MCN-201:
SUSTAINABLE ENGINEERING

Module 4

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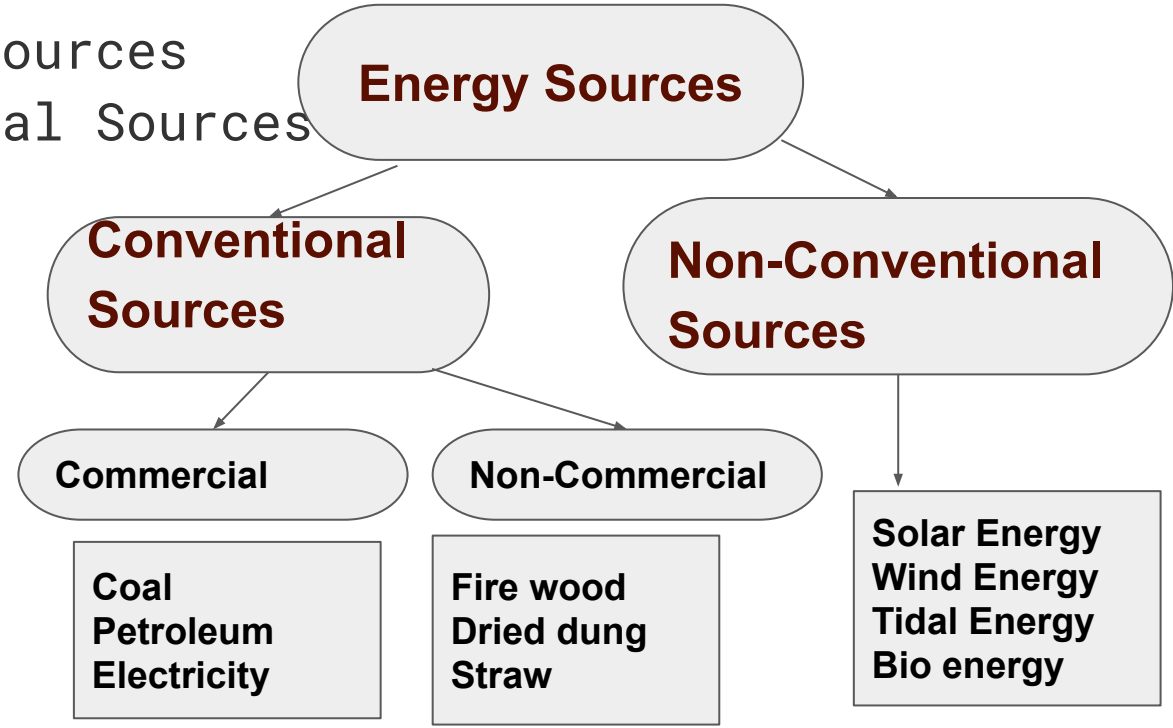
Module 4

- ★ Resources and its utilisation: Basic concepts of Conventional and non-conventional energy
- ★ Solar energy
- ★ Fuel cells
- ★ Wind energy
- ★ Small hydro plants
- ★ Bio-fuels
- ★ Energy derived from oceans and Geothermal energy.

1. Basic concepts of Conventional and non-conventional energy

The two major sources of energy is classified as:

- Conventional Sources
- Non-Conventional Sources



Conventional Sources of Energy

Conventional Sources of Energy are also known as non-renewable sources of energy and are available in limited quantity apart from hydroelectric power. Further, it is classified under commercial and non-commercial energy.

- ## Commercial Energy Sources

Coal, electricity and petroleum are known as commercial energy since the consumer needs to pay its price to buy them.

- **Coal:** Coal is the most important source of energy.The annual production went up to 343 million tons in India
- **Electricity:** Electricity is a common form of energy used for domestic and commercial purposes, and it is mainly utilized in electrical appliances like fridges, T.V, washing machines and air conditioning.

- ## Non-commercial Energy Sources

Generally, the freely available energy sources are considered non-commercial energy sources. Examples of non-commercial energy sources include straw, dried dung, firewood.

Non-Conventional Sources of Energy

Non-conventional sources are also known as renewable sources of energy. Examples of non-conventional sources of energy include solar energy, bioenergy, tidal energy and wind energy.

