

تكنولوجيا الطاقة وتطبيقاتها



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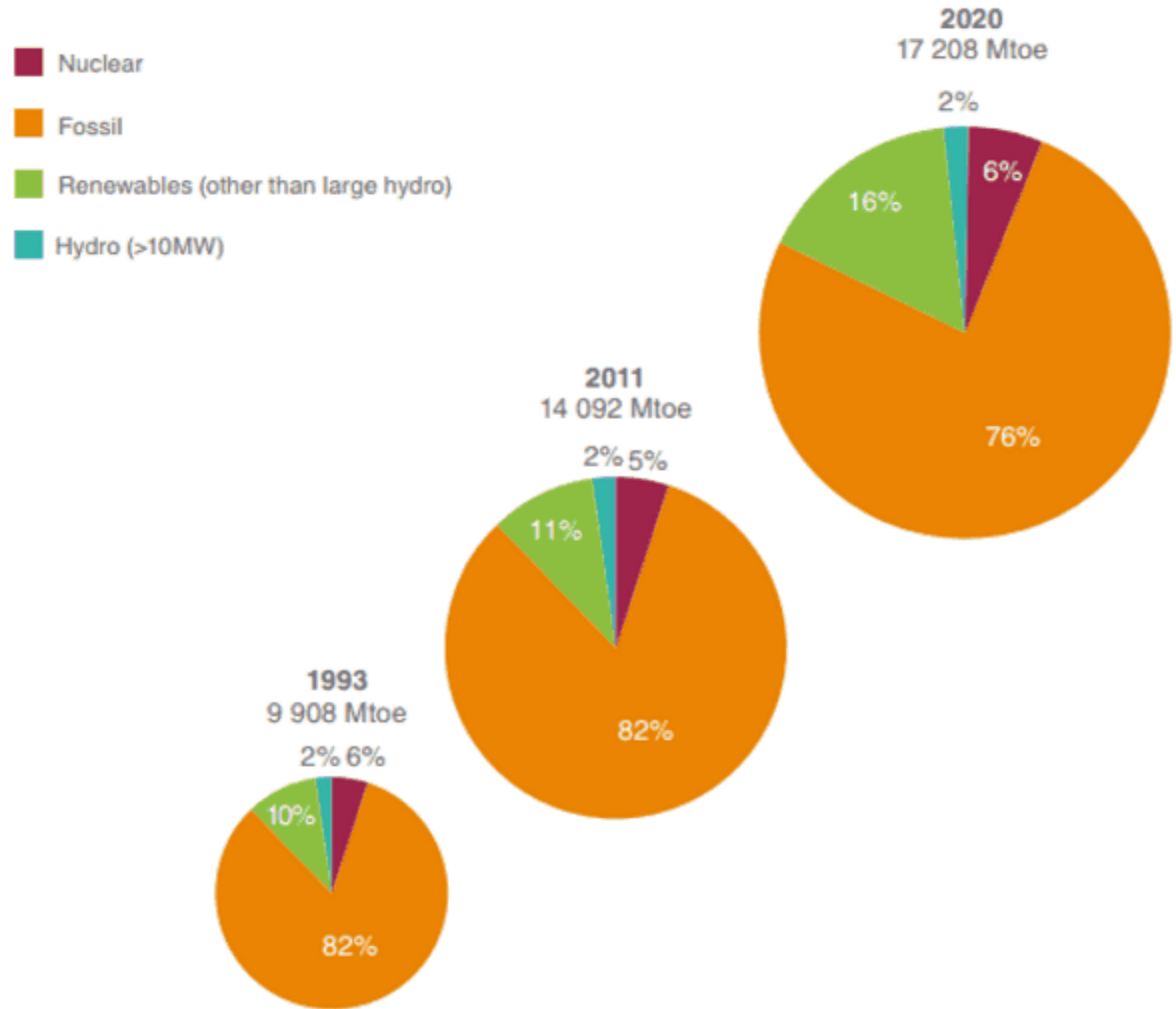
What is Energy

Physicists, who are scientists who study force, motion and energy, say that energy is the ability to do work, and work is moving something against a force, like gravity. In physics, energy is the ability to do work, or the ability to move or elicit change in matter. In effect, the amount of energy something has refers to its capacity to cause things to happen. Measure of the ability of a body or system to do work or produce a change, expressed usually in joules or kilowatt hours (kWh).

TOTAL AND BY ENERGY TYPE

World total energy consumption in 2020 was 17.208 million tones of oil equivalent (mtoe). Most is extracted from conventional fossil (coal, oil, natural gas) and nuclear (uranium) reserves.

Renewable energy (wind, solar, hydroelectric, geothermal and biomass) is growing rapidly in recent years, now reaching 16 % of the world total energy consumption, which is more than double of nuclear energy consumption (6 %).



Energy Categories

Non-Renewable Energy

- Nuclear
- Fossil Fuel

Renewable Energy

- Hydro Power
- Wind Energy
- Oceanic Energy
- Solar Power Energy
- Geothermal Energy
- Biomass Energy
- Bio-fuel
- Biogas



Non-renewable energy

Non-renewable energy is energy which is taken from the sources that are available on the earth in limited quantity and will vanish fifty-sixty years from now. Non-renewable sources are not environmentally friendly and can have serious affect on our health. They are called non-renewable because they cannot be re-generated within a short span of time. Non-renewable sources exist in the form of fossil fuels:, natural gas, oil, coal and nuclear

FOSSIL FUEL ENERGY

Coal, petroleum, and natural gas are called fossil fuel as these are formed by the decomposition of the remains of dead plants and animals buried under the earth for a long time. Coal is formed by carbon, hydrogen, oxygen, nitrogen and varying amounts of Sulphur. The dead plants from the swamps are piled up with sand and mud on top. Without water the carbon increases and forms a hard black substance called coal. Coal is used as a fossil fuel to produce electricity and heat in something such as a train.

Types of Coal

- Lignite
- Bituminous Coal
- Anthracite



- Lignite is a low grade brown coal, which is soft with high moisture content. The principal lignite reserves are in Neyveli in Tamil Nadu (South Indian state) and are used for generation of electricity.



- Bituminous Coal that has been buried deep and subjected to increased temperatures. It is the most popular coal in commercial use. Metallurgical coal is high grade bituminous coal which has a special value for smelting iron in blast furnaces.



- Anthracite is the highest quality hard coal.



IMPACT OF COAL MINING ON ENVIRONMENT

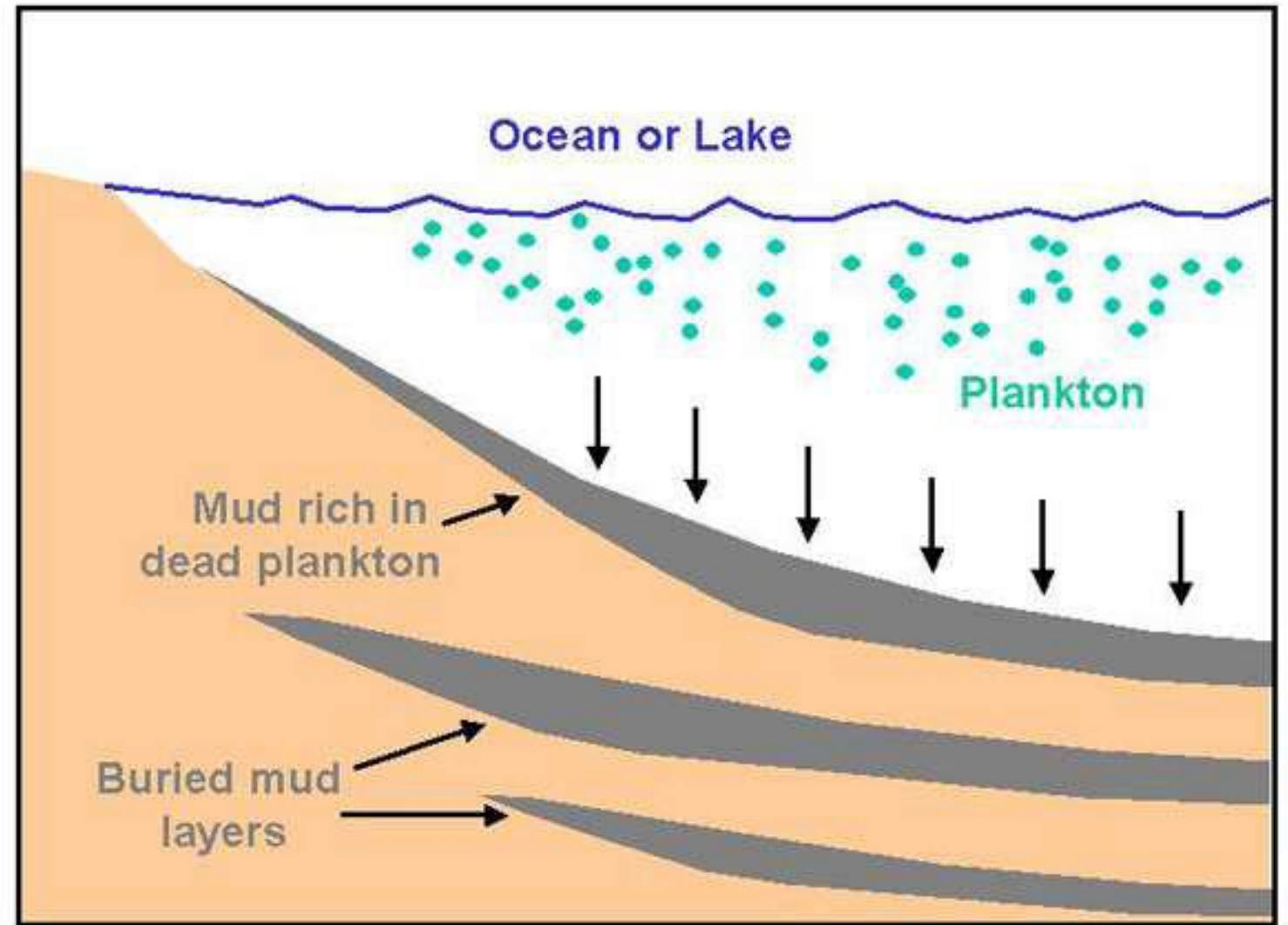
- Impact of mining on Air
- CO₂ emission
- Ozone depletion
- Global warming and climate change
- Mine fires
- Impact on water
- Impact on land
- Mining waste



Petroleum

Petroleum or mineral oil is the next major energy source in India after coal. It provides fuel for heat and lighting, lubricants for machinery and raw materials for a number of manufacturing industries. Petroleum refineries act as a “nodal industry” for synthetic textile, fertilizer and numerous chemical industries.

Oil was formed from plants called plankton. When the plankton dies, it sinks in the bottom of the sea and is buried under layers of sand and mud. When these layers are mixed it turns into a hard rock, but when bacteria ate the plankton, it turned into ooze, which is now oil. • Oils are used for ,Fuel for lamps , fertilizers, pens, car gas, heating oil for home, planes, ships, factories, food



Advantages;

- Widely and easily distributed all over world
- Easy to store and transport
- Cleaner and easier to burn than coal
- Reliable electricity

Disadvantages;

- Growing demand
- Non-renewable and fast depleting (used up fast)
- Burning produces carbon dioxide which is major cause for global warming\leaves harmful products when combusting
- Increasing prices



Natural Gas

- Natural gas is an important clean energy resource found in association with or without petroleum. It is used as a source of energy as well as an industrial raw material in the petrochemical industry. Natural gas is considered an environment friendly fuel because of low carbon dioxide emissions and is, therefore, the fuel for the present century.
- It is formed from a plant called plankton just like oil. The plankton died, sank to the bottom, and sand and mud covered it up. Over the years, bacteria and heat pressure turned the plankton into natural gas.
- Natural gas is used as fossil fuel when people are heating homes, buildings, heating water, fertilizations or cooking



Nuclear Energy

- Nuclear or Atomic Energy is obtained by altering the structure of atoms. When such an alteration is made, much energy is released in the form of heat, and this is used to generate electric power.
- Nuclear power plants provide about 5.7% of the world's energy and 13% of the world's electricity.
- Nuclear energy is a powerful source of energy, generated during a nuclear reaction, by change in the nucleus of an atom.
- Environmentalists for nuclear energy contend that nuclear power is a sustainable energy source that reduces carbon emissions.

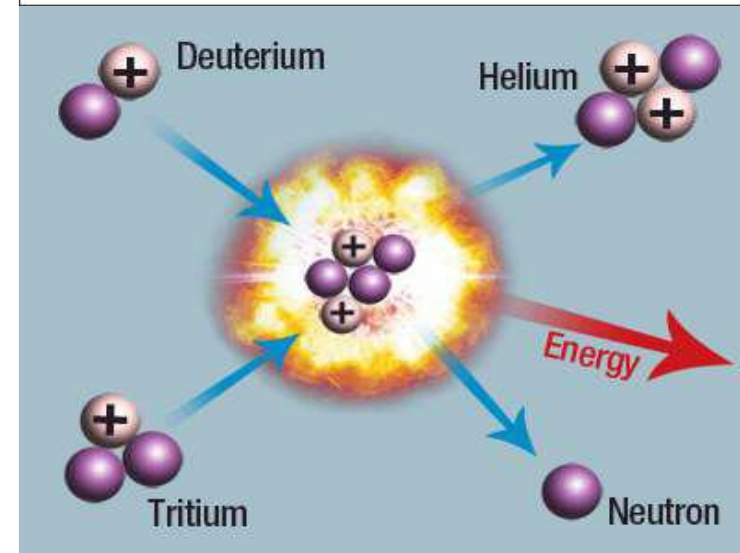
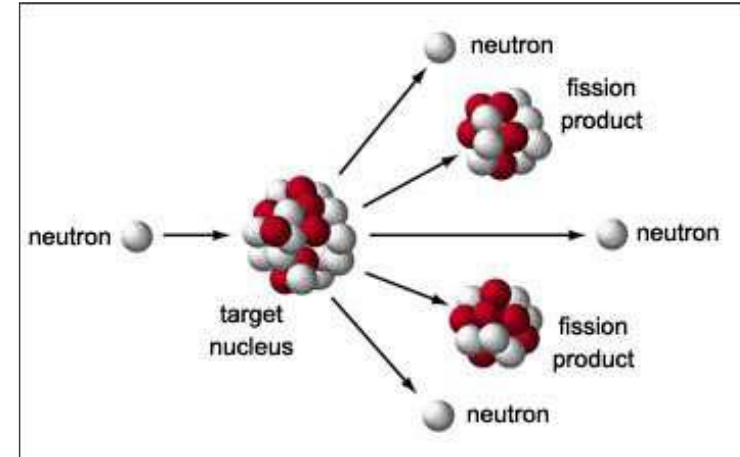


- Two ways to obtain nuclear energy:

- Nuclear fission
- Nuclear fusion

- Nuclear fission reaction, the nucleus of a heavy radioactive element like uranium, plutonium or thorium splits up into smaller nuclei, when bombarded by low energy neutrons. A huge amount of heat is generated in this process, which is used in nuclear power plants to generate electricity.


