

Program : Diploma in Electrical and Electronics Engineering	
Course Code : 5033A	Course Title: Renewable Energy Power Plants
Semester : 5	Credits: 4
Course Category: Program Core	
Periods per week: 4 (L:3 T:1 P:0)	Periods per semester: 60

CO4	Explain the methods of power generation using ocean energy, Fuel cells and MHD system.		
M4.01	Illustrate the generation of electrical energy from tides and waves	3	Understanding
M4.02	Explain the principle of operation of Ocean thermal energy conversion systems	3	Understanding
M4.03	Summarize the working of fuel cells	4	Understanding
M4.04	Outline the principle of operation of MHD system.	3	Understanding
	Series Test – II	1	

Ocean energy conversion systems- introduction

Tidal Power-Basic concepts-advantages-disadvantages-tidal power plants-single basin system- double basin system

Ocean Wave energy- Basic systems - Float system(buoys) - Oscillating water column (brief idea only)

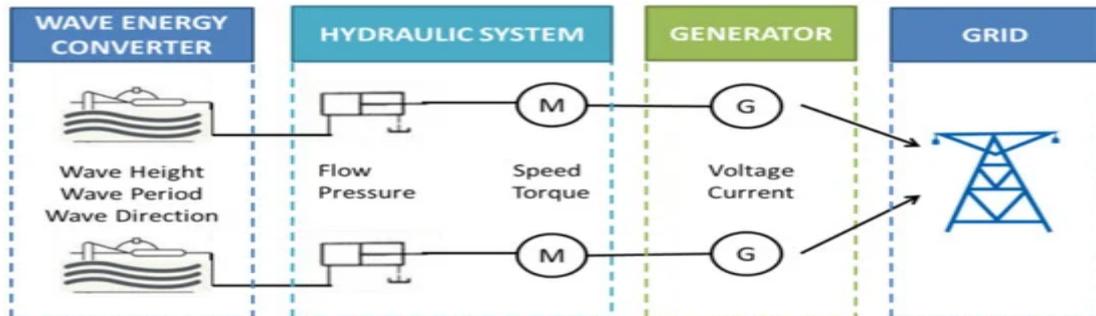
Ocean Thermal Energy Conversion Systems -principle of operation- block diagrams- Open cycle- closed cycle

Fuel cells - features - -principle of operation - hydrogen and oxygen fuel cells-advantages - disadvantages-applications- differences between battery and fuel cells.

MHD system-generation of electric power -principle of operation - block diagram

OCEAN ENERGY CONVERSION SYSTEM

Tidal power is a renewable energy source that uses the kinetic energy of tides to generate electricity. The tides are created by the gravitational pull of the sun and moon on Earth. This causes the seas to move in a cyclical pattern. Tidal power is a form of hydropower. The movement of water pushes a turbine to generate electricity.



TIDAL POWER ADVANTAGES

Renewable: Tidal power is a renewable energy source that can be predicted and has a high power output.

Environmentally friendly: Tidal power is a clean energy source that doesn't emit greenhouse gases.

Efficient at low speeds: Tidal power can generate energy even when the tide is moving slowly.

Affordable to maintain: Tidal power plants are inexpensive to run and require few staff.

TIDAL POWER DISADVANTAGES

Expensive: Tidal power plants are expensive to construct and require large initial capital investments.

Limited site availability

Only a few sites have tides that rise and fall far enough to generate sufficient energy.

Environmental impact

Tidal power systems can reshape a delicate seashore environment, which can threaten species that already live there.

Construction time

Tidal power plants take a long time to construct.

SINGLE BASIN ARRANGEMENT

In a single basin arrangement, power can be generated only by intermittently. In this arrangement only one basin interacts with the sea. Sea and basin are separated by a dam and the flow between them is through sluice ways located conveniently along the dam. The rise and fall of tidal water levels provide the potential head.

