UNIT 2

Energy Sources

Q.1. What are the Conventional sources of energy for the humanity?

Ans. The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent.

At the same time it is becoming increasingly difficult to discover and exploit their new deposits. It is envisaged at known deposits of petroleum in our country will get exhausted by the few decades and coal reserves are expected to last for another hundred years. The coal, petroleum, natural gas and electricity are conventional sources of energy.

Coal: Coal is one of the most important sources of energy and is being used for various proposes such as heating of housed, as fuel for boilers and steam engines and for generation of electricity by thermal plants.

Coal has also become a precious source of production of chemical of industrial importance coal is and will continue to be the mainstay of power generation in India. It constitutes about 70% of total commercial energy consumed in the country.

Oil and Natural Gas: Like coal, petroleum is also derived from plants and also from dead animals that lived in remote past. Natural gas has also been produced in the Earth's curst by the similar process as petroleum and this is also a combustible fuel.

The exploitation of oil on a large scale started after 1960, the year when the first commercial well is reported to have come into existence. In India, efforts made by the Oil and Natural Gas Corporation since the late 1950s have led to the identification of a number of oil and gas deposits both offshore and onshore.

Natural gas is also emerging as an important source of energy in India's commercial energy scene in view of large reserves of gas that have been established in the country, particularly, in South Basin off west coast of India. Natural gas in also making significant contribution to the household sector.

About 30% of the country's output of LPG comes from this source. About three- fourths as the total gas comes from Mumbai high and rest is obtained from Gujarat, Andhra Pradesh, Assam Tamil Nadu and Rajasthan. The Oil and Natural Gas Corporation has made a significant hydro carbon finding and Reliance Industries struck gas off the Orissa coast in Bay of Bengal.

Electricity: It is another conventional source of power, which is playing a barometer of a nation's economic well-being. Availability of abundant electricity means unrestricted growth of industries, transport and agriculture.

There are various sources from which electricity is being produced. Depending upon raw material used, there are three types of electricity (i) Hydroelectricity (ii) Thermal electricity (steam, gas, oil) (iii) Nuclear electricity.

Q.2. What are the different energy resources that exist on our planet?

Ans. There are many different energy resources on our planet, but they are all classified into two primary groups – renewable energy resources, and non-renewable energy resources. Some energy resources generate additional energy, which is then converted into electrical energy. Examples of these types of energy include geothermal energy and hydro electric energy.

Renewable energy resources are energy resources that are directly available, immediately accessed, and can be consistently replaced. In other words, renewable energy resources are energy resources that replace, or renew themselves and that will never run out. Solar energy, energy that is harnessed form the sun, is a good example of one of many renewable energy resources, because we will never run out of the sun's rays or its power. Other examnles of renewable energy sources include wind energy, water energy, and wave energy.

Nonrenewable energy resources on the other hand are just the opposite. These energy resources are as the name implies, non-renewable. Our Earth is fixed with a finite amount of these energy resources, and once we run out, we will not be able to use those energy resources ever again. Fossil fuels, coal, oil, and gas, are all examples of non-renewable energy resources.

India is facing an acute energy scarcity which is hampering its industrial growth and economic progress. Setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources, such as biomass energy, solar energy, wind energy and geothermal energy. Apart from augmenting the energy supply, renewable resources will help India in mitigating climate change. India is heavily dependent on fossil fuels for its energy needs. Most of the power generation is carried out by coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission.

Q.3. What do you understand by Fossil Fuel? Explain the types of fossil energy.

Ans. Fossils (from Classical Latin *fossilis*, literally "obtained by digging ") are the preserved remains or traces of animals, plants, and other organisms from the remote past. The totality of fossils, both discovered and undiscovered, and their placement in *fossiliferous* (fossil-containing) rock formations and sedimentary layers (strata) is known as the *fossil record*.

Fossil fuels are fuels formed by natural processes such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. Fossil fuels contain high percentages of carbon and include coal, petroleum, and natural gas. They range from volatile materials with low carbon: hydrogen ratios like methane, to liquid petroleum to nonvolatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields, alone, associated with oil, or in the form of methane clathrates. The theory that fossil fuels formed from the fossilized remains of dead plants by exposure to heat and pressure in the Earth's crust over millions of years..

Types of fossil energy

Coal: The fuel that powered the West's industrialisation is still the most popular fossil fuel: around 6.2 billion tonnes are consumed annually, 75% of which is burned to produce electricity. A little under half of the world's power is made this way.

