RAMA UNIVERSITY

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FACULTY OF ENGINEERING AND TECHNOLOGY

Non-conventional energy resources

Renewable energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy - bio-fuels grown sustain ably), hydropower etc., are some of the examples of renewable energy sources.

Solar energy is fast becoming popular in rural and remote areas.

It is expected that use of solar energy will be able to minimise the dependence of rural households on firewood and dung cakes, which in turn will contribute to environmental conservation and adequate supply of manure in agriculture.

Various forms of renewable energy

- Solar energy
- Wind energy
- Bio energy
- Hydro energy
- Geothermal energy
- Wave and tidal energy

Advantage of Non Conventional Energy Resources

- Cheaper and renewable
- Scarcity of fossil fuels
- Rural energy need
- Inexhaustible and environment friendly

Cont…

Disadvantage of Non Conventional Energy Resources

•Inconsistent, Unreliable Supply.

•Pollution.

•Harmful to Wildlife and Surrounding Environment.

•High Cost.

•Not Every Non-Conventional Energy Source Is Commercially Viable.

•Location-Specificity Means Lower Chances of Universality.

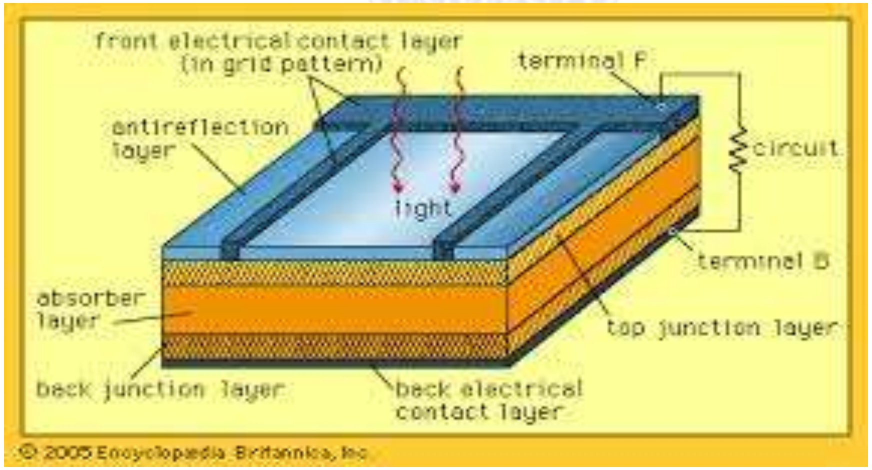
•Low Efficiency Levels

Solar cell

Solar cell, also called **photovoltaic cell**, any device that directly converts the energy of light into electrical energy through the photovoltaic cell.

The overwhelming majority of solar cells are fabricated from silicon—with increasing efficiency and lowering cost as the materials range from amorphous to polycrystalline to crystalline silicon forms.

Unlike batteries or fuel cells, solar cells do not utilize chemical reactions or require fuel to produce electric power, and, unlike electric generators, they do not have any moving parts.



Solar Cell Materials

The operation of a photovoltaic (PV) cell requires three basic attributes:

•The absorption of light, generating either electron-hole pairs or excitons.

•The separation of charge carriers of opposite types.

•The separate extraction of those carriers to an external circuit.

•The basic component of a solar cell is pure silicon, which is not pure in its natural state.

•Solar cells are typically named after the semiconducting material they are made of. These materials must have certain characteristics in order to absorb sunlight.

•Solar cells can be classified into first, second and third generation cells. The first generation cells—also called conventional, traditional or wafer-based cells—are made of crystalline silicon, the commercially predominant PV technology, that includes materials such as polysilicon and monocrystalline silicon.

•Second generation cells are thin film solar cells, that include amorphous silicon, CdTe and CIGS cells and are commercially significant in utility-scale photovoltaic power stations, building integrated photovoltaics or in small stand-alone power system.

•The third generation of solar cells includes a number of thin-film technologies often described as emerging photovoltaics—most of them have not yet been commercially applied and are still in the research or development phase.

A solar power plant is any type of facility that converts sunlight either directly, like Photovoltaics, or indirectly, like Solar Thermal plants, into electricity.

They come in a variety of 'flavors' with each using discretely different techniques to harness the power of the sun.

Solar cell array

Combining several solar panels creates an array, which is part of your solar system. The size of your solar array depends on where you live, the position of your roof and the energy needs of your family.

Solar Cell is a semiconductor device that can convert solar energy into DC electricity through the Conversion of solar light energy into electrical energy. When light shines on a Solar Cell, it may be reflected, absorbed, or passes right through. But only the absorbed light generates electricity.

When photons hit a solar cell, they knock electrons loose from their atoms. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electrons flow through such a circuit, they generate electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array. The more panels you can deploy, the more energy you can expect to generate.

Solar thermal power plants

Solar thermal power plants are electricity generation plants that utilize energy from the Sun to heat a fluid to a high temperature. This fluid then transfers its heat to water, which then becomes superheated steam. This steam is then used to turn turbines in a power plant, and this mechanical energy is converted into electricity by a generator. This type of generation is essentially the same as electricity generation that uses fossil fuels, but instead heats steam using sunlight instead of combustion of fossil fuels.[2] These systems use solar collectors to concentrate the Sun's rays on one point to achieve appropriately high temperatures.