- Nuclear fusion reaction involves the combination or fusion of two light elements to form a heavier element and release uncontrollable energy. Thus, it cannot be used to generate electricity, unlike fission reaction. The heat and light that we get from sun, is all due to the continuous reactions going on inside it. We can now imagine how much energy would be released in the nuclear fusion reaction, that it is the source of sun's energy



ADVANTAGES OF NUCLEAR ENERGY

- Nuclear plants bring job and prosperity to country
- Provides the world with the most of its electricity
- Not many nuclear have happened; natural disasters cause more damages
- Canada has easy access to uranium
- Its good for the economy
- Lot of energy is produced from a small amount of uranium
- Do not emit CO₂
- Generating electricity from nuclear energy cause little pollution

DISADVANTAGES OF NUCLEAR ENERGY

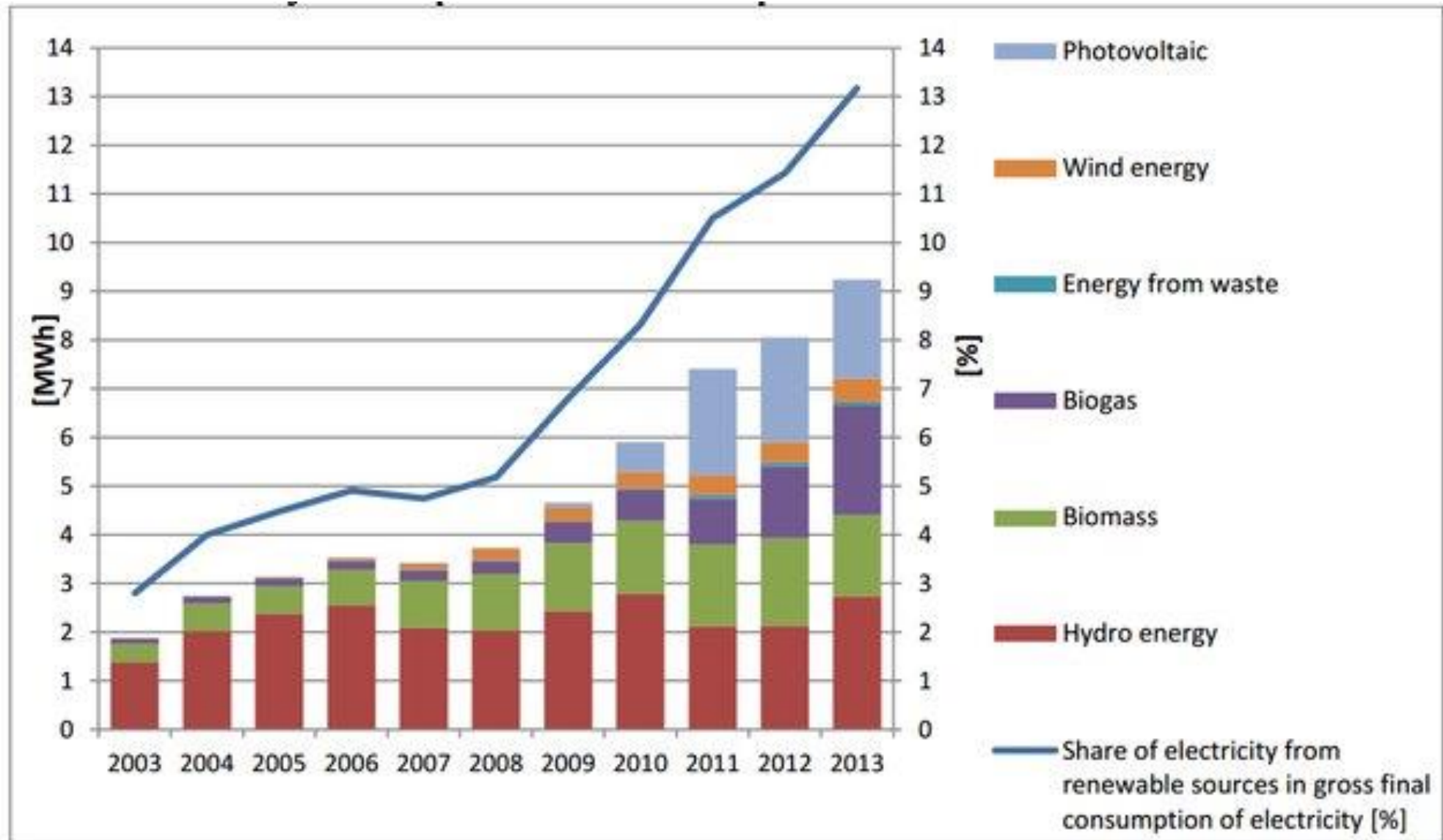
- Disposing of nuclear waste is very difficult and needs to be done after a lot planning by the experts
 - The radioactive waste takes years to be no longer hazardous
 - Waste must be stored very carefully for a long time
 - Storing is a huge problem.
 - Waste is very dangerous. It is radioactive
 - Nuclear power plants are very expensive to build
 - Uranium is not renewable and can lead to environmental problems through mining and processing
- 

Renewable Energy – “any sustainable energy source that comes from natural environment”

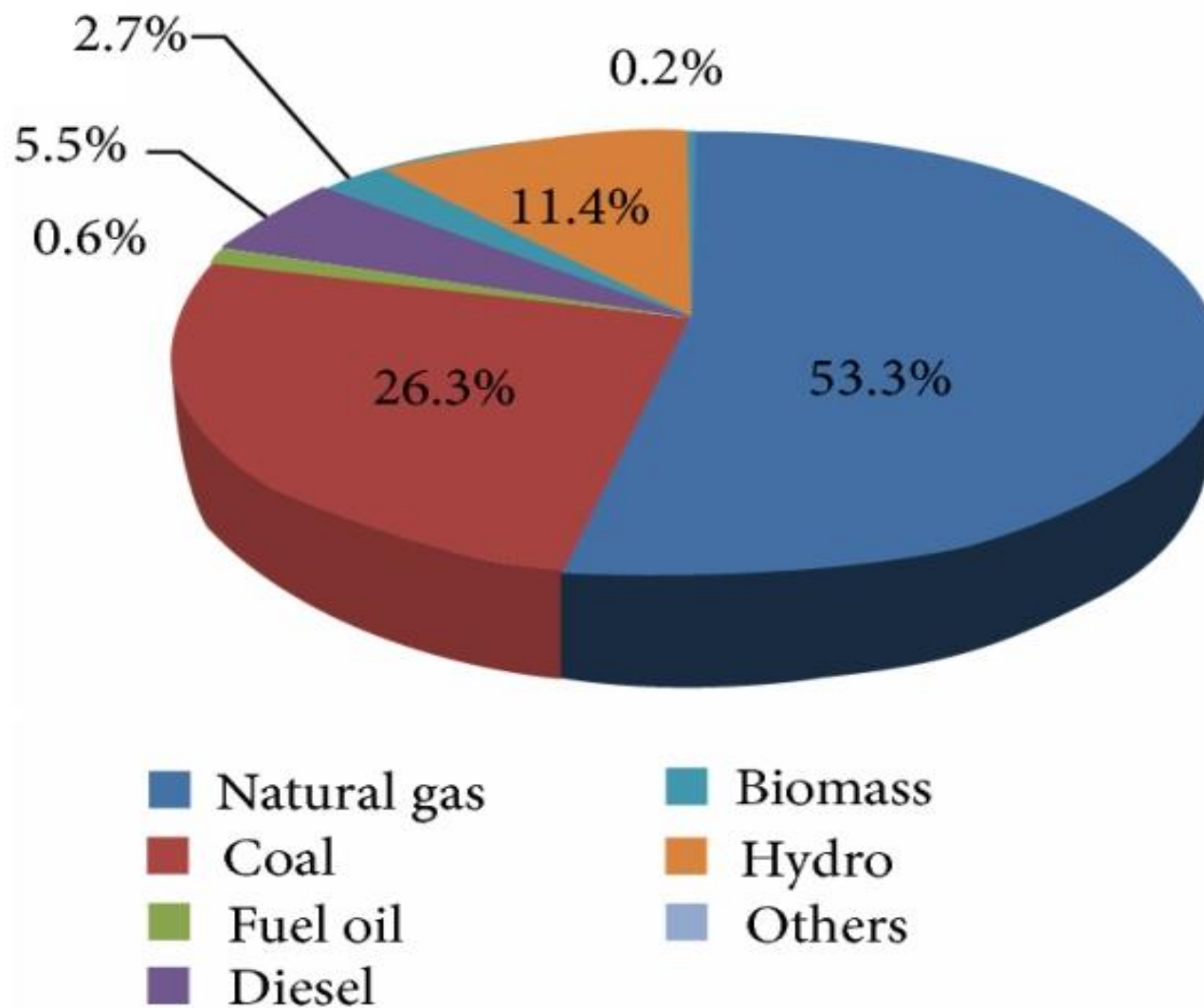
Some Aspects of Renewable Energy

- It exists perpetually and in abundant in the environment
- Ready to be harnessed, inexhaustible
- It is a clean alternative to fossil fuels
- “energy that is derived from natural process that are replenished constantly” -- defined by the **renewable energy working party of the international energy agency**

Contribution of Renewable Energy in World Electricity Production



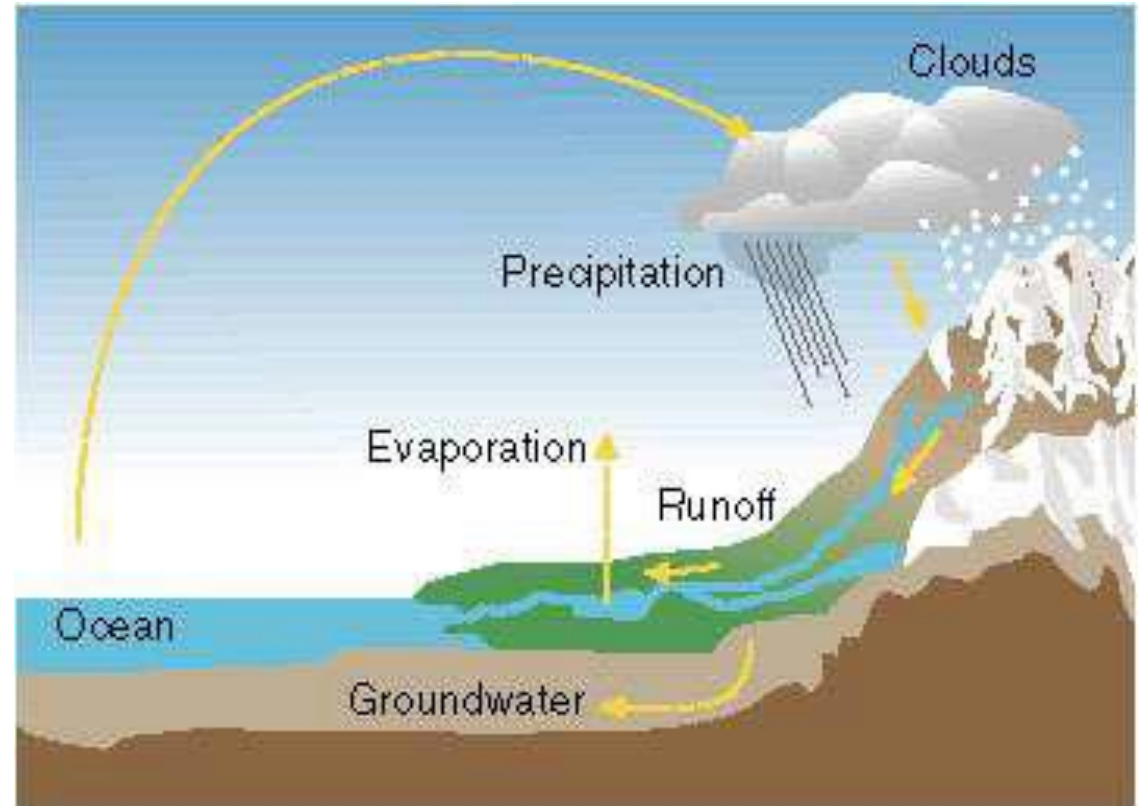
Share of installed capacity



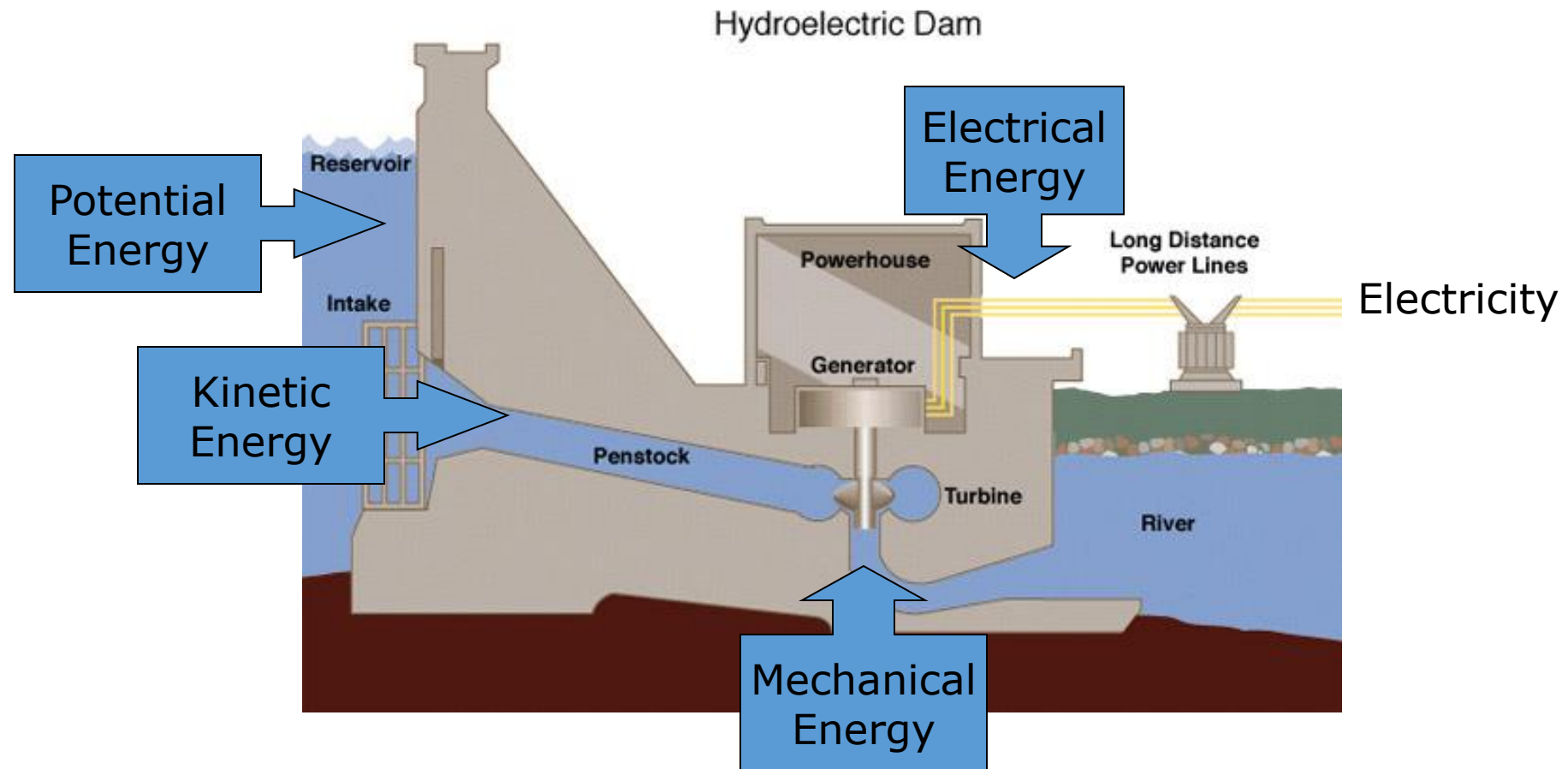
Share of installed capacity as of December 31, 2012, in Malaysia

Hydro Energy

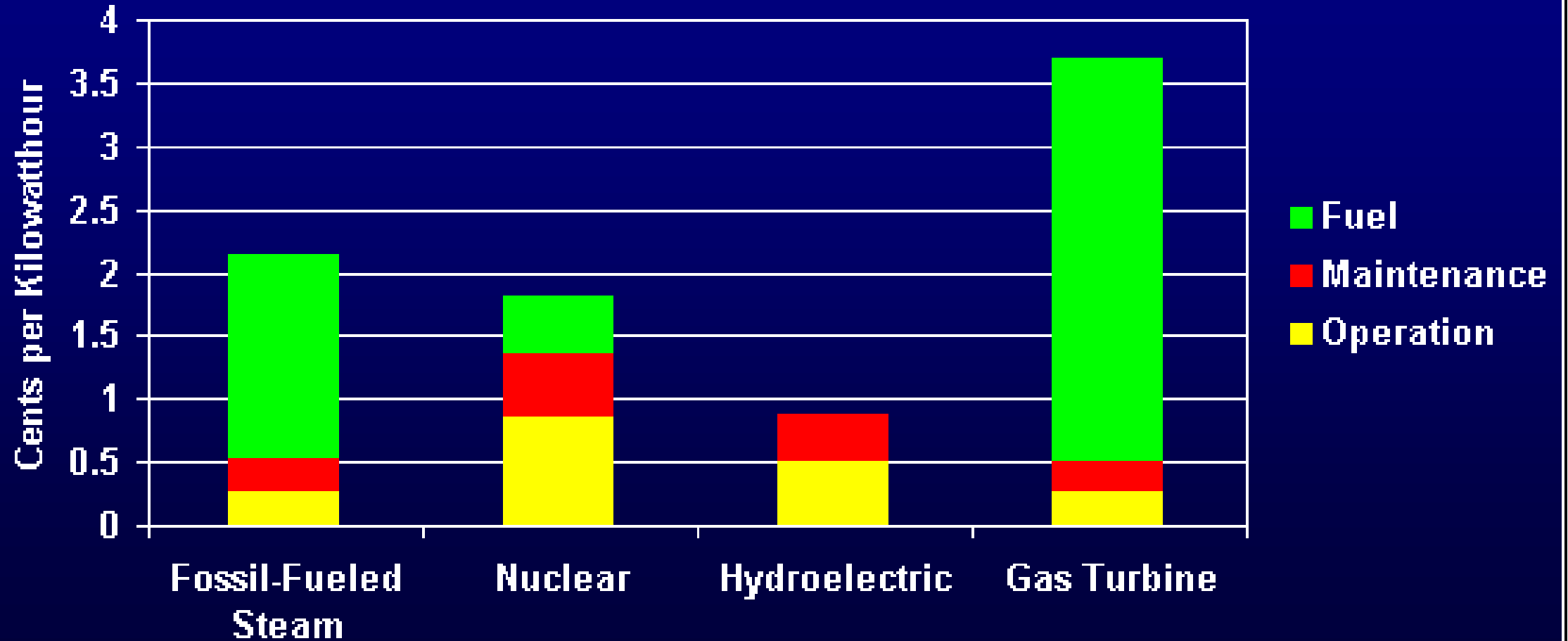
Hydro or water energy is the conversion of hydropower into electricity. Hydropower refers to the force of water flow that turns turbines and powers generators, which then store the electricity into power grids for mass consumption. The hydropower process is a clean renewable energy resource because the water cycle occurs naturally. The movement of water throughout Earth's systems is called the hydrologic cycle. This cycle is influenced by solar energy like other clean energy sources. This is because the amount of heat from the sun causes the water to change in the atmosphere, making it solid, liquid, or gas. Historically, one of the first uses of hydro power was for mechanical milling, such as grinding grains.