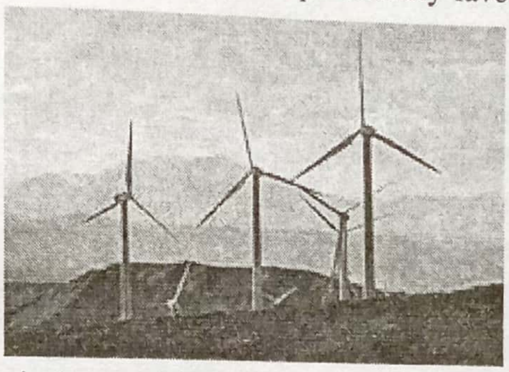
Gas: Gas is a cleaner fuel than coal and it provides the UK with about 40% of its primary energy. We are the world's fourth largest producer, with more than 200 off-shore fields in production and reserves of c18 billion barrels of oil equivalent.

Oil: Oil is the fossil fuel most in the headlines, especially now as its price has more than doubled in the space of a year. Although factors such as war and commodity speculation are influencing that price, it is widely believed that oil production peaked at 82 million barrels per day in 2005.

Q.4. Explain in detail about:

(i) Wind Power **(ii) Hydro Power**

Ans. Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites, are preferred locations for wind farms. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favourable sites.



Globally, the long-term technical potential of wind energy is believed to be five times total current global energy production, or 40 times current electricity demand, assuming all practical barriers needed were overcome. This would require wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines.

(ii) Hydro Power: Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea well, can yield considerable amounts of energy. There are many forms of water energy:

- Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. The largest of which is the Three Gorges dam in the Peoples Republic of China and a smaller example is the Akosombo Dam in Ghana.
- Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a remote-area power supply (RAPS).
- Run-of-the-river hydroelectricity systems derive kinetic energy from rivers and oceans without the creation of a large reservoir.

Q.5. What is Solar Energy?

Ans. Solar energy applies energy from the sun in the form of solar radiation for heat or to generate electricity. Solar powered electricity generation uses either photovoltaics or heat engines (concentrated solar power). A partial list of other solar applications includes space heating and cooling through solar architecture, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Solar energy capture is also being linked to research involving water splitting and carbon dioxide reduction for the development of artificial photosynthesis or solar fuels.

Q.6. Explain the theory of solar cells in detail.

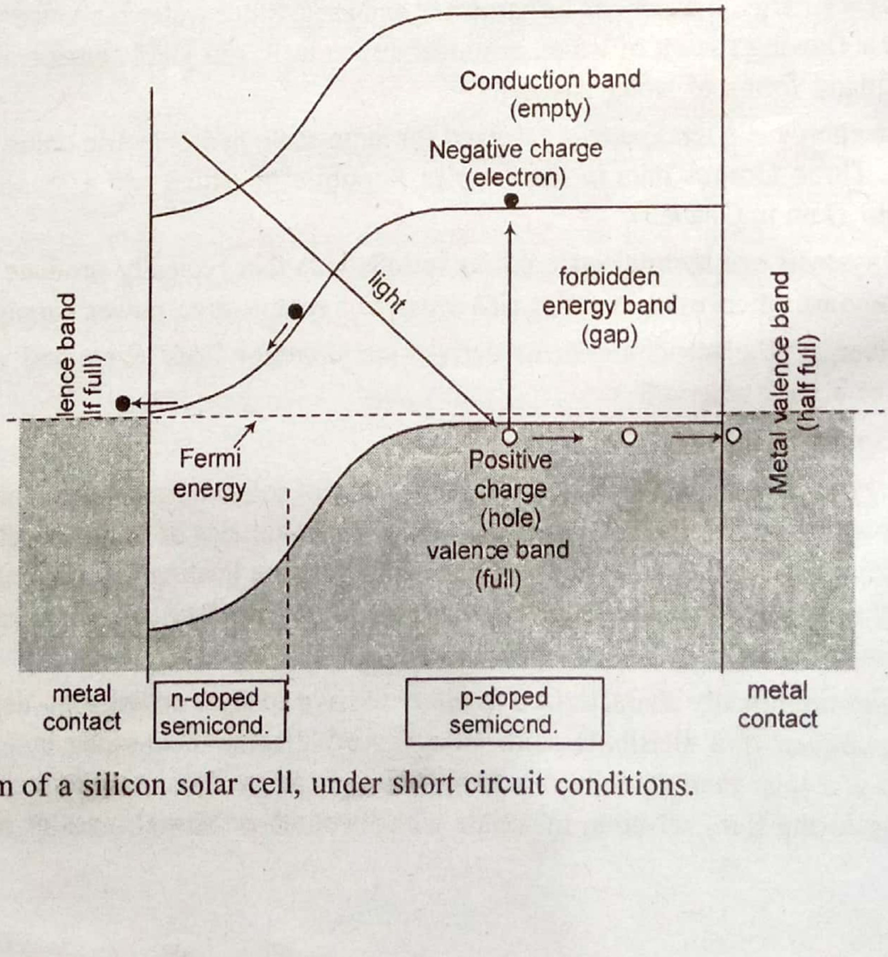
Ans. The theory of solar cells explains the physical processes by which light is converted into electrical current when striking a suitable semiconductor device. The theoretical studies are of practical use because they predict the fundamental limits of solar cell performance, and give guidance on the phenomena that contribute to losses and solar cell efficiency.

1. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
2. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction.
3. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

Photo generation of charge carriers

When a photon hits a piece of silicon, one of three things can happen:

1. The photon can pass straight through the silicon — this (generally) happens for lower energy photons,
2. The photon can reflect off the surface,
3. The photon can be absorbed by the silicon, if the photon energy is higher than the silicon band gap value. This generates an electron-hole pair and sometimes heat, depending on the band structure.



Band diagram of a silicon solar cell, under short circuit conditions.

When a photon is absorbed, its energy is given to an electron in the crystal lattice. Usually this electron is in the valence band, and is tightly bound in covalent bonds between neighbouring atoms, and hence unable to move far. The energy given to it by the photon "excites" it into the conduction band, where it is free to move around within the semiconductor. The covalent bond that the electron was previously a part of now has one fewer electron — this is known as a hole. The presence of a missing covalent bond allows the bonded electrons of neighbouring atoms to move into the "hole," leaving another hole behind, and in this way a hole can move through the lattice. Thus, it can be said that photons absorbed in the semiconductor create mobile electron-hole pairs.

A photon need only have greater energy than that of the band gap in order to excite an electron from the valence band into the conduction band. However, the solar frequency spectrum approximates a black body spectrum at about 5,800 K, and as such, much of the solar radiation reaching the Earth is composed of photons with energies greater than the band gap of silicon. These higher energy photons will be absorbed by the solar cell, but the difference in energy between these photons and the silicon band gap is converted into heat (via lattice vibrations — called phonons) rather than into usable electrical energy.

Charge carrier separation: There are two main modes for charge carrier separation in a solar cell:

1. Drift of carriers, driven by an electric field established across the device
2. Diffusion of carriers due to their random thermal motion, until they are captured by the electrical fields existing at the edges of the active region.

In thick solar cells there is no electric field in the active region, so the dominant mode of charge carrier separation is diffusion. In these cells the diffusion length of minority carriers (the length that photo-generated carriers can travel before they recombine) must be large compared to the cell thickness. In thin film cells (such as amorphous silicon), the diffusion length of minority carriers is usually very short due to the existence of defects, and the dominant charge separation is therefore drift, driven by the electrostatic field of the junction, which extends to the whole thickness of the cell.

Once the minority carrier enters the drift region, it is 'swept' across the junction and does not return. This sweeping is an irreversible process since the carrier typically relaxes to a lower energy state before it has a chance to be elastically scattered back to its starting point.

Q.7. Explain the following in detail:

(i) Biomass **(ii) Bio-Fuel** **(iii) Geo-Thermal Energy**

Ans. Biomass (plant material) can be a renewable energy source, but importantly, only if the rate of extraction does not exceed the rate of production, as non-renewable biomass usage can easily occur, such as the historical Deforestation during the Roman period and the present Deforestation of the Amazon Rainforest.

Through the process of photosynthesis, plants capture the sun's energy. When the plants are burnt, they release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy.

In general there are two main approaches to using plants for energy production: growing plants specifically for energy use (known as first and third-generation biomass), and using the residues (known as second-generation biomass) from plants that are used for other things. The best approaches vary from region to region according to climate, soils and geography.

The proportion of truly renewable biomass in use is uncertain, as for example peat, one of the largest sources of biomass, is sometimes regarded as a renewable source of energy. However due to peats extraction rate in industrialized countries far exceeding its slow regrowth rate of 1mm per year, and due to it being reported that peat regrowth takes place only in 30-40% of peatlands, there is considerable controversy with this renewable classification. Organizations tasked with assessing climate change mitigation methods differ on the subject, the UNFCCC classify peat as a fossil fuel due to the thousand plus year length of time for peat to re-accumulate after harvesting, another organization affiliated with the United Nations also classified peat as a fossil fuel. However, the Intergovernmental Panel on Climate Change (IPCC) has begun to classify peat as a "slow-renewable" fuel, with this also being the classification used by many in the peat industry.

Further controversy surrounding the classification of all biomass as "renewable" centres around the fact that depending on the plant source, it can take from 2 to 100 years for different sources of plant energy to regrow, such as the difference between fast growing switch grass and slow growing trees, therefore due to the high emission intensity of plant material, researchers have suggested that if the biomass source takes longer than 20 years to regrow, they argue the plant source should not be regarded as renewable from a climate change mitigation standpoint.

As of early 2012, 85 of 107 biomass plants operating in the U.S. had been cited by federal or state regulators for violating clean air or water laws over the past five years. The Energy Information Administration projected that by 2017, biomass is expected to be about twice as expensive as natural gas, slightly more expensive than nuclear power, and much less expensive than solar panels.

(ii) Biofuels include a wide range of fuels which are derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Liquid biofuels include bio alcohols, such as bioethanol, and oils, such as biodiesel. Gaseous biofuels include biogas, landfill gas and synthetic gas.

Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feed stocks for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil. However, according to the European Environment Agency, biofuels do not address global warming concerns.

Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe.

(iii) Geothermal energy is from thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective *geothermal* originates from the Greek roots *geo*, meaning earth, and *thermos*, meaning heat.

The heat that is used for geothermal energy can be from deep within the Earth, all the way down to Earth's core – 4,000 miles (6,400 km) down. At the core, temperatures may reach over 9,000 °F (5,000 °C). Heat conducts from the core to surrounding rock. Extremely high temperature and pressure cause some rock to melt, which is commonly known as magma. Magma convicts upward since it is lighter than the solid rock. This magma then heats rock and water in the crust, sometimes up to 700 °F (371 °C).

From hot springs, geothermal energy has been used for bathing since Palaeolithic times and for space heating since ancient Roman times, but it is now better known for electricity generation.

Q.8. What is Biogas production? Explain the Anaerobic digestion process.

Ans. Biogas typically refers to a gas produced by breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal feces, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas originates from biogenic material and is a type of bio fuel.

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste, plant material, and crops.[1] Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes

Biogas is practically produced as landfill gas (LFG) or digester gas. A *biogas plant* is the name often given to an anaerobic digester that treats farm wastes or energy crops. Biogas can be produced using anaerobic digesters. These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process,as an air-tight tank transforms biomass waste into methane producing renewable energy that can be used for heating, electricity, and many other operations that use any variation of an internal combustion engine, such as GE Jenbacher gas engines.] There are two key processes: Mesophilic and Thermophilic digestion.

Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill. The waste is covered and mechanically compressed by the weight of the material that is deposited from above. This material prevents oxygen exposure thus allowing anaerobic microbes to thrive. This gas builds up and is slowly released into the atmosphere if the landfill site has not been engineered to capture the gas. Landfill gas is hazardous for three key reasons. Landfill gas becomes explosive when it escapes from the landfill and mixes with oxygen. The lower explosive limit is 5% methane and the upper explosive limit is 15% methane. The methane contained within biogas is 20 times more potent as a greenhouse gas than is carbon dioxide. Therefore, uncontained landfill gas, which escapes into the atmosphere may significantly contribute to the effects of global warming. In addition, landfill gas impact in global warming, volatile organic compounds (VOCs) contained within landfill gas contribute to the formation of photochemical smog.

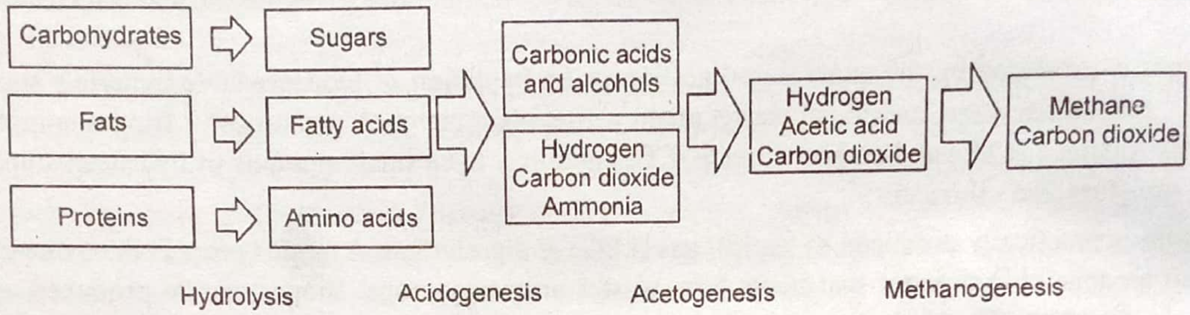
Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. It is used for industrial or domestic purposes to manage waste and/ or to release energy.

The digestion process begins with bacterial hydrolysis of the input materials to break down insoluble organic polymers, such as carbohydrates, and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide.[2] The methanogenic archaea populations play an indispensable role in anaerobic wastewater treatments.

It is used as part of the process to treat biodegradable waste and sewage sludge. As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. Anaerobic digesters can also be fed with purpose-grown energy crops, such as maize.

There are four key biological and chemical stages of anaerobic digestion:

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis



Q.9. What is Tidal Power? Give advantages and disadvantages of wave energy.

Ans. Tidal power, is a form of wave power and shares a common group of issues and solutions. The equipment mechanisms are similar and are still experimental. The environmental impact is interchangeable.

The major difference between the two is the manner in which they retain the water to produce power. Both mechanisms use a turbine which spins to create the power. Tides are much slower and water is retained, while waves are fairly repeatable and storage of water is far lower.

