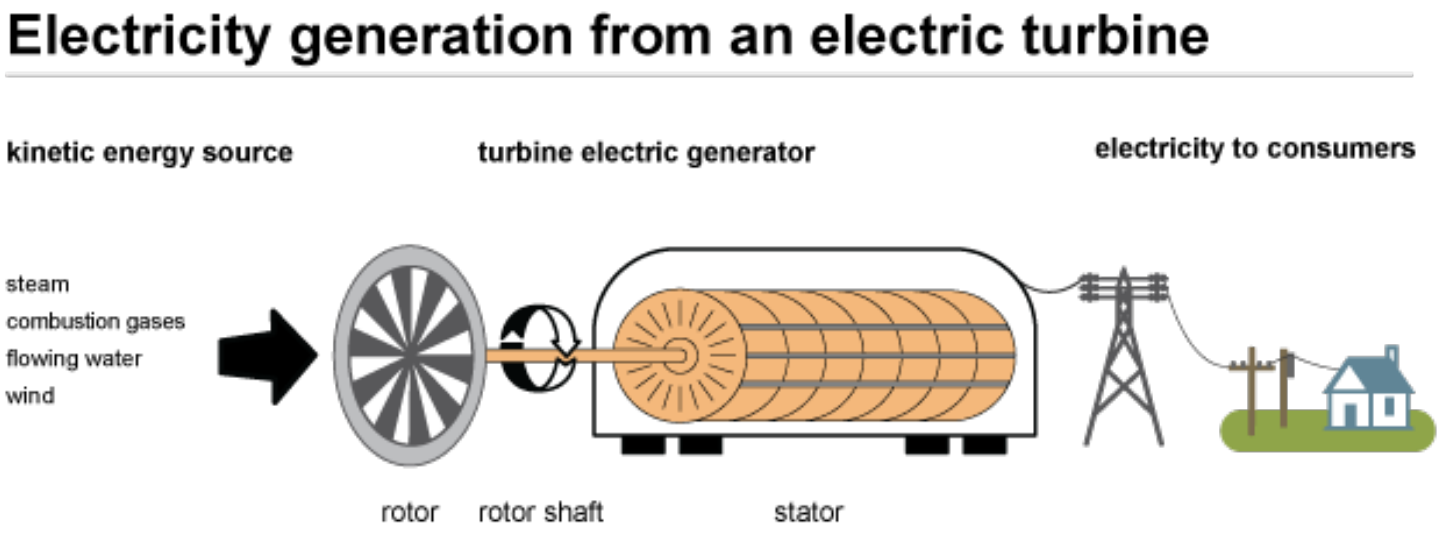
- Most electricity is generated by **electromagnetic induction** which transforms kinetic energy into electric energy.
- **Turbine:** a machine, often containing fins, that is made to revolve by gas, steam or air (it is connected to a generator).



- **Generator:** a machine that converts mechanical energy into electrical energy.







Fossil Fuels and Biofuels:

- These produce a massive amount of energy during combustion that is used to heat water and convert it into steam, which thereby drives the turbines.

Fossil Fuel	Biofuel Alternative
Coal	none
Gasoline	Alcohols (e.g. Ethanol)
Diesel Fuel	Vegetable Oils
Natural Gas	Biogas

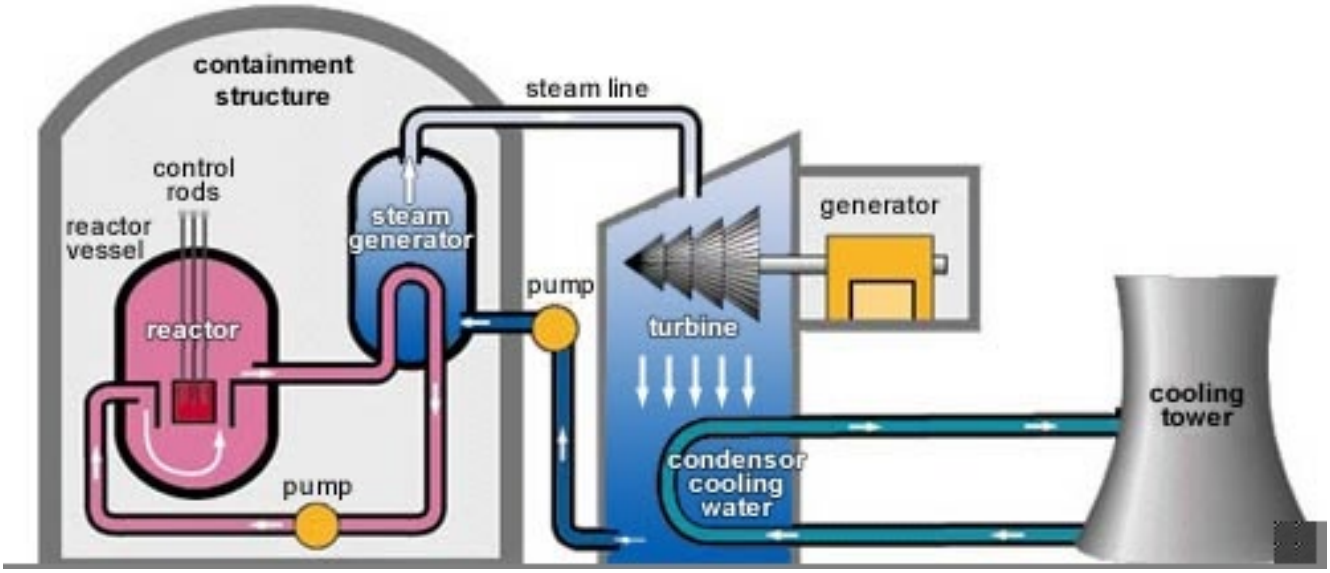
Biofuel vs Fossil Fuel

Characteristic	Biofuel	Fossil Fuel
Type	Renewable	Nonrenewable
Source	Modern plants and recently produced organic waste	Organisms that have been dead for millions of years
Impact on health	Nontoxic	Usually has toxic ingredients and biproducts
State of industry	Growing	Declining

DB Difference Between.net

Nuclear Power:

- Uranium, a radioactive element, releases huge amounts of energy when nuclear fission (splitting of the atom) occurs.
- This energy is used to heat the water, produce steam, and rotate the turbines.