Benefits and Drawbacks

•These plants can produce dispatchable baseload energy, which is important as it means these plants produce a reliable amount of energy and can be turned on or up at will, meeting the energy demands of society.

•there are still associated environmental effects of these plants as a full life cycle analysis can show all associated carbon dioxide emissions involved in the building of these plants. However, emissions are still much lower than those associated with fossil fuel plants.

•Some of the drawbacks include the large amount of land necessary for these plants to operate efficiently.

•A final potential impact of the use of large focusing mirrors is the harmful effect these plants have on birds.

Thermal energy storage for solar heating and cooling

Solar heating and cooling technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling and pool heating for residential, commercial and industrial applications. These technologies displace the need to use electricity or natural gas.

Thermal energy can be generated from many renewable sources, such as solar, biomass, and geothermal. These systems are known collectively as renewable heating and cooling technologies. Systems which change sunshine into usable thermal energy are referred to as solar heating and cooling (SHC) technologies.

Solar Water Heating

Solar water heating systems can be installed on every home in the U.S., and are composed of three main elements: the solar collector, insulated piping, and a hot water storage tank.

Solar Cooling

There are two kinds of solar cooling systems: desiccant systems and absorption chiller systems. In a desiccant system, air passes over a common desiccant or “drying material” such as silica gel to draw moisture from the air and make the air more comfortable. The desiccant is regenerated by using solar heat to dry it out.

The Economics of Solar Heating and Cooling

•Typical commercial applications include space heating, cooling, and water heating. Building types that are particularly well-suited for these solar applications, according to SEIA, include “military facilities, manufacturing plants, large multi-family residential buildings and affordable housing, municipal facilities, hotels, elderly and student housing, hospitals, sport centers, and agricultural operations.

•EIA notes that capital expenditures (CAPEX) for solar heating and cooling systems are often higher than conventional fuel systems, but on the other hand, operational expenses (OPEX) are much lower because the fuel is generated and supplied for free. Budgeting fuel expenses becomes a thing of the past, lowering OPEX significantly with the transition to clean, renewable solar heating and cooling technologies.

•Solar cooling applications are very useful, as air conditioning represents a major strain on the electrical grid when weather is very hot outside. Using this same heat and strong sunshine to produce solar air conditioning is an ideal solution to reduce this strain. Also referred to as solar-assisted cooling, properly sized residential solar cooling systems may also be used for space heating during winter months.

•Solar heating systems are very effective at capturing the sun’s energy. With today’s technology, SEIA reports that solar heating systems “typically produce 45 kWhth to 102 kWhth per square foot of installed collector area per year (or 1.5 to 3.5 therms/ft2 in equivalent heat units), which is up to 80% of all the available solar energy hitting the surface of the collector.”

Geothermal Energy

•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.

•A renewable energy source because the water is replenished by rainfall and the heat is continuously produced inside the earth.

•Geothermal energy is generated in the earth's core about 4000 miles below the surface.

•Temperature hotter than the earth's surface are continuously produced inside the surface by slow decay of radiactive particles, a process that happens in all rocks.

•It is contained in the rocks and fluids beneath the earth's crust and can be found as far down to the earth's hot molten rock, magma.

•To produce power from geothermal energy, wells are dug a mile deep into underground reservoirs to access the steam and hot water there, which can then be used to drive turbines connected to electricity generators. There are three types of geothermal power plants; dry steam, flash and binary.

•It's clean and sustainable. Resources of geothermal energy range from the shallow ground to hot **water** and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

Role of Thermodynamics

The production of electricity from a geothermal source is about producing work from heat.

Electricity production from heat will never be successful unless appropriate respect is paid to the second law of thermodynamics.

The type of energy conversion system used to produce electrical power from a geothermal resource depends on the type and quality (temperature) of the resource.

Geothermal power is generated by using steam or a secondary hydrocarbon vapor to turn a turbine-generator set to produce electrons.

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials.

Geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity.

Magneto hydrodynamics (MHD)

- **Magneto hydrodynamics (MHD)**; also magneto-fluid dynamics or hydromagnetics) is the study of the magnetic properties and behavior of electrically conducting fluids. The word "**magneto hydrodynamics**" is derived from magneto- meaning magnetic field, hydro- meaning water, and dynamics meaning movement.
- The fundamental concept behind MHD is that magnetic fields can induce currents in a moving conductive fluid, which in turn polarizes the fluid and reciprocally changes the magnetic field itself. The set of equations that describe MHD are a combination of the Navier–Stokes equations of fluid dynamics and Maxwell's equations of electromagnetism. These differential equations must be solved simultaneously, either analytically or numerically.
- The efficiency of conductive substances should be increased to increase the operational efficiency of a power generating device.
- The required efficiency can be achieved when a gas is heated to become plasma/fluid or adding other ionizable substances like the salts of alkali metals.
- To design and implement an MHD generator, several issues like economics, efficiency, contaminated hypo ducts are considered.

Principle of working of MHD Power plant

•The principal of MHD power generation is very simple and is based on Faraday's law of electromagnetic induction, which states that when a conductor and a magnetic field moves relative to each other, then voltage is induced in the conductor, which results in flow of current across the terminals.