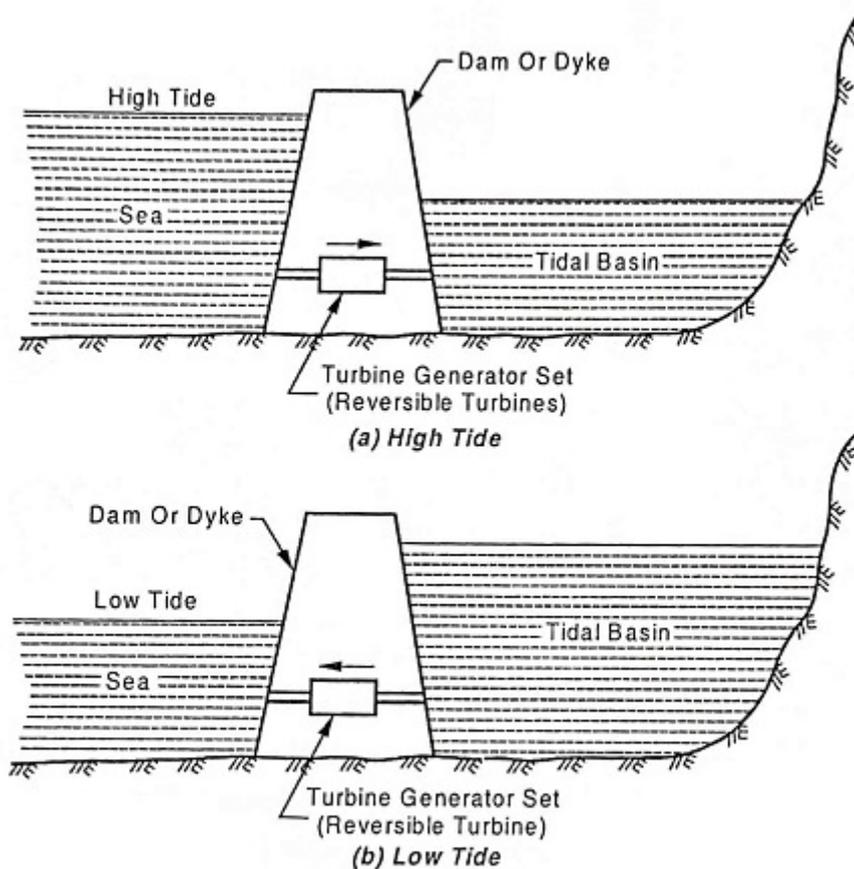


Fig.4.32. General Arrangement of Tidal Power Plant - Single Basin.

WORKING

When the incoming tide sea level and tidal-basin level are equal, the turbine way is closed. When the sea level rises, the turbine valves are opened and the sea water flows into the basin through the turbine runner generating power. This also raises the level of water in the basin. The turbine continues to generate power until the tide passes through the turbine. Bypass valve then quickly opens to let water into the basin to gain maximum level. When sea and basin water level are equal, the valves are closed as well as the turbine conduit. The basin level then stays constant while the tide continues to go out. After sufficient head has developed, the turbine valves are again opened and water now flows from basin to the sea, thereby generating power. The plant continues to generate power till the tide reaches its lowest level.

DOUBLE BASIN ARRANGEMENT

A double basin scheme can provide power continuously or on demand, which is a great advantage. The drawback is that the civil works become more extensive. In the simplest double-basin scheme there must be a dam between each basin and the sea and also a dam between the basins, containing the power house. One basin is maintained always a lower level than the other. The lower reservoir empties at low tide, the upper reservoir is replenished at high tide. If the generating capacity is to be large, the reservoirs must be large which means that long dams would be required.