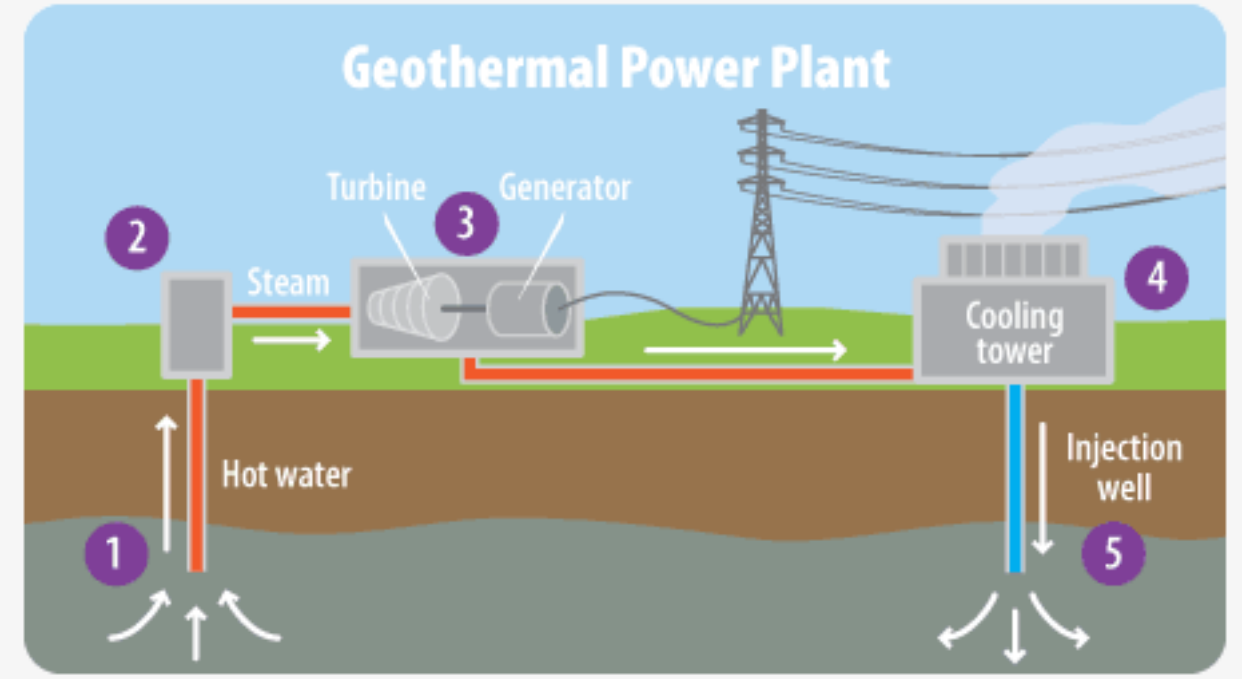


Geothermal Power:

- Cold water is pumped under pressure into a layer of hot rocks.
- The rocks heat the water.

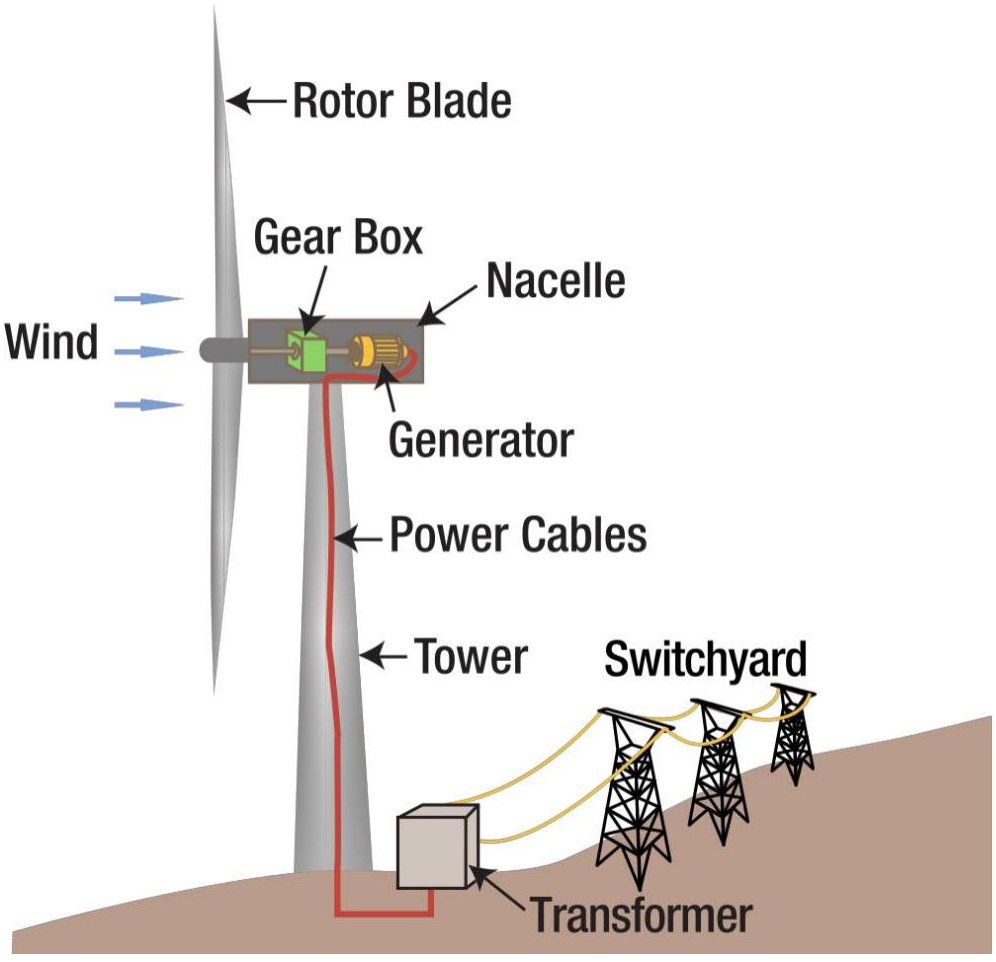
The hot water returns to the surface under pressure and heats the second supply of water using a heat exchanger.

- The steam produced in the second supply moves the turbine, generating electricity.