Advantages:

- Wave power is a renewable Energy Source.
- Wave Energy Is a Clean Fuel.
- Wave Energy is Environmentally Friendly - it doesn't destroy the environment.
- There is plenty of it.
- Tides/Waves are always predictable.
- you can always produce a significant amount of energy.
- you don't need fuel so it doesn't cost that much.
- Waves are free and will not run out so the cost is in building the power station.
- Wave power does not produce greenhouse gases.
- There are very few safety risks with wave power generation.

Disadvantages

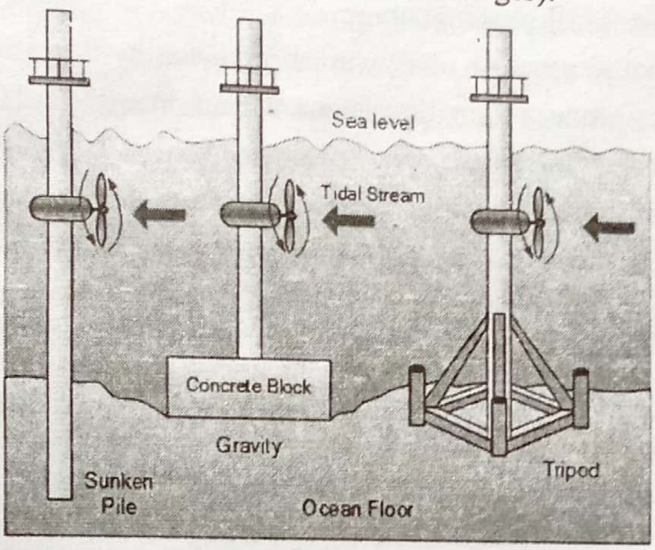
- Harnessing the power of it is difficult.
- It can cost a lot of money and requires further research.
- If the whole tidal/wave energy scheme does get popular real estate will be losing money for beach front houses since they will be using the beaches for the tidal/wind farms.
- It depends where you put it for the costs so not much good financially
- May interfere with mooring and anchorage lines commercial and sport fishing.
- Waves can be big or small so you may not always be able to generate electricity.

- You need to find a way of transporting the electricity from the sea onto the land.
- Not many people have tried to generate electricity this way yet so the equipment is expensive.
- It is believed that harnessing wave or tidal power will eventually slow the rotation speed of the planet. It is currently believed that we could cause as much as a full day of loss to our calendars every two thousand years by collecting enough energy from waves and tides.

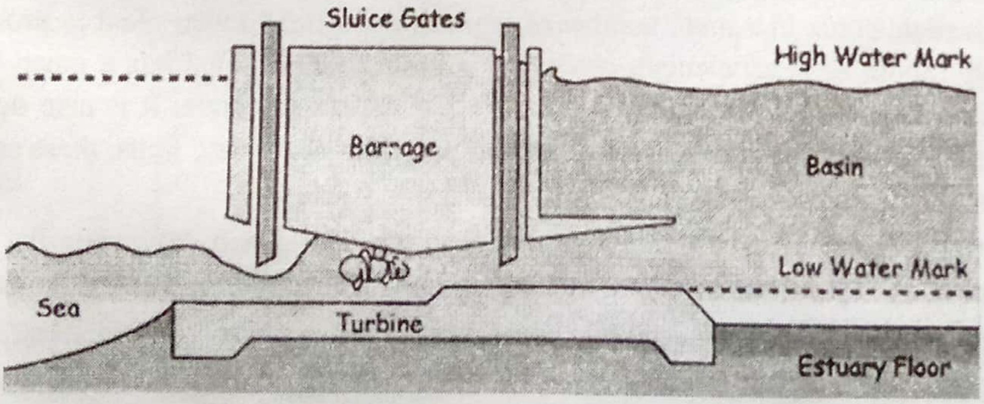
Q.10. Explain types of Tidal Power technology in use today.

Ans. Tidal power technology is constantly evolving. However, the most common technology today can be classified into three main categories:

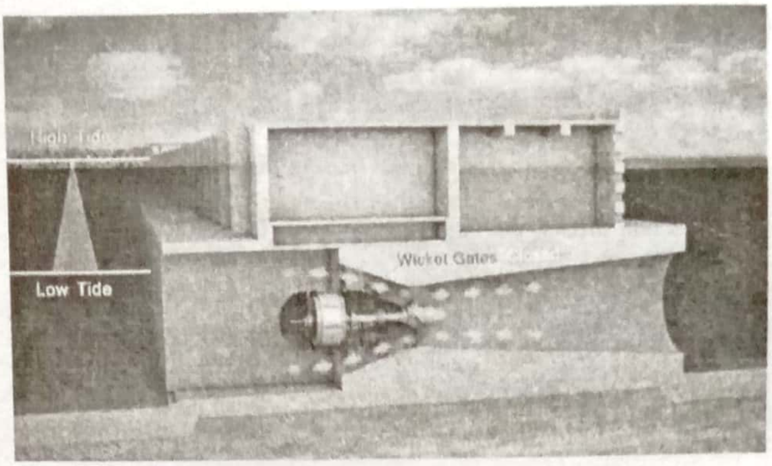
- **In-Stream Devices** make use of the kinetic energy of moving water to power turbines, in a similar way as windmills use moving air. This method is gaining in popularity because it's removable, it can be scaled up gradually (from one device, to an array, to a larger farm), and has lower potential costs and ecological impact (compared to barrages).