- **Solar Energy**

Solar Energy is produced by sunlight. The photovoltaic cells are exposed to sunlight based on the form of electricity that needs to be produced. The energy is utilized for cooking and distillation of water.

- **Wind Energy**

Wind energy is generated by harnessing the power of wind and mostly used in operating water pumps for irrigation purposes. India stands as the second-largest country in the generation of wind power.

- **Tidal Energy**

Tidal energy is generated by exploiting the tidal waves of the sea. This source is yet to be tapped due to the lack of cost-effective technology.

Conventional Sources of Energy	Non-conventional sources of energy
These sources of energy are also known as a non-renewable source of energy	These sources of energy are also known as a renewable source of energy
They find both commercial and industrial purposes	They are mainly used for household purposes
These can be considered to be one of the reasons for the cause of pollution	These are not responsible for the cause of pollution
Coal, fossil fuels are two examples	Wind, solar energy and Biomass two examples

2. Solar energy

★ Solar energy is a sustainable energy and is inherently more sustainable than fossil fuel energy sources. As a way of converting the sun's energy into electrical energy, solar panels make use of the single most sustainable resource on the planet - the light of the sun.

Solar Sustainability

★ Sustainability means "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

★ Solar energy embodies this widely accepted definition of sustainability because the sun's energy can be used indefinitely without diminishing its future availability.

★ Most experts agree that the sun is the most important source of renewable energy.

Renewable

- Solar energy is considered a renewable resource, as opposed to non-renewable energy sources, such as fossil fuels, which are finite.
- There is more than enough solar power to provide for all the energy needs of the planet, even if the Earth's population continues to grow and consume more energy, making it an important component of effort to combat climate change.

Non-Polluting

- Fossil fuels cause pollution as they are consumed, while solar energy does not, which is another way that it embodies the principles of sustainability.
- Solar panels sit idly on rooftops or in large solar arrays, creating no waste products, noise or any other outputs - just clean electrical energy.

Disadvantages of Solar

High Costs

A major reason why solar energy has not become more widespread is that it is not yet economically sustainable.

Non-Renewable Materials

★ While the sun is in an inherently sustainable energy source, some of the materials needed to make solar panels are not sustainable.

★ Solar panels are built with rare minerals, such as selenium, that will eventually be exhausted if solar panel manufacturers continue to extract them at an accelerating pace.

Applications of solar technologies include:-

Solar water heating:

★ Heat from the sun is used to heat water in glass panels on our roof.
★ Water is pumped through pipes in the panel.
★ Using the heat from the sun, water pipes get hot and heat the water without using electricity.

Solar Cars:

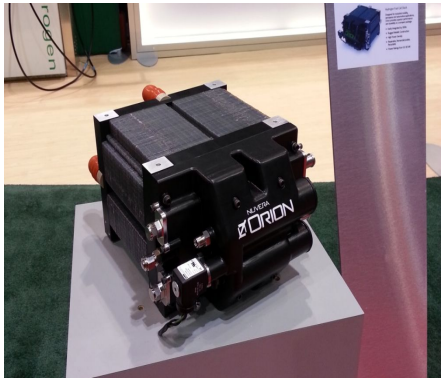
★ It is an electrical vehicle which is recharged from solar energy or sunlight.
★ Solar panels are used on this car that absorb light and then convert it into electrical energy.
★ This electrical energy is stored in batteries used within the car, so that we can drive these vehicles in night time too.

3. Fuel cells

- Fuel cells is an **electrochemical cell** that generates electrical energy from fuel via an electrochemical reaction.
- In a fuel cell, hydrogen and oxygen are combined to generate electricity, heat, and water.
- Fuel cells are used today in a range of applications, from providing power to homes and businesses, keeping critical facilities like hospitals, grocery stores, and moving a variety of vehicles including cars, buses, trucks, trains, and more.