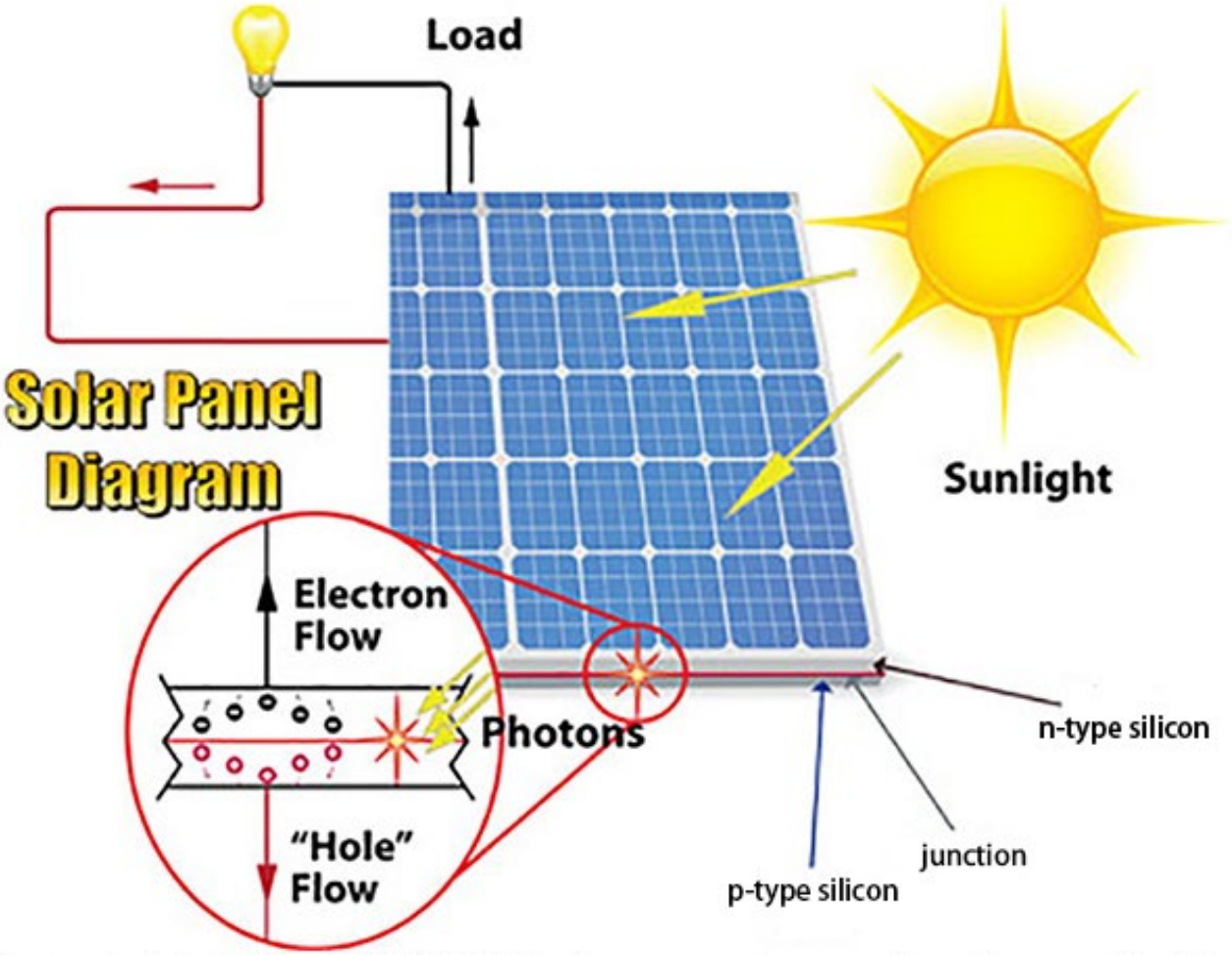
Wind Power:

- Wind turbines have shafts (blades) that rotate due to wind.
- Gearbox maximises the rotation of the shaft.
- Brakes slow down or stop the rotor in very windy conditions, preventing damage to
  the blade.
- As the turbine rotates, the generator produces electricity.



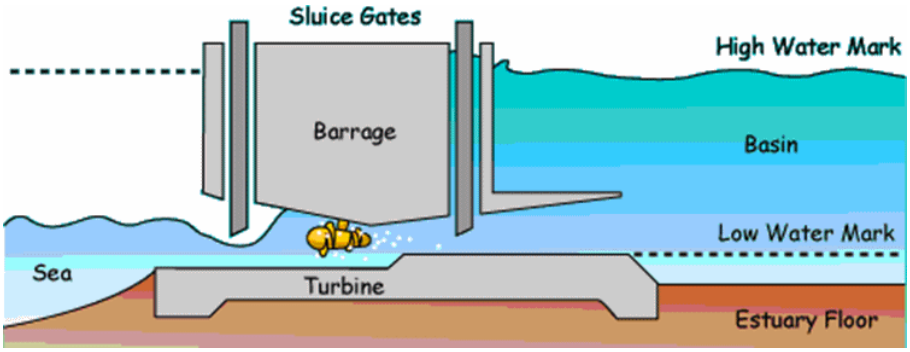
Solar Power:

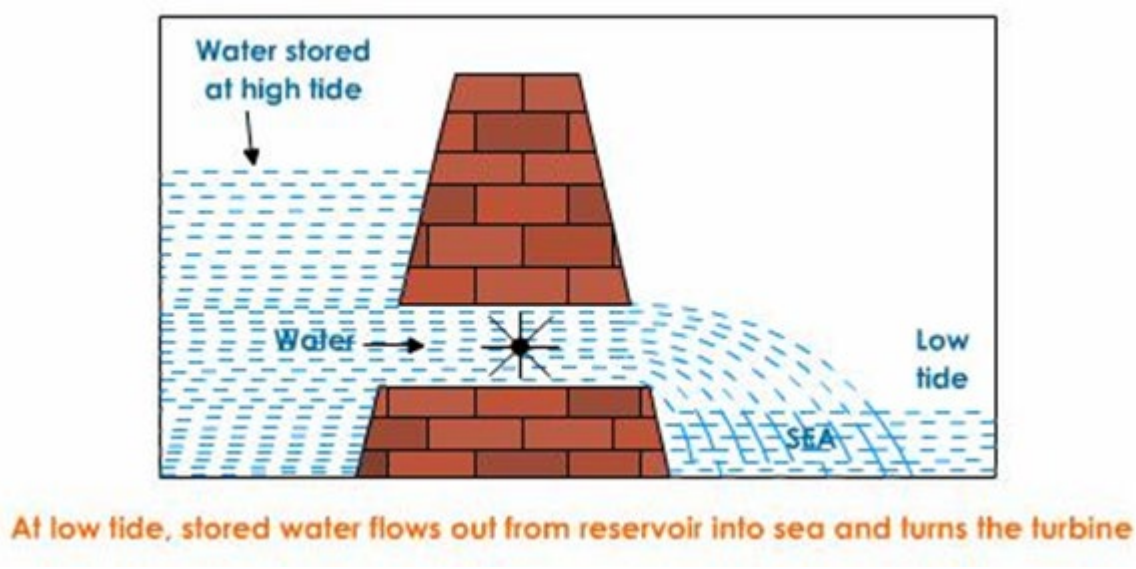
- Uses photovoltaic cells that produce a small electric charge when exposed to light.
- A bank of cells organised into solar panels produce a significant amount of electricity.