Hydro Power to Electric Power



Average Power Production Expense per KWh



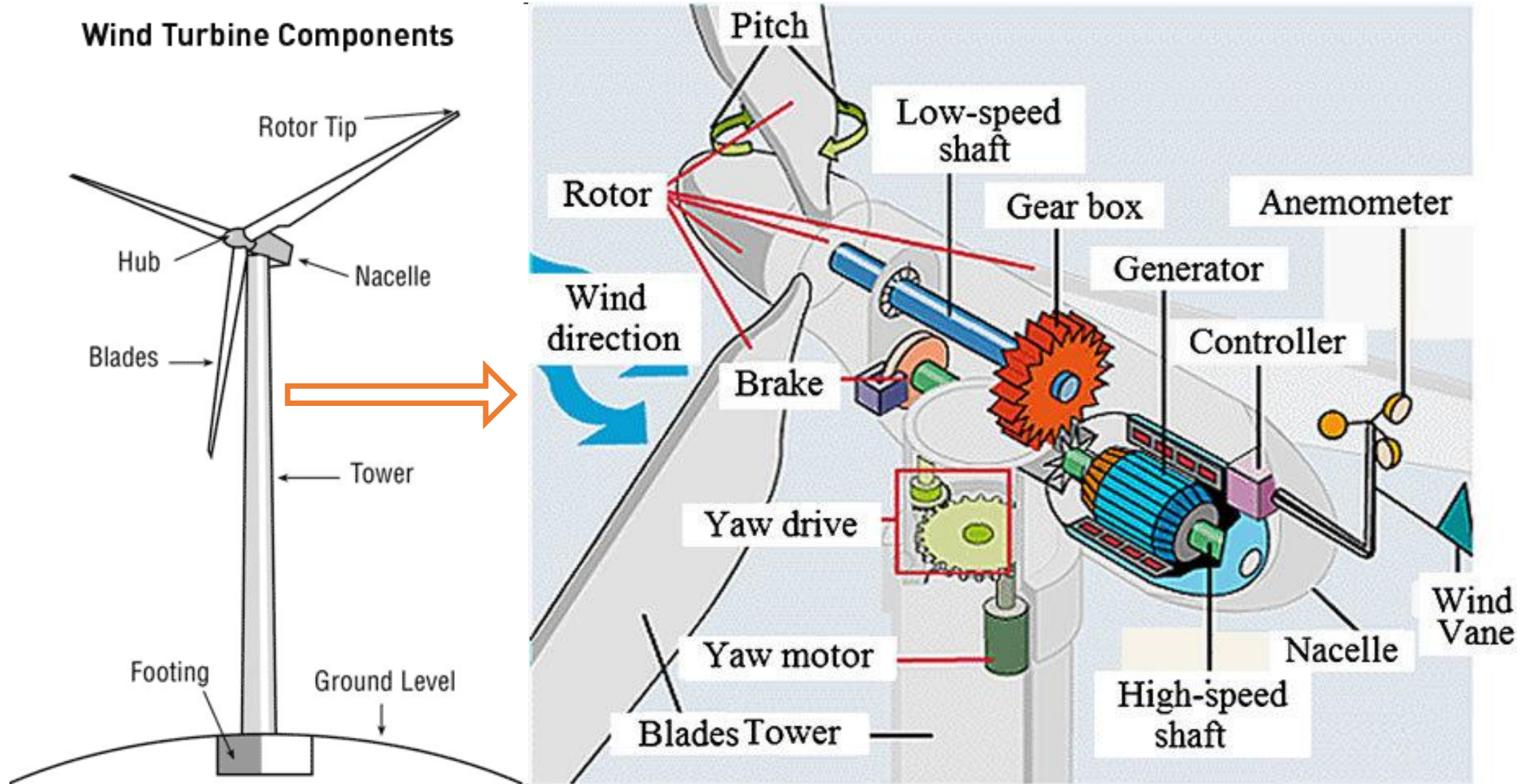
Wind Energy

Wind energy is a free, renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants or green house.

It's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas, which emit particulate matter, nitrogen oxides, and sulfur dioxide causing human health problems and economic damages' gases.



Wind Energy Electricity Generation



Ocean energy

Ocean energy refers to all forms of renewable energy derived from the sea.

There are three main types of ocean technology:

These technologies include:

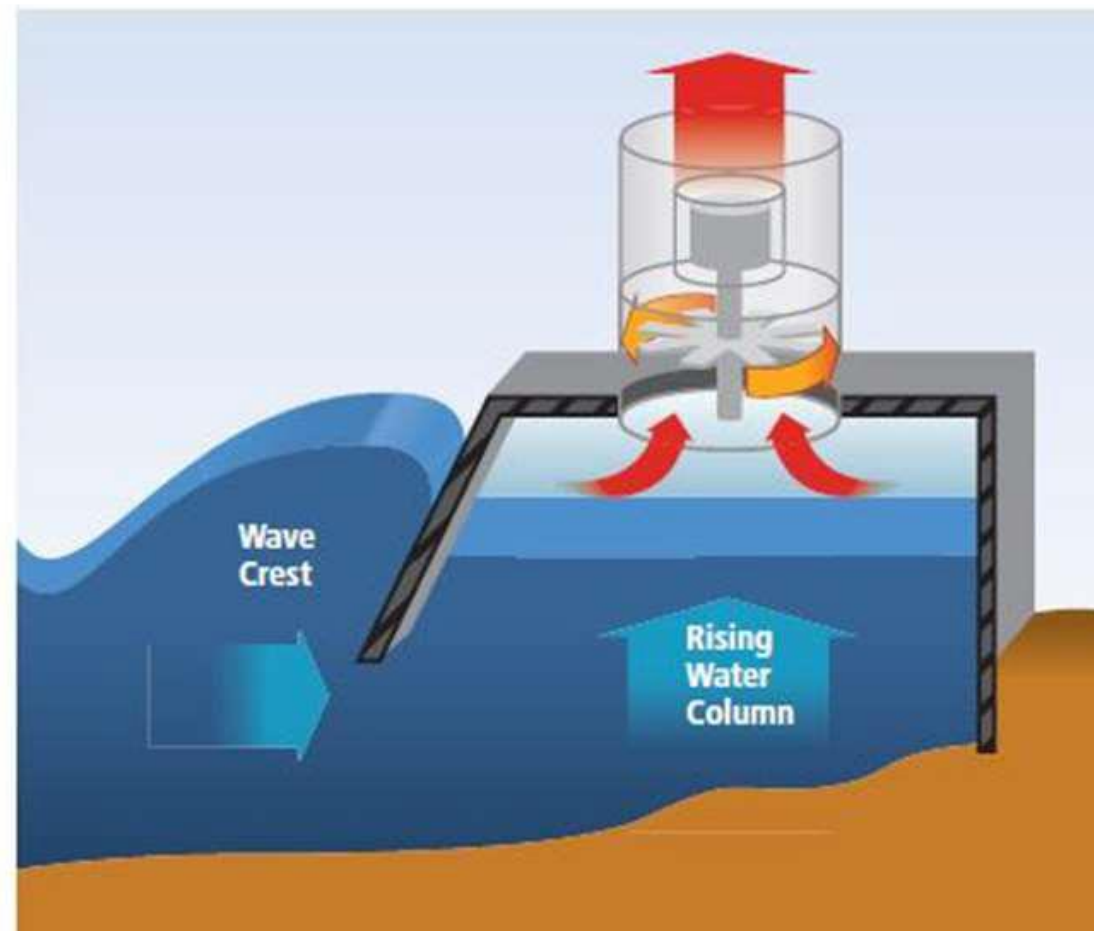
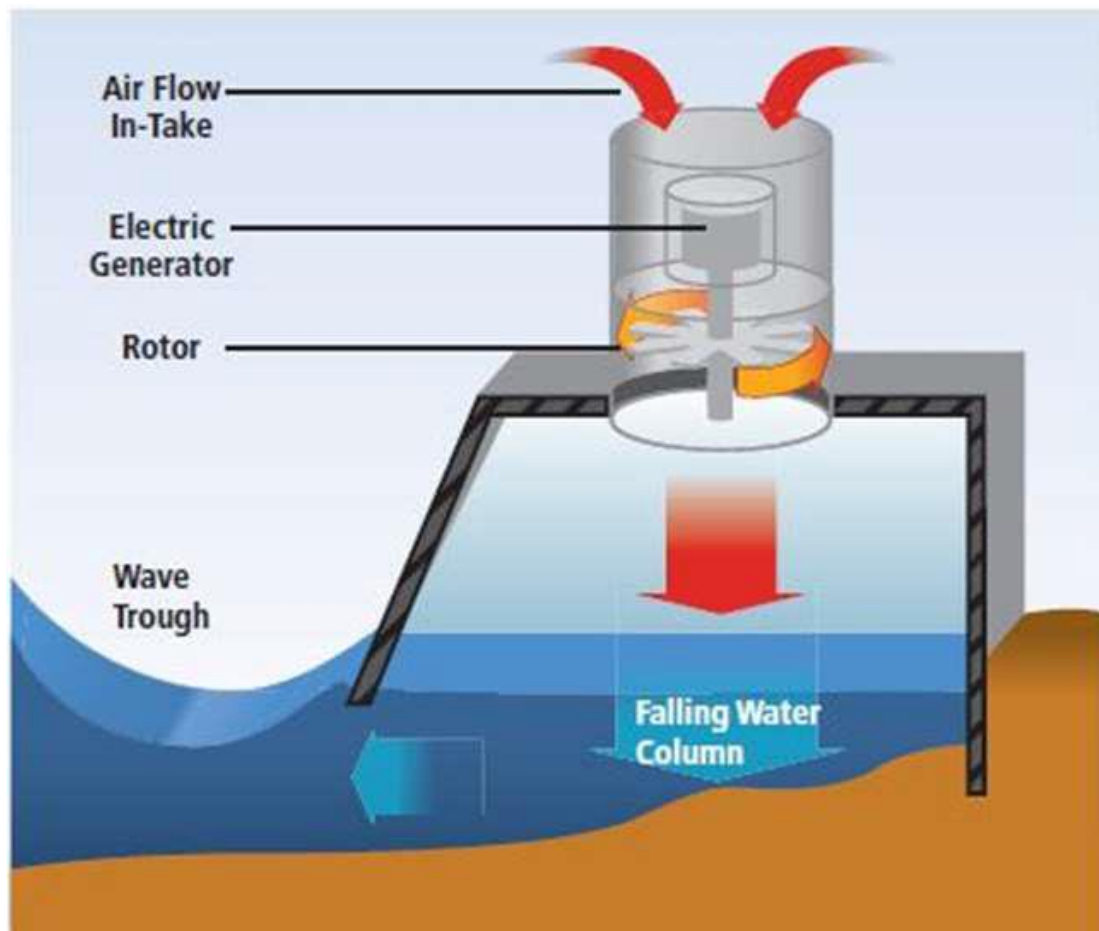
- ❑ Wave energy converters, which generate power from surface waves.
- ❑ Tidal energy converters, which generate power from the movement of tidal currents.
- ❑ Ocean thermal energy converters, which generate power from thermal differences between warm surface seawater and cold deep seawater.



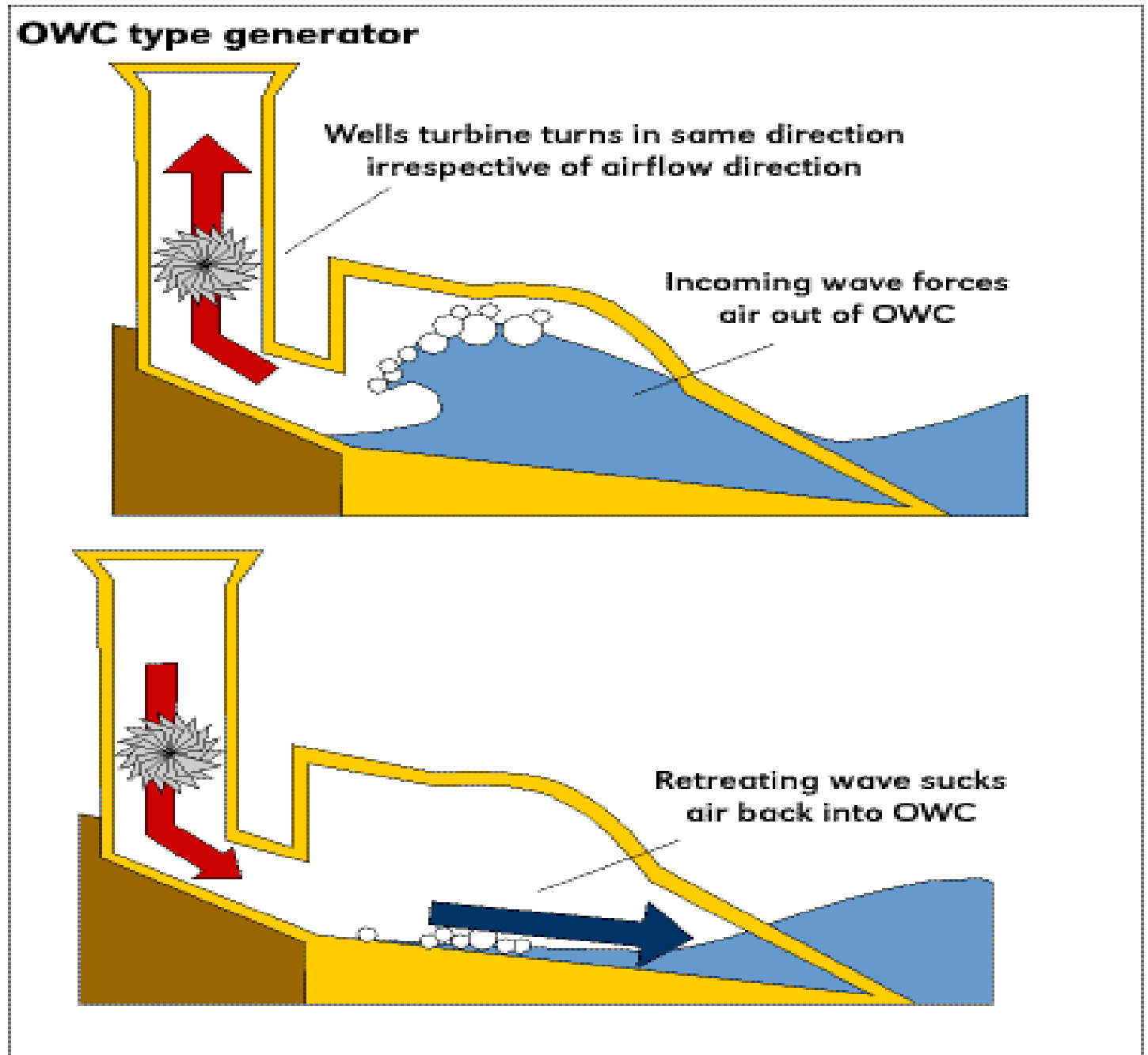
❑ Wave energy

Kinetic energy (movement) exists in the moving waves of the ocean. That energy can be used to power a turbine. The wave rises into a chamber. The rising water forces the air out of the chamber. The moving air spins a turbine which can turn a generator. When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed.