These are 4 common categories of fuel cells:

- Proton Exchange Membrane (PEM) fuel cells
- Alkaline fuel cells
- Solid oxide fuel cells
- Phosphoric acid fuel cells

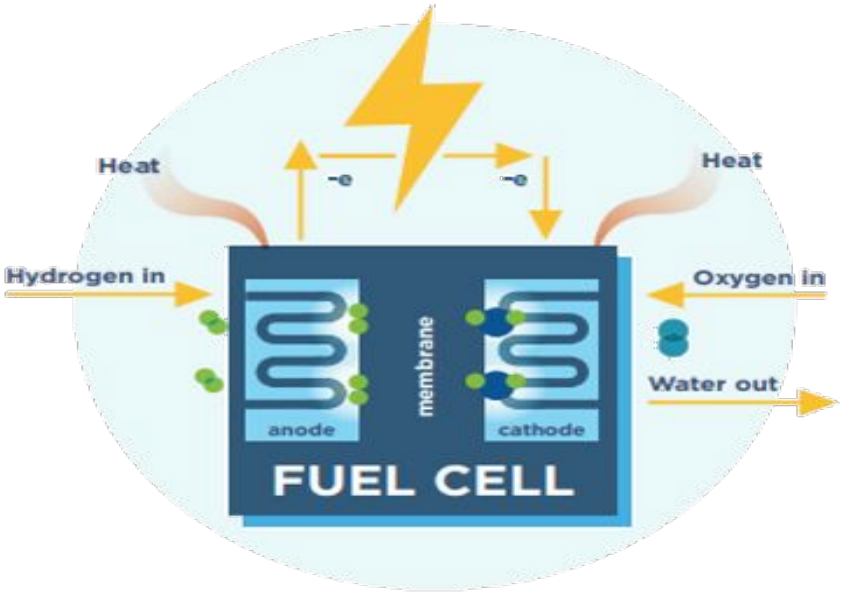


- A fuel cell is composed of an anode, cathode, and an electrolyte membrane. A typical fuel cell works by passing hydrogen through the anode of a fuel cell and oxygen through the cathode.

HOW FUEL CELLS WORK

A fuel cell is an electrochemical energy conversion device – it utilizes hydrogen and oxygen to generate electricity, heat, and water.

1. The hydrogen atoms enter at the anode.
2. The atoms are stripped of their electrons in the anode.
3. The positively charged protons pass through the membrane to the cathode and the negatively charged electrons are forced through a circuit, generating electricity.
4. After passing through the circuit, the electrons combine with the protons and oxygen from the air to generate the fuel cell's byproducts: water and heat.



Advantages

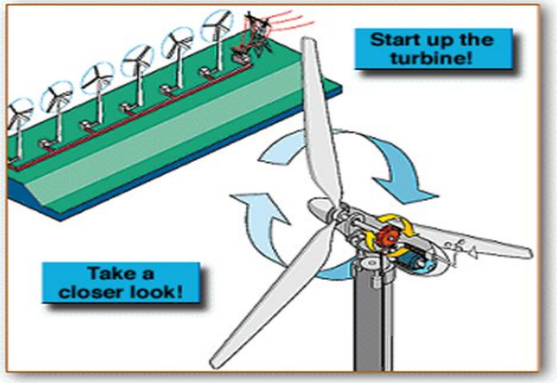
- ❏ Fuel cell systems are a clean, efficient, reliable, and quiet source of power.
- ❏ Fuel cells do not need to be periodically recharged like batteries, but instead continue to produce electricity as long as a fuel source is provided.
- ❏ Fuel cells are also scalable. This means that individual fuel cells can be joined with one another to form stacks. In turn, these stacks can be combined into larger systems.

Disadvantages

- ❏ Overall production cost is high.
- ❏ Hydrogen is very prone to catch fire, or even exploding

4. Wind energy

- Wind is a form of Solar energy
- Wind is caused by the uneven heating of the earth's surface and rotation of the Earth Wind
- Turbines convert the kinetic energy in the wind to mechanical power
- The wind turns the blades, which spin a shaft, Which connects to a generator.
- A generator can convert the mechanical power into electricity



What is Wind Energy?

- Wind energy is the converting of wind power to electrical power through the use of windmills or turbines.
- Electricity produced is sent to transformers where voltage is increased and sent to the power grid via transmission lines.