- **Barrages** make use of the potential energy in the difference in height – or head – between high and low tides. They are essentially dams across the full width of a tidal estuary – or the mouth of a river that has a free-flowing connection to the ocean. Barrages have very high costs, a worldwide shortage of viable sites and associated environmental concerns.



- **Tidal Lagoons** are similar to barrages but can be constructed as self-contained structures not extending fully across an estuary. Some suggest this may reduce both costs and overall impacts. They can be configured to generate continuously, which is not the case with barrages.



Advantages and Disadvantages

- Once the dam is built, Tidal power is cheap.
- There are no greenhouse gases or other wastes produced by it.
- Tidal Power facilities produce a predictable amount of energy.
- Major Power Dam building projects are very expensive.
- In order for a project to be successful, there must be a high tidal range.
- Maintenance of a tidal power facility can be difficult.
- By changing the flows of tides with dams there can be negative impacts on aquatic and shoreline ecosystems.

Q.11. State challenges specific to Tidal Energy systems.

Ans. Challenges Specific to Tidal Energy Systems

The problems and barriers mentioned below are relevant to all forms of tidal projects (barrages, streams and lagoons), unless specifically mentioned.

- **High cost:** The main detriment of tidal energy is the cost; tidal plants are expensive to build
- **Effects on ecosystem:** Presence of tidal plants can result in damages such as reduced flushing, winter icing and erosion, which can change the vegetation of the area and disrupt the balance.
- **Regional limitations:** Similar to other ocean energies, tidal energy has several prerequisites that make it available only in a small number of regions. For a tidal power plant to produce electricity effectively (about 85% efficiency), it requires a basin or a gulf that has a mean tidal amplitude (the differences between spring and neap tide) of 7 meters or above. It is also desirable to have semi-diurnal tides where there are two high and low tides every day. Thus, there are not too many suitable sites for tidal barrages.
- **Time limitations:** Tidal provides power for about ten hours each day, when the tide is actually moving in or out. So, it does not provide energy for electricity all through the day.
- **Problems specifically related to tidal barrages**
  - o Tidal barrages may block outlets to open water. Although locks can be installed, this is often a slow and expensive process.
  - o Barrages affect fish migration and other wildlife- many fish like salmon swim up to the barrages and are killed by the spinning turbines. Barrages may also destroy the habitat of the wildlife living near it

- o Barrages may affect the tidal level - the change in tidal level may affect navigation, recreation, and cause flooding of the shoreline

Q.12. What are solar ponds?

Ans. A **solar pond** is a pool of saltwater which acts as a large-scale solar thermal energy collector with integral heat storage for supplying thermal energy. A solar pond can be used for various applications, such as process heating, desalination, refrigeration, drying and solar power generation.

A solar pond is simply a pool of saltwater which collects and stores solar thermal energy. The saltwater naturally forms a vertical salinity gradient also known as a "halocline", in which low-salinity water floats on top of high-salinity water. The layers of salt solutions increase in concentration (and therefore density) with depth. Below a certain depth, the solution has a uniformly high salt concentration.

There are 3 distinct layers of water in the pond:

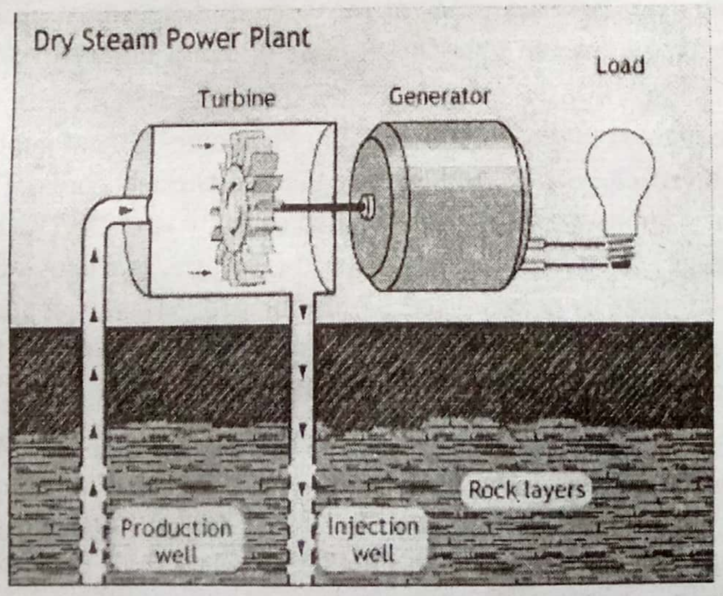
- The top layer, which has a low salt content.
- An intermediate insulating layer with a salt gradient, which establishes a density gradient that prevents heat exchange by natural convection.
- The bottom layer, which has a high salt content.