•A magneto hydrodynamic (MHD) generator is a device that generates power directly by interacting with a rapidly moving stream of fluid, usually ionized gases/plasma.

•MHD devices transform heat or kinetic energy into electrical energy. The typical setup of an MHD generator is that both turbine and electric power generator coalesce into a single unit and has no moving parts, thus, eliminating vibrations and noise, limiting wear and tear.

•MHDs have the highest thermodynamic efficiency as it operates at higher temperatures than mechanical turbines.

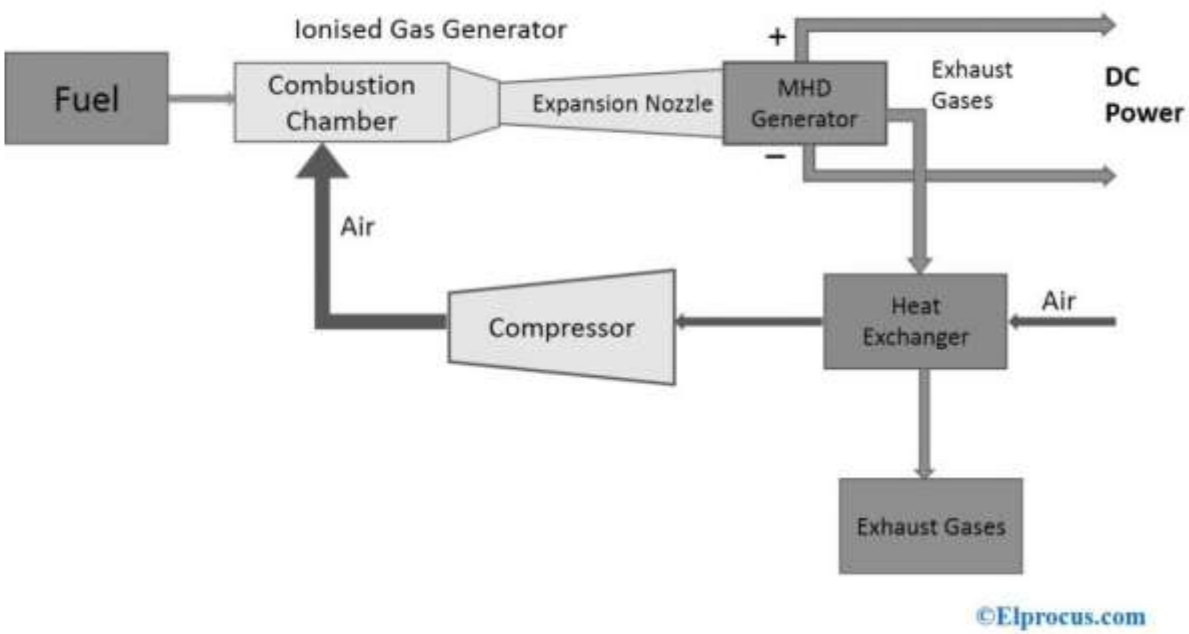
•MHD generator is commonly referred to as a fluid dynamo, which is compared to a mechanical dynamo – a metal conductor when passed through a magnetic field generates a current in a conductor.

•However, in the MHD generator, conducting fluid is used instead of a metal conductor. As the conducting fluid (conductor) moves through the magnetic field, it produces an electrical field perpendicular to the magnetic field. This process of electric power generation through MHD is based on the principle of Faraday's law of electromagnetic induction.

When the conducting fluid flows through a magnetic field, a voltage is generated across its fluid and it is perpendicular to both the fluid flow and the magnetic field as per Fleming's Right Hand Rule.

MHD Generator Working

- The MHD generator requires a gas source of high temperature, which can be either a coolant of a nuclear reactor or can be high-temperature combustion gases produced from coal.
- As the gas and fuel pass through the expansion nozzle, it decreases the pressure of the gas and increases the speed of fluid/plasma through the MHD duct, and increasing the overall efficiency of the power output. The exhaust heat produced from the fluid through the duct is the DC power. It used to run the compressor to boost the fuel combustion rate.