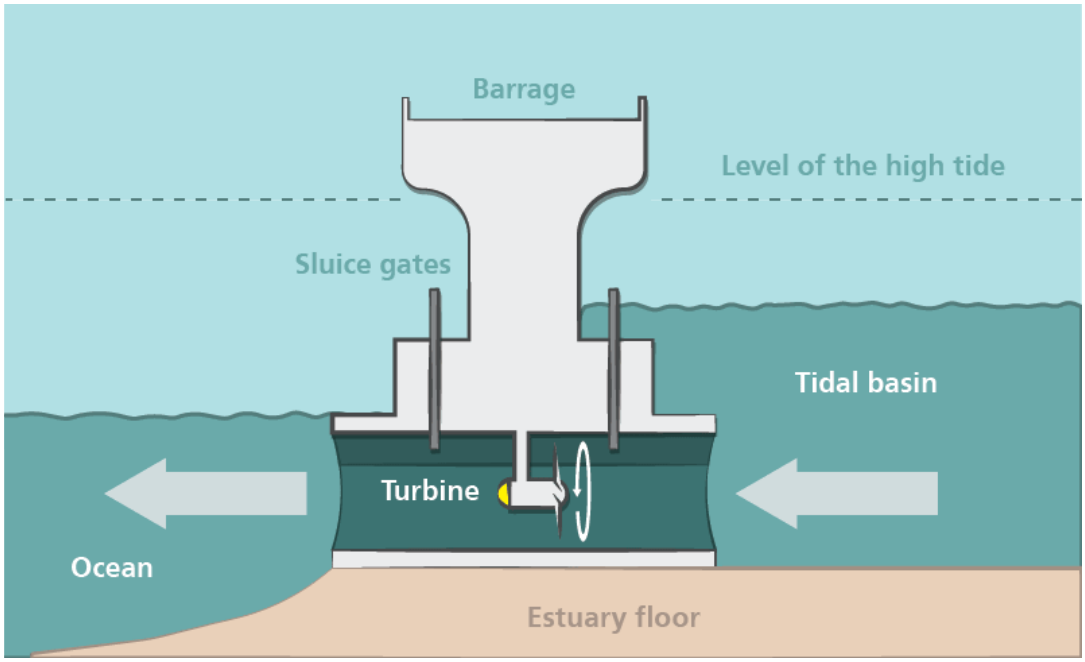


Tidal Power:

- Uses the natural rise and fall in the level of water in an area.
- When the levels drop, water is held back by a tidal barrage (a small dam that releases water back through a turbine).