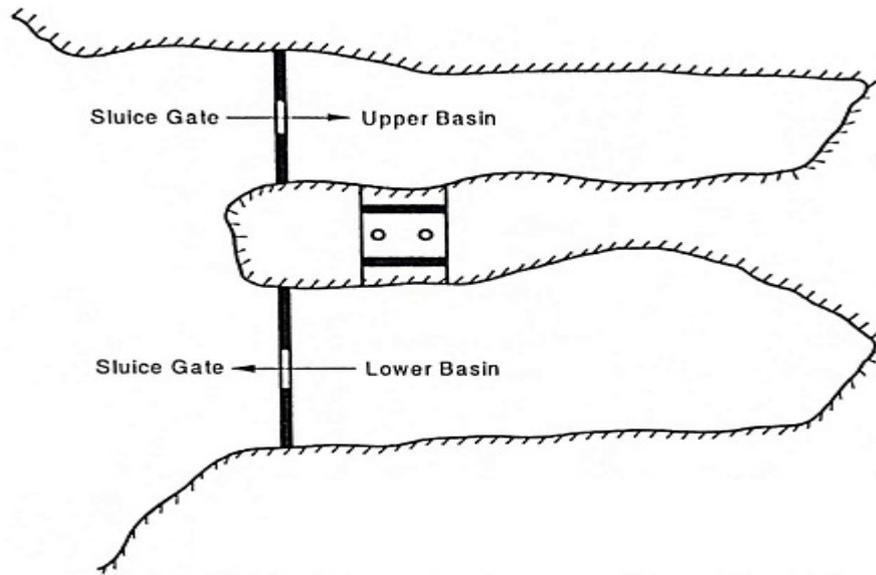
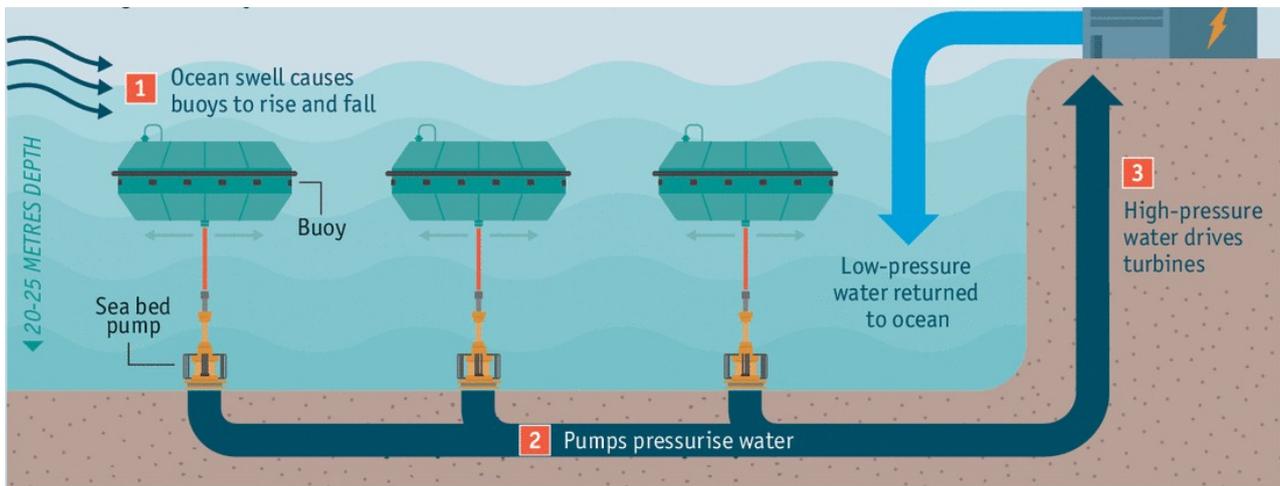


Fig:4.33. Tidal Power Plant - Double Basin Operation.