Q.13. What is Geo-Thermal Energy and why it is considered as renewable source of energy?

Ans. Geothermal energy originates from the heat retained within the Earth since the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. Most high temperature geothermal heat is harvested in regions close to tectonic plate boundaries where volcanic activity rises close to the surface of the Earth. In these areas, ground and groundwater can be found with temperatures higher than the target temperature of the application. However, even cold ground contains heat, below 10 feet or 3 meters, the ground is consistently 12.8 °C (55 °F) in moderate climates, and it may be extracted with a heat pump.

Q.14. Discuss in detail about Steam power plants and also about Geothermal Power plants and its application.

Ans. Steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. (Also eliminating the need to transport and store fuels!)



This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal electricity. These plants emit only excess steam and very minor amounts of gases.

The technology to generate electricity from this hot water and steam is called "wet geothermal technology". In contrast to the experimental hot dry rock technology mentioned above, wet geothermal technology has existed for more than a century. It is commercially proven, highly reliable technology that provides electricity for 60 million people around the world — a figure that is increasing rapidly.

Electricity can be generated from wet geothermal resources in several ways. Geothermal Electric Limited plans to install a "binary" system, which involves *two separate circuits* for fluids.

The most common type of geothermal power plant to date is the flash power plant with a water cooling system. This system uses geothermal reservoirs of water with temperatures greater than 360°F (182°C). In this system, very hot water (above water's boiling point at standard atmospheric pressure) flows up through wells under its own pressure. As the water is pumped from the reservoir to the power plant, the drop in pressure causes the water to convert or "flash" into steam that is separated in a surface vessel (the steam separator) and delivered to a turbine that powers a **generator**. Leftover water and condensed steam are injected back into the reservoir for reuse. Flash plants emit small amounts of steam and gases.

Recent advances in geothermal technology have made it possible to produce electricity economically from lower-temperature **geothermal resources**, at 212° (100°C) to 302°F (150°C). Known as "binary" geothermal plants, these facilities reduce the emission rate to zero. In the binary process, geothermal water is used to heat another liquid, such as isobutene, that boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger used to transfer the heat energy from the geothermal water to a secondary fluid (also known as the "working fluid"). The secondary fluid vaporizes into gaseous vapour (like steam) and the force of the expanding vapour turns the turbines that power the generators. If the power plant uses air cooling, the geothermal fluids never make contact with the atmosphere before they are pumped back into the geothermal reservoir — effectively making the power plant emission-free.

Applications: In the geothermal industry, *low temperature* means temperatures of 300 °F (149 °C) or less. Low-temperature geothermal resources are typically used in direct-use applications, such as district heating, greenhouses, fisheries, mineral recovery, and industrial process heating. However, some low-temperature resources can generate electricity using binary cycle electricity generating technology.

Approximately 70 countries made direct use of 270 Peta joules (PJ) of geothermal heating in 2004. More than half went for space heating, and another third for heated pools. The remainder supported industrial and agricultural applications. Global installed capacity was 28 GW, but capacity factors tend to be low (30% on average) since heat is mostly needed in winter. The above figures are dominated by 88 PJ of space heating extracted by an estimated 1.3 million geothermal heat pumps with a total capacity of 15 GW. Heat pumps for home heating are the fastest-growing means of exploiting geothermal energy, with a global annual growth rate of 30% in energy production.

Direct heating is far more efficient than electricity generation and places less demanding temperature requirements on the heat resource. Heat may come from co-generation via a geothermal electrical plant or from smaller wells or heat exchangers buried in shallow ground. As a result, geothermal heating is economic at many more sites than geothermal electricity generation. Where natural hot springs or geysers are available, the heated water can be piped directly into radiators. If the ground is hot but dry, earth tubes or downhole heat exchangers can collect the heat. However, even in areas where the ground is colder than room temperature, heat can still be extracted with a geothermal heat pump more cost-effectively and cleanly than by conventional furnaces. These devices draw on much shallower and colder resources than traditional geothermal techniques, and they frequently combine a variety of functions, including conditioning, seasonal, solar energy collection, and electric heating. Geothermal heat pumps can be used for space heating essentially anywhere.

Geothermal heat supports many applications. District heating applications use networks of piped hot water to heat many buildings across entire communities. More than 72 countries have reported direct use of geothermal energy, Iceland being the world leader. 93% of its homes are heated with geothermal energy, saving Iceland over $100 million annually in avoided oil imports. Reykjavík, Iceland has the biggest district heating system on the globe. Once known as the most polluted city in the world, it is now one of the cleanest due to geothermal energy.

Q.15. What is Hydrogen Fuel? How does it work?