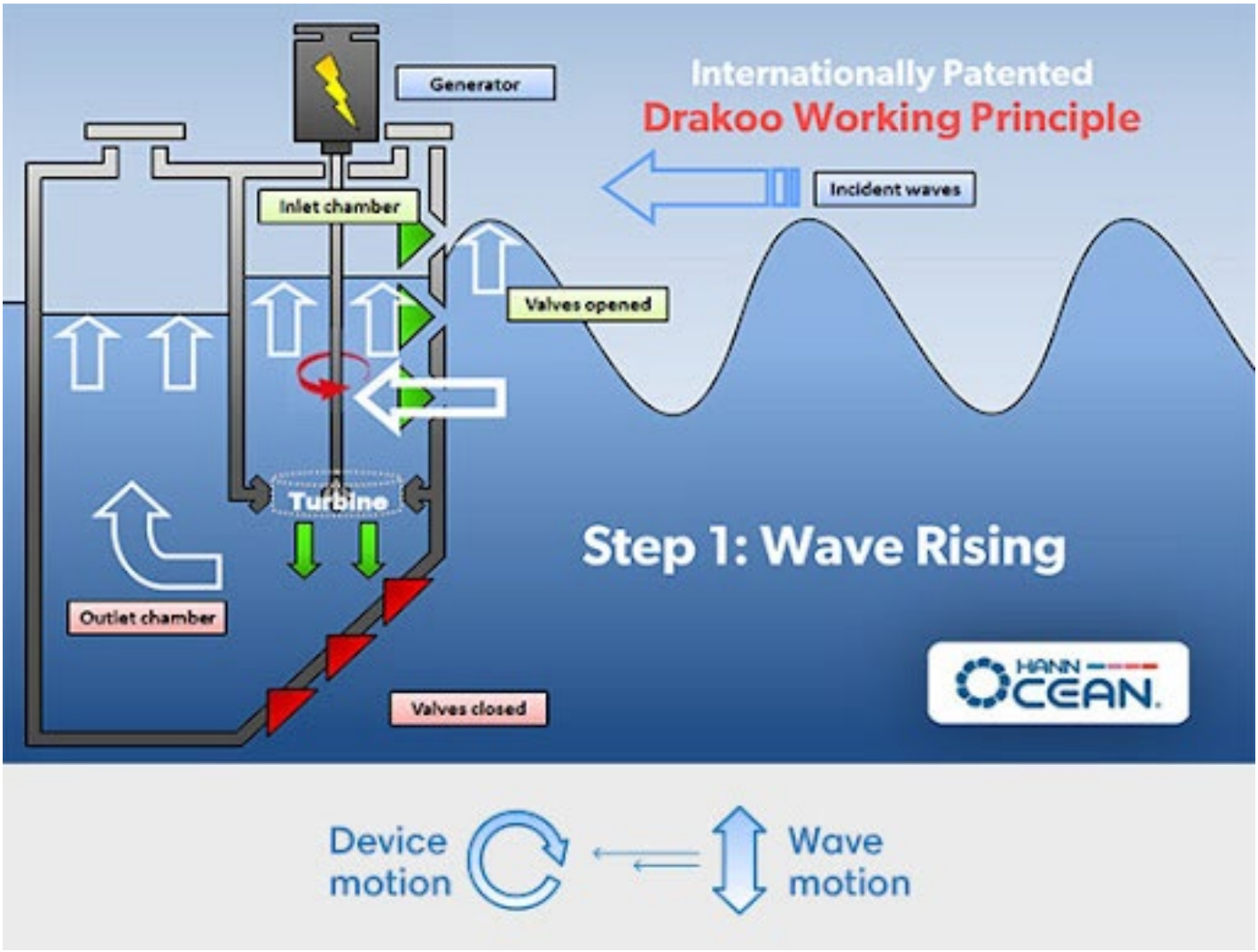




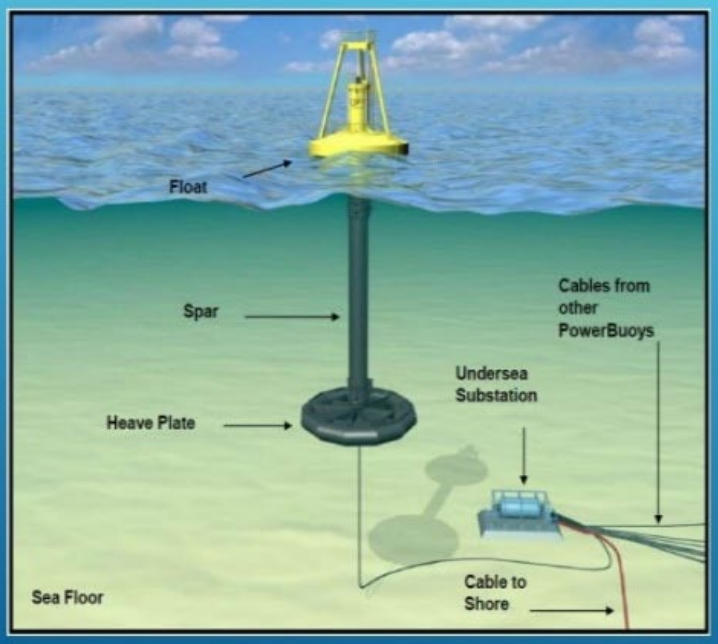


Wave power:

- Also uses turbine and generator.
- Uses the smaller differences in water levels that are caused by wind.