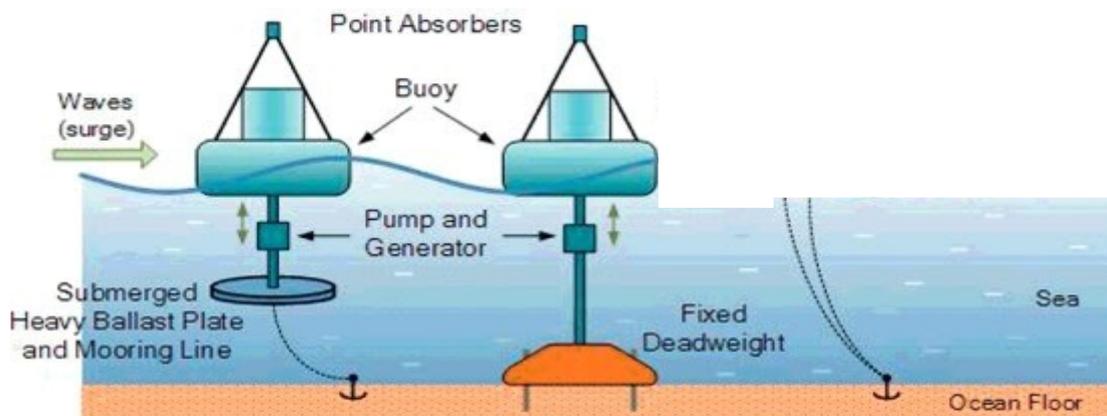
OCEAN WAVE ENERGY-

There are many types of technology used to convert wave energy into electricity. One of these methods is Oscillating bodies that use floating buoys or platforms rising and falling with the swell. They are fixed to the seafloor via a hydraulic pump. The buoy moves up and down along ocean swell crests and troughs, activating the hydraulic pump which pushes water or air through a turbine, which in turn rotates a generator to produce electricity. Below is a diagram of how wave energy is used to generate electricity.

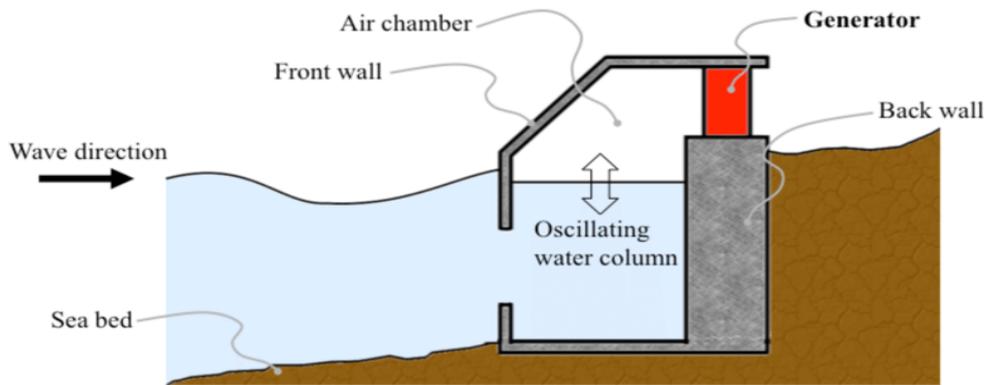


FLOATING BUOYS

As the buoy bobs up and down in the waves, an oscillatory mutual force reaction is generated between the freely moving absorber and the heavy plate causing a hydraulic pump in between to rotate a generator producing electricity.