Oscillating water columns (OWC) are a type of Wave Energy Converter that harness energy from the oscillation of the seawater inside a chamber or hollow caused by the action of waves. OWCs have shown promise as a renewable energy source with low environmental impact

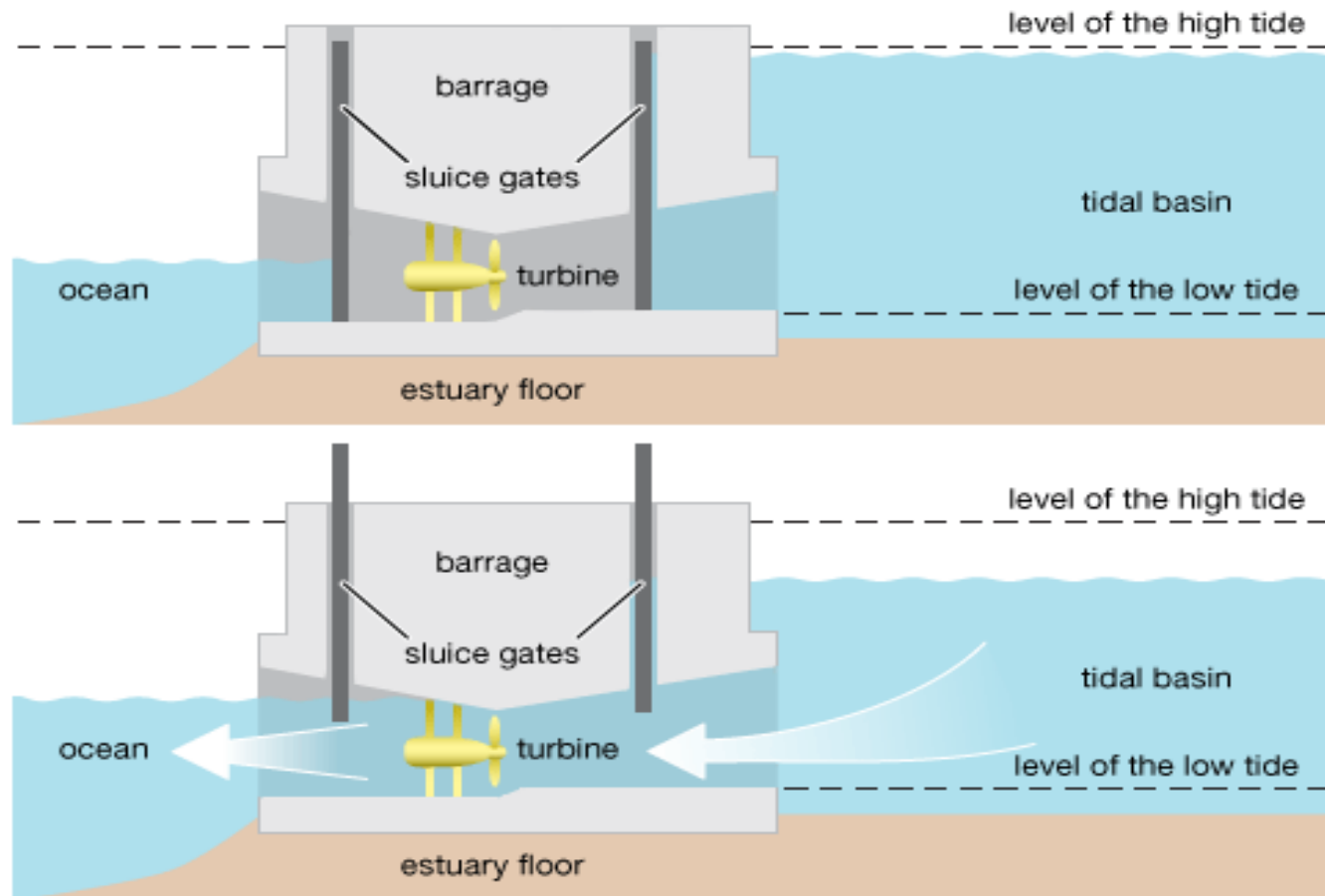


❑ Tidal energy

Tidal energy, produced either by tidal-range technologies using a barrage (a dam or other barrier) to harvest power between high and low tide; tidal-current or tidal-stream technologies; or hybrid applications.

Two types of tidal plant facilities.

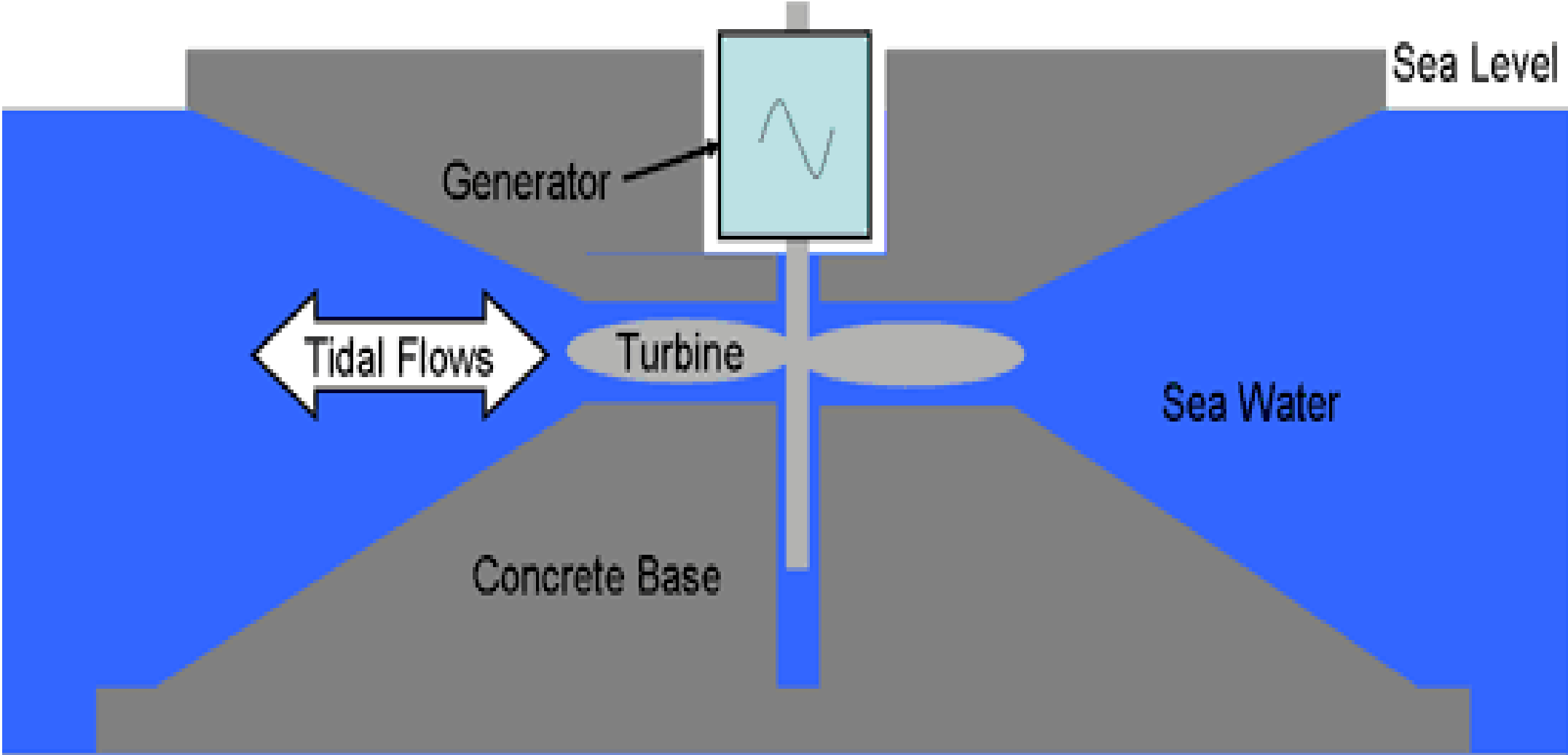
- • Tidal barrages
- • Tidal stream generator



➤ Tidal barrages

Tidal barrages make use of the potential energy in the difference in height (or head) between high and low tides.

Electric Power from Tidal Flows



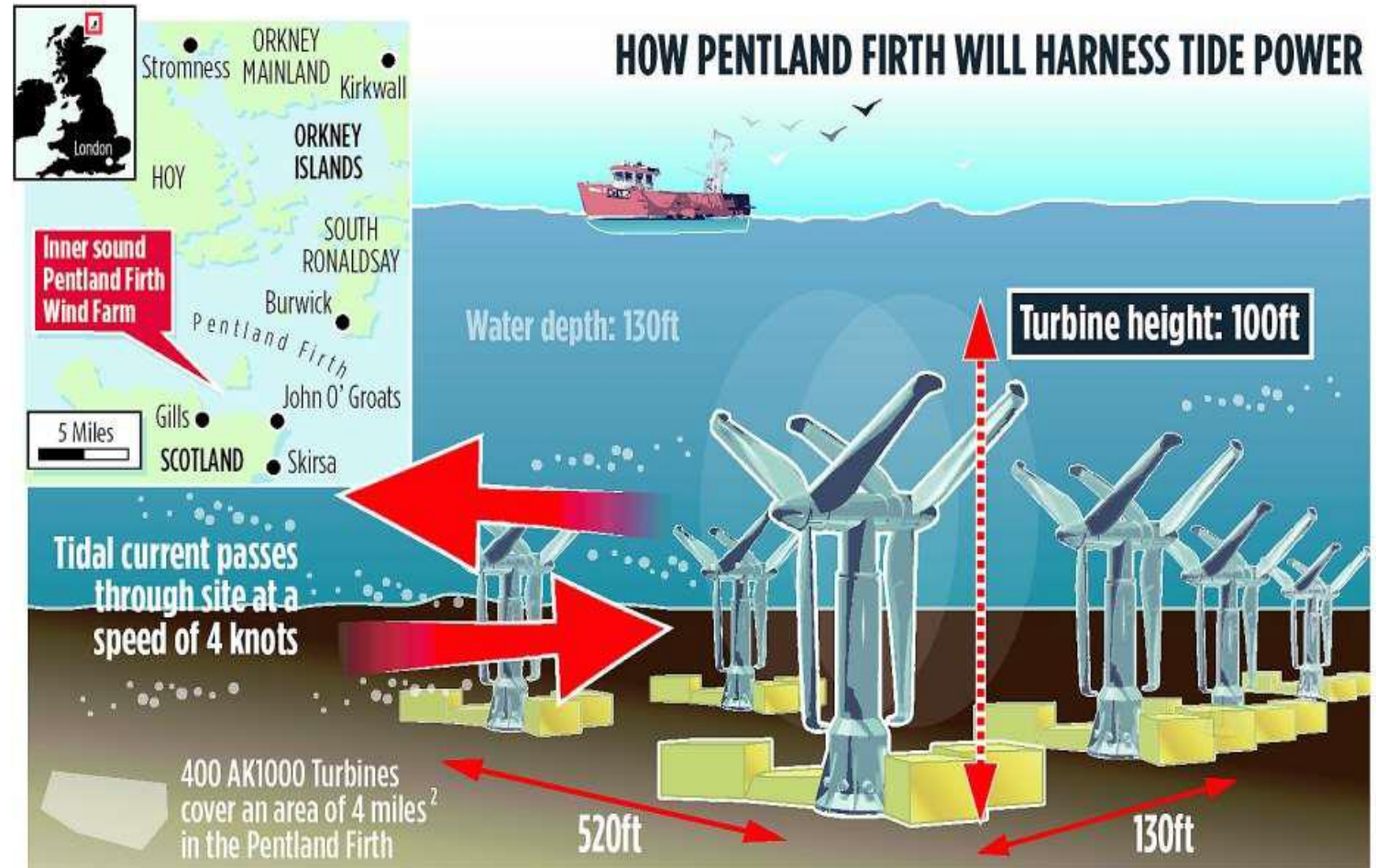
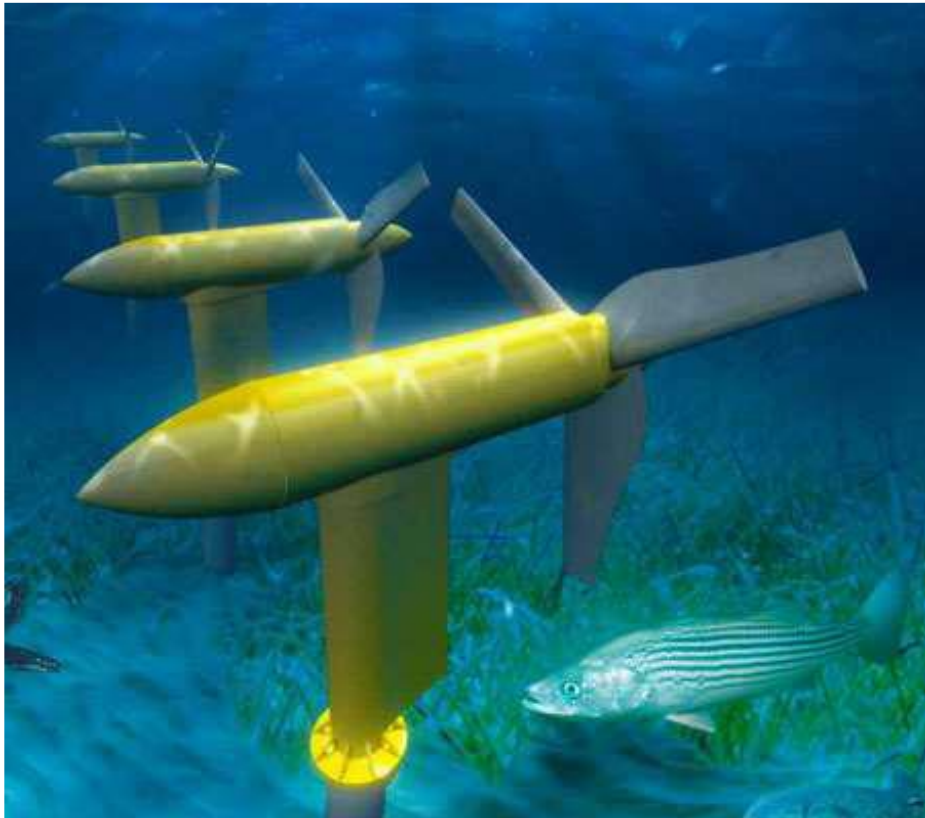
La Rance Barrage

The largest tidal power station in the World Generated by its 24 turbines with a peak rating of 240 Megawatts.
Power 240,000 homes.