Advantages of Wind Power

- The wind blows day and night, which allows windmills to produce electricity throughout the day.
- Wind energy is a domestic, renewable source of energy that generates no pollution and has little environmental impact.
- The decreasing cost of wind power and the growing interest in renewable energy sources should ensure that wind power will become a viable energy source in worldwide.
- Produces no waste or greenhouse gases.
- Wind farms can be tourist attractions.
- A good method of supplying energy to remote areas.

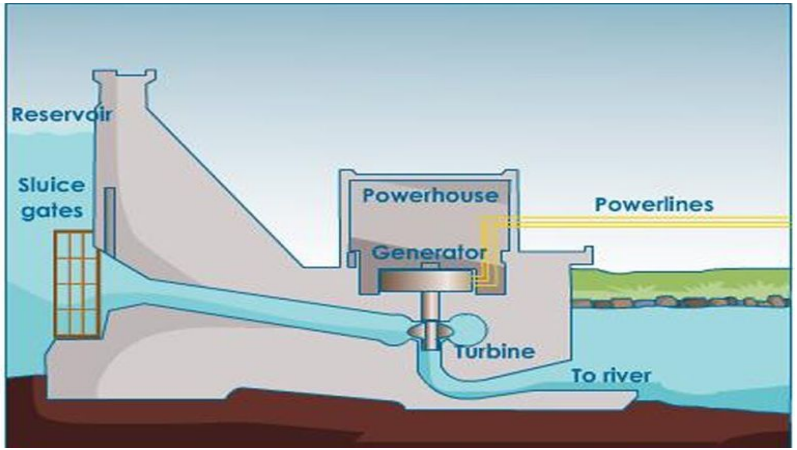
Disadvantages of Wind Power

- Suitable areas for wind farms are often near the coast, where land is expensive.
- The wind is not always predictable - some days have no wind.
- Can kill birds - migrating flocks tend to like strong winds.
- Can affect television reception if you live nearby.

5. Small hydro plants

★ **Hydroelectricity** refers to the electricity generated by hydropower; the production of electric power through the use of gravitational force of the falling or flowing water.

★ Hydropower is renewable, clean and non-polluting energy resource. Through hydropower, the energy in falling water is converted into electricity.



- Flowing water is directed to a turbine through a passage called “penstock”.
- The flowing water causes the turbine to rotate, converting the water’s kinetic energy to mechanical energy.
- The mechanical energy produced by the turbine is converted into electrical energy using a turbine generator.
- The electrical energy is then fed into gridlines to be used in homes industries etc.

Advantages of Hydropower Plants

- Water is available throughout the year
- Operational and maintenance cost is lower than other power plants
- The cost of fuel is nil
- Hydro Plants are made for multiple purposes
- The requirement of working staff is less. The cost of expenses is lower as compared to other plants.