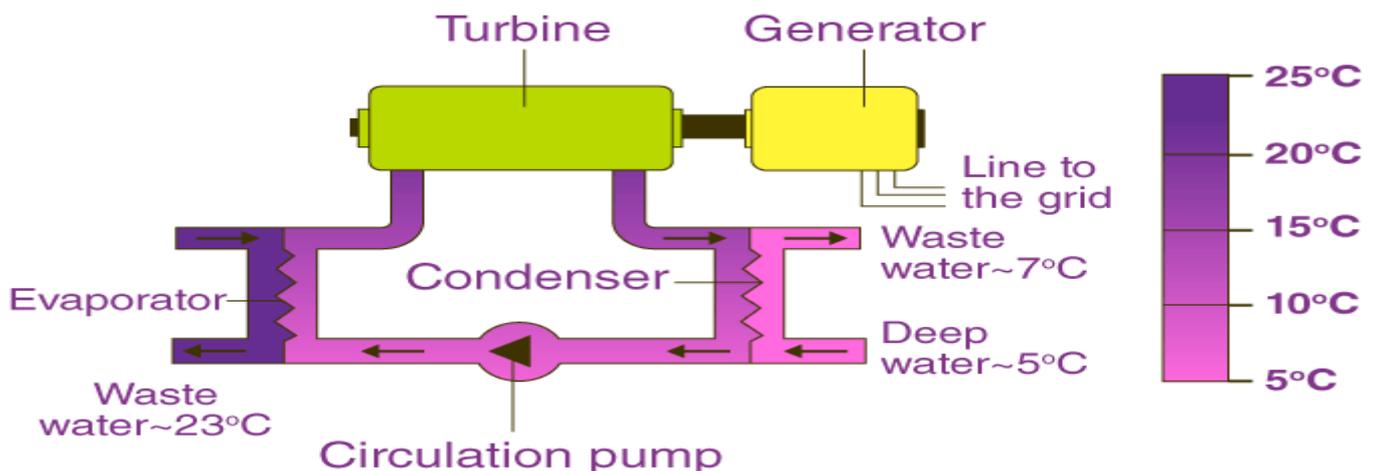
OSCILLATING WATER COLUMN



The principle of OWC power generation is to convert wave energy into compressed air energy to drive air turbine generators to generate electricity. OWCs are structures made of concrete or steel that have an air chamber with an opening at the bottom to allow access to seawater. The wave action compresses and decompresses the trapped air, which is forced through a turbine coupled to a generator thus electricity is generated.

OCEAN THERMAL ENERGY CONVERSION SYSTEMS

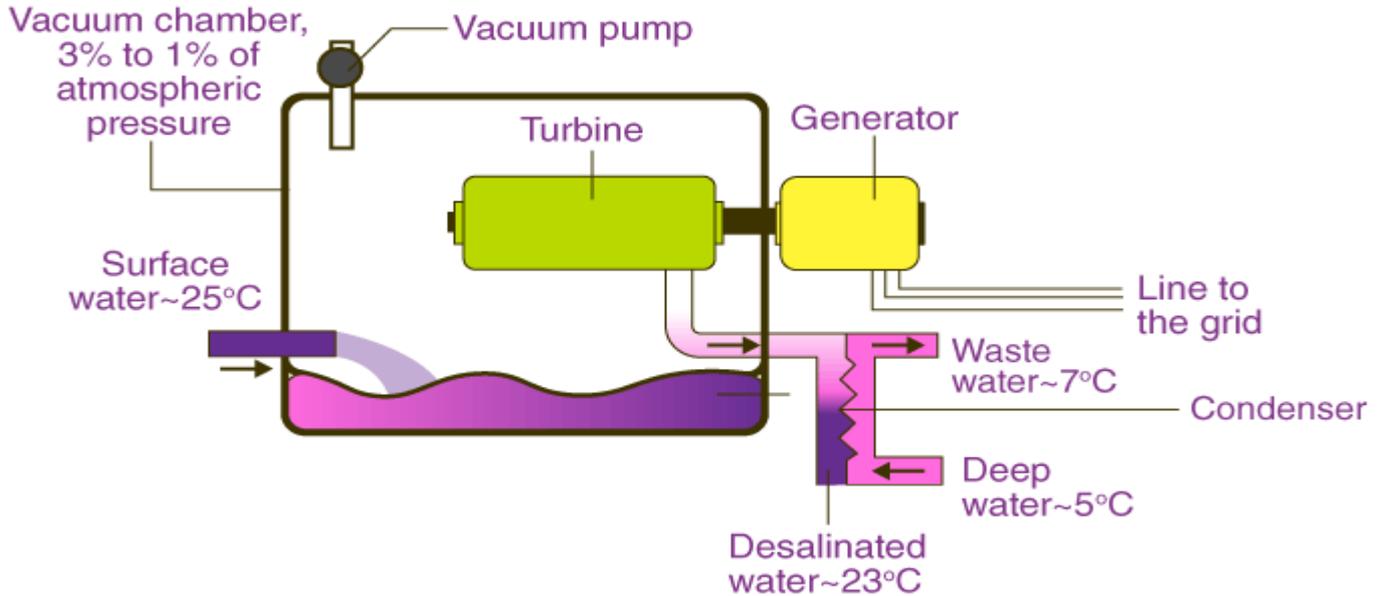
An ocean thermal energy conversion (OTEC) system has six main components: Evaporator, Condenser, Turbine, Generator Working fluid and Circulation pump. Ocean Thermal Energy, also called Ocean Thermal Energy Conversion (OTEC), refers to using the temperature difference between the deep parts of the sea, which are cold and the shallow parts of the sea, which are hot, 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. Here the efficiency of the system depends on the temperature difference. Greater the temperature difference, the greater the efficiency. The temperature difference in the oceans between the deep and shallow parts is maximum in the tropics, 20°C to 25°C. Tropics receive a lot of sunlight which warms the surface of the oceans, increasing the temperature gradient.