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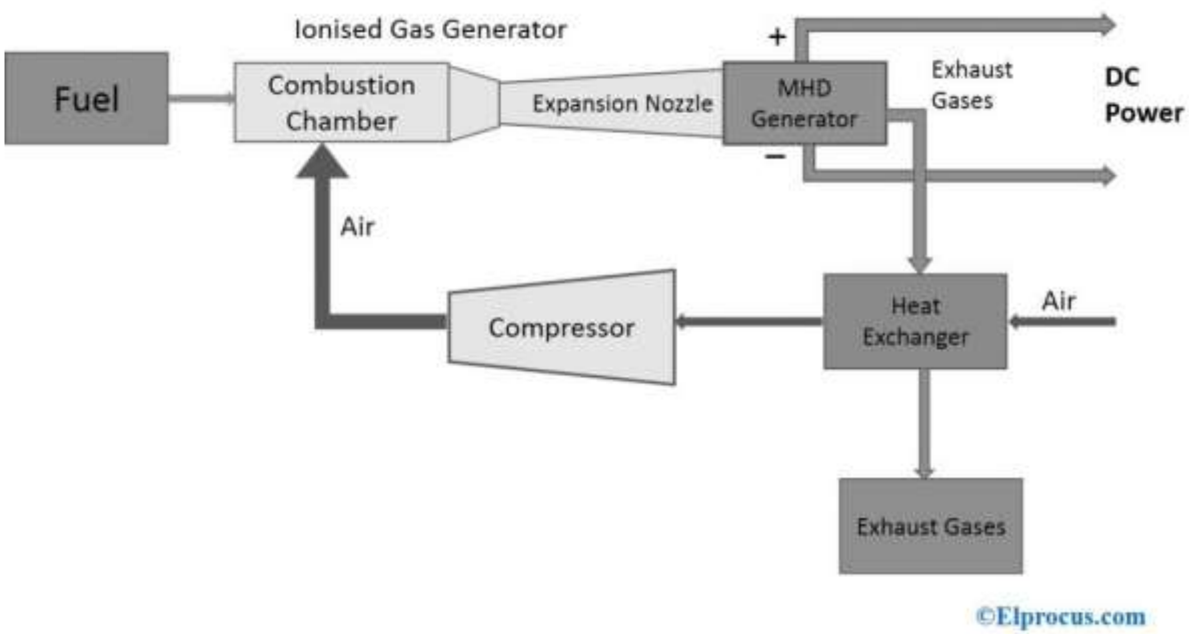


Advantages, Disadvantages and Applications

Advantages

•The advantages of the MHD generator include the following.

•MHD generators convert heat or thermal energy directly into electrical energy

•It has no moving parts, so mechanical losses would be minimal

•Highly efficient Has higher operational efficiency more than conventional generators, therefore, the overall cost of an MHD plant is less compared to conventional steam plants

•Operational and maintenance costs are less

•It works on any type of fuel and has better fuel utilization

Disadvantages

The disadvantages of the MHD generator include the following.

•Aids in the high amount of losses that include fluid friction and heat transfer losses

•Needs large magnets, leading to higher costs in implementing MHD generators

•High operating temperatures in the range of 200°K to 2400°K will corrode the components sooner

Applications of MHD Generator

•The applications are

•MHD generators are used for driving submarines, aircraft, hypersonic wind tunnel experiments, defense applications, and so on.

•They are used as an uninterrupted power supply system and as power plants in industries

•They can be used to generate electric power for domestic applications

Fuel cell

•**Fuel cell**, any of a class of devices that convert the chemical energy of a fuel directly into electricity by electrochemical reactions. A fuel cell resembles a battery in many respects, but it can supply electrical energy over a much longer period of time.

•This is because a fuel cell is continuously supplied with fuel and air (or oxygen) from an external source, whereas a battery contains only a limited amount of fuel material and oxidant that are depleted with use.

•For this reason fuel cells have been used for decades in space probes, satellites, and manned spacecraft.

•A **fuel cell** is an electrochemical cell that converts the chemical energy of a fuel and an oxidizing agent into electricity through a pair of redox reactions.

• Fuel cells are different from most batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction, whereas in a battery the chemical energy usually comes from metals and their ions or oxides that are commonly already present in the battery, except in flow batteries.

•Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

•There are many types of fuel cells, but they all consist of an anode, a cathode, and an electrolyte that allows ions, often positively charged hydrogen ions (protons), to move between the two sides of the fuel cell.

•A fuel cell has essentially the same kinds of components as a battery. Each cell of a fuel cell system has a matching pair of electrodes. These are the anode which supplies electrons, and the cathode which absorbs electrons.

•Both electrodes must be immersed in and separated by an electrolyte, which may be a liquid or a solid but which must in either case conduct ions between the electrodes in order to complete the chemistry of the system.

Types of fuel cells

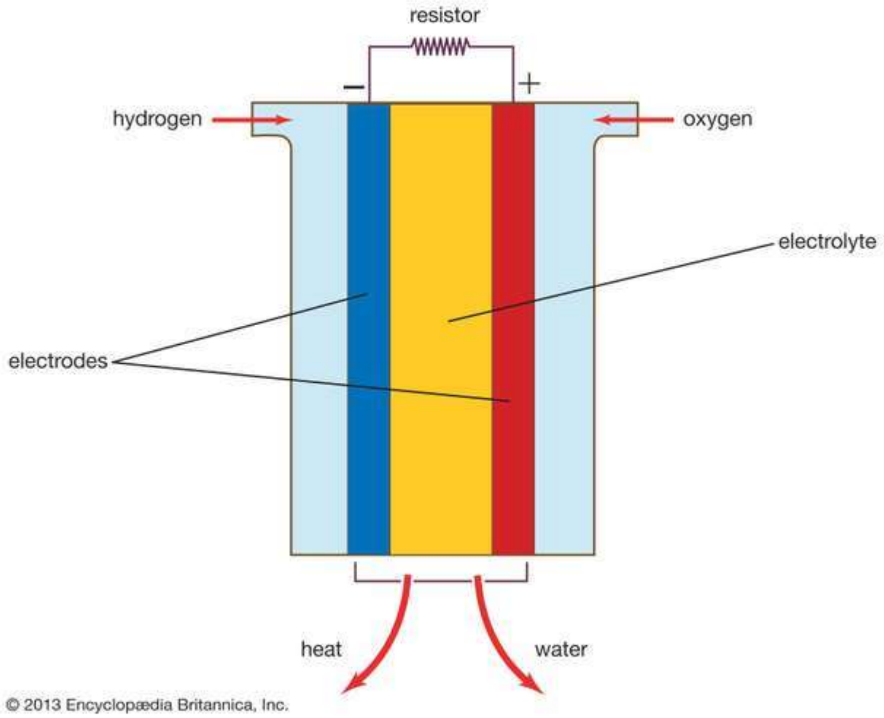
•Fuel cells are made up of three adjacent segments: the anode , the electrolyte and the cathode.