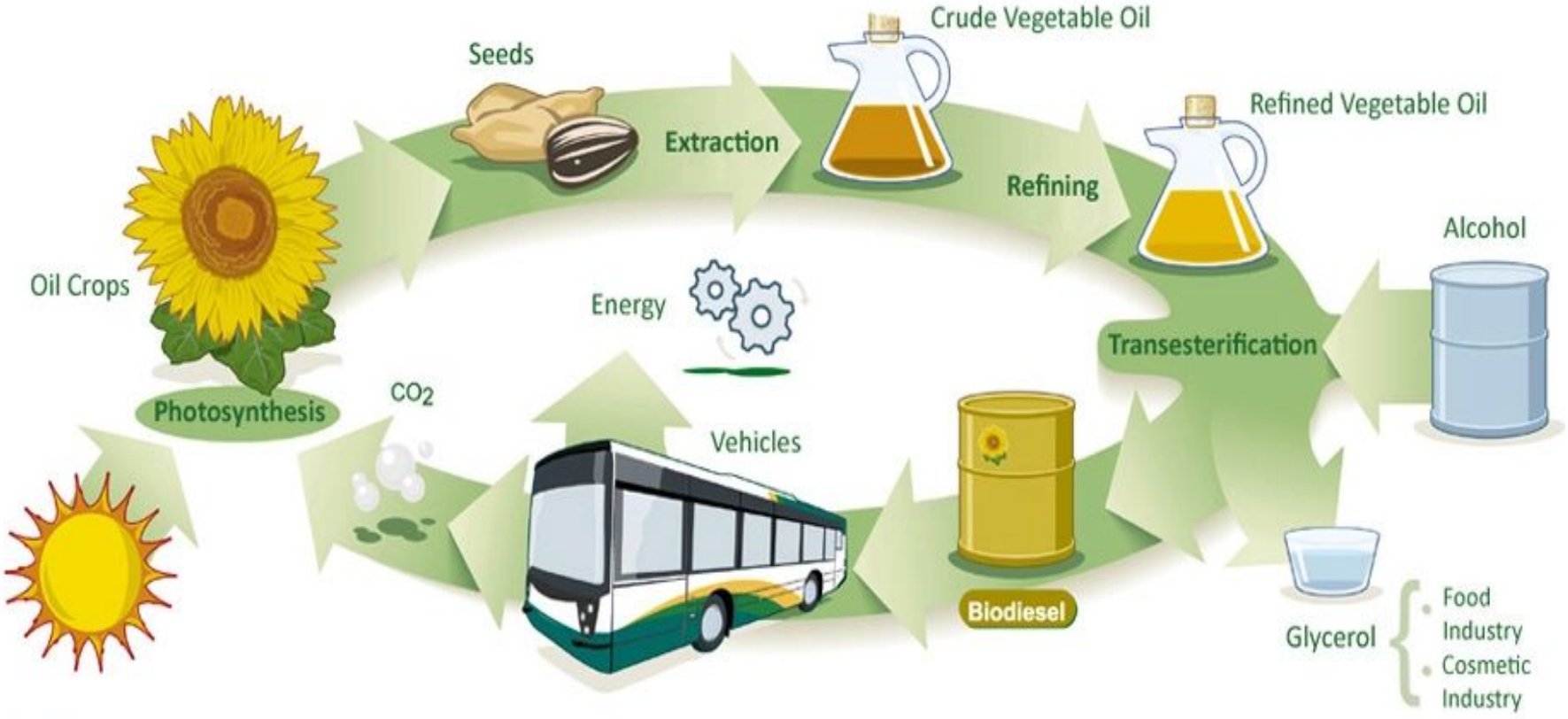
Disadvantages of Hydropower Plants

- Embankment construction cost is high
- Land space requirement for set up is large
- Water must be abundant to continue the process
- Aquatic life is effected
- Embankment areas need to be evacuated for flood plains.

6. Bio-fuels

- ★ **Biofuel**, any fuel that is derived from **biomass**—that is, plant or algae material or animal waste.
- ★ Since such feedstock material can be refill readily, biofuel is considered to be a source of renewable energy