TYPES OF OCEAN THERMAL ENERGY CONVERSION SYSTEMS

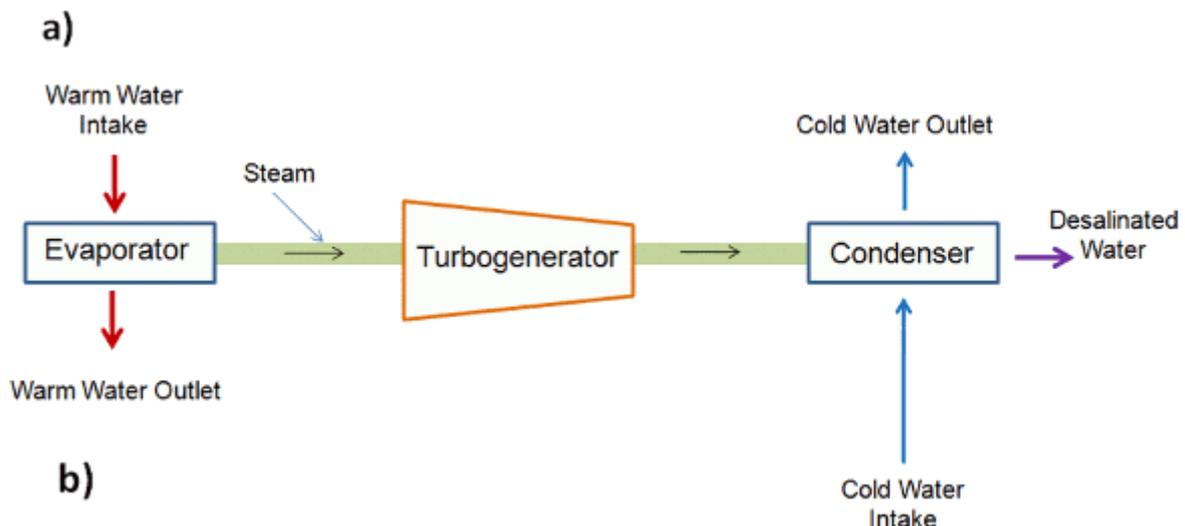
1. Closed Cycle
2. Open Cycle

CLOSED CYCLE



Closed cycle Ocean Thermal Energy Conversion systems use a working fluid with a low boiling point, Ammonia, for example, and use it to power a turbine to generate electricity. Warm seawater is taken in from the surface of the oceans and cold water from the deep at 50. The warm seawater vaporises the fluid in the heat exchanger, turning the generator's turbines. The fluid now in the vapour state is brought in contact with cold water, which turns it back into a liquid. The fluid is recycled in the system, which is why it is called a closed system.

OPEN CYCLE



Open cycle OTEC directly uses the warm water from the surface to make electricity. The warm seawater is first pumped into a low-pressure chamber, where it undergoes a drop in boiling point due to the pressure drop.

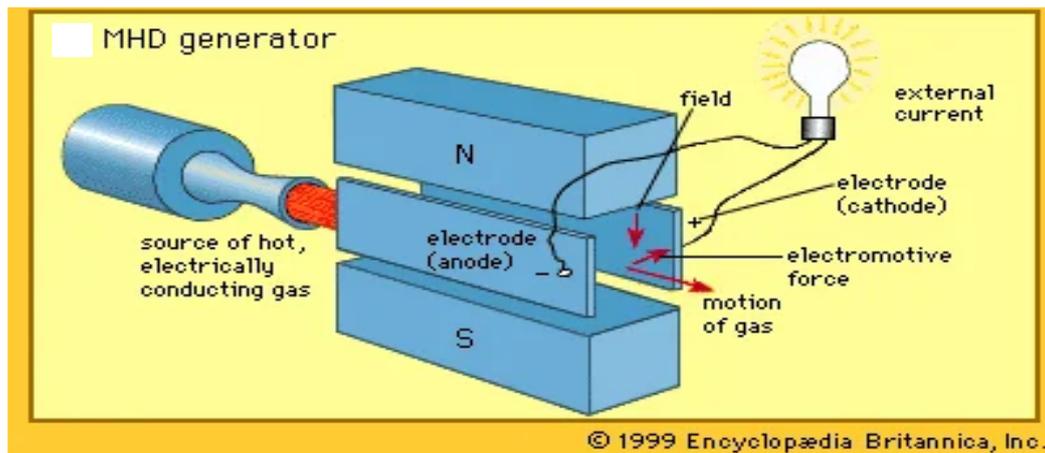
This causes the water to boil. This steam drives a low-pressure turbine which is attached to an electrical generator. The advantage this system has over a closed system is that, in the open cycle, desalinated water is obtained in the form of steam. Since it is steam, it is free from all impurities.