•The electrolyte substance, which usually defines the *type* of fuel cell, and can be made from a number of substances like potassium hydroxide, salt carbonates, and phosphoric acid.

•The fuel that is used. The most common fuel is hydrogen.

•The anode catalyst, usually fine platinum powder, breaks down the fuel into electrons and ions.

•The cathode catalyst, often nickel, converts ions into waste chemicals, with water being the most common type of waste.



Classification of fuel cells

Alkaline fuel cells

These are devices that, by definition, have an aqueous solution of sodium hydroxide or potassium hydroxide as the electrolyte. The fuel is almost always hydrogen gas, with oxygen as the oxidizer.

Zinc or aluminum could be used as an anode if the by-product oxides were efficiently removed and the metal fed continuously as a strip or as a powder. Fuel cells generally operate at less than 100 °C (212 °F) and are constructed of metal and certain plastics. Electrodes are made of carbon and a metal such as nickel.

Phosphoric acid fuel cells

They can use a hydrogen fuel contaminated with carbon dioxide and an oxidizer of air or oxygen. The electrodes consist of catalyzed carbon and are arranged in pairs set back-to-back to create a series generation circuit. The framing structure for this assembly of cells is made of graphite, which markedly raises the cost.

Molten carbonate fuel cells

The fuel consists of a mixture of hydrogen and carbon monoxide generated from water and a fossil fuel. The electrolyte is molten potassium lithium carbonate, which requires an operating temperature of about 650 °C.

Solid oxide fuel cells

Solid oxide fuel cells would be designed for use in central power-generation stations where temperature variation could be controlled efficiently and where fossil fuels would be available.

Solid polymer electrolyte fuel cells

The electrodes are catalyzed carbon, and several construction alignments are feasible.

Working of fuel cells

•Fuel Cell is an electrochemical device that is used to convert an open source fuel into electricity. An electrolytic process has to take place inside a cell in which there is an open source fuel [hydrogen] and an oxidant [oxygen].

•Both the fuel and oxidant reacts in the presence of an electrolyte. Both the fuel and oxidant are introduced into the cell, where they react and the output product is carried out of the cell and stored.

•The electrolyte is left as it is inside the cell. This process can take place non-stop for a long time as long as the flow of resources are maintained.

•The result obtained by combining hydrogen and oxygen is water. As a result of this process, electricity is formed. Although batteries are also electrochemical devices, they are different from a fuel cell. They use reactants from an external source and the chemicals have to be stored inside the battery.

•These chemicals react to each other to produce the electricity. Thus they use closed source fuel. As the device stores the required energy in a chemical form, the battery has to be recharged at intervals or have to be replaced.

Need of Fuel Cells

The main reason for the use of fuel cell is the increasing dependency on the use of fossil fuels. The whole world has burnt so much fossil fuel like oil to such an extent that they have become one of the main reasons for the pollution. This pollution has eventually resulted in the global warming and extreme climate change. Other than the environmental problems, the use of oil has become large enough that the sources of production have become less. As a result more challenging expeditions will have to be made for oil deposits which results in a very high oil price.

Advantages and Limitations of Fuel Cells

Advantages of fuel cells

i) **High efficiency** – Most fuel cells are 60%-80% energy efficient. However, this efficiency can increase to 85%, when these fuel cells are used in a cogeneration system.

ii) **Clean** – Fuel cells work with little to no emissions, the only byproducts being electricity, heat and water. They are thus, much cleaner than traditional power generation, producing 97% less nitrogen oxide emissions than the thermal power plants.

iii) **Scalable** – can be stacked onto one another

iv) **No Noise** – More silent in operation when compared to the conventional sources of power generators. There are no moving parts in a fuel cell stack, making them quieter.

v) **Low Maintenance** – Though the initial cost is higher, fuel cell technology does not involve much maintenance. Fuel cells do not degrade over time, unlike batteries, and can, therefore, provide electricity continuously.

Limitations of fuel cell

- Expensive to manufacture due the high cost of catalysts (platinum)
- Lack of infrastructure to support the distribution of hydrogen
- A lot of the currently available fuel cell technology is in the prototype stage and not yet validated.
- Hydrogen is expensive to produce and not widely available

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Thermo-electrical and thermionic Conversions:

A **thermionic converter** consists of a hot electrode which thermionically emits electrons over a potential energy barrier to a cooler electrode, producing a useful electric power output.

Principle of Thermionic Converter:

•A thermionic generator (converter) converts heat energy directly to electrical energy by utilizing thermionic emission effect. All metals and some oxides have free electrons which are released on heating.