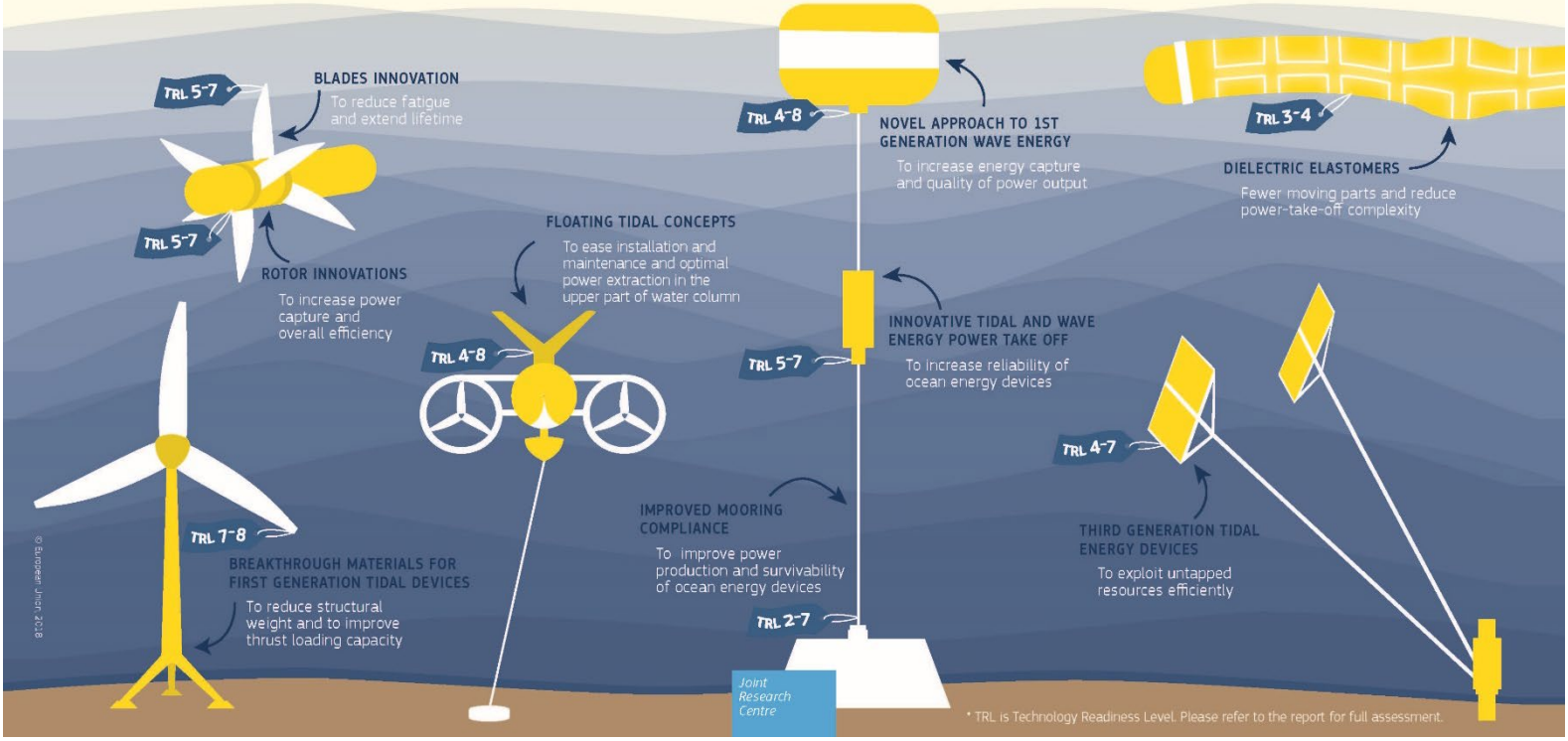


1. Float type wave energy converter



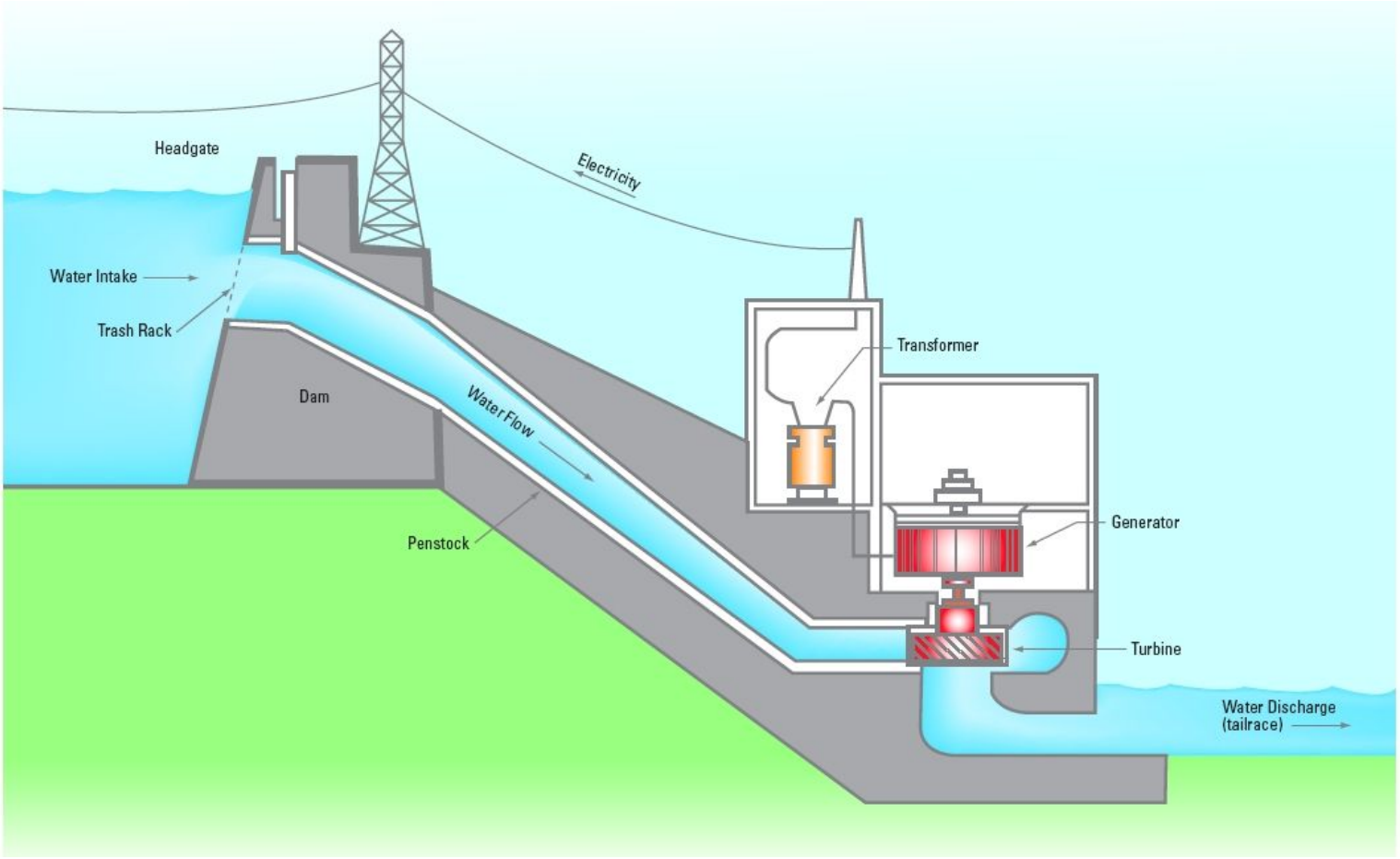
- This device floats on the surface of the water, held in place by cables connected to the seabed.
- Buoys use the rise and fall of swells to drive hydraulic/air pumps and generate electricity.
- EMF generated by electrical transmission cables and acoustic of these devices may be a concern for marine organisms.
- The presence of the buoys may affect fish, marine mammals, and birds as potential minor collision risk and roosting sites

How is research tackling the need for **cost reduction** and **reliability** of ocean technologies?



Hydro-electric Power:

- Uses a dam on a river to store water in a reservoir.
- Water is released from the reservoir that flows through the turbine, rotating it.
- The turbine then activates a generator that generates electricity.



Advantages and Disadvantages of:

Fossil Fuels:

ADVANTAGES:

- Plentiful supply
- Provides job opportunities (mining and processing)
- The technology used is well-known and the methods of extraction are well-practiced.

DISADVANTAGES:

- Carbon dioxide and toxic gases are released when burnt (contributes to global warming).
- • Damages local area.
- Limited supply (non-renewable).

Biofuels:

ADVANTAGES:

- Renewable source
- Growing more plants uses carbon dioxide.
- Plentiful suppl

DISADVANTAGES:

- Carbon dioxide and toxic gases are released when burnt.
- Lot of land needed
- Shortage of land for agriculture (increase in food prices).
- Removal of natural ecosystems (reduction in biodiversity).

Nuclear Power:

ADVANTAGES:

- Does not produce carbon dioxide.
- Large amount of energy is produced with a small amount of fuel.
- Provides job opportunities.

DISADVANTAGES:

- Risk of radiation leakage.
- Radioactive waste cannot be recycled since it is active for centuries;
- Limited supply (non-renewable).

Geothermal Power:

ADVANTAGES:

- Does not produce carbon dioxide (doesn't contribute to global warming).
- Unlimited supply (renewable).

DISADVANTAGES:

- Expensive to install.
- Only certain areas have suitable conditions.

Wind Power:

ADVANTAGES:

- Does not produce carbon dioxide (doesn't contribute to global warming).
- Renewable.
- Very low cost once built

DISADVANTAGES:

- Generation of electricity is weather-dependent.
- Only certain locations are suitable;
- Visual impact.
- Uses a large area.

Solar Power:

ADVANTAGES:

- Does not produce carbon dioxide (doesn't contribute to global warming).
- Costly to build

DISADVANTAGES:

- Weather-dependent.

Tidal Power:

ADVANTAGES:

- Does not produce carbon dioxide ∴ doesn't contribute to global warming.
- Tidal movements are not weather-dependent.

.DISADVANTAGES:

- Limited to specific coastal areas
- Impact on tourism and local fishermen.

Wave Power:

ADVANTAGES:

- Does not produce carbon dioxide (doesn't contribute to global warming).
- Renewable.

DISADVANTAGES:

- Limited to specific areas.
- Not very efficient at present.

Hydro-electric Power:

ADVANTAGES:

- Does not produce carbon dioxide (doesn't contribute to global warming).
- Water can be reused

DISADVANTAGES:

- Dams impact the natural flow of water.

Villages and ecosystems may be destroyed

Key Term:

Fossil fuel: a carbon-based fuel, formed over many millions of years from the decay of living matter. **Non-renewable**: an item or resource that exists in a finite amount that cannot be replaced.
Renewable: an item or resource that will not be used up or can be replaced.
Electromagnetic induction: a process used for generating electricity that uses the movement of a metal coil and a magnet.
Generator: a machine that converts mechanical energy into electrical energy.
Turbine: a machine, often containing fins that is made to revolve by the use of gas, steam or air.
Solar power: harnessing energy from sunlight.
Tidal power: the use of tides (the natural change in sea level) to generate electricity.
Wave power: the use of changes in the height of a body of water to generate electricity.

Energy demand

Domestic demand:

- The impact of more efficient manufacturing process has meant that many goods have become more affordable.
- Created by affordability, availability and social status.
- Most of the purchases that are considered as necessities now increase the demand for energy supplies, notably electricity.

    - Fruits and vegetables, that aren't naturally available in the season locally, are produced in glasshouse or in areas with a favourable climate and are then transported.
    - In both the scenarios (glasshouse operation and transport), the energy cost is significant.

Industrial demand:

- Manufacturing requires the use of large amounts of energy throughout the production e.g. iron and steel production.
- Advanced manufacturing techniques made the products that were once luxury items, cheaper.
    - So, more people want to buy them.
    - The demand for the product increases.
    - The demand for energy (needed for production) also increases.

Transport:

- Manufacturers supply customers across the globe.
- This decreases production costs in countries that import, but increases the transport costs as they require large amounts of fossil fuels to operate.
- There has been a significant increase in the amount of shipping and air transport journeys.