This water can be used for domestic, industrial, or agricultural purposes

MHD(Magneto hydrodynamic) SYSTEM

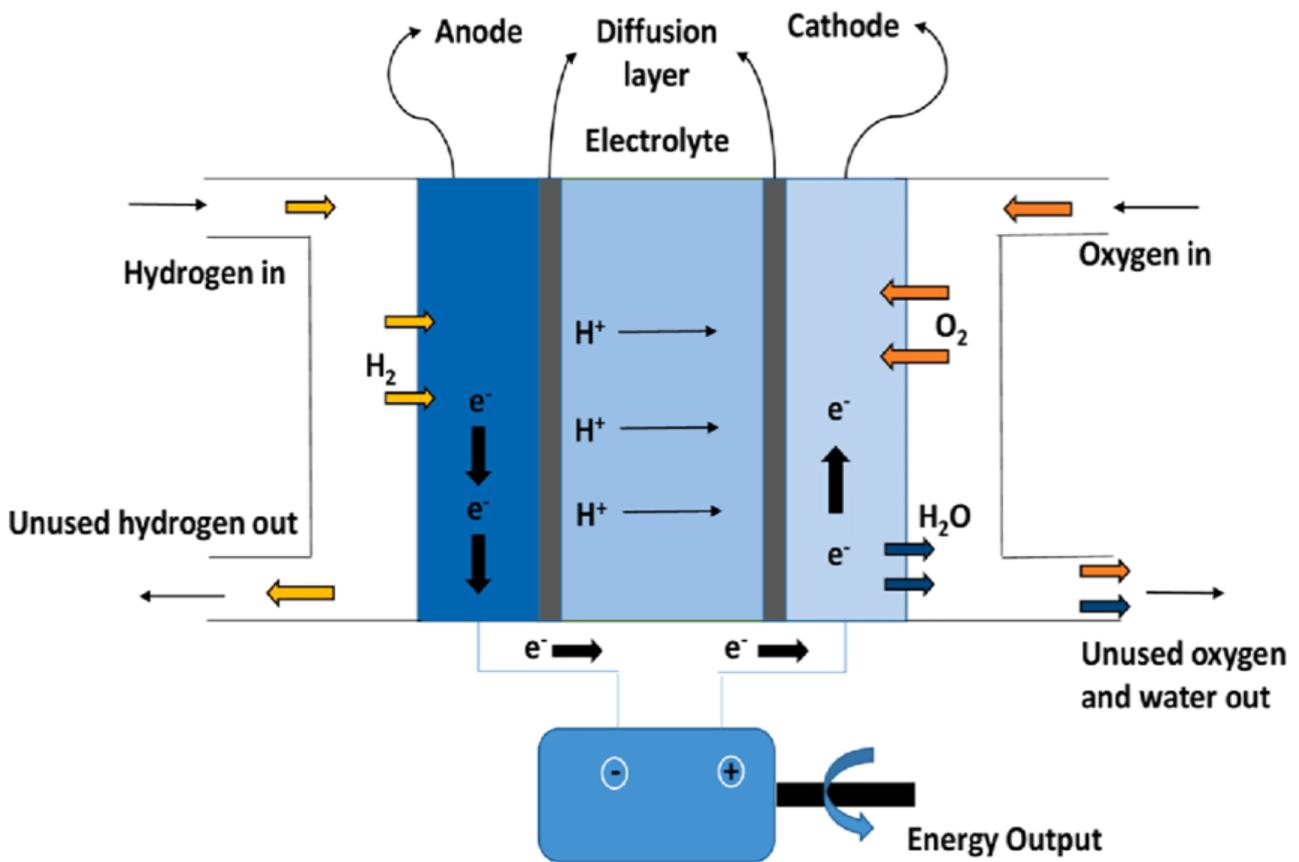
They convert heat or kinetic energy directly into electricity.