The Biodiesel Cycle



Types of Biofuels

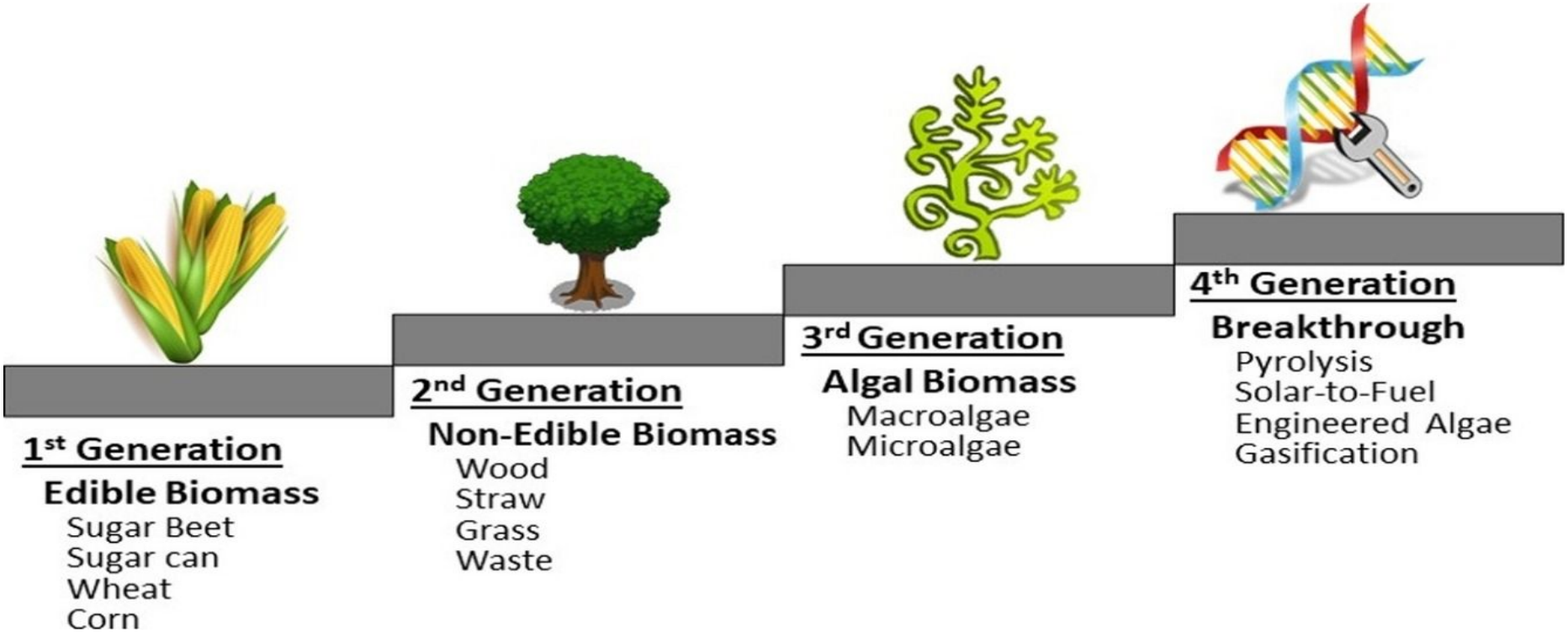
two categories: gaseous biofuel and liquid biofuel.

- ***Gaseous Biofuel:*** two types - Biogas and syngas are
- ***Biogas and Biomethane :*** Biogas is methane generated in the process of anaerobic digestion of organic matter by anaerobes.
- ***Syngas:*** Syngas is a mix of carbon monoxide, hydrogen, and other hydrocarbons, which is produced by partial combustion of biomass.

- ***Liquid Biofuel:*** ***two types*** **-** bioethanol and biodiesel.
- ***Bioethanol:*** Bioethanol is a type of alcohol produced by fermentation, often from carbohydrates made in sugar or starchy crops like corn, sugarcane, or sweet sorghum.
- ***Biodiesel :***Biodiesel, as the most common biofuel in Europe, is generated from oils or fats using transesterification.

Biofuel Generations

There are four generations of biofuels based on how they are made.



Biofuels Advantages

- ***Efficiency***

Biofuel is produced from renewable resources and relatively less-flammable than fossil diesel.

- ***Cost***

As of now, the cost of biofuels in the market is the same as gasoline.As the demand for biofuels increases, it is also possible that they will become cheaper in the future.

- ***Durability***

Biofuels are compatible with current engine designs and work very well in most conditions.

- ***Easy Access to Resources***

Biofuels are made from various sources, including manure, crop waste, algae, other byproducts, and plants grown specifically for fuel.

- ***Reduction in Greenhouse Gas Emissions***

Studies show that biofuels decrease greenhouse gases by up to 65 percent.

Biofuels Disadvantages

- ***Food Shortage***

Biofuels are obtained from crops and plants that contain large amounts of sugar. However, most of these crops are also accepted as food products.

- ***Weather Limitations***

Biofuels are less suitable for application in low temperatures.

- ***Use of Fertilizers***

This is a problem that biofuel crops, food crops, gardens, and lawns have in common all over the world. The growth of all of these plants is better when fertilized.

7. Energy derived from oceans and Geothermal energy

- Ocean Thermal Energy, also called Ocean Thermal Energy Conversion (OTEC), is an electricity generation system
- OTEC using the temperature difference between the deep parts of the sea, which are cold and the shallow parts of the sea, which are cold, to run a heat engine and produce useful work.
- The deeper parts of the ocean are cooler because the heat of sunlight cannot penetrate very deep into the water.
- Greater the temperature difference, the greater the efficiency.