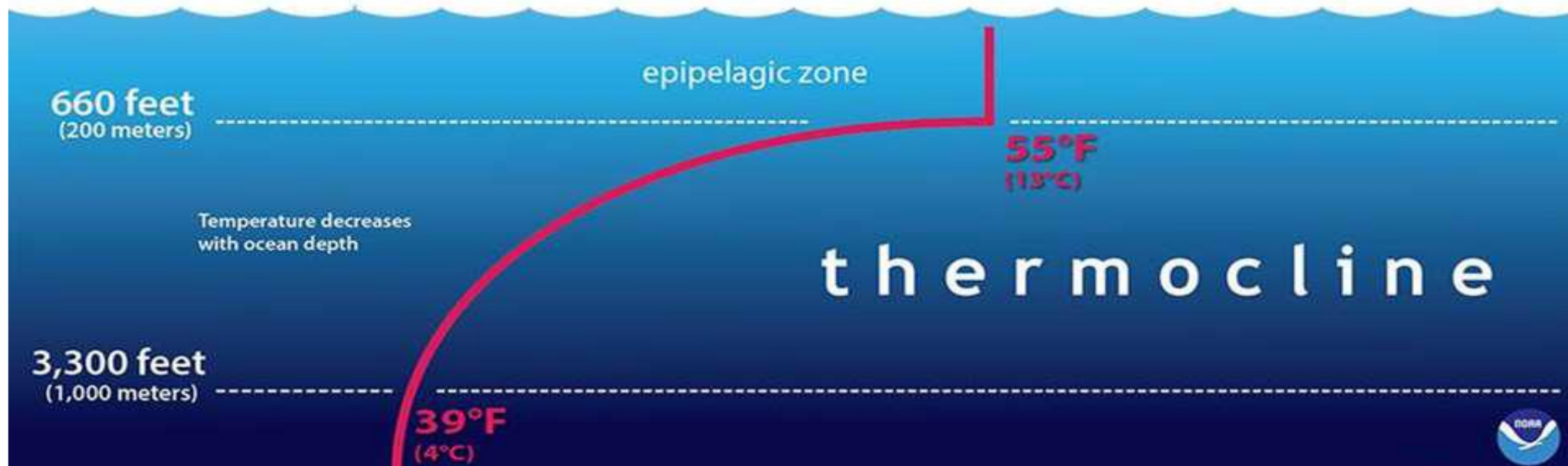
➤ Tidal stream generator

A tidal stream generator, often referred to as a tidal energy converter (TEC), is a machine that extracts [energy](#) from moving masses of water, in particular [tides](#), although the term is often used in reference to machines designed to extract energy from run of river or tidal estuarine sites. Certain types of these machines function very much like underwater [wind turbines](#), and are thus often referred to as tidal turbines. They were first conceived in the 1970s during the oil crisis

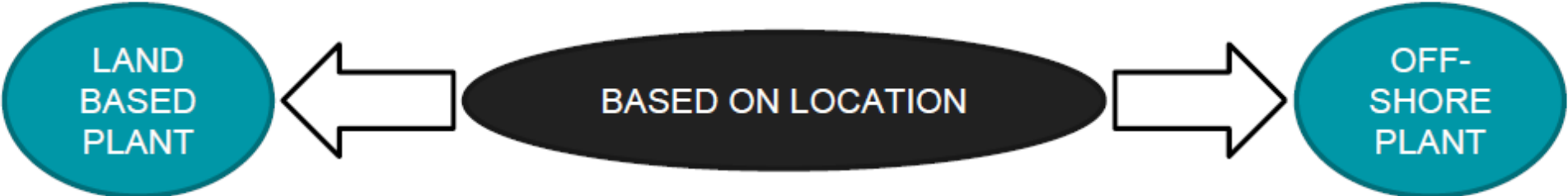
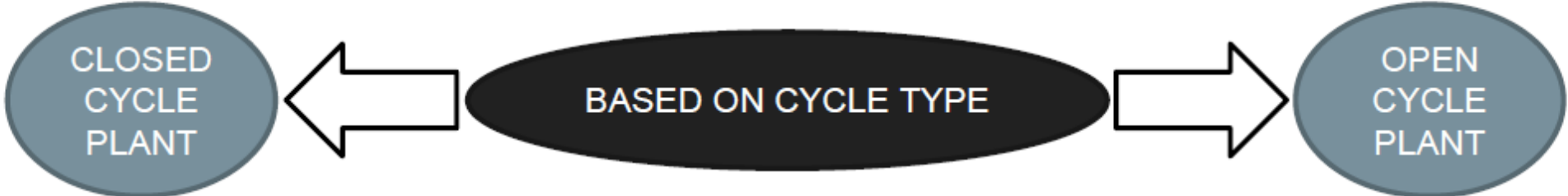


❑ The ocean's thermal energy

Uses the temperature difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce useful work, usually in the form of electricity. Power plants can be built that use this difference in temperature to make energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water.

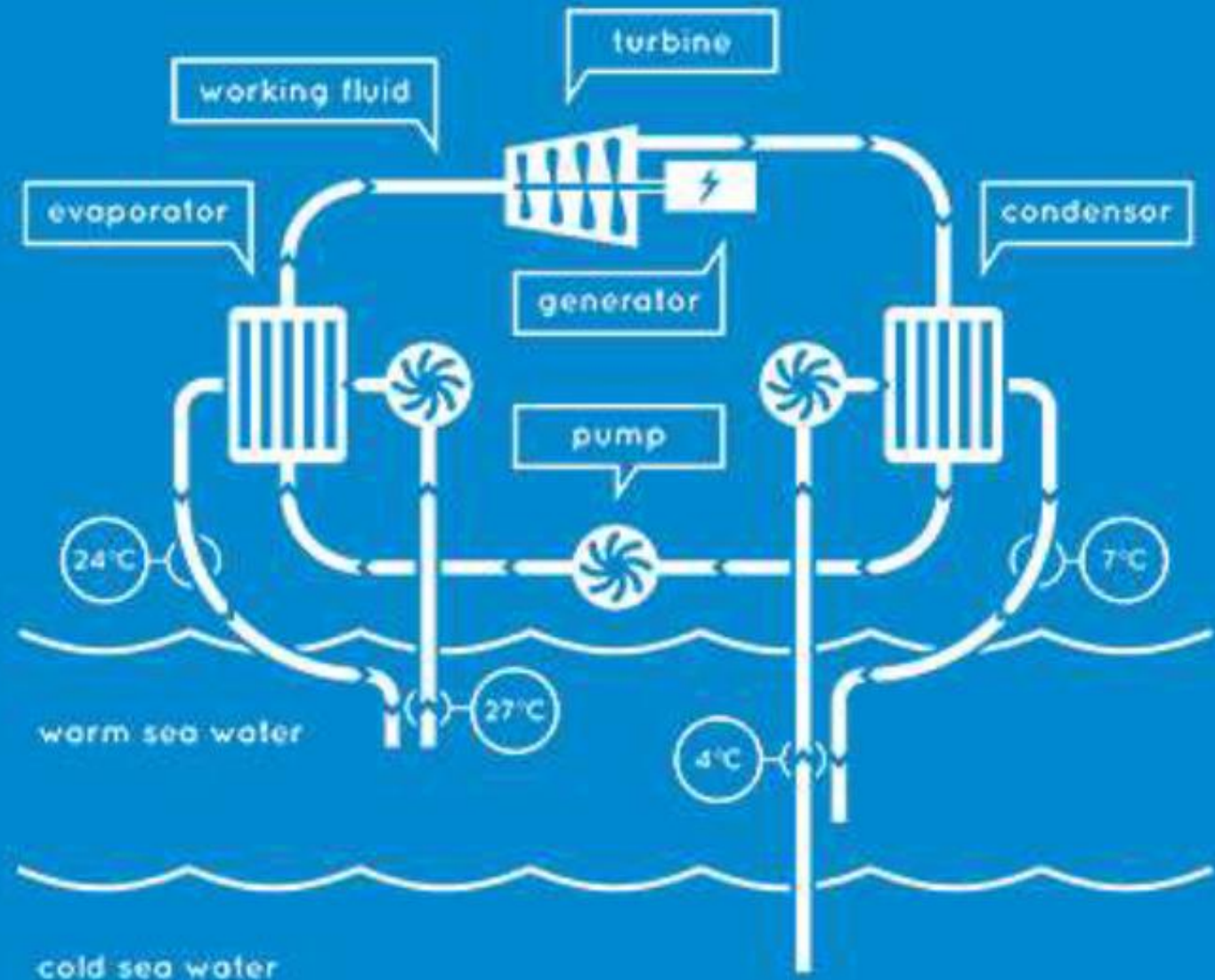


CLASSIFICATION



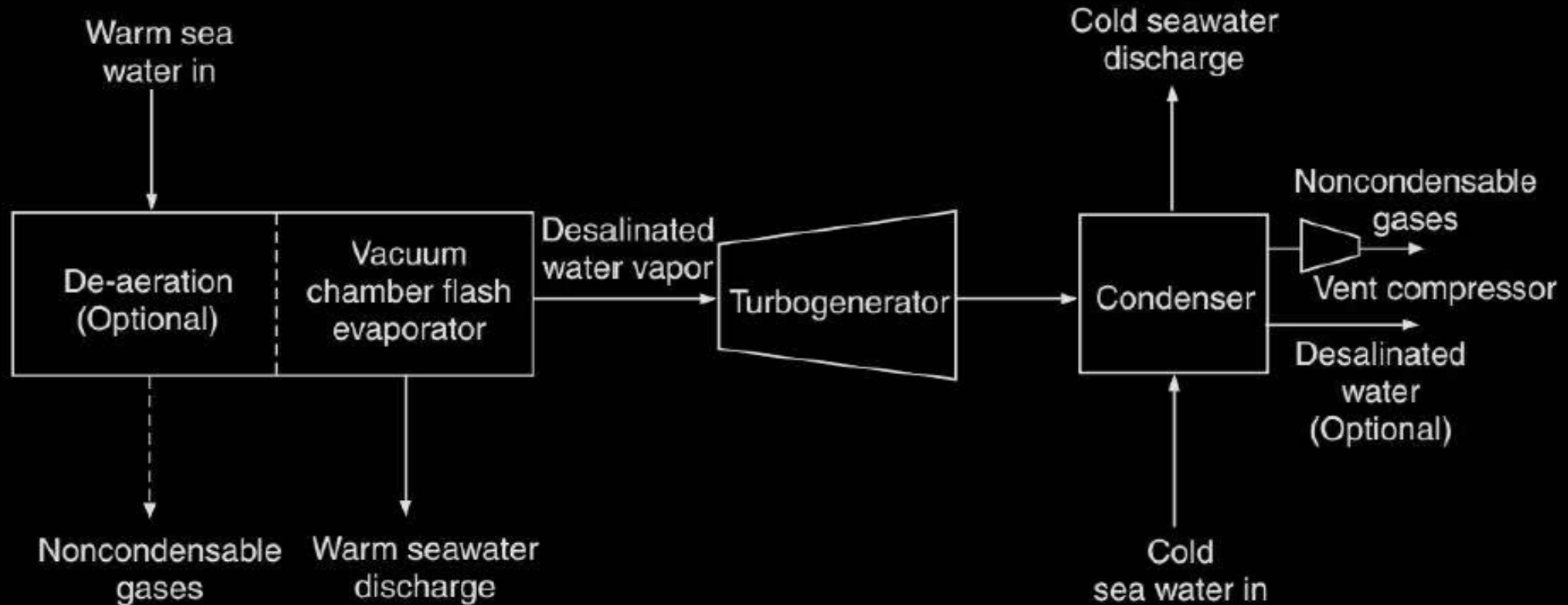
CLOSED CYCLE OTEC PLANT

- Low boiling point working fluid is used (e.g. ammonia)



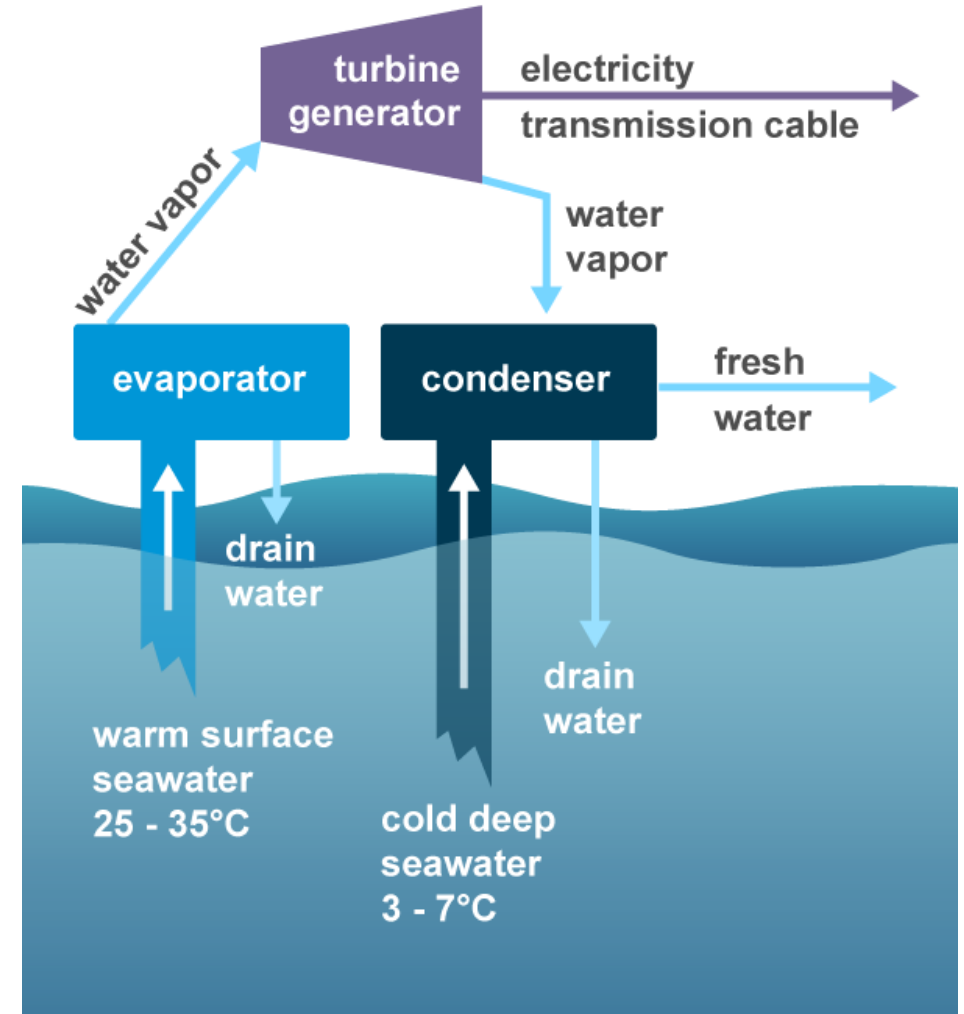
OPEN CYCLE OTEC PLANT

- Sea water is itself the working fluid
- Desalinated water is a byproduct

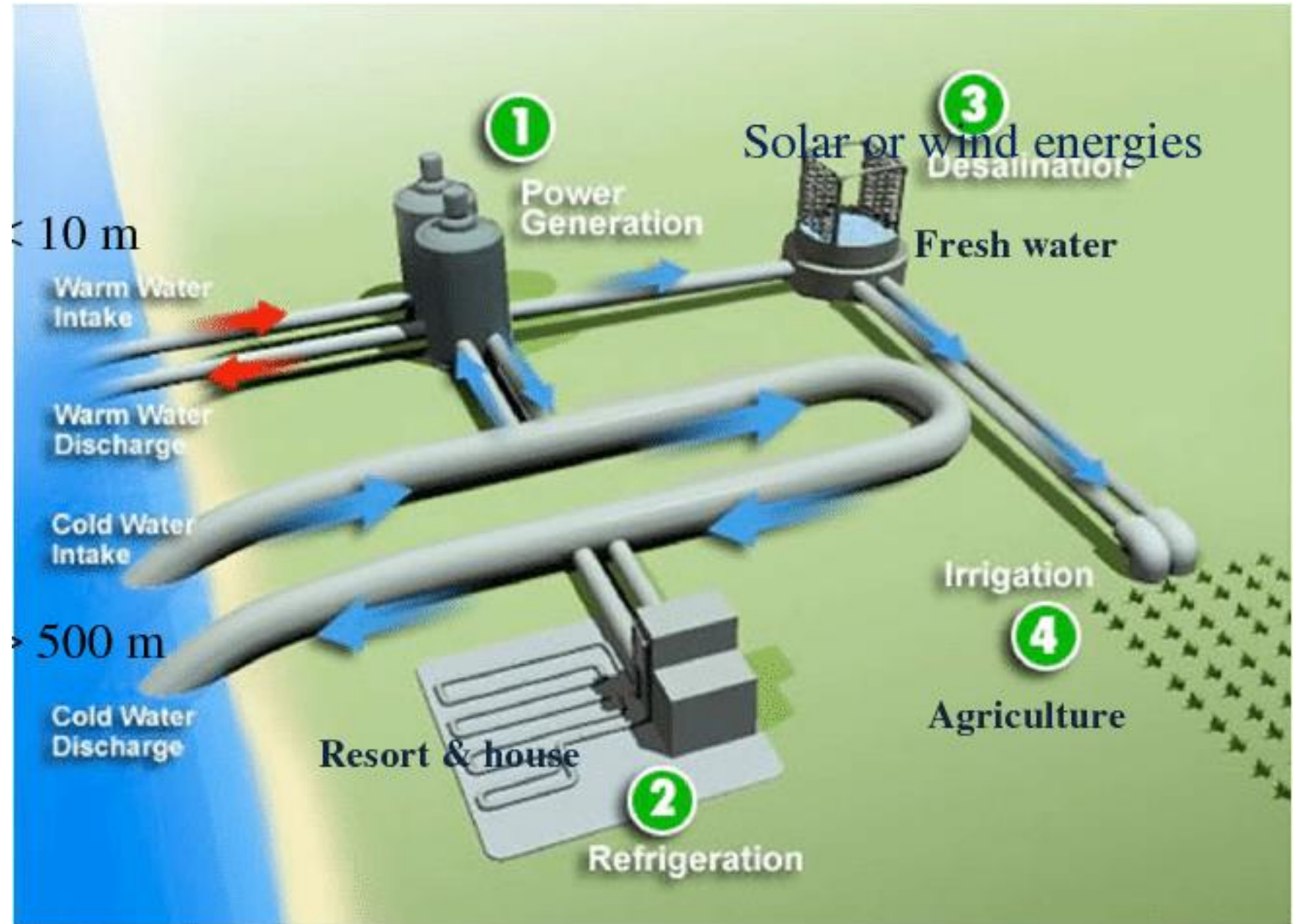


Ocean Thermal Energy Conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) is a process that can produce electricity by using the temperature difference between deep cold ocean water and warm tropical surface waters. OTEC plants pump large quantities of deep cold seawater and surface seawater to run a power cycle and produce electricity. OTEC is firm power with clean energy source, environmentally sustainable and capable of providing massive levels of energy. Energy from the sun heats the surface water of the ocean. In tropical regions, surface water can be much warmer than deep water. This temperature difference can be used to produce electricity and to desalinate ocean water. Ocean Thermal Energy Conversion (OTEC) systems use a temperature difference (of at least 20° Celsius or 36° Fahrenheit) to power a turbine to produce electricity. Warm surface water is pumped through an evaporator containing a working fluid. The vaporized fluid drives a turbine/generator. The vaporized fluid is turned back to a liquid in a condenser cooled with cold ocean water pumped from deeper in the ocean. OTEC systems using seawater as the working fluid can use the condensed water to produce desalinated water.