•A thermionic generator (converter) converts heat energy directly to electrical energy by utilizing thermionic emission effect. All metals and some oxides have free electrons which are released on heating. In a thermionic converter, electrons act as the working fluid in place of a vapour or gas.

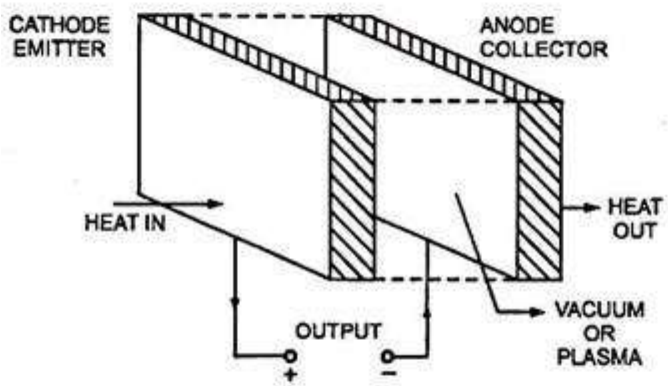

Fig. 7.12. ***Principle of Thermionic Converter***

Limitation of Thermionic Convertor

•The operating temperature of cathode is very high, so costly materials like tungsten, rhenium are required for cathode.

•Special shields of ceramic are required for protection of cathode from corrosive combustion gases.

•The collector may also have to be made of molybdenum coated with cesium.

•Ionised cesium vapour has to be filled in the interspace to reduce the space charge barrier to promote electron emission from the cathode.

Applications of Thermionic Converter

Thermionic Converter in a Nuclear Reactor

Thermionic Converter in the Riser Tube of a Boiler

MHD Thermionic-Steam Power Plant

Wind Energy

Wind energy is a form of solar energy.Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity.

Wind energy offers many advantages, which explains why it's one of the fastest-growing energy sources in the world.

Advantages of Wind Power

- •Wind power is cost-effective.
- •Wind creates jobs.
- •Wind is a domestic source of energy.
- •It's sustainable.
- •Wind turbines can be built on existing farms

Challenges of wind power

Wind power must still compete with conventional generation sources on a cost basis.

Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed.

Wind resource development might not be the most profitable use of the land.

Turbines might cause noise and aesthetic pollution.

Wind plants can impact local wildlife.

Wind characteristics

Wind has two important characteristics – direction and speed. The direction of wind can be gauged using an instrument called the wind vane. It s also called winter vane. Every wind has two parts, the front and the rear. A very common shape for wind vane is the shape of an arrow.

When wind blows, it presses more on the rear part of the wind vane as it has a greater surface area. The arrow align itself such that its tip point in direction from which the wind is blowing will be marked on the wind vane.

Speed of wind is measure by anemometer.

Energy Conversion Systems

•**Energy conversion**, the transformation of energy from forms provided by nature to forms that can be used by humans.

•Many of the energy converters widely used today involve the transformation of thermal energy into electrical energy. The efficiency of such systems is, however, subject to fundamental limitations, as dictated by the laws of thermodynamics and other scientific principles.

• In recent years, considerable attention has been devoted to certain direct energy-conversion devices, notably solar cells and fuel cells, that bypass the intermediate step of conversion to heat energy in electrical power generation.

•The law of conservative energy is applied not only to nature as a whole but to closed or isolated systems within nature as well.

•Thus, if the boundaries of a system can be defined in such a way that no energy is either added to or removed from the system, then energy must be conserved within that system regardless of the details of the processes going on inside the system boundaries.

Performance and Limitations of Energy Conversion Systems

- The limitation of wind power is that no electricity is produced when the wind is not blowing. Thus, it cannot be used as a dependable source of base load power.
- Utilities and merchant generators will not invest huge sums of money into a technology that does not work when the wind is not blowing.
- Wind power will probably increase its market share when we develop a 'smart grid' that can handle multiple distributed generation input sources of electrical power.
- A wind energy conversion system is powered by wind energy and generates mechanical energy that sends energy to the electrical generator for making electricity.
- Wind energy conversion systems (WECS) are designed to convert the energy of wind movement into mechanical power.
- With wind turbine generators, this mechanical energy is converted into electricity and in windmills this energy is used to do work such as pumping water, mill grains, or drive machinery.

Bio-mass

•**Biomass** is plant or animal material used for energy production (electricity or heat), or in various industrial processes as raw substance for a range of products.

•Biomass is biological organic matter derived from living or recently-living organisms.

•Bioenergy is the energy contained (stored) in biomass.

•Two forms of biomass

•Raw: forestry products, grasses, crops, animal manure, and aquatic products (seaweed

•Secondary: materials that undergone significant changes from raw biomass. Paper, cardboard, cotton, natural rubber products, and used cooking oils.

•Biomass is considered renewable as either a feedstock or waste and due to government incentives, corporate sustainability goals and climate change initiatives, a majority of the conversion technologies use biomass to produce various forms of renewable energy.

•The type of energy includes electrical power, thermal energy, renewable natural gas, biodiesel, jet fuel, and ethanol.

•Biomass also can be used as a substitute for fossil fuels in the manufacturing of high value products including plastics, lubricants, industrial chemicals, and many other products derived from petroleum or natural gas.