- In open cycle OTEC, the seawater plays a multiple role of a heat source, working fluid, coolant and heat sink.
- Warm surface water enters an evaporator where the water is flash evaporated to steam under particle vacuum.
- Low pressure is maintained in the evaporator by a vacuum pump.
- The low pressure so maintained removes the non-condensable gases from the evaporator.

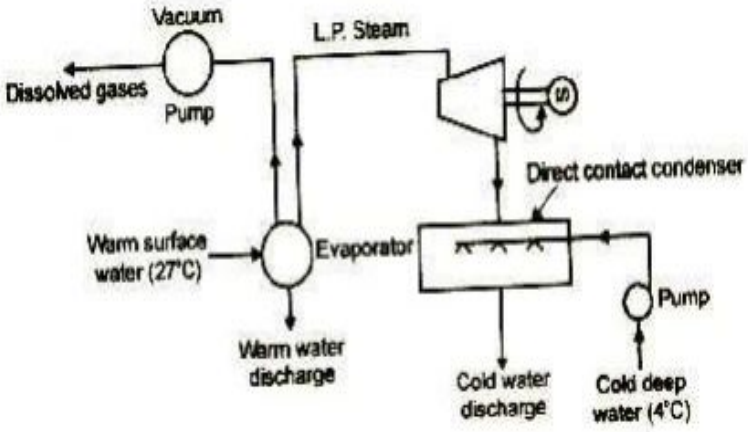


Figure: OTEC – open cycle.

- The steam and water mixture from evaporator then enters a turbine, driving it thus generating electricity.
- The exhaust from the turbine is mixed with cold water from deep ocean in a direct contact condenser and is discharged to the ocean.
- The cycle is then repeated. Since the condensate is discharged to the ocean, the cycle is called open.

- Here, a separate working fluid such as ammonia, propane or Freon is used in addition to water.
- The warm surface water is pumped to a boiler by a pump.
- This warm water gives up its heat to the secondary working fluid thereby losing its energy and is discharged back to the surface of the ocean.
- The vapours of the secondary working fluid generated in the boiler, drive a turbine generating power.
- The exhaust from the turbine is cooled in a surface condenser by using cold deep seawater, and is then circulated back to the boiler by a pump.

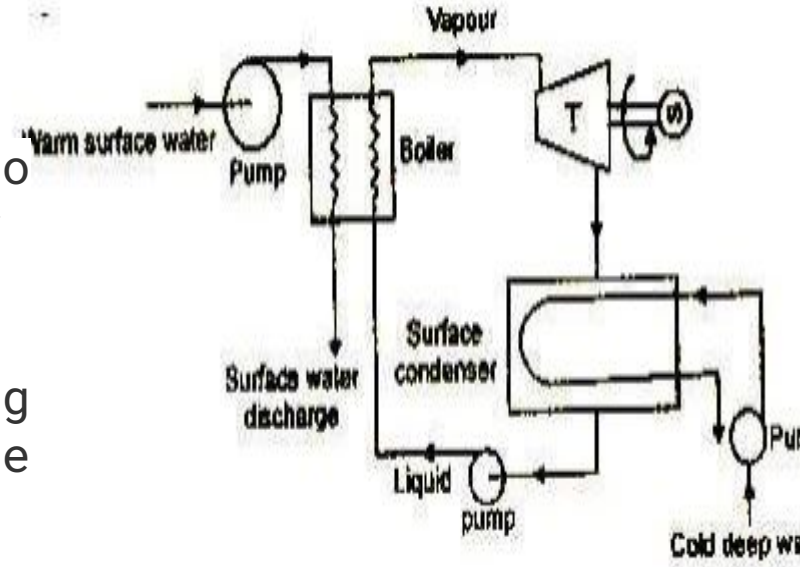


Figure: OTEC – closed cycle

Advantages of OTEC

1. Ocean is an infinite heat reservoir which receives solar incidence throughout the year.
2. Energy is freely available.

Disadvantage of OTEC

1. Efficiency is very low, about 2.5%, as compared to 30-40% efficiency for conventional power plants.

2. Capital cost is very high.