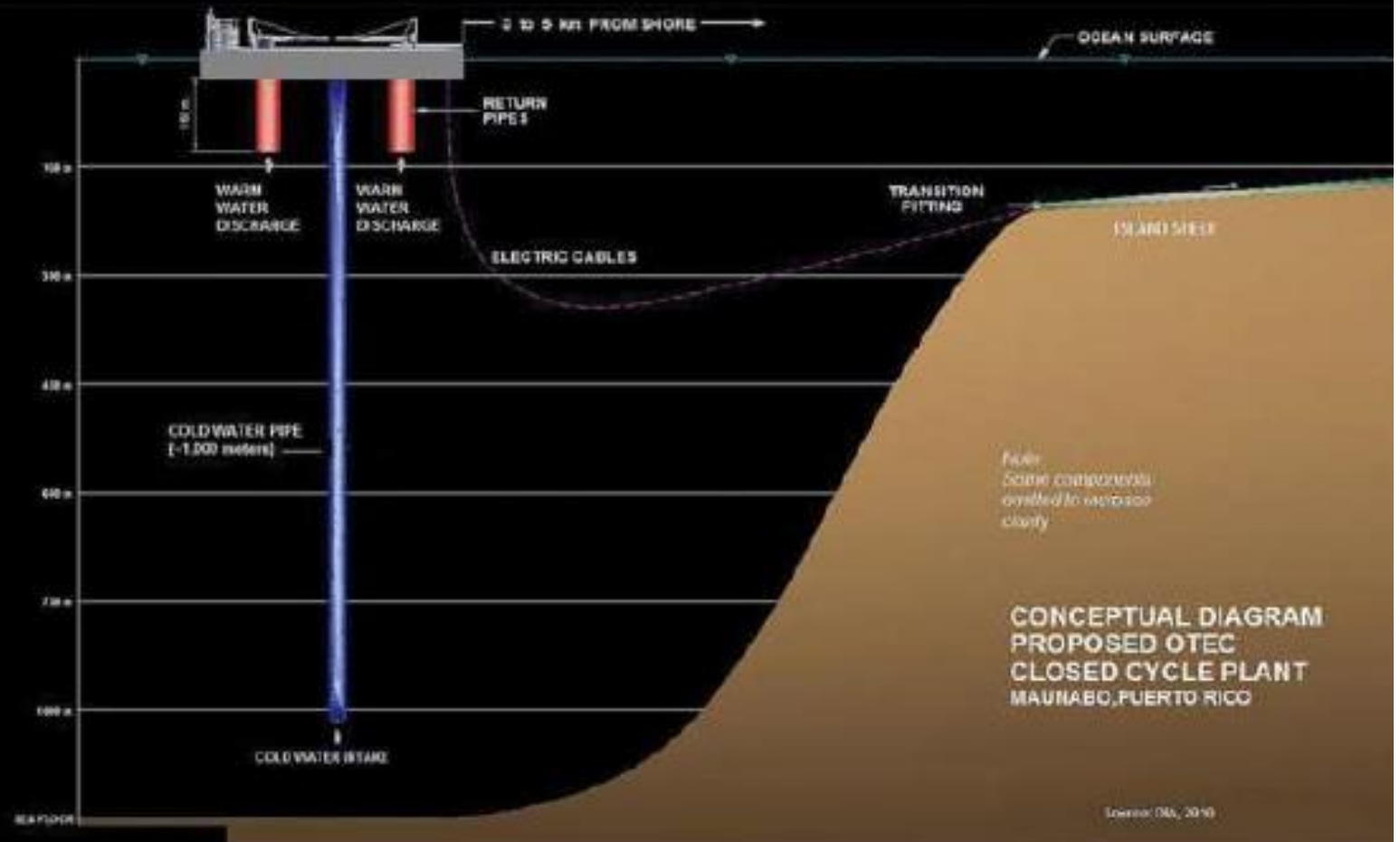
LAND BASED OTEC PLANT
Ocean Thermal Energy Conversion (OTEC)



OFFSHORE OTEC PLANT

Right: A concept of a proposed floating type plant in Puerto Rico

Below: A floating type plant off the coast at Keahole Point, Hawaii



The Solar Power Energy

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available. Solar technologies can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use. Two main commercial ways of conversion of sunlight into electricity.

- Concentrating Solar Thermal Plant (CSP)
- Photovoltaic Plants (PV)
- Solar Heating & Cooling Plants

CSP and PV both have their markets. PV is very successful in decentralized applications, whereas CSP offers advantages for central and large-scale applications. CSP power plants are the most cost-efficient way to generate and to store dispatchable CO₂-free electricity. However, there is no competition between both. Rather, they have to be seen as complementary technologies.

PLF of CSP – In the range of 20 % to 30 %

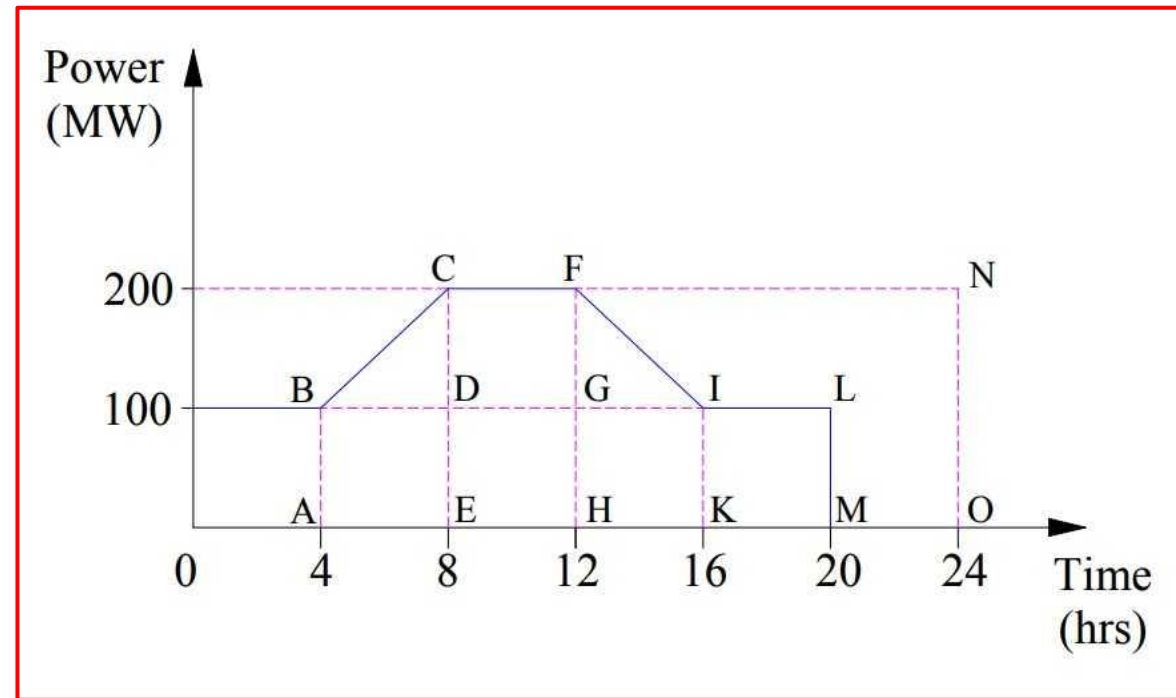
PLF of PV – In the range of 15 % to 20 %

Plant Load Factor (PLF) is the ratio of average power generated by the plant to the maximum power that could have been generated for a given time period

Calculation of Plant Load Factor:

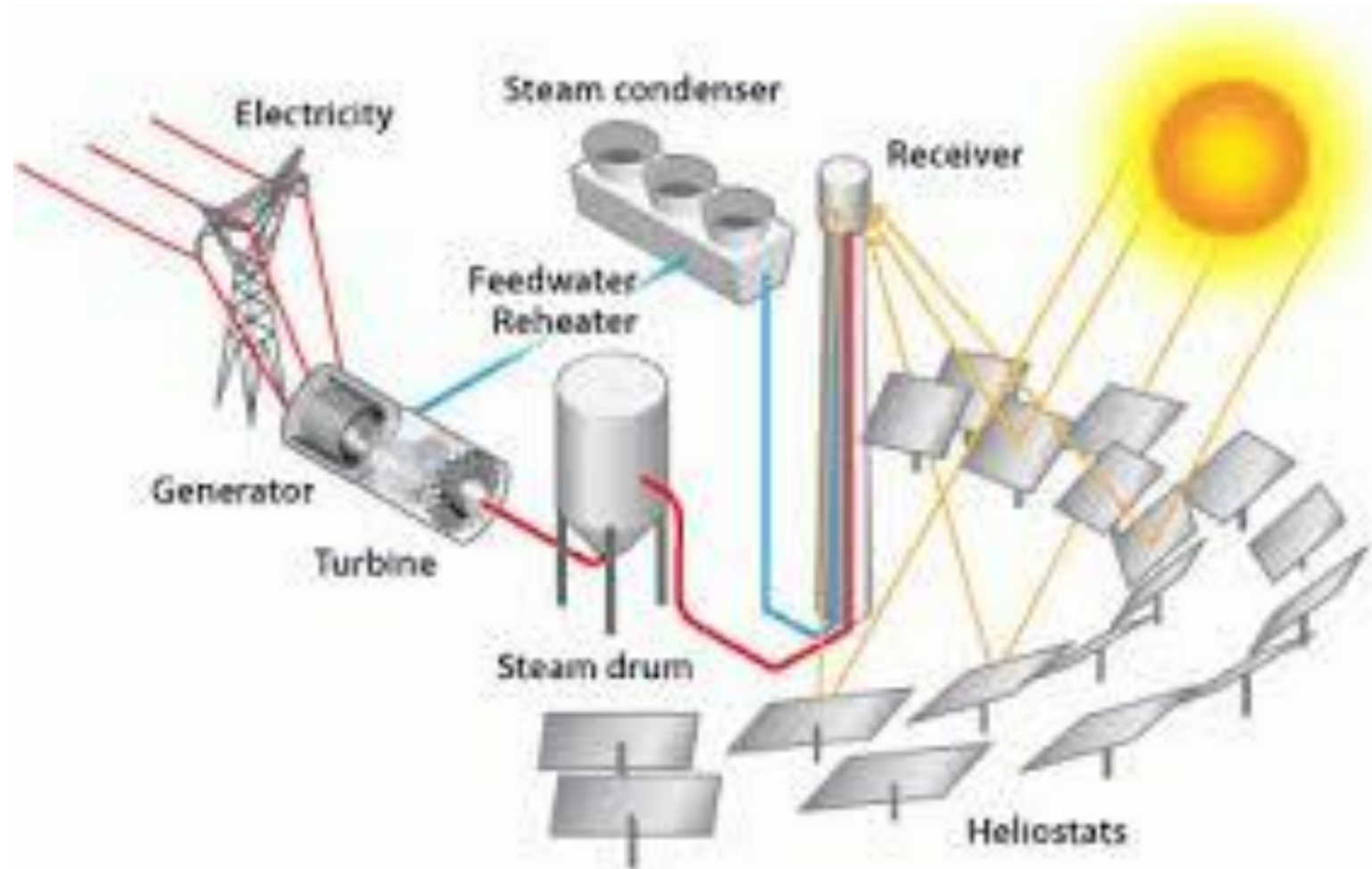
We already discussed the mathematical representation of PLF. It is calculated for a certain time period as per the definition. Therefore, it may either be calculated from Load Curve or Load Duration Curve. If we have the load curve, then Plant Load Factor can be calculated using (1). But for calculation from load duration curve, it is calculated by using energy interpretation i.e. (2). Let us consider a load curve as shown below and try to calculate the Plant Load Factor

$$\text{Plant Load Factor, PLF} = P_{\text{avg}} / P_{\text{max}}$$



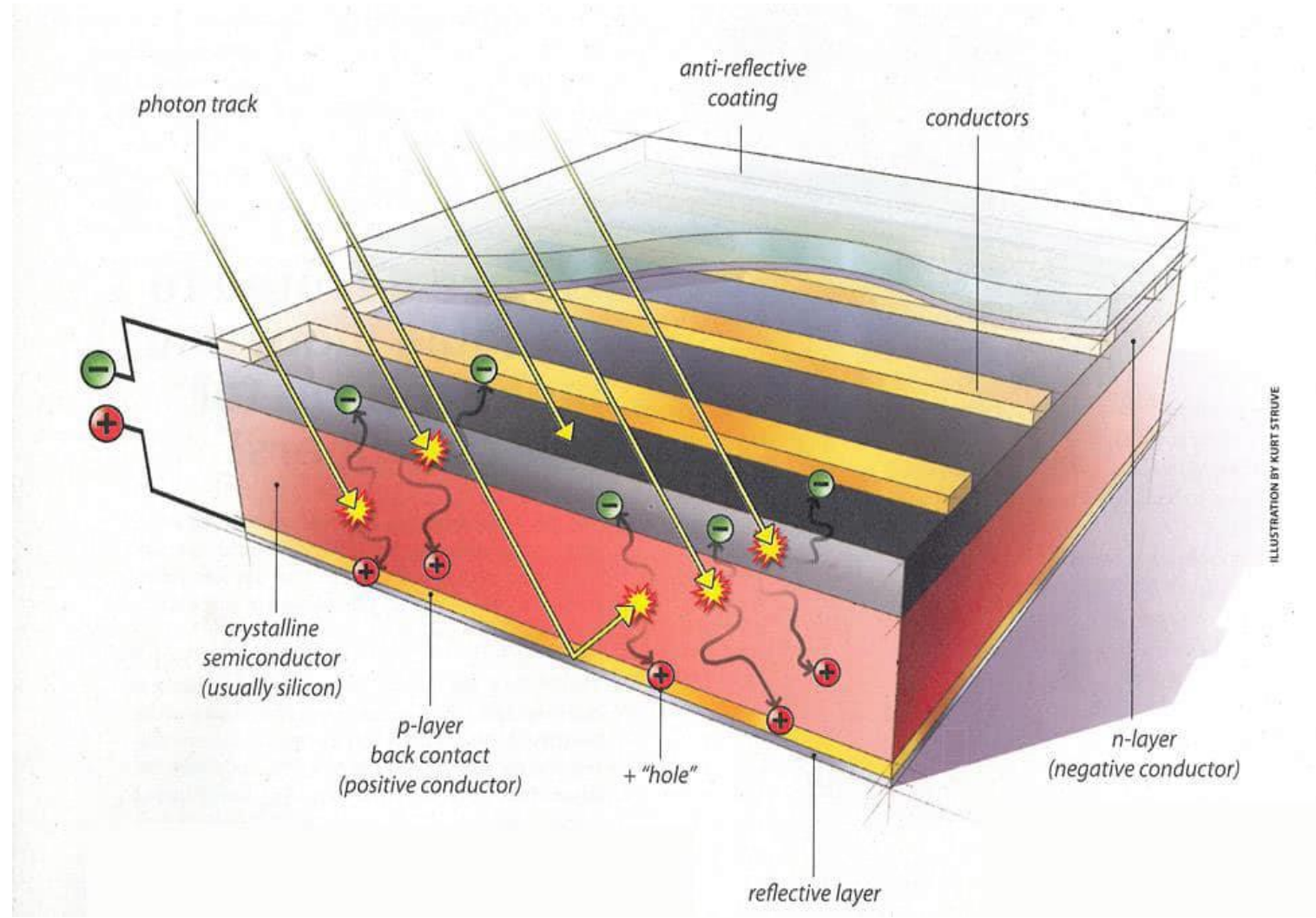
○ Concentrating Solar Thermal Plant (CSP)