Ans. Hydrogen fuel is a zero emission fuel when burned with oxygen. It can be used in fuel cells or internal combustion engines to power electric vehicles or electric devices. It has begun to be used in commercial fuel cell vehicles such as passenger cars, and has been used in fuel cell buses for many years. It is also used as a fuel for spacecraft propulsion.

Hydrogen is found in the first group and first period in the periodic table, i.e. it is the first element on the periodic table, making it the lightest element. Since hydrogen gas is so light, it rises in the atmosphere and is therefore rarely found in its pure form, H_2. In a flame of pure hydrogen gas, burning in air, the hydrogen (H_2) reacts with oxygen (O_2) to form water (H_2O) and releases energy.

$$2H_2\,(g) + O_2\,(g) \longrightarrow 2H_2O(g) + \text{energy}$$

If carried out in atmospheric air instead of pure oxygen, as is usually the case, hydrogen combustion may yield small amounts of nitrogen oxides, along with the water vapor.

The energy released enables hydrogen to act as a fuel. In an electrochemical cell, that energy can be used with relatively high efficiency. If it is used simply for heat, the usual thermodynamics limits on the thermal efficiency apply.

Hydrogen is usually considered an energy carrier, like electricity, as it must be produced from a primary energy source such as solar energy, biomass, electricity (e.g. in the form of solar PV or via wind turbines), or hydrocarbons such as natural gas or coal.

Q.16. Discuss the situation of biofuel production in India.

Ans. In India, a bioethanol program calls for E5 blends throughout most of the country targeting to raise this requirement to E10 and then E20. In 2003, the national government set a 5% mandated blending target for gasoline. Since then, petroleum with an ethanol blend has been developed and used in nine states and four territories: Andhra Pradesh, Daman, Diu, Goa, Dadra, Nagar Haveli, Gujarat, Chandigarh, Haryana, Pondicherry, Karnataka, Maharashtra, Punjab, Tamil Nadu and Uttar Pradesh. In 2005, the country became the world's fourth largest producer of ethanol at 1.6 billion liters and at the same time the world's largest consumer of sugar.

The country aims to replace 20% of the country's diesel requirement with biodiesel in accordance with the National Biodiesel Mission (NBM) by 2012. The NBM has been, and will continue to be, implemented in two stages: First is a demonstration project, which was carried out over the period

2003-2007 aimed at cultivating 400,000 hectares of Jatropha expected to yield about 3.75 tons of oilseed per hectare annually. The project has also demonstrated the viability of other related activities/ projects such as seed collection and oil extraction. In addition, the government will build a transesterification plant. Second, a commercialization period which started in 2007 and will proceed until 2012 will continue with Jatropha cultivation. The plan also involves the installation of more transesterification plants that will position India to meet 20 per cent of its diesel needs through biodiesel. High ethanol prices and low availability of sources has compelled the government to amend its 5% blending target with the notification that 5% bioethanol blended petrol shall be supplied in identified areas if

(a) The indigenous price of ethanol offered for ethanol blended petrol programme is comparable to that offered by the indigenous ethanol industry for alternative uses,

(b) The indigenous delivery price of ethanol offered for the ethanol blended petrol programme at a particular location is comparable to the import parity price of petrol at that location, and

(c) There is an adequate supply of ethanol. To encourage investment, there are also tax incentives and excise cuts. At the state level, the Maharashtra government offers waivers of government fee from the 1 percent turnover tax on anhydrous ethanol, INR500 per kiloliter (US$0.048 per gallon) permit fee, 4 percent sales tax, 10 percent surcharge on sales tax, INR1,500 per kiloliter (US$0.14 per gallon) import fee, INR300 per kiloliter (US$0.029 per gallon) service charges and 3 percent Octroi, which is a local tax collected on various articles brought into the district for consumption.

By 2030, it is expected that India will soon become the world's third largest economy due to its speedy growth. In 2005, the GDP of India was US$0.6 trillion, and it is forecasted to reach US$6.1 trillion by the year 2030 at an annual growth rate of 9%.

The country has about 125 ethanol producers with a total capacity of 1.25 billion liters of ethanol. Most of these ethanol-producers are found in sugar cane growing states like Maharashtra and Uttar Pradesh, which also operate in states such as Tamil Nadu, Andhra Pradesh, Karnataka and Gujarat. India ranks No. 12 in the 2008 Ernst and Young Indices but may rise higher in the ranking once the country is able to coordinate tax incentives between states and state and federal legislation. At present, the country has about 11 factories in the Uttar Pradesh facilities and is expected to produce about 75 million liters of anhydrous alcohol by end-September with 7 units in Tamil Nadu (production capacity of 62.5 million liters of anhydrous alcohol); 8 in Karnataka (anhydrous alcohol production capacity of 66.5 million liters); and 4 units in Andhra Pradesh (capacity of over 40 million liters). Similar steps have also been taken by the cooperative sector units in Maharashtra, Punjab and UP.