Economic factors:
Personal and national wealth:

- **If economic conditions are good:**
  - Higher employment
  - More money to spend on luxury items;
  - Increase in demand for the product;
  - Increase in demand for energy (for production).

- **If economic conditions are poor:**
  - Families have less money to spend on luxury items;
  - Need to make savings;
  - Reduce the use of fuel;
  - Reduce the purchase and use of electrical items.
  - Decrease in the demand for energy.

- **Decline in the economy of one country can have a global impact.**
- Ex. Reduction in the economy of China meant a worldwide:
  - Reduction in production of steel.
  - Decrease in the amount of manufactured goods (transported by ships).
  - Decrease in the price of oil (energy source).

Climate:

- The demand for energy with regard to climate depends on the country.
- People living in a temperate climate are likely to experience colder winters, so the energy demand for heating would be far higher.
- They also experience fewer hours of daylight.
- This increases the usage of electrical lighting.
- Climate change (excessive heat or cold) increased the energy consumption (particularly in urban areas).
- Need for additional heating or Installation and operation of air-conditioning units.

Assessment:

1. The table below shows the approximate amount of energy used per head of population in a year.

Country	Energy used per head of population/watt year^{-1}
Eritrea	188
Iceland	22560
Sri lanka	636
USA	9538

a) What percentage of annual energy use of a person from Iceland is used by an equivalent person from Eritrea?

b) .....
.....
.....

c) Explain the reason for the difference in the energy use between two higher countries and the two lower use countries?

d) .....
.....
.....

e) Iceland relies mainly on geothermal energy as its power source. Describe how this could be used to generate electricity.

f) .....
.....
.....

g) It has been stated that a healthy or strong world economy is poor news for energy use. Describe why this might be thought to be the case.

h) .....
.....
.....

Conservation and management of energy resources

Strategies for effective energy use:

- **Reduce consumption:**
  - Reducing the amount of energy used to heat a building.

- Using more equipment and less energy if the equipment uses energy efficiency. e.g. reducing the amount of energy used to heat buildings in colder climate.
- Standard house loses heat through a variety of routs (30-35% through the roof, 18-25% through walls, 21-31% through windows, and 6-9% through air leakage).
- Different technologies can be used to reduce this heat loss. One of them being **insulation**
- **Insulation** is constructing using material with good insulation properties prevents loss of heat.
  - **Loft insulation**: adding an insulation layer into the roof space.
  - **Underfloor insulation**: adding an insulation layer on the floor e.g. carpet.
  - **Cavity wall insulation**: a gap between inside and outside walls is filled with an insulating material, causing the heat to pass through more slowly.
  - **Double glazing**: two panes of glass with a gap in the middle to act as an insulator. This sealed gap is usually filled with air or an inert gas e.g. argon.
  - **Triple glazing** can also be used, but it is too expensive.
- Electrical devices must be turned off when not in use.
- Devices can be left in 'standby' mode and can be accessed rapidly.
- More energy-efficient devices must be bought.
- Developing alternative fuels for vehicles and further development in engine technology.
- 'Scrappage' schemes: remove inefficient machines from use (electrical appliances or vehicles).

- **Energy from waste:**
  - Reusing existing materials to extract energy from them before they are disposed.
  - Anaerobic digestion: breaking down of organic matter (waste food and vegetation) using bacteria.
  - This process takes place in a sealed container and releases methane (a flammable gas) that can be used for heating purposes.

- The composted waste can be used as organic matter to improve soil structure.
- Household rubbish can be incinerated (burnt) to produce heat that can be used to generate electricity.
  ADVANTAGES: Waste from burning (ash) is small in volume. Thus, it doesn't take up much space.
  DISADVANTAGES: Produces poisonous gases during combustion.
- The food processing industries use large quantities of cooking oil, these vegetable oils, once used, need to be disposed.
- These oils can be collected and recycled into biofuels suitable for running vehicles;
- It can be used exclusively or as an additive.

- **Education**:
  - Benefits of the technology must be communicated to others.
  - Promote new ways of thinking;
  - The message must be that significant savings in energy bills can be made over the longer term, reducing energy use.
  - Energy-efficiency ratings must be provided for new products to compare with the old ones.
  - Laws passed by the government to make changes rapidly:

a. Stricter building regulations: new constructions must be more energy efficient.

b. Preventing the sales of inefficient types of electrical devices.

- Some governments Incentive to encourage the purchase of more efficient technologies:

a. Insulating older houses that are energy efficient;
b. Replacing older, inefficient electrical devices;
c. Scrapping older, inefficient cars that emit more pollutants.

- **Exploiting existing energy resources:**
  - The type of energy source used depends on social, environmental and economic factors.
  - The current solution is to use a renewable resource as a primary energy source when possible and have a fossil-fuel

(or biofuel) powered station available as a backup when weather conditions are not suitable.
- This is a reliable source for industry and households and reduces the amount of fossil fuels used.

- **Transport policies:**

Government initiative include**:**
- Regulations regarding the quality of exhaust gases from vehicles.
- Check on the fuel efficiency.
- Restrictions on where vehicles may go.
- Taxation on fuels.
- Surcharges for travelling to certain places at peak times.
- Improving public transport so it is easier and cheaper than using cars.
- Improving routes for cyclists and pedestrians.
- Encouraging car-sharing;
- Restricting when cars can be used e.g. odd even rule in Delhi and Paris.
- Providing grants to buy more fuel-efficient vehicles and for vehicles using cleaner technology such as electric-powered vehicles.