Concentrating solar power (CSP) plants use mirrors to concentrate the sun's energy to drive traditional steam turbines or engines that create electricity. The thermal energy concentrated in a CSP plant can be stored and used to produce electricity when it is needed, day or night. Today, roughly 1,815 megawatts (MWac) of CSP plants are in operation in the United States

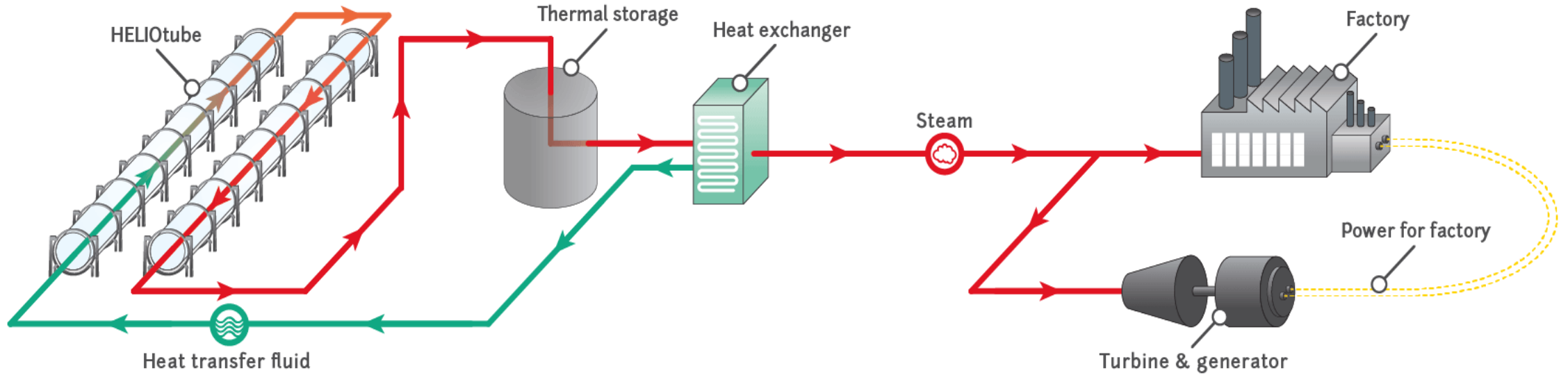


○ Photovoltaic Plants (PV)

Photovoltaic (PPV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid



Solar thermal energy to replace fossil fuels in factories



A Heat Transfer Fluid (HTF) is heated in the solar field and stored in energy storage tanks before it is diverted to a heat exchanger (HE) where it creates steam. The HTF is running through a closed loop where it flows back to the solar field where it gets heated again. The technology can also be used as a pre-heater.

Factories can benefit from Solar Industrial Process Heat (SHIP) (and also from electricity generated by steam turbines). SHIP could serve applications in the low and medium temperature range between 90° and 350°C where 59 % of the industrial heat demand (783TWh) is set.

Four industrial segments are most suitable for SHIP applications: Food and Beverage, Pulp and Paper, Chemicals, Textile & Leather.

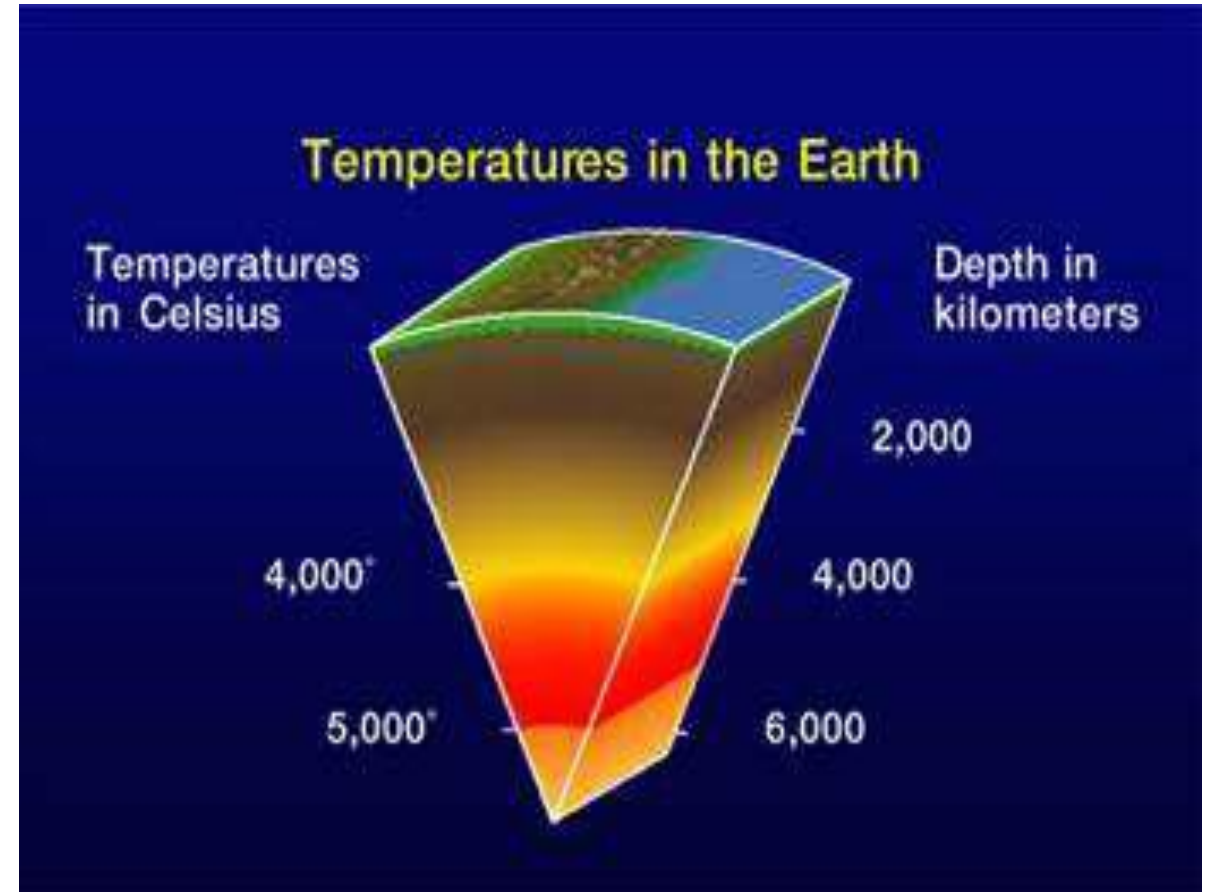
Geothermal Energy

is heat derived within the sub-surface of the earth. Water and/or steam carry the **geothermal energy** to the Earth's surface. Depending on its characteristics, **geothermal energy** can be used for heating and cooling purposes or be harnessed to generate clean electricity.

Geothermal Reservoirs

Reservoirs can be suspected in the areas where we find:

- Geyser: is a vent in Earth's surface that periodically ejects a column of hot water and steam.
- Boiling mud pot: This viscous clay-water mixture creates a marshy or muddy area, with the hot mud boiling and bubbling out .
- Volcano: is a vent in the crust of the earth or another planet or a moon from which usually molten or hot rock and steam issue
- Hot springs: s a spring produced by the emergence of geothermally heated groundwater that rises from the Earth's crust. While some of these springs contain water that is a safe temperature for bathing, others are so hot that immersion can result in an injury or death



The heat energy can be brought to earth surface by following ways

- Directly from hot springs/ geysers
- Geothermal heat pump

Uses are broadly classified as:

Direct use

Indirect use

Direct use of Geothermal Energy

Hot springs, used as spas.

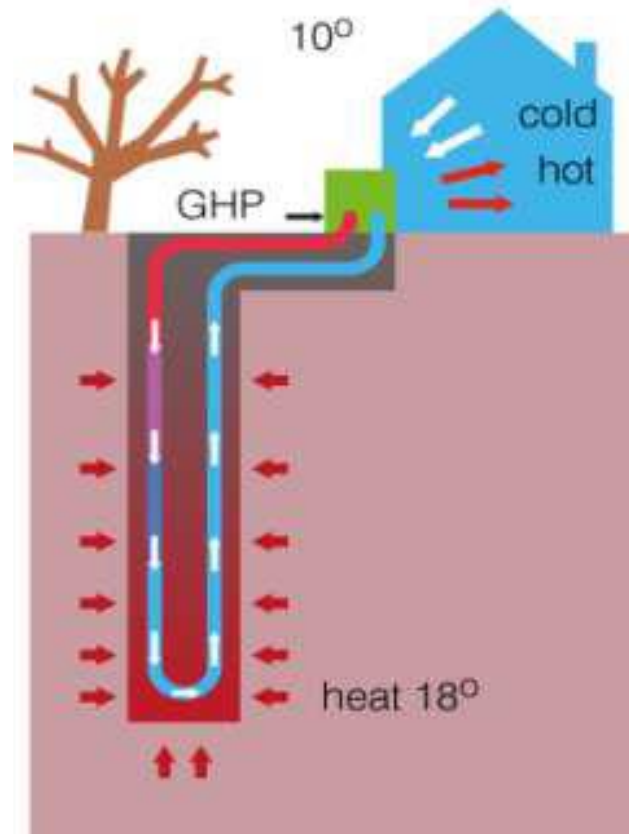
Heating water at fish farms.

Provide heat for buildings.

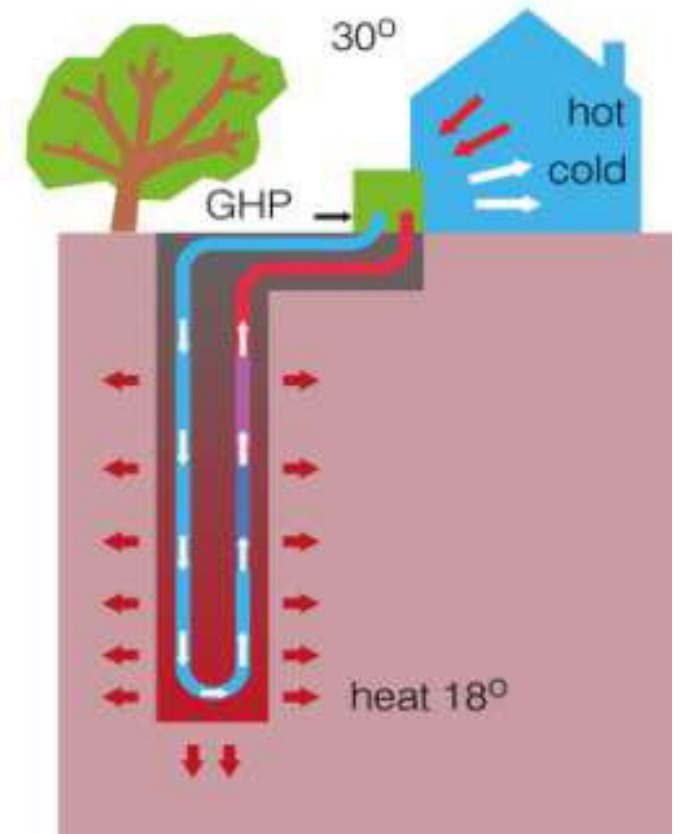
Raising plants in greenhouses, drying crops.

Provides heat to industrial processes.

Winter



Summer

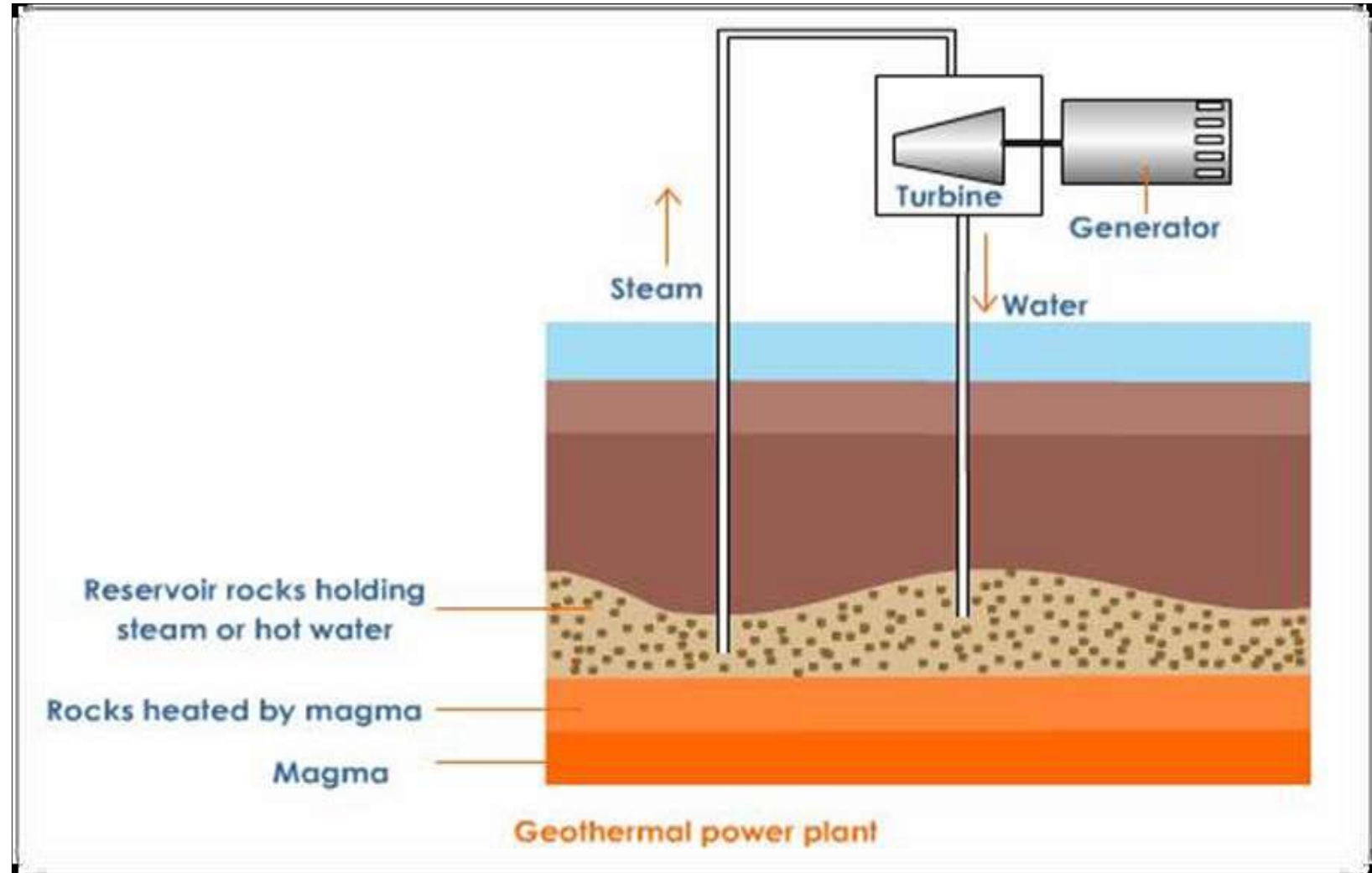


Indirect use of Geothermal Energy

➤ Electricity Generation:

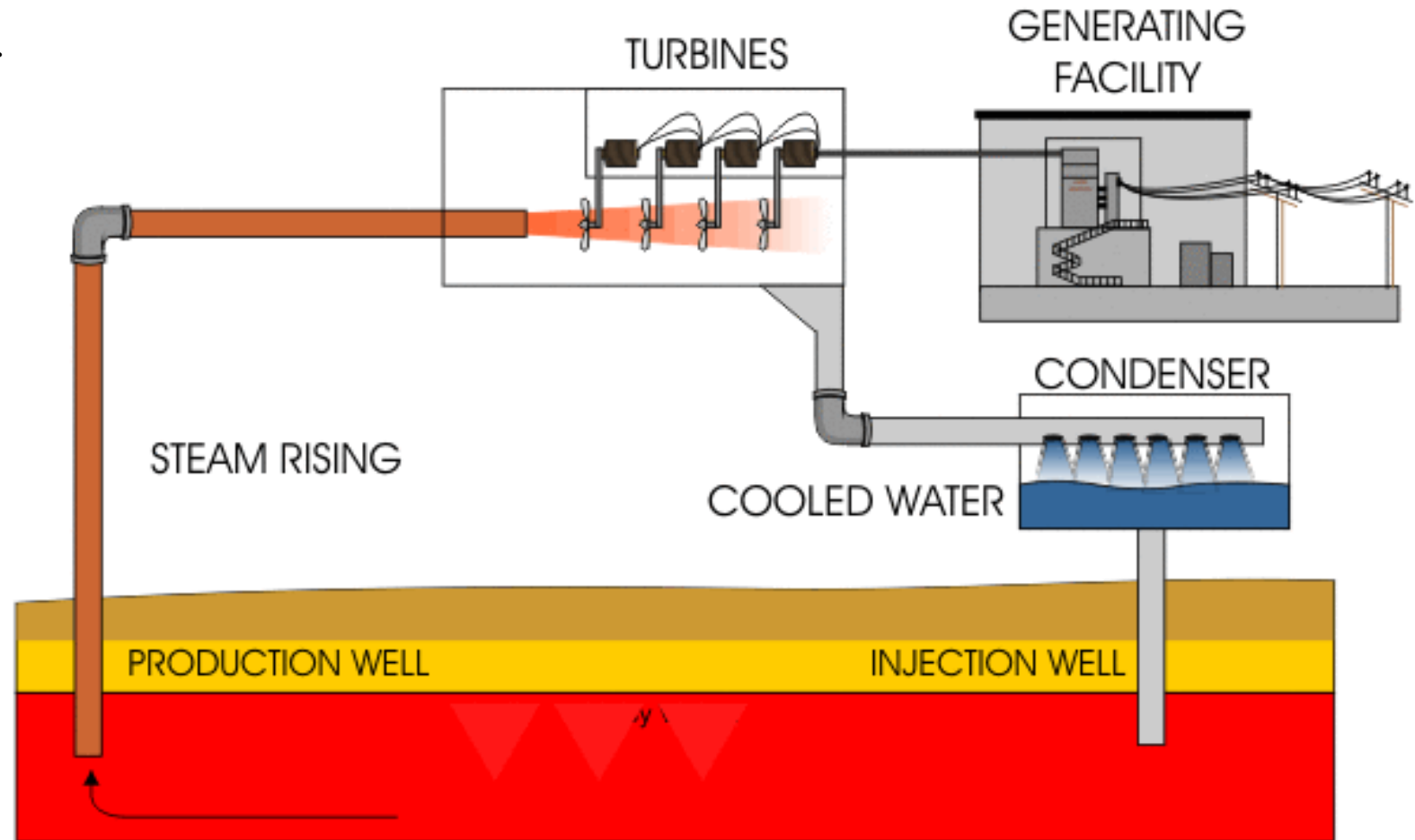
There are 3 types of power plants

- Dry steam power plant
- Flash steam power plant



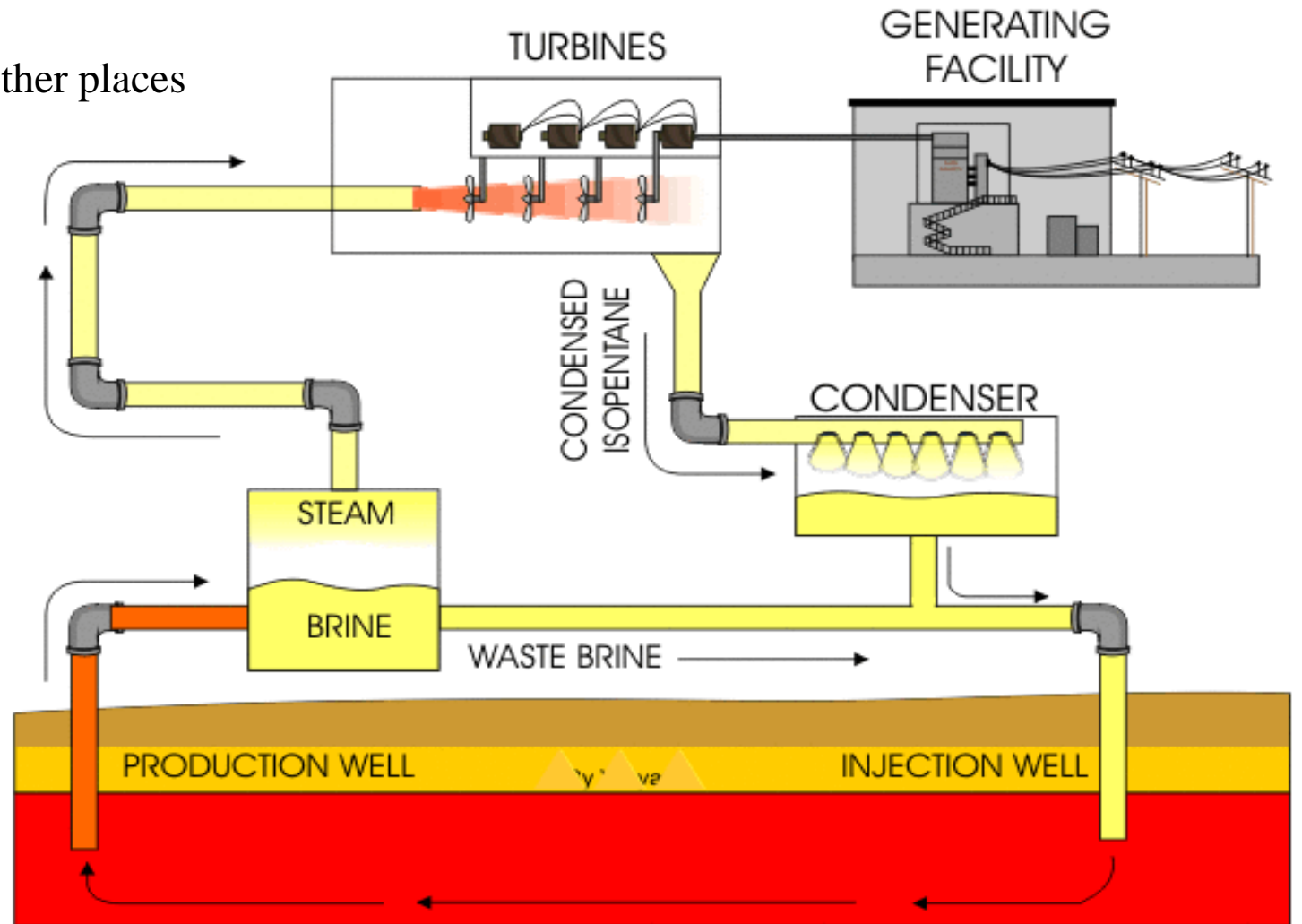
- Dry steam power plant

- The oldest type of Geothermal power plant used.
- Geothermal reservoir containing pure steam is required.
- Pure dry steam drives turbine.
- Very rare type of geothermal power plant.
- Operating at California, Italy, and Japan.



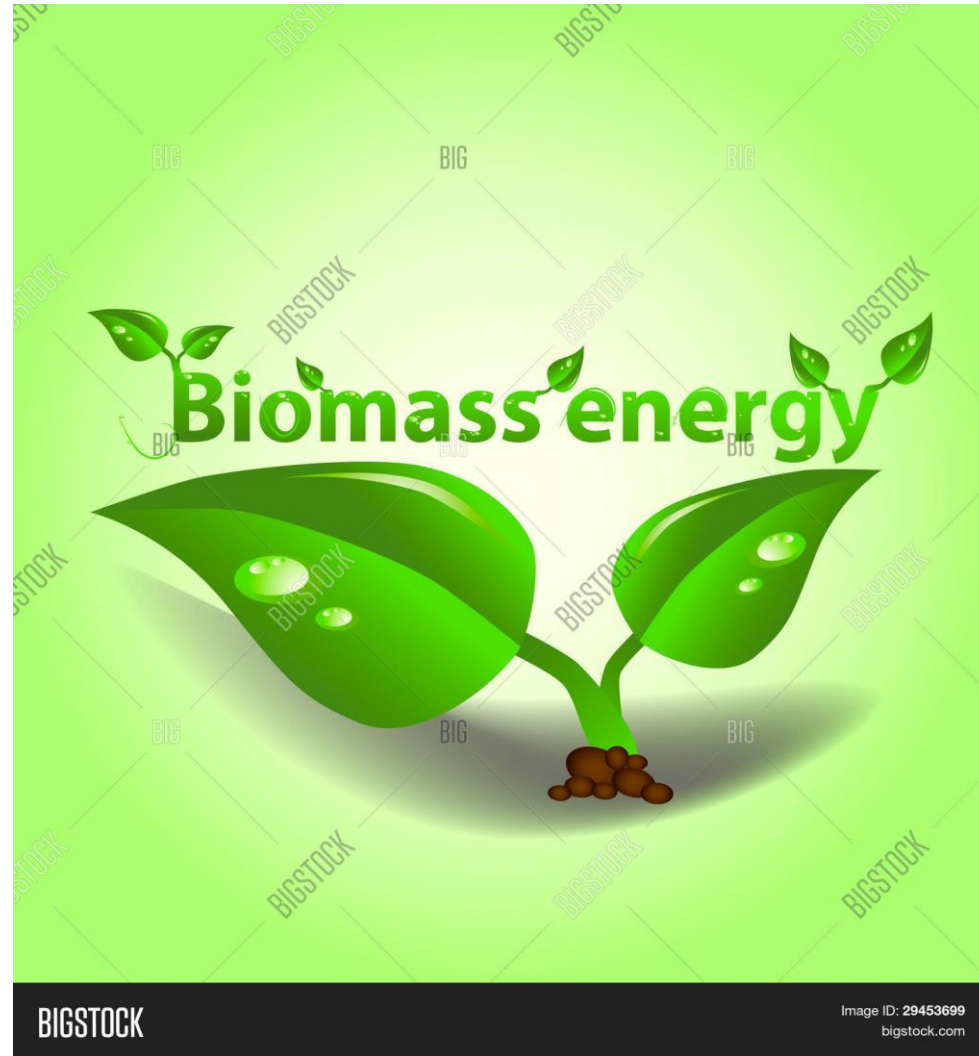
- Flash steam power plant

- Commonly used geothermal power plant.
- Geothermal reservoirs containing both hot water & steam is required.
- Pressure changing system is required.
- Operating at Hawaii, Nevada, Utah & some other places



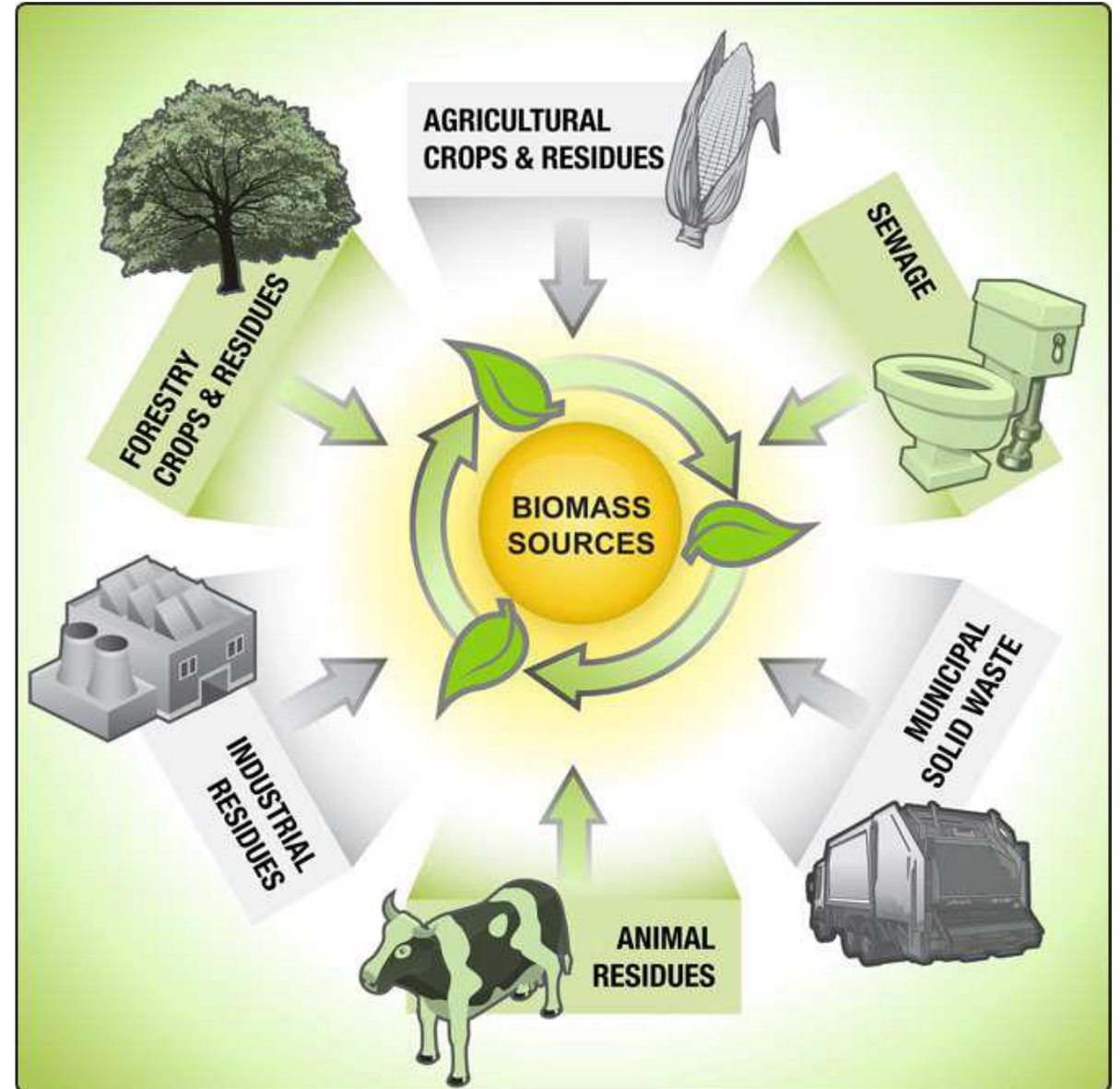
Biomass Energy

Biomass energy is a renewable and sustainable source of energy derived from organic material and can be used to generate electricity and other forms of power. Organic material containing bioenergy is known as biomass. Biomass is biological material derived from living, or recently living organisms. In the context of biomass as a resource for making energy, it most often refers to plants or plant-based materials which is not used for food or feed and are specifically called lignocellulose biomass. Biomass energy is the energy which is contained inside plants and animals. This can include organic matter of all kinds: plants, animals, or waste products from organic sources.



Biomass comes from a variety of sources which include:

- Wood from natural forests and woodlands
- Forestry plantations
- Forestry residues
- Agricultural residues such as straw, Stover, cane trash and green agricultural wastes
- Agro-industrial wastes, such as sugarcane bagasse and rice husk
- Animal wastes
- Industrial wastes, such as black liquor from paper manufacturing
- Sewage
- Municipal solid wastes (MSW)
- Food processing wastes



BIO-FUEL

Biofuel (also called agro fuel) is a bioorganic fuel. It is obtained by the fermentation of biomass. The process by which micro-organisms break down complex organic substances generally in the absence of oxygen to produce alcohol and carbon dioxide is called Fermentation

Examples of Biofuel

Ethanol:

It is produced from sugarcane. Its CALORIFIC VALUE is less than petrol. It also less heat when compared to petrol.

Methanol:

It is easily obtained from ethanol. Its CALORIFIC VALUE is too low when compared to gasoline and diesel.

Gasohol:

It is a mixture of ethanol + gasoline. It is used in cars and buses.

BIOGAS

Biogas contains 55-65% methane, 30-40% CO₂, and the remainders are impurities like H₂S, H₂, N₂ gases. Cattle dung can produce 0.037 m³ of biogas per kg of cow dung. The calorific value of gas is 21000 to 23000 kJ/kg or about 38000 kJ/m³ of gas. The material from which biogas is produced retains its value as fertilizer or as animal feed which can be used after certain processing.

Biogas can be produced by digestion pyrolysis or hydro gasification. Digestion is a biological process that occurs in absence of O₂ and in presence of anaerobic organisms at atmospheric pressure and temperatures of 35°C-70°C. The container in which the digestion takes place is called digester. When organic matter undergoes fermentation, the anaerobic bacteria extracts oxygen by decomposing the biomass at low temperatures up to 65°C in the presence of moisture. (80-95%), the gas so produced is called biogas.