MHD systems use a gaseous conductor, such as an ionized gas, instead of solid conductors. The gas is passed through a strong magnetic field at a high velocity, which generates a current. Electrodes can be placed in the stream to extract the current. MHD systems have a conversion efficiency of around 50%, compared to less than 40% for the most efficient steam plants. With improvements in technology, thermal efficiencies of 60-65% are expected in the future. There are three types of MHD systems: open, closed, and liquid-metal.



FUEL CELLS

Fuel cells are devices that convert chemical energy into electrical energy. They work by combining a fuel, such as hydrogen or methane, with oxygen to create electricity. The first fuel cells were invented in 1838 by Sir William Grove. They have two electrodes, called the anode and cathode, where the reactions that produce electricity take place. An electrolyte carries charged particles from one electrode to the other. A fuel cell is similar to a battery and consists of an anode, a cathode, and an electrolyte. The fuel gas diffuses through the anode and is oxidized, releasing electrons to the external. On the anode side, hydrogen molecules divide into protons and electrons. They produce the waste, which is water.



FUEL CELLS ADVANTAGES,

Clean energy: Fuel cells produce electricity through a chemical reaction between hydrogen and oxygen, which means they emit only water and heat as byproducts.

High efficiency: Fuel cells can convert chemical energy into electrical energy with efficiencies of up to 60%.

Reliability: Fuel cells can provide continuous power for long periods of time without the need for refueling.

Scalable: Fuel cells are modular and can scale to a site's energy needs.

Environmentally beneficial: Fuel cells greatly reduce CO_2 and harmful pollutant emissions.

FUEL CELLS DISADVANTAGES:

Cost: Fuel cells can be expensive to manufacture and install. The cost of hydrogen fuel can also be higher than other types of fuel.

Efficiency: Hydrogen fuel cells are not as efficient as batteries and cannot store as much electricity. They also have significantly higher energy losses than batteries.

Infrastructure: There is a lack of infrastructure to support the distribution of hydrogen. Development Hydrogen fuel cells are not a quick and easy solution. They require significant research and development.

Cost per unit of energy

Hydrogen fuel cells currently cost more per unit of energy than other sources of power, including solar energy.

		Batteries	Fuel Cells
1	Energy Storage Mechanism:	Batteries store energy chemically within the device itself.	They do not store energy like batteries but produce electricity as long as fuel and oxygen are supplied.
2	Energy Density:	Batteries typically have a higher energy density compared to fuel cells, which means they can store more energy for a given volume or weight	Fuel cells have a lower energy density because they rely on the continuous supply of fuel and oxygen.
3	Rechargeability:	Batteries are rechargeable. They can be charged and discharged multiple times	Fuel cells are not inherently rechargeable in the same way as batteries.
4	Environmental Impact:	Have environmental concerns related to mining and disposal of materials.	Fuel cells, particularly hydrogen fuel cells, are often considered more environmentally friendly because they produce electricity with few or no harmful emissions
5	Application	Batteries are commonly used in a wide range of applications, including portable electronics, electric vehicles, grid energy storage	Fuel cells are typically used in specific applications, such as backup power systems, stationary power generation, and some types of transportation (e.g., hydrogen fuel cell vehicles).
6	Efficiency:	Batteries are generally highly efficient at converting chemical energy into electrical energy and vice versa, with minimal energy loss.	Fuel cells can be highly efficient, especially in certain applications, but their efficiency can be affected by factors like fuel purity and operating conditions.