- **Development of new resources:**

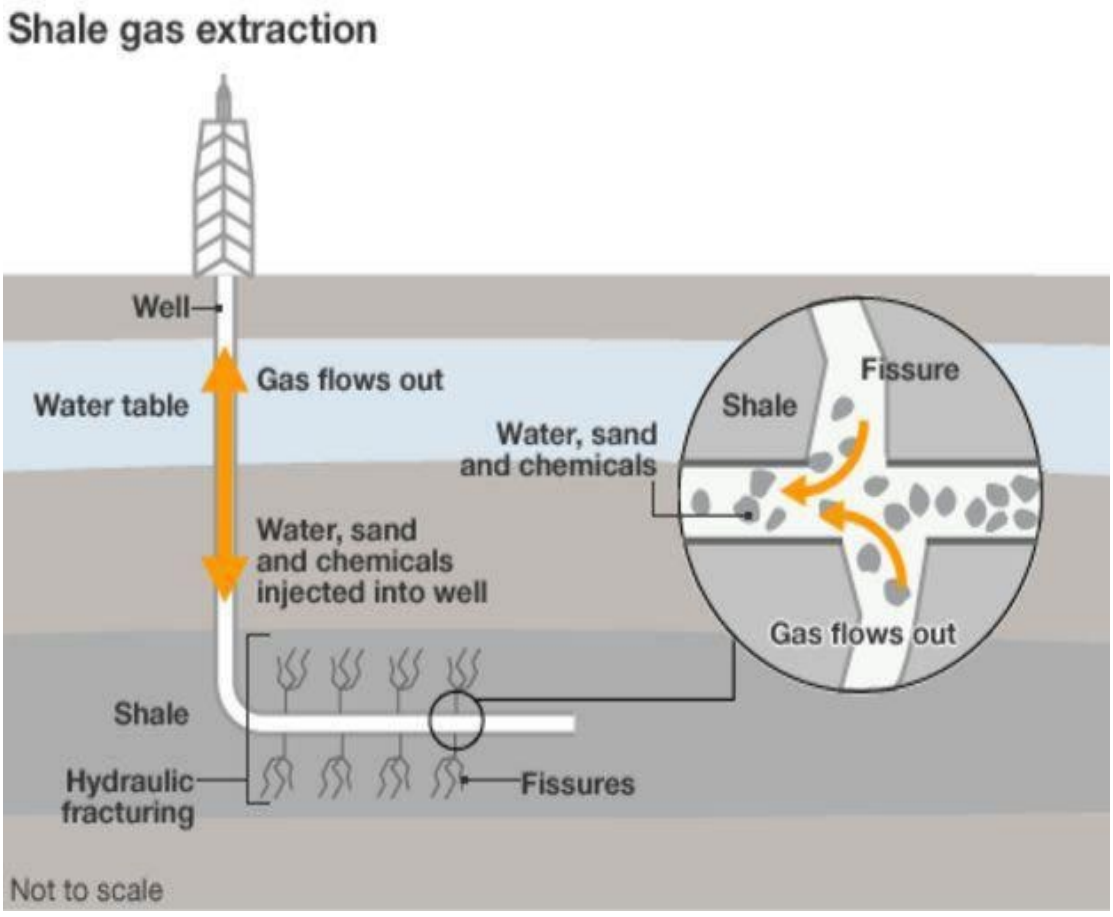
Fracking:
- Obtaining oil or gas from shale rock by splitting them open using water, sand and chemicals.
- A vertical hole (2-3 km deep) is drilled to reach the fuel-rich rocks (shale rocks).
- Water, sand and chemicals are pumped down into the shale rock layer.
- This causes the rock to fracture, releasing oil and natural gas, which are forced back to the surface and collected.
- Purpose of the three components:
  - Water: easy to handle (in high pressure).
  - Chemicals: stop the blockage of pipes.
  - Sand: keeps the cracks in the rock open (proppant).

ADVANTAGES

• Allow access to more oil and gas.
  • Less pollution than burning coal.
  • Provide many jobs locally.
  • Reduce the need to import oil or gas.
  • The need to import reduces;

DISADVANTAGES

  • Risk of toxins entering the water table.
• Chemicals are toxic and may affect local residents.
• Uses a lot of water; may cause water scarcity;
• Noise pollution.
• Natural areas damaged.
• May cause additional Earth tremors by lowering the level of rock.



Impact of oil pollution

Despite of the research into other forms of energy, the world is still very reliant on oil because:

- It is relatively easy to store and transport.
- It is easier to extract from the ground than solid materials such as coal.
- It can be made into a number of different products.
- It produces less pollution when burnt compared with coal.

Oil is not present in every location, so the supplies have to be transported to the customers. Oil is toxic and spillage can cause great damage.

- **the Main causes of marine oil spills:**
  - Offshore oil extraction: leakage from the rigs.
  - Oil pipelines: leaks in the oil pipework.
  - Shipping: risk of collision or damage to oil tankers.

- **Effects of an oil spill:**

Organism or habitat	**IMPACT OF OIL**
PHYTOPLANKTON	• Oil floats on the surface of the water and blocks the sunlight from entering. The phytoplankton can't photosynthesise, so they die.
FISH	• Shortage of food; reduction in phytoplankton. • Oil floating on the surface prevents gas exchange.

	• Fish become short of oxygen and die. • Direct contact of the fish with oil affects their gills.
BIRDS	• Shortage of food as fish and other creatures die. • May consume oil when eating fish (toxic). • When hunting for food, feathers get covered with oil, affecting their ability to fly.
MAMMALS	• Food sources are depleted. • Mammals may also swallow oil while feeding (toxic). • Coating of oil will affect their skin.
REEFS	• Complete devastation of the reef due to lack of oxygen (species die). • Areas may be covered in oil.
BEACHES	• Oil (washed by tides) coats rocks; • Organisms in shallow water and rock pools may die due to toxic effects of the oil. • Animal food sources and tourism are affected.

Management of oil pollution

- **Reducing oil spills in marine environments:**
  - MARPOL (Marine Pollution): International Convention for the Prevention of Pollution from Ships.
  - **Regulations of the MARPOL:**

▪ Supervise the transport of oil at sea.

▪ All tankers must be certificated to show they have appropriate systems in use.

▪ Else, it can result in a heavy fine or the ship may not be permitted to leave port.

  - **Tanker design:**

▪ Oil spill can be caused by damage to the hull (a hole in the hull of the boat causes its contents to leak).

▪ Increase in the number of compartments within the hull of the ship: if one of the compartment's damaged, the contents of the whole ship aren't lost.

▪ Double-hulled tankers: if the outer layer's damaged, the contents are still secure by the inner plate.

▪ Though double-hulled tankers cost more than single-hulled, the risks of oil spill are far less.

  - **Minimising the impact of oil spills**:

▪ Floating booms: a floating barrier is used to surround the oil slick, preventing it from spreading.

▪ This process works well when the spill covers a relatively small area and the sea is calm.

▪ Detergent sprays: detergents help break down the oil slick into smaller droplets that eventually degrade, and disperse it.

▪ They are effective on smaller spills, but cause damage to the coral reefs themselves as they're not tolerant to detergents.

▪ Skimmers: clean the water using a material that oil easily attaches to.

▪ The skimmer drags oil off the seawater surface, that is then scrapped off into a container.

▪ This system is used when oil slick is contained within a boom and the sea is calm.
▪ When the oil reaches beaches, it can only be removed by hand (difficult and time-consuming).

Key Terms

Fracking: the common term for hydraulic fracking, the process of obtaining oil or gas from shale rock by the breaking open to rocks using water, sand and chemicals.
Proppants: a material, such as sand, used to keep cracks in the shale rocks open to allow gas or oil extraction.
Double hulled: a ship design that uses a second layer, allowing the cargo to remain safe if the external layer is damaged.