•On combustion, the carbon from biomass is released into the atmosphere as carbon dioxide (CO_2). After a period of time ranging from a few months to decades, the CO_2 produced from combustion is absorbed from the atmosphere by plants or trees.

•There are four types of conversion technologies currently available that may result in specific energy and potential renewable products:

Thermo chemical conversion

Thermal conversion is the use of heat, with or without the presence of oxygen, to convert biomass into other forms of energy and products. These include direct combustion, pyrolysis, and torrefaction.

Combustion is the burning of biomass in the presence of oxygen. The waste heat is used to for hot water, heat, or with a waste heat boiler to operate a steam turbine to produce electricity. Biomass also can be co-fired with existing fossil fuel power stations.

Pyrolysis convert biomass feedstocks under controlled temperature and absent oxygen into gas, oil and biochar (used as valuable soil conditioner and also to make graphene). The gases and oil can be used to power a generator and some technologies can also make diesel and chemicals from the gases.

Torrefaction is similar to pyrolysis but in a lower operating temperature range. The final product is an energy dense solid fuel often referred to as “bio-coal”.

Thermochemical conversion is commonly referred to as gasification. This technology uses high temperatures in a controlled partial combustion to form a producer gas and charcoal followed by chemical reduction. A major use for biomass is for agriculture residues with gas turbines. Advanced uses include production of diesel, jet fuel and chemicals.

Biochemical Conversion involves the use of enzymes, bacteria or other microbes to break down biomass into liquids and gaseous feedstocks and includes anaerobic digestion and fermentation. These feedstocks can be converted to energy, transportation fuels and renewable chemicals.

Chemical Conversion involves the use of chemical agents to convert biomass into liquid fuels which mostly is converted to biodiesel.

Ocean Thermal Energy Conversion (OTEC)

- **Ocean Thermal Energy Conversion** (**OTEC**) uses the ocean thermal gradient between cooler deep and warmer shallow or surface seawaters to run a heat engine and produce useful work, usually in the form of electricity. OTEC can operate with a very high capacity factor and so can operate in base load mode.
- Ocean Thermal Energy Conversion (OTEC) technology uses a turbine generator to create renewable energy from the temperature difference between cold, deep seawater circulating in the ocean and surface seawater warmed by the sun. In order to produce power with the low temperature range, a working fluid with low boiling point is used.
- The amount of energy created is dependant on the amount of water available to cool or heat the working fluid.
- The Okinawa OTEC project has a maximum capacity of 100kW, but since it does not always have access to the maximum capacity due to other seawater users, will often produce less electricty.
- This is due to the previous use of water by local industries and the Okinawa Deep Seawater Research Center, and does not hinder the project's goal of demonstration and testing.
- Ocean thermal energy conversion (OTEC) is a process or technology for producing energy by harnessing the temperature differences (thermal gradients) between ocean surface waters and deep ocean waters.
- 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 77° 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.

Principles of OTEC Plant Operation

•OTEC or ocean thermal energy thermal conversion is a technology which converts solar radiation absorbed by the oceans to electric energy. The ocean's can be considered as the world's largest solar energy collector as it covers two third of the earth surface.

•The working principle of an OTEC plant is that it uses the warm water to heat and vaporize a liquid (working fluid) and this working fluid develops pressure which forces it to evaporate and the expanding vapour runs through a heat engine like turbine, generator, and it is condensed back into a liquid by cold water brought up from depth and the cycle is repeated.

•There are basically three types of OTEC power plant:

1. Closed cycle
2. Open cycle
3. Hybrid cycle

•Most of the electricity we use comes from heat engines of one kind or another. A heat engine is a machine that cycles between two different temperatures, one hot and one cold, usually extracting heat energy from a fuel of some kind.

•In a steam engine or a steam turbine, for example, coal heats water to make hot, high-pressure steam, which is then allowed to expand and cool down to a lower temperature and pressure, pushing a piston and turning a wheel as it does so.

•The greater the temperature difference between the hot steam and the cooled water vapor it becomes, the more energy can be extracted

Advantages and disadvantages

Advantage

•OTEC sounds immensely attractive: it's clean, green renewable energy that doesn't involve burning fossil fuels, producing large amounts of greenhouse gases, or releasing toxic air pollution. By helping to reduce our dependence on fuels such as petroleum, OTEC could also help to reduce the "collateral" damage the world suffers from an oil-dependent economy—including wars fought over oil and water pollution from tanker spills.

• It could also provide a very useful source of power for tropical island states that lack their own energy resources, effectively making them self-sufficient. As we've already considered, open-cycle OTEC can play a useful part in providing pure, usable water from ocean water.

•OTEC can also be used to produce fuels such as hydrogen; the electricity it generates can be used to power an electrolysis plant that would split seawater into hydrogen and oxygen, which could be bottled or piped ashore and then used to power such things as fuel cells in electric cars.

•The waste cooling water used by an OTEC plant can also be used for **aquaculture** (growing fish and other marine food such as algae under controlled conditions), refrigeration, and air conditioning.

Disadvantages

•The biggest problem with OTEC is that it's relatively inefficient.

•The laws of physics say that any practical heat engine must operate at less than 100 percent efficiency; most operate well below—and OTEC plants, which use a relatively small temperature difference between their hot and cold fluids, have among the lowest efficiency of all: typically just a few percent.

•OTEC plants have to work very hard (pump huge amounts of water) to produce even modest amounts of electricity, which brings problems.

Wave and Tidal Wave

•A tidal wave is a **shallow water wave** caused by the **gravitational interactions** between the Sun, Moon, and Earth.

•A tidal wave is a regularly reoccurring shallow water wave caused by effects of the gravitational interactions between the Sun, Moon, and Earth on the ocean.

•**Tidal power** harnesses the energy from the tidal force and wave action in order to generate electricity. Unlike other primary energy flows, it is a predictable source of energy because tides occur at expected times.

• This predictability has an advantage over wind and solar power since the sun may or may not shine on a particular day and the wind doesn't always blow the expected amount.

• Tidal power is still not a dispatchable source of electricity as it is available when nature provides it, not necessarily when it is needed.

•Tidal power is not a widely used energy resource at the moment because its costs outweigh the advantages. Previously only very specialized locations were able to support these technologies.

•However, recent improvements are making tidal power much more cost effective and adaptable to a wider range of locations. If support for tidal power continues to increase the industry will likely grow

Working principle of Tidal power plants

•Tide or wave is periodic rise and fall of water level of the sea. Tides occur due to the attraction of sea water by the moon. Tides contain large amount of potential energy which is used for power generation.

•When the water is above the mean sea level, it is called flood tide. When the water level is below the mean level it is called ebb tide.

•The ocean tides rise and fall and water can be stored during the rise period and it can be discharged during fall.

• A dam is constructed separating the tidal basin from the sea and a difference in water level is obtained between the basin and sea.

During high tide period, water flows from the sea into the tidal basin through the water turbine. The height of tide is above that of tidal basin. Hence the turbine unit operates and generates power, as it is directly coupled to a generator.

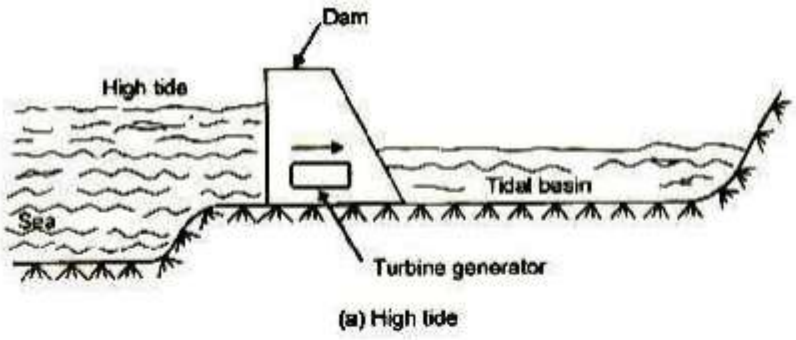

Figure: High tide

Cont…

•During low tide period, water flows from tidal basin to sea, as the water level in the basin is more than that of the tide in the sea. During this period also, the flowing water rotates the turbine and generator power.

•The generation of power stops only when the sea level and the tidal basin level are equal. For the generation of power economically using this source of energy requires some minimum tide height and suitable site.

• Kislaya power plant of 250 MW capacity in Russia and Rance power plant in France are the only examples of this type of power plant.

Advantages of tidal power plants

1. It is free from pollution as it does not use any fuel.
2. It is superior to hydro-power plant as it is totally independent of rain.
3. It improves the possibility of fish farming in the tidal basins and it can provide recreation to visitors and holiday makers.

Disadvantages

1. Tidal power plants can be developed only if natural sites are available on the bay.
2. As the sites are available on the bays which are always far away from load centres, the power generated has to be transmitted to long distances. This increases the transmission cost and transmission losses.

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Waste Recycling Plants

•The efficiency of any recycling plant, tyre recycling plant depends on the performance of its component parts.

•"Recyclate" is a raw material that is sent to, and processed in a **waste recycling plant** or materials recovery **facility** which will be used to form new products. ... For example, plastic bottles that are collected can be re-used and made into plastic pellets, a new product.

•Under the single-stream **recycling** system, all recyclables go into a single bin. At the **recycling plant**, recyclables are loaded onto a conveyer belt and pushed off in response to certain stimuli: Metals lift iron-based metals from the belt; puffs of air blow paper from the line, and so on.

•There are **three types of recycling**, known as primary, secondary and tertiary. Primary **recycling** means that the **recyclable** material/product is recovered and reused without being changed in any way and usually for the very same purpose.

•**Recycling** steel and tin cans saves 60 to 74 percent; **recycling** paper saves about 60 percent; and **recycling** plastic and glass saves about one-third of the energy compared to making those products from virgin materials. ... In many cases, **recycling** can **actually** be a net positive financial benefit.

Questions

Which of the following is a nonrenewable energy resource

1. Solar
2. Methane
3. Hydroelectric
4. coal

What is the leading source of energy used in the United States today?

1. Coal
2. oil resources
3. Natural gas
4. Nuclear power

Energy resources derived from natural organic materials are called ________.

1. geothermal energy sources
2. fossil fuels
3. Biomass
4. all of these

Solar energy stored in material such as wood, grain, sugar, and municipal waste is called __________.

1. Fossilfuels
2. Biomass
3. geothermal energy
4. natural gas